Preparation of authentic assessment instruments on instrumental analysis practice project-based to improve graduate competence

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Abstract. The instrument has been tested to measure students' competency level. Competencies measured include mastery of instrumentation analysis concepts, basic laboratory skills, instrumentation analysis skills, critical thinking skills, and scientific work abilities. Mastery of instrumentation analysis concepts is assessed through tests, basic laboratory skills and instrumentation analysis skills assessed through observation, critical thinking skills and scientific work abilities assessed through product assessment in the form of designs and reports from the project. The test results obtained that information from 30 test questions mastery instrumentation analysis concepts there is only 25 valid questions and measurement instruments mastery of the overall concept reliable with reliability 0.845. Authentic assessment instruments and rubrics as guidelines for evaluating basic laboratory skills, instrumentation analysis skills, and critical thinking skills, scientific work abilities were tested through 6 observers. Overall the results of the inter-rater reliability test obtained by interclass correlation (ICC) above 0.7 which means that authentic assessment instruments are valid and reliable.

1. Introduction

Learning chemical analysis instrumentation experiments that have the character of verification has not been able to increase the competence of chemistry students as expected. Students are still weak in the mastery of concept and explanation ability for instrumentation analysis and critical thinking skills in solving problems [1–3]. The further consequence of low competence is that students will have difficulty competing in the global era due to the lack of authentic experience gained during lectures [4]. Increasing the competence of chemical graduates will be difficult to obtain if the learning model used is still centered on lecturers who will cause passive students. Surely this paradigm must be changed by emphasizing student-centered active learning. A student-centered learning model that can be applied in chemical analysis instrumentation experiments that will provide authentic experiences such as project-based learning, discovery-based learning, inquiry-based learning, and problem-based learning [5-9].

Project-based learning as a suitable learning model is used to reform the learning model of verification practice into explorative learning. With project-based learning, students become more critical, creative and will gain authentic experience in using various laboratory equipment and in solving real-world problems and are recommended as effective learning models to apply in college[10-12].
An authentic assessment is very suitable to be applied in Project-based learning. Through authentic assessment, students can demonstrate the ability to complete tasks and solve problems. Authentic assessment is an activity to measure the level of students’ knowledge and skills through questions at the application thinking level or higher. Authentic assessment is done comprehensively to assess the start of the input, process, and learning output so that the student must be able to show the three realms of learning result that is knowledge, attitude, and skill in a real situation. An authentic assessment is carried out continuously in the context of a meaningful learning or real-world environment and reflects the true learning experience. This information is obtained through observations, experiments, and journals in real-world contexts, so that actual student capability information will be obtained [13].

2. Methods
The purpose of the study was to test the student competency assessment instruments through authentic assessment. Student competencies assessed included 1) mastery of instrumentation analysis concepts, 2) basic laboratory skills, 3) instrumentation analysis skills, 4) critical thinking skills, 5) communication skills, and 6) scientific work abilities, and 7) responsibility attitude. The trial was conducted with a large number of respondents [12]. Before testing the competency assessment instrument, expert validation was carried out on the learning device which included mastery test questions, instrument analysis, and authentic assessment sheets. Feasibility testing is also carried out on the chemical analysis instrumentation experiments guide for project-based which includes feasibility tests, language feasibility tests, and material feasibility tests.

Mastery of the instrumentation analysis concept was assessed through concept mastery tests of 135 students taking chemical analysis instrumentation experiments. Authentic assessment observation sheets to measure basic laboratory skills, instrumentation analysis skills, communication skills, and responsibility attitudes were tested for reliability in the chemical analysis instrumentation experiments class with 36 students and 6 observers. The use of product assessment sheets from the project was also tested in the same way to measure critical thinking skills and scientific work abilities. Quantitative statistical evaluation of collected data is processed using SPSS version 20 software to draw conclusions [14].

2.1. Data collecting instrument
Expert validation of the chemical analysis instrumentation experiments for project-based, mastery of instrumentation analysis concepts, and authentic assessment sheets carried out by 3 material experts and education experts. The mastery test instrument for the instrumentation analysis concept consists of 30 multiple-choice questions. The basic laboratory skills assessment sheet (skills using laboratory equipment, weighing skills with an analytical balance, titration skills) consisted of 24 observation items. The instrumentation analysis skills assessment sheet consists of skills using a pH-meter (14 items), skills using a conductometer (15 items), and skills using a spectrophotometer (14 items). The critical thinking skills assessment sheet consists of 12 items, communication skills (15 items), scientific work abilities (23 items), and responsibility (5 items).

