Analysis of students’ competence in chemistry cognitive test construction based on revised bloom’s taxonomy

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Abstract. The test is one of the tools used to measure the cognitive competence of students. The ability to develop tests is one of the competencies teachers and prospective teachers must possess. Revised Bloom’s Taxonomy combines cognitive levels and types of knowledge in constructing cognitive tests. The subject of this study was a postgraduate student in the Chemistry Education Study Program of Makassar State University consisting of 25 people. The purpose of this study was to analyze the students competence in construction of chemistry cognitive tests based on the Revised Bloom’s Taxonomy. This research is quantitative descriptive. Analysis of student competency in developing tests is measured by the test suitability indicators with cognitive levels and types of knowledge. The results of the analysis show that the students competence percentage construction questions level C1, C2, C3, C4, C5, C6 respectively: 98%, 89%, 96%, 89%, 65%, and 60%. The percentage of students competence in tests construction according to the type of knowledge, respectively for the types of factual, conceptual, procedural, and metacognitive knowledge are 84%, 83%, 85%, and 83%. Thus it can be concluded that the student competences in constructing of Chemistry cognitive test based on Revised Bloom’s Taxonomy is in a good category.

1. Introduction
One of the important competencies teachers and prospective teachers must possess is the ability to develop assessment of learning processes and outcomes. This is emphasized in the Minister of Education and Culture Regulation No. 23 of 2016 concerning Educational Assessment Standards, that assessment of student learning outcomes in primary and secondary education includes aspects of attitudes, knowledge and skills. Assessment and evaluation of student learning outcomes is one of the abilities that must be possessed by a teacher [1]. Quality of learning provided by the teacher is largely determined by their competency related to the profession. This is consistent with the results of research [2] that test construction competence and quality are essential tools required by any teacher if teaching and learning goals are to be achieved. [2]recommended workshops and seminars to improve teachers’ competence in test construction.

Examinations have become an important factor directing the work of both teacher and student [3]. According to [4], educational evaluation is an important role in improving the education quality. This shows that learning evaluation is a very important activity in the education system because evaluation is a tool to measure the success of teachers in teaching while also functioning to measure the success of students. The importance of evaluation activities in learning makes evaluation an integral part of learning.
The ability of teachers to understand evaluations is classified as pedagogical competency. Pedagogical competence is the ability to manage the learning of learners includes an understanding of learners, instructional design and implementation, evaluation of learning outcomes, and the development of learners to actualize their potential [Mulyasa in 7].

Professional teachers are teachers who have the ability to plan learning, implement learning, evaluate learning and have a high responsibility in improving student learning achievement [1]. Competence will be realized in the form of mastery of professional deeds in performing its function as a teacher. A number of strategies can reinforce the linkages between the evaluation and assessment framework and classroom practice. A strong emphasis on teacher evaluation for the continuous improvement of teaching practices within the school is one key link.

Classroom assessment and evaluation are highly concerned with qualitative judgments that are used to improve students' knowledge and learning. According [5] the quality of a test given by a teacher is closely linked with its ability to provide the kind of information needed regarding students’ performances. A well written test allows the teacher to accurately and consistently measure students’ mastery of specific contents taught in class. Results of such tests allow teachers to measure to some degree, how effective their instruction has been.

[6] stated that currently the tendency of teachers in the field still uses tests as the main instrument in recording student learning outcomes. Test items should be developed that challenge students to apply their knowledge and skills in realistic, action-oriented contexts [7].

According Ololube in [2] evaluated competencies of professional and non-professional teachers in Nigeria. The researcher reported that professional teachers tend to construct various effective evaluative instruments more than the non-professional teachers. It was also found in Ololube’s study that professional teachers have the propensity to employ various evaluation techniques correctly, which is not likely with the non-professional teachers. The author therefore concludes that professional teachers kept assessment records more accurately than non-professional teachers. The conceptual knowledge test is an efficient way to measure the conceptual knowledge [8].

