

Basic Competency of Chemical Practicum: Development and Validation of Assessment Instruments

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Abstract: Research has been carried out on the development and validation of instrumental assessments of laboratory basic competencies in chemical practicum. The purpose of this study was to produce a valid instrument for the basic computation of chemical practicum. In this study, the assessment instruments developed cover 3 aspects, namely the cognitive aspects with test instruments, the effective and psychomotor aspects with observation instruments in practical activities. The method used in the development of this assessment instrument is the 4D method which includes defining, designing and disseminating stages. Based on the results of the development, there were 3 assessment instruments in the form of 4 pages of cognitive aspect measurement test instruments and 1 sheet of observation instruments for affective and psychomotor aspects. Each instrument has also been tested for validity with content validation methods by 2 experts which produce validity in very valid criteria with an average value of 3.83 (cognitive), 3.83 (affective) and 3.67 (psychomotor).

1 INTRODUCTION

Chemical practicum for prospective chemists is needed to provide practical experience besides theoretical in the classroom (Rakhman, 2017). Practical experience is the most valuable aspect of teacher education programs, but the question is how to approach conventional practices and alternative models prepared by the teacher? The technical focus of the model on developing skills is more mastering lesson plans, and classroom management as an important component, but that is not enough preparation for pre-service teachers. Practicums must require time for growth and learning, where the teacher preservice to understand the broader implications of being a teacher and to appreciate the ultimate goal of teaching in helping learners (Belliveau, 2007). Practicum is one of the student-centered teachings that describes teaching strategies where the teacher is more facilitating than direct teaching, in a student-centered teaching strategy, the teacher consciously places more attention on involvement, initiative, and social interaction students (Kurniawati, 2015). Practical learning models have advantages, including making students believe more in the truth based on their own experiments, developing attitudes to conducting

exploratory studies of science and technology, an attitude from a scientist, supported by modern didactic principles, namely students learning by experiencing or observing themselves process or event, students are spared from verbalism, enriching experiences with things that are objective and realistic, developing attitudes of scientific thinking, and learning outcomes will be long-lasting and internalization (Pamungkas, 2017).

The problem is that the measurement of the practicum is based on the assessment of cognitive aspects only, which should be in this learning method can integrate three aspects of assessment at once. Practicum activities which are observation-based learning activities and testing in this laboratory should be more measurable on the psychomotor and affective aspects. In this article, it is reported that the validation of basic practicum assessment instruments for chemical practicum has been developed.

2 METHOD

This research was a development research (R & D) instrument of basic practicum chemistry competency assessment for students of chemical education. The

assessment instruments that were developed related to aspects of basic laboratory skills (psychomotor), attitude (affective) in the practicum that are directly related to workplace security and safety in the laboratory, and knowledge (cognitive) about the material in practicum learning measured from the achievement of learning competencies. Development of assessment instruments was done using the 4D method (define, design, develop, and disseminate). The initial stage of this development began with defining the achievement of chemistry practicum learning. The design stage was carried out in the second step which includes; limitation of learning achievement in chemistry practicum, designing a lattice instrument for chemical practicum assessment which includes psychomotor, affective and cognitive aspects. At the development stage, a draft observation instrument for psychomotor and affective was done, test questions, answers and scoring rubrics, allocation of working time, and design of layout assessment instruments. In the development phase, instrument validation and limited trials were conducted for first semester students of the 2018/2019 academic year, Chemistry Education Study Program, FKIP, Khairun University, Ternate. Instrument validation was carried out with the belief data validation technique involving 3 experts in the field of educational evaluation. The validity of the observation instrument psychomotor and affective aspects of chemistry practicum was measured from Suitability with learning outcomes, steps in chemistry practicum, layout, and scoring. Whereas the validity of the test instrument in the form of questions was assessed from compatibility with learning outcomes, clarity of language (sentence questions and statements) in the questions, clarity of pictures and illustrations of questions, suitability of time allocation and scoring, and design and layout of questions. While the dissemination phase by publishing a competency assessment instrument that has been declared valid and tested in this article.