2.2. Data analysis
The results of test mastery of instrumentation analysis concept were carried out by different power test questions, the level of difficulty of the question, and the validity of the items, and the instrument reliability testing. Data from observations using basic laboratory skills assessment instruments, instrumentation analysis skills, communication skills, responsibility attitude with the criteria of 4 Likert scale options tested reliability. The product evaluation data to measure critical thinking skills and scientific workability with criteria for 4 Likert scale tests were tested for reliability. Testing is done using SPSS version 20 software.
3. Results and Discussion

An authentic assessment has similarities with performance appraisals. In performance appraisal, students are required to apply their knowledge or skills. The rating of thinking involved in doing assignments on performance appraisal is the same as authentic assessment. Performance assessment is an assessment carried out by observing student activities in doing something. This assessment is suitable to be used to assess the achievement of competencies that require students to perform certain tasks such as lab work. Performance appraisal can be done by using a checklist, rating scale. The purpose of authentic assessment is to find out the abilities of students in the real-world context. Form questions on authentic assessment questions above the level of memorization, i.e. analytic skills, the ability to integrate what is learned, creativity, the ability to cooperate. The development of good authentic assessments is begun by identifying standards for students as a reference in carrying out learning and in conducting assessments [1].

After going through several stages of revision and improvement according to expert validator advice, the chemical analysis instrumentation experiments consist of practical manuals, concept mastery test questions, observation sheets, and rubrics, and product and rubric assessment sheets declared feasible and valid to use. Some suggestions and input from expert validators are 1) experiments user guide: differentiating standard solution and working solution, eliminating the details of the tools used for experiments, making work methods in descriptive form, 2) mastering test questions concepts: improving the order of answers, improving writing procedures and grammar, 3) observation sheet: the preparation of rubrics is simpler and easier to observe. Learning devices that have been declared feasible and valid are then used for testing in the chemical analysis instrumentation experiments.

3.1. The results of the reliability test from the test question of mastering the concept of instrumentation analysis

The mastery test instrument for the instrumentation analysis concept was tested on chemistry study program students in the 5th semester who were pursuing chemical analysis instrumentation. The trial involved 135 respondents at the end of the semester in the 2017/2018 school year. The results of the test on mastery instrument analysis using SPSS software obtained data as stated in Table 1. A good test instrument must meet 3 criteria, different power, a good level of difficulty, and valid [15]. There are 3 items that have low differential power and 5 items that are invalid. Overall there are 5 questions that do not meet the requirements, namely questions number 14, 18, 19, 20 and 26 so that the question must be revised or discarded. If the 5 test questions that do not meet the fixed requirements are used as part of the instrument for mastering the analysis concept, the instrumentation will produce reliability of 0.776. If the 5 test questions that do not meet the discarded requirements will produce reliability of 0.845. Both choices still produce a valid and reliable test instrument because the reliability is above 0.7 [14]. Overall, the mastery test instrument is a valid and reliable instrumentation analysis concept to measure the mastery level of the instrumentation analysis concept. Taking into account the length of time the questions are too long at the time of the trial, then 5 questions that do not meet the requirements are discarded.

Table 1. The results of the test analysis of mastering the concept of instrumentation analysis

| Measurement                     | Results          | N  | Results                                      | Reliability |
|---------------------------------|------------------|----|----------------------------------------------|-------------|
| 1. Different power questions    | Low: 3 Medium: 6 Height: 21 | 135 | Items number 14, 18, 19, 20 and 26 need to be discarded | 0.845       |
| 2. The level of difficulty of the question | Easy: 8 Medium: 13 Difficult: 9 |     |                                              |             |
| 3. Item validity                | Valid: 25 Invalid: 5 |     |                                              |             |

Conclusion: The concept mastery test instrument is reliable
3.2. Reliability test results from authentic scoring sheets

Authentic assessment instruments consist of observation sheets of basic laboratory skills, instrumentation analysis skills, responsibility attitudes, critical thinking skills assessment sheets, and scientific work abilities that have been tested on 36 students. The chosen respondents were students from the chemistry study program who were taking the chemical analytical instrumentation experiments in the 6th semester of the 2017/2018 academic year. Testing this authentic assessment sheet aims to determine the reliability and level of readability and clarity of the rubric that has been made by the researcher. The test was carried out by using an authentic assessment observation sheet by 6 observers. The observation sheet is said to be valid and reliable if the results of the assessment by several observers produce data that is not significantly different. This is indicated by the results of inter-rater reliability measurements resulting in the amount of interclass correlation (ICC) above 0.7. The complete trial results are listed in Table 2.