At the higher education level, especially in the Chemistry Education master's program, competencies regarding the development of assessment instruments are provided through the Assessment course. There are those who have teacher work and some are still prospective teachers. This course is important for teachers or prospective teachers because it is needed to find out the effectiveness of the learning programs that are implemented.

The Original "Bloom’s Taxonomy" has been used to evaluate cognitive domains. This taxonomy consists of six major categories: knowledge, comprehension, application, analysis, synthesis and evaluation [9]. In order to address the weaknesses in the Original Taxonomy, [10] revised of Bloom Taxonomy. The most notable change in the revised taxonomy is the move from one dimension to two dimension. Instructional objectives typically formulated in terms of a verb-noun relationship. Thus, statements of objectives typically consist of (a) some subject matter content (i.e verb or verb phrase). The verb or verb phrase describes the cognitive process involved. In the Original taxonomy, the knowledge category embodied both noun and verb aspects. The noun or subject matter aspect was specified in the knowledge’s extensive subcategories. The verb aspect or the cognitive process was included in the definition given to knowledge in that the learner will be expected to be able to recall or recognise knowledge. Revised Bloom’s taxonomy consists of two dimensions with several levels each. The levels within the dimensions have a hierarchical nature, meaning that every higher level presupposes the presence of the lower levels [11]. According [12] the revised Taxonomy separates the noun and verb component of the original knowledge category into two separate dimensions: the knowledge Dimension (noun aspect) and Cognitive Process Dimension (verb aspect) The verb generally describes the intended cognitive process. The noun generally describes the knowledge students are expected to acquire or construct. Consider the following example: "The student will learn to distinguish (the cognitive process) among element, compound, and mixture (the knowledge). The Bloom Taxonomy revised is contrast with the single dimension of the original Taxonomy. In single Dimension One: Cognitive Processes, which range from simple to complex, according to the difficulty level of the mental process vertically, and ranging from simple to complex horizontally according to the number of items in which a mental process is involved. The Bloom Taxonomy
revised framework is two-dimensional are cognitive process and knowledge. Their interrelationships as the Taxonomy Table 1. The cognitive process dimension (i.e., the columns of the table) contains six categories: Remember, Understand, Apply, Analyse, Evaluate, and Create. The continuum underlying the cognitive process dimension is assumed to be cognitive complexity; that is, Understand is believed to be more cognitively complex than Remember, Apply is believed to be more cognitively complex than Understand, and so on.

The knowledge dimension (Table 1) contains four categories: Factual, Conceptual, Procedural, and Metacognitive. These categories are assumed to lie along a continuum from concrete (Factual) to abstract (Metacognitive). The Conceptual and Procedural categories overlap in terms of abstractness, with some procedural knowledge being more concrete than the most abstract conceptual knowledge. According to this taxonomy, each level of knowledge can correspond to each level of cognitive process, so a student can remember factual or procedural knowledge, understand conceptual or metacognitive knowledge, or analyse metacognitive or factual knowledge.

Table 1. The revised bloom’s taxonomy table

| Knowledge Dimension       | Cognitive Process Dimension |
|---------------------------|-----------------------------|
|                           | 1  | 2  | 3  | 4  | 5  | 6  |
|                           | Remembe | Understa | Appl | Analyze | Evaluate | Create |
| Factual Knowledge         |    |     |     |       |         |       |
| Conceptual Knowledge      |    |     |     |       |         |       |
| Procedural Knowledge      |    |     |     |       |         |       |
| Metacognitive Knowledge   |    |     |     |       |         |       |

Table 2 show the major types and subtypes of the knowledge dimension. There are four type of knowledge dimension: factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge.