3 RESULTS AND DISCUSSION

3.1 Determination and Definition of Learning Outcomes in Basic Chemical Practicum

Chemical practicum for chemistry teacher candidates at Khairun University was designed in 3 years of learning divided into 3 learning outcomes each year. In the first year, the targeted learning

outcomes were to know and be able to operate the glassware in the chemical laboratory properly and safely, the learning outcomes in the second year were to do chemical preparation and separation. While learning achievement in the third year was able to conduct analysis and synthesis of chemicals (Rakhman, 2017). The research reported in this article was more focused on developing the basic laboratory chemistry competency assessment instrument which was the learning achievement in the first year of basic chemistry practicum learning in the first year for chemistry education prospective students. The achievement of basic learning in the chemistry lab in the first year was to know and be able to operate glassware in the chemical laboratory properly and safely, described in 3 aspects of assessment, assessment of cognitive, affective and psychomotor aspects. In detail, the process of describing learning outcomes in the assessment aspect was presented in Figure 1. Flowchart of assessment aspects of laboratory basic competencies in chemistry practicum.

Basic competencies in chemical practicum for chemistry teacher candidate students were translated into 3 measurements, namely measurement of cognitive aspects which includes measurement of ability to recognize and understand symbols, equipment and characteristics of chemicals in practicum. The description of the cognitive aspects was then derived in 4 measurement indicators including; recognize and understand the symbol of work safety and safety in the laboratory. This indicator aims to measure the ability of students in identifying potential risks of workplace accidents that originate from the workplace environment and knowledge in taking preventive actions against potential risks. The second indicator was knowing and understanding symbols that show the characteristics of chemicals in the laboratory. This indicator aims to measure the level of understanding of students in recognizing the potential risks of chemicals used in practicum. Both indicators related to student recognition and understanding of the symbols in the laboratory are a description of the knowledge of workplace safety in the laboratory (Ismail, 2016). While the third indicator of the cognitive aspects, namely, the use of glassware in the laboratory was intended to measure students' knowledge of the types of glassware in the laboratory that was used in chemical practicum. And the fourth cognitive aspect indicator that was related to students' understanding of preparation using glassware in a chemistry lab in a laboratory is based more on measuring student knowledge in organizing glassware for practicum. What was meant by the knowledge of organizing glassware for practicum is the knowledge of students in using several glass

tools such as in the process of dissolving solids or dilution of solutions that require knowledge to choose, collect and use glassware in an organized manner (Hamidu, 2014). The measurement of cognitive aspects is carried out using test techniques using the stuffing instrument. This technique was chosen with consideration of the speed of time needed, the scope of the questions that were structured and measured, and the ease in applying in measurements (Lestari, 2016).

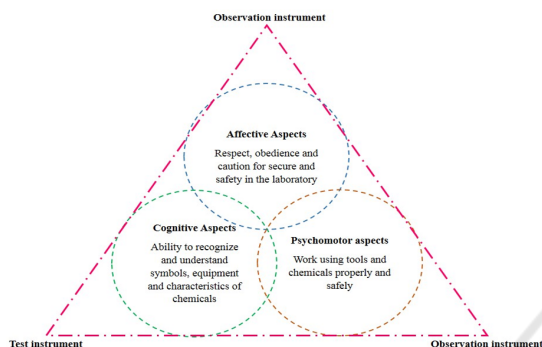


Figure 1: A Description of the Basic Competence of Chemical Practicum.

Affective or attitude aspects in the basic practicum of chemistry practicum are described as attitudes and behaviors that underlie the safety and success of practicum activities in the laboratory. The attitude in question was respect, obedience, and caution in doing work in the laboratory. An attitude of respect was explained in the form of a measurement of student courtesy when it starts entering the laboratory until it exits the laboratory. Obedience was explained in the measurement of seriousness in work, compliance, and adherence to the rules and practical work instructions when working in the laboratory. While carefully measured in the accuracy of students at work during laboratory work (Koseoglu, 2010). While the measurement technique on the affective aspects was used observation techniques. Psychomotor aspects of the basic chemical practicum were described as students' skills in using tools and chemicals correctly and safely. The skills of students in working using tools and chemicals in the laboratory are very important because it involves safety and works safety in the laboratory. The potential risk of workplace accidents in the laboratory was caused by a lack of skills in using tools and chemicals in the laboratory (Hamid, 2012). In measuring skills aspects, the indicators developed include: using chemicals as needed, this indicator ensures that students use chemicals wisely in accordance with the instructions. The second indicator, use the glass tool carefully and according

to instructions. Indicators of the use of glassware were intended to ensure the competence of students in working carefully and safely. The third indicator was to place/treat equipment and chemicals safely and neatly. This indicator was intended to measure the skills of students who were careful in using tools and chemicals. While the fourth indicator was related to the use of personal protective equipment during the practicum. This indicator was used in measuring student awareness of occupational safety risks in the laboratory (Somez, 2017).

