

Development of integrated Assessment to Measure student's Analytical Thinking Skills and Scientific Attitudes for Chemical Equilibrium Topic

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Abstract: Technological advances which are the parameters of the new era have an impact on the demands for increasing skills. The current demand for skills is in the form 21st-century skills, including analytical thinking skills. In addition, scientific attitudes are part of the science elements that are required to be mastered by students in this century, therefore it is necessary to have an instrument that can measure these two skills, based of this, an integrated assessment instrument is developed which aims to determine the characteristics of the instrument, the feasibility and the results of the measurement of an integrated assessment of students' analytical thinking skills and scientific attitudes on chemical equilibrium material for 11th grade of senior high school. All test subjects came from six schools in the city of Mataram, West Nusa Tenggara province. Sample take by stratified random sampling technique. The test results were analyzed using the Partial Credit Model 1 Parameter-Logistic (PCM 1-PL) approach in Item Response Theory (IRT) by the Winsteps program. All items were declared fit. The measurement results using this integrated assessment instrument show that students' analytical thinking skills and scientific attitudes on chemical equilibrium material are 36.5% in the moderate category.

Keywords: Analytical Thinking Skills; PCM 1-PL; IRT; Stratified Random Sampling; Scientific Attitudes.

Introduction

Education is the basic thing that is very important in every country. Education has to improve its quality because of the demands of the times (Cahyani, 2015). There are demands that must be met by every actor in education which are commonly referred to as the demands of the 21st century (Akani, 2017). These demands must be met by students to face the times and advances in technology and it's become a benchmark for the progress of a country's education. However, based on facts, it proves that the quality of education in Indonesia is still below the standard where the ranking of Indonesian science education is ranked 62 out of 70 countries. The Organization for Economic Co-operation and Development (OECD) observed that in 2012 science

education had increased but was still weak or classified as low (Dewi et al., 2013). To realize the progress of education in the midst of this globalization era, it is necessary to improve the system of national education, one of which is the professionalism of educators, to create personality, self-control, and community skills, especially education actors (Didis, 2015).

Chemistry is one part of learning science. Chemistry is the science that speaks about the structure something substances, color change, taste, and properties something substances (Adhiya & Laksono, 2018). Whereas learning chemistry is very important, it becomes important because chemistry knowledge is needed to face global competition, progress science, and progress technology and is something knowledge basic must be owned by every participant. However, based on

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the result of the study, many participant students who think that chemistry as a science is not important because of their assumption about the difficulty in learning chemistry (Dolipas et al., 2015). Chemical equilibrium is one of the theories that are important in the learning of chemistry. A lot of research about equilibrium chemistry at school that chemical equilibrium is a very important material however difficult to work on (Akani, 2017). Other studies also showed that chemical equilibrium often occurs misconceptions that lead to students misunderstanding concepts (Eskandar et al., 2013).

Analytical thinking skills is a necessary thing for studying chemistry and sharpened in self student for prepare students in the competitive world of work and face development of the times and the era of globalization. Analytical thinking skill is an aspect cognitive in bloom's taxonomy and become one of the high-level thinking activities (Sadhu, 2018). where students are able to analyze and apply their knowledge. Then only 43% of students are able to answer question with high level Skills, where should be needed to reach the exact number in developing student international is 75% of total student entirely (Demircioglu et al., 2018).

Scientific attitude is another important one in the chemistry and one demand 21st century, so that participants more ready in facing impact global competition, where scientific attitude is a behavior or attitude from a participant in accept a learning in the form of ideas or theory as well as reciprocal reaction as question nor opinion (Dewi et al., 2013). Scientific attitude is considered and implemented in upgrade quality learning participant students (Newby et al., 1987). According to Dewi et al. (2013), understanding power educator or teacher about scientific attitude is low so that scientific attitude knowledge possessed by participants no once be measured or don't get attention clearly. Study of Mudalara (2012), shows existence connection among scientific attitude and results of student learning.

