The computer-assisted testlet assessment instrument to measure students’ learning difficulties in chemical bonding

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Abstract. Many students assume that the chemistry subject is difficult. We create a Testlet Assessment Instrument (TAI) as a diagnostic tool that can be used to detect students’ level of difficulty in learning chemistry. Hence, this study aims to analyze the computer-assisted TAI to measure students’ learning difficulties in the chemical bond subject matter for class X students of the senior high school in Madiun of East Java Indonesia. This study used descriptive-quantitative analysis methods and 15 students from 3 different schools as participants. The computer-assisted TAI consists of 10-question stems, that’s stem 1 until stem 10. The result showed that for stem 8 only 4% students can answer correctly and thus the stem is considered the most difficult. Scoring of the TAI used graded scoring with 4 categories. The implication for applying the computer-assisted TAI for measuring students’ difficulties in chemical bonding subject was discussed.

1. Introduction
An examination of studies shows that most of the basic concepts that are less studied in learning basic physical and chemical concepts[1-2]. Identify what difficulties students face in learning this concepts more research needs to be done. More research needs to be done to identify what difficulties students face in learning because teaching and learning difficulties are important. Both science educators and cognitive researchers agree that efforts to understand and improve science education must focused on the essential of knowledge [3-4].

The assessment and teaching of 21st century skill projects were sited very much in this space, of establishing frameworks within which to link assessment and teaching. The project closed normally in 2012 with development and delivery of a conceptual framework for twenty-first-century skills [5]: a focus on two skills, areas-collaborative problem solving and ICT literacy in digital networks, an approach to formative assessment, and teacher professional development modules [6]. Assessment and teaching of 21st century skills provided an approach to assess students with online and collaborated tasks. Student navigation of digital networks and problem-solving behavior was captured electronically in activity log files for synchronous scoring and reporting against developmental progressions. The progressions provided guidelines for the teacher about how students might demonstrate the skills at increasing levels of sophistication and competence such that these could be integrated into their teaching. How the insights into these complex twenty-first-century skills might be translated into classroom practice is the challenge for national education systems globally [7].

Modern testing is beginning to move away from thinking that focuses on items as the molecular construct out of which tests are built. Test builders are beginning to use as the fundamental units of which tests are manufactured. The psychometric foundation for such an idea was provided and...
They called this new construct the computer-assisted TAI [9]. Thus a test developer can take pains to avoid the context effects elaborated upon previous [10]. This means that test developers can focus on what test structure measures best the construct of interest and trust that there will be an appropriate scoring model available for it. This has not been the case in the past [9].

Chemical bonding is one of the keys and basic concepts in chemistry. Clearly, many of the concepts thought in chemistry in both secondary schools as well as in the colleges are highly based on understating the fundamental ideas related to this concept. Nevertheless, the concept is perceived both by the teachers as well as by learners as difficult in teaching-learning. Very often, when considering the teaching of chemical bonding, the arguments are focused on pedagogical issues rather than scientifically related disagreements [1]. There is no doubt that chemical bonding is one of the key concepts in chemistry and therefore is one of the most fundamental ones. It is also one of the areas in the physical sciences where understanding is developed through diverse models – which are in turn built upon the range of physical principles and when learners are expected to interpret a disparate range of symbolic representations for chemical bonds [1]. Among the students’ difficulties, the abstract nature of the chemical concepts was a common theme. This is also recognized by the lectures. The other difficulty which is related to the nature of the subject, or general chemistry, is the mathematical content of the course. Some students refer to chemistry as too mathematical. The study presented here allows for some solutions in certain diagnose the extent to which students’ difficulties in learning chemical bonds might be solved.

2. Method

The method of the study used descriptive-quantitative analysis. We designed an assessment instrument in the form of the computer-assisted testlet where this instrument is used to see how far the level of difficulty of students in learning chemical bonds. This computer-assisted TAI consists of 10 stems and 30 question in the form of multiple choice that is arranged hierarchically according to the problem. Each stem of chemical bond subject matter covers sub-topics namely, electron configuration, type of ionic bond, the tendency of bonding an element, type of covalent bond, the correct statement of covalent bonds, and determining the number of lone electron pairs on the Lewis structure. Examples of diagnostic instrumentsof difficulty learning in the form of testlet is shown in figure1.

![Figure 1. Diagnostic instruments of difficulty testlet](image)

This research was conducted in the Madiun, East Java, Indonesia. The respondents were 15 students from three different school. Each student was asked to work on this computer-assisted TAI to
completion so that the pattern of answers to questions that had been done by students, could be recorded by the system so that it could be analyzed based on the TAI. scoring used graded with 4 categories is shown in table 1.

| No. | Assessment Aspect                                      | score |
|-----|--------------------------------------------------------|-------|
| 1   | Wrong answer in the whole steps                        | 0     |
| 2   | The correct answer in the first step, but wrong or nor answer in step 2 or 3 | 1     |
| 3   | The correct answer in the first and second steps but wrong in step 3 | 2     |
| 4   | Correct answer at all steps                            | 3     |

3. Results and Discussion

The use of TAI was tested to 15 students. It is expected that the instrument can be used to measure the student’s difficulty in chemical bonding percentages with these indicators as shown in table 2.