Table 1: Design Indicators and Sub Indicators of Cognitive Aspects

Indicator	Assessment (sub-indicator)
Recognizing and understanding security and safety in the laboratory.	<ol style="list-style-type: none"> 1. Knowing the symbols of security and safety in the laboratory. 2. Knowing the potential accidents risk in the laboratory. 3. Knowing the sources of accidents risk in the laboratory.
Able to recognize and understand the characteristics and handling of chemicals in the laboratory.	<ol style="list-style-type: none"> 1. Knowing the characteristics of chemical symbols. 2. Knowing chemical handling pre and post practicum.
Able to recognize and understand the use of glassware in the laboratory.	<ol style="list-style-type: none"> 1. Able to recognize several pictures of chemical glassware 2. Knowing the function of several chemical glassware
Able to recognize and understand the use of glassware for simple preparation in the laboratory.	<ol style="list-style-type: none"> 1. Mentioning some glassware for practicum preparation

3.2 Designing Instruments for Assessing Basic Competency in Chemical Practicum

In this stage, an assessment design is carried out in the form of a worksheet for test instruments and

observation statements for observation instruments. The question instrument for the measurement of basic knowledge was elaborated from an indicator of cognitive aspects to recognize and understand the symbols, equipment, and characteristics of chemicals. The design of indicators and sub-indicators of assessment instruments to measure basic knowledge of chemical practicum is shown in table 1.

The design of evaluation instruments for affective aspects in the form of observation instruments is carried out by compiling measurement statements in observations during the practicum derived from assessment indicators. The design of the affective aspect assessment is presented in table 2. There are at least 13 measurement statements that are considered to represent indicators of competency attainment in the aspect of attitude during the practicum in the laboratory. Measurement of this attitude aspect is based on efforts to cultivate behavior for work safety and safety in the laboratory.

Table 2: Design of Affective Aspect Observation Instruments.

Indicator	Assessment
Polite	1. Stay calm, and not making noise 2. Speak politely 3. Looking neat 4. Be respectful
Dedicated	1. Have a work plan in the laboratory 2. Focus on practicum and observing 3. Speak as needed
Obey the rules	1. Using work safety equipment. 2. Maintain security and safety 3. Work according to plan
Good work	1. Preparing practical equipment precise and accurate. 2. Organizing the tools well and responsibly. 3. Getting practicum data accurately.

The design of the method of assessment of the observation instrument of psychomotor aspects was based on four indicators which became the core activities in the basic chemistry practicum at the first meeting. In the basic chemical practicum activities at the first meeting, learning outcomes were focused on the activities of the use and management of chemicals and glassware in accordance with the instructions in the practicum guidelines, to the proper use of personal protective equipment as standard security and safety procedures in the

laboratory. Psychomotor aspect observation instruments are designed by compiling measurement instruments derived from indicators of learning achievement of psychomotor aspects of basic chemistry practicum learning. Detailed design of psychomotor observation instruments is presented in table 3.

Table 3: Design of Psychomotor Observation Instruments.

Indicator	Assessment
Polite	5. Stay calm, and not making noise 6. Speak politely 7. Looking neat 8. Be respectful
Dedicated	4. Have a work plan in the laboratory 5. Focus on practicum and observing 6. Speak as needed
Obey the rules	4. Using work safety equipment. 5. Maintain security and safety 6. Work according to plan
Good work	4. Preparing practical equipment precise and accurate. 5. Organizing the tools well and responsibly. 6. Getting practicum data accurately.