To measure the Analytical thinking skills and Scientific attitude need the own assessment, now days there is no the assessment that conduct those two skills in one assessment, so it is necessary to develop the assessment that able to measure two skills in one assessment. Integrated assessment is one of an interdisciplinary approach to assessment based on combining, communicating knowledge and interpreting from diverse scientific disciplines to policy in such a way that an entire cause effect chain of a problem can be evaluated from a synoptic perspective. In the other hand now days Mardapi et al. (2012), showed that many of instrument evaluation results learning that has not able to fulfill precondition as proper the assessment.

Method

This study is research and development or R&D. This Study has chosen because of based on the aim to develop and produce product instrument. The 4-D Development Model has typical and considered stages in accordance with development model of the integrated instruments (Smits et al., 2011). This development model developed by Thiagarajan (1974), one of the advantages of this model is the convenience in understood and implemented, in the other development models that are more difficult for implemented and understood Ad'hiya & Laksono, (2018). This development model started with definition, design, develop, and end with disseminate (Sumintono, 2015) that can be show in figure 1 bellow 4D by (Thiagarajan, 1974).

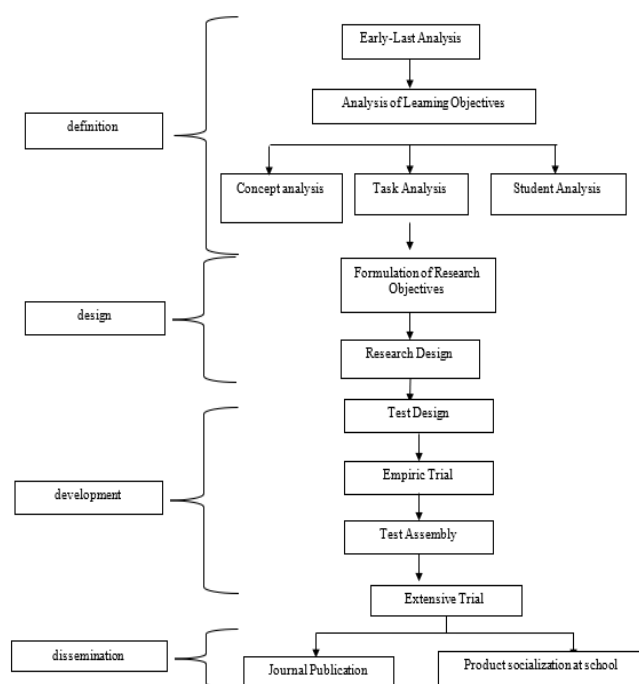


Figure 1. Achievement Indicator Integrated

The main purpose of the integrated assessment is the measurement of knowledge and mastery of a material or a person's insight into an object and aims to determine decision making on multidisciplinary knowledge of a source or individual, the integrated indicator was appeared from combining the Indicator of Analytical Thinking Skills and Indicator of Scientific Attitude, that can show at Table 1.

Trial of empiric validation is validated by two expert judgments consisting of from one expert evaluation learning, one expert theory learning, as originating corrector from lecturer at Yogyakarta State University and six high school chemistry teachers for produce validation contents item question, goal from involvement lecturer expert in validation item and

shown appropriate advice. Determination test subject development instrument based on similarity average score in chemistry exam lesson and similarities index performance school in the city of Mataram. Lianacre argues that in analysis Rasch's model is if the data in the form dichotomy with size minimum sample is 30 participants (Sumintono, 2015). Whereas for polytomy data, a minimum of 50 participants is used. Because of the use modeling Rasch model 1- PL can be used with criteria a sample of 30-300 participants. Determination subject study using a stratified random sampling technique based on the index achievements and rankings results exam school on chemistry in Mataram city at 2020.