Table 2. Description of knowledge dimension of revised bloom’s taxonomy

| Knowledge Dimension       | Description                                                                 |
|---------------------------|-----------------------------------------------------------------------------|
| Factual knowledge         | The basic elements students must know to be acquainted with a discipline or solve problem in it |
| Conceptual knowledge      | The interrelationships among the basic elements within a larger structure that enable them to function together |
| Procedural knowledge      | How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods |
| Metacognitive knowledge   | Knowledge of cognition in general as well as awareness and knowledge of one’s own cognition |

2. Methods
This research used the descriptive method. The research was conducted in the 2017/2018 academic year. The research sample was selected by purposive sampling taking into account the study sample were students who took the Chemistry Learning Assessment course. The study sample consisted of 25 students from the Chemical Education Master Program in State University of Makassar. The data from the research were collected through content analysis of questions developed by the students. Each student is given the task of developing 24 items based on basic competencies on cognitive aspects in class X, XI, and XII which are given randomly. The indicators used in the assessment of the questions developed by the students are: 1) the suitability of the items with the dimensions of the cognitive process, and 2) the suitability of the items with the knowledge dimension based on the Revised Bloom’s Taxonomy. The results of question was constructed by students are analysed in the form of percentages.
3. Result and Discussion

3.1. Student Competence Develops Chemical Questions Based on the Dimensions of Cognitive Processes

The results of the analysis of the percentage of students' ability to develop high school chemistry questions are presented in Figure 1. The questions made by students refer to Basic Chemical Competencies in knowledge aspects from class X, XI, and XII. That competencies presents the suitability of the questions made by students at various levels of the dimensions of the cognitive process. In general, it appears that the ability of students to make chemical questions at levels C1 (remember), C2 (understand), C3 (apply), and C4 (analysis) is high, while the ability of students to develop questions level C5 (evaluate) and C6 (create) classified as medium. Level C1 to C3 questions are often made by students, while C5 and C6 level questions are rarely developed by students. According Sousa in [6] that within each level of the taxonomy there is also potential for an increasing degree of difficulty of question which may be needed before learners ready to progress towards a greater level complexity is in their thinking.

This is in accordance with the results of [13] that teachers generally make questions at levels C1 to C3. Although C1 to C3 questions are commonly made by students but there are still some mistakes in determining cognitive levels. For example there is a question item that reads "explain the understanding of the rate of reaction". The question is categorized into level C2, even though it is actually classified as level C1. In this question students want students to only mention the meaning of the reaction rate but use the word "explain". In this case the verb used is incorrect.

![Figure 1. Student competence in constructing questions according to cognitive process dimensions](image)

A question example of analysing: Given several elements 11X, 12Y, 16M, 17N. What elements can form of ionic compounds and covalent compounds. Explain". To solve on the problem, students first write down the electron configuration of each element, then determine the location of the elements in the table periodic. Furthermore, students can determine the elements that can form ionic compounds and covalent compounds and provide their chemical formula. [14] stated that Bloom's taxonomy can help teacher to devise learning objectives and to plan question which offer increasing levels of challenge to all students.

3.2. Student Competence Develops Chemical Questions Based on the Dimension of Knowledge

The results of student competency analysis developing chemical questions based on the knowledge dimension are presented in Figure 2. In the figure it appears that student competence develops procedural questions higher than factual knowledge. Student competency develops conceptual and metacognitive questions relatively lower than questions of factual and procedural dimensions of knowledge.
Student competency in developing questions based on the dimensions of knowledge is good. However, this competency still needs to be trained. According [15], the competence of teacher helps teacher candidates improve their own knowledge and skills during their career.

3.3. Student competency develops questions based on two-dimensional Bloom taxonomy

Figure 3 shows the distribution of student competencies developing cognitive questions at various levels and types of knowledge. In general, students construct more questions that are factual and conceptual compared to procedural questions. Level C1 to C4 questions are more dominant than level C5 and C6 questions.

Profile of student competence constructing question based: A. instructional objectives; B. suitability question with indicators; C. cognitive level and D. knowledge dimension showed on Figure 4. In Figure 4, it appears that student competence constructs questions based on learning objectives, suitability of learning indicators, level of knowledge, and knowledge dimensions reside there is a high category.
Figure 4. Profile of student’s competence constructing question based: A. instructional objectives; B. suitability question with indicators; C. cognitive level and D. knowledge dimension.

4. Conclusion
In general, student competence to construct chemical questions based Revised Bloom’s Taxonomy is in the good category. Students have been able to distinguish aspects of the cognitive process dimension and knowledge dimension.

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