3.3 Designing an Assessment of the Learning Outcomes of Basic Chemistry Practicum

The most important thing in evaluating learning is in the assessment section. Each learning evaluation has a variety of assessment techniques and methods (Tibrani, 2017). In the evaluation instrument of basic competency on chemical practicum, It's used several assessment methods synchronized with the type of evaluation developed. The assessment method used for the type of question on cognitive measurement instruments is the scoring method. This method is used with consideration to facilitate assessing the ability of students. Whereas for the observation instrument of affective and psychomotor measurement used a method of scaling four (liker). Scale four was used in the assessment of observation instruments with the aim of facilitating rapid assessments when students are working in the laboratory (Gobaw, 2016). The results of the evaluation of the cognitive, affective and psychomotor aspects produced will eventually be converted in the form of value, while the conversion

value is then converted in the form of a description of the level of competence.

3.4 Validation of Basic Competency on Chemical Practicum Evaluation Instruments

Validation of evaluation instruments was done using content validation methods. Content validation was carried out by two experts who emphasized two aspects, namely the suitability of the content and use of language in the evaluation instruments developed (Riyani, 2017). Each instrument is validated with a different validation sheet according to the assessment instrument based on aspects developed. The results of content validation by experts on three aspects of assessment are reported in Table 4.

Table 4: Content Validation Results.

Validation aspect	Cognitive	Affective	Psychomotor
Feasibility of content			
Conformity with learning competency indicators	4	4	4
Homogeneous and logical answer	4	-	-
Conformity to the workmanship of the question	4	-	-
The efficiency of observation and assessment time	-	3	4
Suitability of statements with observed activities	-	4	3.5
Language eligibility			
Conformity with learning competency indicators	3.5	4	4
Homogeneous and logical answer	4	-	-
Conformity to the workmanship of the question	4	-	-
Clear observation statement	-	3.5	3.5
Communicative observation statement	-	4	3.5

Based on the validation results, the contents of the content feasibility are very valid with an average value of 4 for the instrument of cognitive aspects, 3.83 for psychomotor observation instruments, and 3.67 for affective aspect observation instruments. In terms of the feasibility of the language used in the evaluation, produced the validity of the evaluation instrument with very valid criteria with the measurement instrument of cognitive aspects of 3.83, psychomotor aspects of 3.67, and the affective aspect of 3.83.

Question instruments for measuring cognitive aspects that have been validated and validated are then readability tests. In the readability test instrument, the assessment of cognitive aspects of the basic competencies of the chemical practicum was carried out by testing the readability of the instrument in 10 students who had passed the basic chemistry practicum course and had the skills to become basic chemistry practicum assistants and conduct an assessment using this instrument later. Readability test instrument for assessing cognitive aspects of the basic competencies of the chemical practicum is presented in Figure 2, the diagram of readability test results.

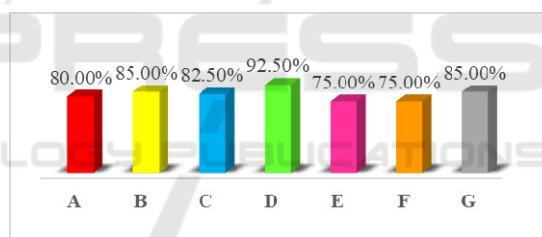


Figure 2: Diagram of test results (instrument cognitive) readability Where: A. Clarity of introduction, B. Clarity of instructions / instructions, C. Language clarity, D. Image clarity, E. Clarity of working time, F. Clarity score per question, and G. Suitability of questions with practicum material.

3.5 Design of the Instrument for Evaluation of Basic Competencies in Chemical Practicum

The design of basic practicum chemistry competency evaluation instruments that have been validated was reported in Figure 3, 4. Question instruments (cognitive aspects), figure 5. Affective observation instruments and psychomotor observation. Figure 3 shows the problem instrument for measuring the basic competencies of the practicum on cognitive aspects on indicators of the ability to recognize and understand work safety and

security, characteristics and handling of chemicals in the laboratory. Assessment instrument of cognitive aspects of basic competencies of the chemical practicum is arranged in four pages. On the first page, a measurement instrument is designed for one indicator consisting of three sub-indicators as many as three questions, a time allocation of fifteen minutes and a total score of 12 with a score weight of each question of 4. The first question is a question of the definition of a symbol of security and works safety in the laboratory with 4 questions in the form of questions. The second question contains questions to mention 4 potential risks of work accidents in the laboratory. While the third question mentions 4 sources of risk of workplace accidents in the laboratory.