Table 1. Integrated Indicator

| Analytical thinking skill | Scientific Attitude | Integrated Indicator |
|---------------------------|---------------------|----------------------|
| Identification Problem | Objectivity | Determining |
| Expressing Review | Open Minded | Reviewing |
| Determining the Solution | Curiosity | Delving |
| Conclude | Humble | Analyzing |
| | Opinions | Concluding |
| | | Evaluating |

At this trial validation stage, several research subjects were carried out, about 235 students of 12th grade in several schools in Mataram city. The use of 12th grade of students as subjects for empiric validation trials has several reasons, including class 12th grade has received previous learning about chemical equilibrium, therefore class 12th grade is considered to have been able to understand several concepts about chemical equilibrium material as evaluation material in this development research. Another reason is because the chemical equilibrium material is at the end of the semester, therefore the use of 11th as a subject for empiric validation trials is not possible.

The subject of the final instrument trial using 11th grade with total 244 students. The use of 11th grade as this subject was due to the consideration of several reasons, some schools used chemical equilibrium material as daily test material and the meter used by the teacher to assess these students as material for the final semester grade report, therefore the value of the measurement results of this instrument was considered to be more valid because these students have just finished learning about chemical equilibrium material.

The data collection technique used is the interview technique. The interview is used to identify and analyze the importance of developing an assessment instrument to measure students' analytical thinking skills and scientific attitudes. Questionnaire Techniques There are several questionnaires used in this study, namely, readability questionnaires for the student, and

validation of items aimed to expert judgment, the Test Techniques at the stage of this instrument in the form of item question description, item question arranged by special and as well as need the ability to answer question. The achievement category for measure the level of student analytical thinking skills and science attitude can be showed in Table 2.

Table 2. The Category of Integrated Assesment Percentage

| Interval | Category |
|---------------|----------|
| >66.75% | High |
| 33.3% - 66.7% | Moderate |
| < 33.3% | Low |

Result and Discussion

The integrated assessment instrument is the product of a study development that refers to this 4D model. This instrument is designed to measure the analytical thinking ability and scientific attitude of students on chemical equilibrium material for 11th grade of senior high school.

There are ten form questions that have been developed in the Instrumental Instruments of Initial - Final Analysis, or it can also be called front-end analysis, which is carried out based on observations and interviews with several high school chemistry tutors in the city of Mataram, West Nusa Tenggara Province. Formulation objective learning or specifying instructional objectives done based on analysis of core competencies (KI) and competencies basic (KD) lesson chemical 11th grade odd semester with curriculum 2013.

Empirical Trial Validation

Result of validation expert analyzed use Aiken formula. Validation result construct aspection, language, validity, practiccality and substance, then known that range value Aikens earned from validator range between 0.65 to 0.81. It means that instrument-built assessment already fulfils the construct aspect. Then for aspect language based on figure 3 is known that range value Aikens earned from validator range between 0.66 and 0.79. It means that instrument assessment made already fulfil aspect language as a tool appraisal. For aspect validity based on figure 4 then is known that range value Aikens earned from validator range between 0.67 and 0.78. It means that instrument assessment made already fulfil aspect validity as a tool assessment. Figure 5 shows that range value Aikens for practicality aspects from validator range between 0.6 and 0.8. It means that instrument assessment made already fulfil aspect practicality as a tool assessment. The assessment of the substance aspect instrument as an evaluation tool has met the requirements because it is in

the range between 0.67 and 0.78.

Significance statistics from V , get determined with correlate *rating category* with number of raters. On research this using 2 experts as corrector and 6 experts or raters with three scale categories, using level 0.05 significance as well as limit the value of V is of 0.83. Based on results estimation made validity fill on the chart seen score Aiken on every item more from 0.7 on each aspect. Based on Thing they could said that at the level of 0.05 significance of all items on the instrument proved valid.