**Table 2. Results of authentic interpreter reliability scoring analysis**

| No | Measurement                      | Observer 1 | Observer 2 | Score (average) | Interclass correlation | Results  |
|----|----------------------------------|------------|------------|-----------------|------------------------|----------|
| 1. | Basic laboratory skills          | Observer 1 | 36         | 78.0833         | 0.923                  | Reliable |
|    | Use glassware, weigh, and titrate| Observer 2 | 36         | 77.5278         |                        |          |
| 2. | Instrumentation analysis skills  | Observer 1 | 36         | 57.8889         | 0.834                  | Reliable |
|    | Using a pH meter                 | Observer 1 | 36         | 57.8889         |                        |          |
|    | Using a Conductometer            | Observer 1 | 36         | 59.4444         |                        |          |
|    | Using a Conductometer            | Observer 2 | 36         | 59.8889         |                        |          |
|    | Using a UV-Vis spectrophotometer | Observer 1 | 36         | 59.5833         | 0.947                  | Reliable |
|    | Using a UV-Vis spectrophotometer | Observer 2 | 36         | 59.8889         |                        |          |
|    | Using a UV-Vis spectrophotometer | Observer 1 | 36         | 50.7778         | 0.862                  | Reliable |
|    | Using a UV-Vis spectrophotometer | Observer 2 | 36         | 51.6944         |                        |          |
| 3. | Critical thinking skills, scientific work abilities | Observer 1 | 36         | 61.7222         | 0.950                  | Reliable |
|    | Project design                   | Observer 1 | 36         | 61.7222         |                        |          |
|    | Project design                   | Observer 2 | 36         | 62.7500         |                        |          |
|    | Project report                   | Observer 2 | 36         | 55.4722         | 0.998                  | Reliable |
|    | Project report                   | Observer 2 | 36         | 54.8333         |                        |          |

The basic laboratory skills observation sheet consists of 3 observation criteria, namely the skill of using glassware, weighing skills with the analytic balance sheet, and titration skills. On each observation sheet, a rubric has been included as an observer guideline in making observations. The testing of the basic laboratory skills observation sheet aims to see whether the rubric that has been compiled as a guideline in conducting the assessment has a reliable level of readability. Rubrics that have a high level of readability will produce data that is not biased by each observer, and vice versa if the rubric has a low level of readability, it will produce biased data. From the test results, it can be seen that the two observers had an ICC magnitude of 0.923. Because the ICC obtained greater than 0.7 means an observation instrument to measure basic laboratory skills reliably [15].

The observation sheet of instrumentation analysis skills consists of 3 observation criteria, namely the skill of using a pH-meter, the skill of using a conductometer, and the skill of using a UV-Vis spectrophotometer. On each observation sheet, a rubric has been included as an observer guideline in making observations. From the test results, it can be seen that the two observers had an ICC amount of 0.834 for the pH meter, 0.947 for the conductometer, and 0.862 for the UV-Vis spectrophotometer. Because the ICC obtained is greater than 0.7, it means that the observation instrument and rubric are guidelines for measuring reliable instrumentation analysis skills [16].

The critical thinking skills assessment sheet and scientific work abilities in project-based learning consist of 2 assessment criteria, namely product design project and report on the results of project activities that have been carried out. Components of critical thinking skills assessed include elementary clarification, independent clarification, judgment, inference, and strategies. The overall critical thinking
skills assessment sheet has 12 indicators. Components of scientific work abilities assessed include observation and asking questions, planning experiments, carrying out experiments, communicating, and applying. The overall critical thinking skills assessment sheet has 23 indicators [17], [18]. The results of the assessment of critical thinking skills showed that the two observers had an ICC magnitude of 0.950 for the project design, and 0.998 for the project report. Because the ICC obtained greater than 0.7 means that the instrument for assessing critical thinking skills and rubrics as a guide for assessing critical thinking skills is reliable.

3.3. Constraints and solutions in the implementation of trials
The main obstacle experienced in the instrument trials was a large number of students as participants in the chemical analysis instrumentation experiments. In one class there were 36 students. In order for the observer to observe the performance appraisal of each student, there will be a need for many observers. Ideally, each observer observes the performance of students as many as 3 people. Because there are 36 students, at least 9 observers are needed. The observer is also required to memorize each student's experiments participant, to avoid misjudgment, it is recommended that each practicum participant is given an ID posted on the chest. The ideal number of students in 1 class in project-based learning is 20 people [19].

From the schedule that was compiled, it turned out that it could not work as planned. The initial design of the experiments was to make a working solution, and the standardization was carried out in 1 meeting. However, in its implementation in 1 meeting only the work solution can be made, so it is necessary to add 1 meeting for standardization activities. Experiments using a pH-meter, conductometer, and UV-Vis spectrophotometer instrument is carried out in 1 meeting and is in accordance with the schedule that has been prepared. The project-based learning activities can be carried out for a minimum of 5 meetings. Overall, the authentic assessment instrument test can run smoothly. It is very important to always follow the schedule prepared in completing the project [8,12].

4. Conclusion
Authentic assessment instruments consisting of mastery of instrumentation analysis concepts, basic laboratory skills observation sheet, and instrumentation analysis, and critical thinking skills assessment sheets and scientific work abilities are very fit and feasible to be used to measure student competency levels in chemical analysis instrumentation experiments.

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