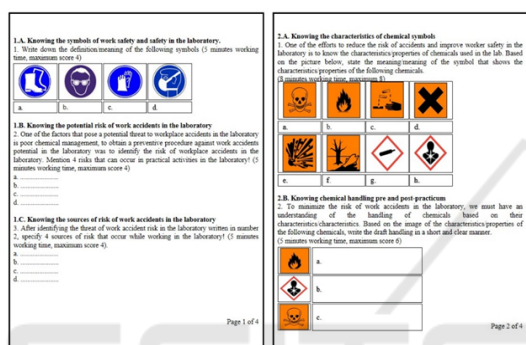


Figure 3: Instrument Questions page 1-2 (Cognitive Aspects).

On page two consists of two questions derived from two measurement sub-indicators about the characteristics and handling of chemicals in the laboratory. The first question is a question to describe 8 symbols of chemical characterization. Whereas the second question consists of 3 items to explain the handling of chemicals according to the symbol of the characteristics of the chemicals presented. To be able to resolve the questions on page 2 of the instrument, a total time allocation of 13 minutes is given with a total score of 14 points, with each point in the number one and two questions at 8 and 6 points.

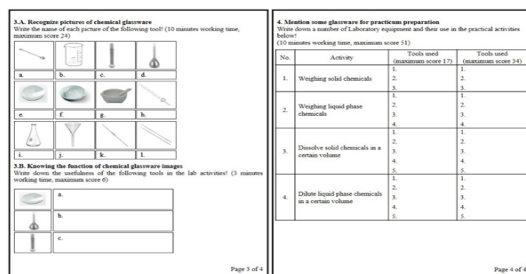


Figure 4: Instrument question page 3-4 (cognitive aspects).

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Page three contains two questions about knowledge to know and understand the use of glassware in basic chemical practicum. The first question has presented to give the name of the tool on 12 pictures of chemical glassware that has been provided on the worksheet. The allocation of time provided to answer this question is 10 minutes with a maximum score of 24 points. Whereas in the next question, the question is directed to know the knowledge of the use of glassware in the picture in the chemical practicum in the laboratory. The total score provided for this question is 6 points with every one correct answer getting 2 points, with a time allocation of 13 minutes to solve the problem on page 3.

The measurement of knowledge and understanding of the use of chemical glassware in simple preparations in the laboratory was presented in the instrument on page 4. In this worksheet, there are four items related to the chemical preparation such as the preparation of solutions and the retailing of chemicals. The question was directed to mention the name of the glassware used and the use of each glass tool in each of the intended preparation activities. Allocation of time to solve this problem for 10 minutes with a total score prepared of 51 points.

Observation instruments for the measurement of affective and psychomotor aspects (Figures 5a and b) are designed in 1 sheet of observation instruments that are equipped with instrument identities, instructions for filling, identities of the students assessed. Assessment sheet and observer legality. Each sheet of observation instruments on both affective and psychomotor aspects, each contains four measurement indicators.

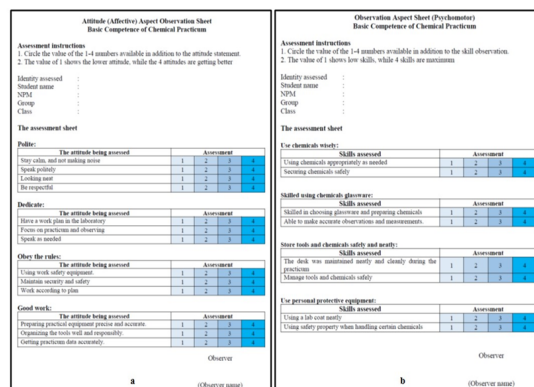


Figure 5: a. Cognitive Aspects of Observation Instruments and b. Psychomotor Aspects.

Both affective and psychomotor observation instruments are based on indicators and measurements as presented in tables 2 and 3. While the score provided in each observation instrument is a scale score of 4 where score enhancement is described as increasingly appropriate attitudes and skills (Fletcher, 1997). The results of the observation of affective and psychomotor aspects are then converted in the form of values which are then integrated with cognitive values based on the test results.

4 CONCLUSION

The chemical practicum basic competency assessment instrument has been successfully developed in three domains of assessment namely cognitive aspects with test instruments, affective and psychomotor aspects with observation instruments in practicum activities. The three instruments have very valid validity with validation values of each instrument 3.83 (cognitive), 3.83 (affective) and 3.67 (psychomotor).

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