Assumption test are using the statistical package program for the social science version 17.0. which is analysis factor exploratory. Analysis result indicates validity construct by empirical test. Test appropriateness sample use Bartlett test and (KMO-MSA) *Kaiser-Meyer-Olkin Measure of Sampling Adequacy*. Bartlett test work to determine the correlation between variables in the developed instrument. On this research, the analysis factor using exploratory *factor analysis* that saw in KMO value. The exploratory factor analysis approach does not used the KMO value under 0.50 (Yilmaz et al., 2011). While in research, this KMO is valued at 0.877 because that approach this could be done.

Besides analysis against KMO and Bartlett, a re-examination was also performed to mark the anti-image. Based on the data show that more anti-image correlation value from 0.5 to all question, with this data all question items are valid in validity construct. Analysis factor for identify between variables in instrument that can saw in mark *eigen value* on matrix variance inter - item covariance. Based on According to Ad'hiy 2018 the eigenvalues should be more from 1.0 to determine total factor. Based on the data there are 2 factors that are formed and explain 65% of the total variance.

The results of the analysis of other factors were also observed with a scree plot. The scree plot results can clarify the visualization of the eigenvalues. Determination of the total factor results from the item test is carried out by taking into account the initial construct, which is the basis for product development. The relatively sloping curve factor explains that there are two factors that are formed, with the main factor as the dominant factor (Ozmen, 2008). Retnawati (2014), explained that if the factor analysis results can explain the 20% variance, then the unidimensional assumption has been fulfilled. The assumption of local independence used to determine the participants' self-reliance skills on the items, the assumption of local independence will be proven automatically with the participant's unidimensional response data to test.

Analysis result from local independence assumption that obtained through matrix variant from *person measures*. Independence test local will fulfill if existing value below the diagonal line in the matrix

variance covariance is zero. Zero value on variance-covariance means that the participant skills in answer the some item question no influential in ability in answer another question, it means is in every item question character independent. It shows that every existing value below the diagonal line in the matrix is all is zero. Based on data show that assumption local independence on instrument is fulfilled. Besides of assumption test analysis of local independence by separated with other tests, The literature shows the assumption local independence already detected in the test of evidence assumption unidimensional. Demars (2010), showed that assumption local independence by automatic proven from the test of evidence assumption unidimensional.

The assumption of invariant item parameters with item parameter estimates in each group of students is different. In this study, the calculations on the assumption test of data grouping the invariance parameters into two groups of data, namely odd and even groups. Estimation is done by determining the linear equation in the presentation of the scatter diagram data. If the linear line equation has a high correlation, it can be indicated that the invariance assumption has been met. This is evident from the many points that are close to the linear line, so it can be said that the item parameter assumptions fulfill. This result means that although the product instrument was test on different students or participants, the characteristics of the instrument items will not change. Test the assumption of ability parameter invariance, shows that the estimation of ability parameter in the item group is different. The test of the assumption of invariance ability in this research item was divided into odd group items and even items. Based on the results obtained are presented in a scatter diagram and the coefficient of the relationship was determined. The Ability Invariance Assumption parameter has met if the data presented in the second group of odd and even question items have a high correlation.

Based on these data conclude that assumption ability parameter invariance already fulfilled which means that ability participant test will not be changed if work with the level difficulties. Suitability item or *fit items* analyzed using rasch model. Analysis of the item product developed to fulfil the condition as good and optimal measurement or not. In accordance or fulfil criteria *fit* if the score fulfils mark *outfit z -standard outfit means-square* and *point measure correlation*.

Every item question has met at least one criteria reception limit on *MNSQ*, *ZSTD*, or *Point Mean Corr* except for item number 10 who passed through limit reception *MNSQ* and *ZSTD* because of that fix on item number 10 with lower-level difficulty question, however because in point 10 it fulfills *Pt Mean Corr Value* so

question permanent considered *fit* Analysis Rasch modeling. Using the Winsteps program the calibration is using PCM-1PL on item question to show suitability item question in fit criteria or not. Sumintono and Widhiarso (2015), argue that item question declared worthy for analysis more carry on as well as suitable with the model the item test fulfills one between reception limit on *MNSQ*, *ZSTD*, or *Point Mean Corr*.

The difficulty parameter level is the difficulty level of estimating an item, expressed in logit units. Difficulty level questions require high ability to answer, in contrast to items with low or easy level of difficulty, so that to answer correctly requires low ability. The range of values between -2.0 to +2.0 logit is an index of the difficulty of something that is considered good. The function of the information test is to describe the accuracy of the items on the instrument that explains how the items describe the participants' latent abilities based on the measurement results using the test instrument that was built. In addition, according to Hambleton et al. (1991), the function information test is a total function item for the information in the test.

Reliability is something that shapes consistency measurement. According to Yilmaz et al. (2011), general reliability is something consistent in research. Approach one measurement (internal consistency *approach*) is something approach measurement with one-time test measurement at the trial stage instrument. According to Shahani and Jenkinson (2016), the approach of one-time measurement is considered efficient and practical in research this is reliability data obtained through the *winstep* program, and got results including high category is about 0.94 for the mark reliability test and 0.96 for the value data item reliability.

The results of the assessment of user responses to the integrated assessment instrument for the substance aspect obtained an average value of 88%, the results were categorized as fairly good scores. The data describes the substance aspect of the instrument that requires analytical thinking skills to be answered correctly, and the items are in accordance with everyday problems, with an easy-to-understand item arrangement and not too many questions, and sufficient time to complete all items given question. Then for the language aspect, an average result of 87% was obtained in a fairly good category. With the use of simple language on the instrument questions, it can make it easier for students to understand the meaning of the questions given, the things that describe the linguistic aspects of the developed instruments are in accordance with the aspects that have been taught by the teacher. The linguistic aspect obtained an average result of 90% and is included in the good category, the appearance of the description aspect on the developed instrument has

met the consistency in writing symbols, the font type and size are proportional.

From all data showed above, this instrument is feasible to use to measure the analytical thinking skills and scientific attitude of student in chemical equilibrium at 11th grade senior high school.

Achievement Skills Integrated Based on Indicator Achievement Competence

Measurement on stage this held in 2021 in November - December on participants 11th grade at four school in the city Mataram in odd semester year teaching 2021. Trial designed the same for every school with allocation 90 minutes time or use two hours of lessons. The achievement result showed in the Table 3.

Table 3. Achievement Skills Integrated Based on Indicator Achievement Competence

| Integrated Indicator | Average percentage (%) |
|----------------------|------------------------|
| Determining | 29.34 |
| Reviewing | 51.13 |
| Delving | 42.23 |
| Analyzing | 23.6 |
| Concluding | 33.8 |
| Evaluating | 48.8 |
| Deciding | 26.9 |
| Average | 36.5 |
| Category | Moderate |

This study is in accordance with the research conducted by Sadhu (2018) that the indicators related to the analysis of the influence of concentration, pressure, volume and temperature tend to have a low level of difficulty. This is evident from the percentages in indicators 2,3, and 6 in the percentage table having a higher percentage score than other indicators. These results are reinforced by research conducted by Sadhu (2018) and Adhiya (2018) that each school has a different percentage of ability and each participant has the skills to answer various kinds of questions. In this study, a number of results were obtained that were not in accordance with the theory, one of which was the 4th indicator where the percentage of indicators in schools with high abilities had a lower percentage of scores than other schools with lower memory. This is possible because there are other factors that influence it are beyond the control of this study. Different things are shown in the data of schools that have a high level of ability, the first indicator is the ability to analyze the balance of factors that affect the shift in the direction of the balance having the highest percentage of achievement compared to the second and third indicators. This is something of an improvement over the two previous grade schools. Based on the data we obtained, the percentage for the first competency

indicator is more than 55% while the second and third indicators are still under the first percentage. According to Adhya (2018) each skill possessed by the participants

is different and there is a strong relationship between students' thinking skills and students' ability levels that shows in figure 2.

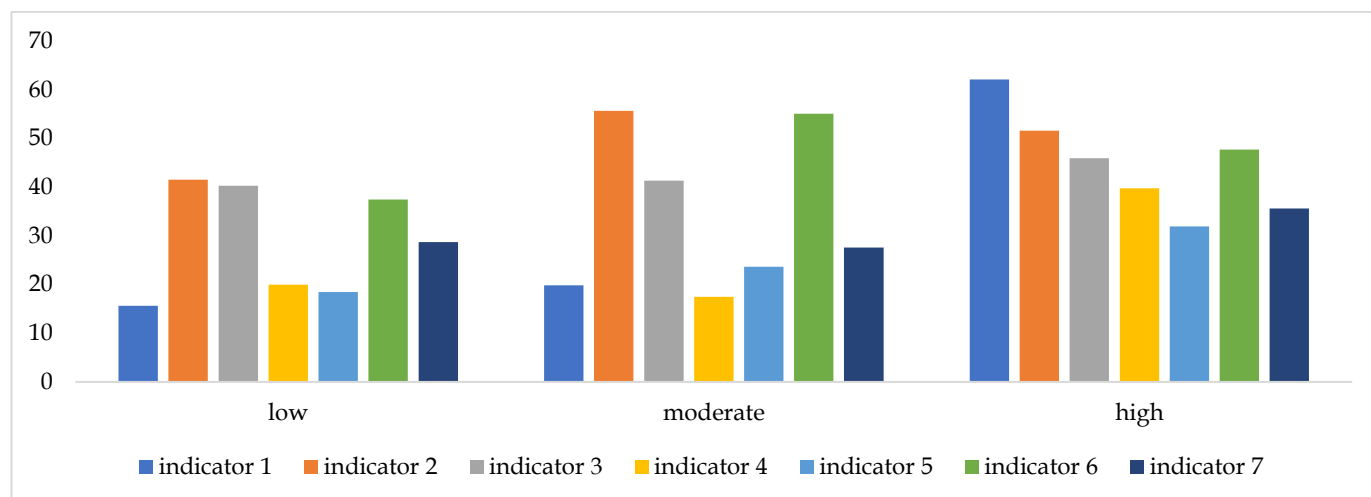


Figure 2. Achievement Indicator Integrated

In figure 2 that the category of schools with low levels of ability, the first integrated indicator is the ability of participants to determine the solution to a problem based on the acceptance of ideas, information and chemical concepts themselves, the lowest percentage is 15.6%. Meanwhile, the highest percentage is found in the second indicator, namely the ability of participants to assess opinions about daily life problems based on receiving information, data or ideas based on chemical designs, which is 42%. The same thing was found at the current level of ability of participants, where it has also seen that the highest percentage of integrated indicators found in the second indicator, which was 55%. According to Adhya (2018), there is a linear relationship between the skills of participants with the level of academic quality and ability of participants.

Conclusion

Based on the results of this research and discussion, the development of an integrated assessment instrument to measure students' analytical thinking skills and scientific attitudes on chemical equilibrium material is appropriate for an assessment to measure students' analytical thinking skills and scientific attitudes on chemistry and the balance material for grade 11. The results of the measurement using an integrated assessment instrument to measure the analytical thinking ability and scientific attitude of students on the chemical equilibrium material for class XI are classified as moderate with a percentage of 36.5%.

Based on the conclusions obtained in this study, there are several suggestions that can be made to benefit

from this development research, the integrated assessment instrument developed is expected to assist teachers in evaluating students' analytical thinking skills and scientific attitudes on chemical equilibrium material. The integrated assessment instrument developed is expected to be used by teachers to improve the quality of learning in schools by increasing students' analytical thinking skills and scientific attitudes.

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