| Stem | Indicators stem of chemical bonding | %     |
|------|-------------------------------------|-------|
| 1    | Electron configuration              | 28%   |
| 2    | Type of ionic bond                  | 35%   |
| 3    | The tendency of bonding an element  | 55%   |
| 4    | Type of covalent bond               | 7%    |
| 5    | The correct statement of covalent bonds | 13%   |
| 6    | Determination the number of lone electron pairs on the Lewis structure | 7%    |
| 7    | Type of metal bond                   | 13%   |
| 8    | Molecular Form                       | 4%    |
| 9    | The value of the electronegativity of an element | 7%    |
| 10   | Electron domains                     | 22%   |

After the students conducted TAI on the chemical bonding subject matter, the result showed its stem of instrument difficulty. About 28% students can answer correctly on stem 1 with indicator electron configuration, 35% on stem 2 with indicator type of ionic bond, 55% on stem 3 with indicator of tendency of bonding an element, 7% on stem 4 of type of covalent bond, 13% on stem 5 of the correct statement of covalent bonds, 7% on stem 6 with indicator determination the number of lone electron pairs on the Lewis structure, 13% on stem 7 of type metallic bond, 4% on stem 8 of molecular form, 7% on stem 9 the value of the electronegativity of an element, and 22% on stem 10 electron domain. The highest percentage is in stem 3 with 55% of students who can answer correctly and lowest at stem 8 only 4% of student can answer correctly. After the students completed the TAI problem, students are given a questionnaire to find out the reasons why many of the students cannot answered correctly on the problem of stem 8. From here it can be seen how far this instrument can measure a student’s ability on chemical bond material and how the feasibility of this instrument is generated from questionnaires.

Therefore, interviews are needed for every student who cannot completed the stem 8 appropriately. Many students argue that students do not understand the material presented at stem number 8, there is still an overlap of understanding between bonding electron pairs and lone pairs of electrons in a bond so that students are still confused in determining it, one of the factors students feel unsure of they have done because of lack of learning motivation in this chemical bond material. Students assume the material of this chemical bond is difficult to imagine in the minds of students, such as the determination of molecular shape and the force produced in a bond that requires analysis in the form
of illustrations in order to find the molecular shape of a compound developed because the teacher can easily analyze where the difficulties of students in learning a material. The result of students develop can be analyzed so that they can be found where their difficulties in learning are related to the material of this chemical bond.

The student fills out a prepared questionnaire. The result of questionnaires and interviews stated that 80% of students had never done the test in the form of testlet, they often get questions in the form of multiple choices and essays that are not hierarchical. 67% of students thought that the testlet was difficult to understand because they didn’t understand it as a whole related to chemical bonds. 80% of students thought that learning about chemical modelling was difficult because the teacher always explained by lecture [11] or with a limited understanding of the previous models[12-13], 20% of students assume that problems with STEM such as in computerized testlet are needed because they assume that by solving problems with a testlet form like this. They must understand the basic concepts first before stepping in to completed the second question so they know where level of understanding. 20% of students finding it difficulties to understand the language used in the testlet questions. 67% of student stated this computer-assisted TAI is very practical and more efficiently. 40% of student stated that for a computerized look still needed improve to be attractive and interesting. 100% according to the computer-assisted TAI students can be used to knowing the ability of students to master chemical bonding material.

In another study, it was found that the majority of students considered science lessons very difficult. Only 1% of students thought that chemistry was easy. This indeed could be a major reason as to why pupils choose not to pursue the study of Chemistry even though they may find it enjoyable and interesting [14]. Many high school and university students experience difficulties with fundamental ideas in chemistry [15]. Many researchers, teachers and science educators argue that the abstract nature of many chemical concepts includes: teaching styles applied in classrooms, lack of teaching aids and lack of chemical language difficulties [15]. Many middle school students and universities have difficulty with basic ideas in chemistry [11]. Most students emerge from introductory courses with limited subject understanding despite the importance of chemical foundations [16] which have been considered difficult subjects for students.

The assessment instruments used by researchers are computerized testlet. Where in this testlet consist of 10 stems, each stem consists of 3 questions. For instance, the cyber school makes teaching and learning environment more visual and concept formation is enhanced. There is a need to integrate computer technologies into learning and teaching [16]. In the chemistry education literature, there have been numerous studies reporting positive effects of the use of computers on students’ achievement [17]. Computer-assisted curricula also provide opportunities for inquiry-based approaches to the learning of chemistry and it seems they discouraged rote memorization and algorithmic problem solving while encouraging conceptual understanding and critical thinking.

Besides giving easiness in correcting, testlet can also result from the cognitive indicator that can be used to measure indicators [18] of chemical bonding. Testlet is designed with multiple choices. Chemical bonding is an abstract topic, something far removed from the daily experiences of secondary school students. As students cannot see an atom, its structure and how it interacts with other atoms, it is difficult for them to understand the concepts involved in the topic of chemical bonding and there is great potential for the formation of alternative conceptions [19]. There are still many students who have difficulty in working on this computer-assisted TAI, this is caused by several factors such as many students who have not really understood the material of chemical bonding so that they cannot solve the problem correctly, the network is in school so that it can inhibit students in working on, and some students to understand questions that would be presented as evaluation material for researchers as an improvement to this computer-assisted TAI being tested back to the next stage [19]. More research needs to be done to identify what sort of difficulties students face in the learning of physical and chemical concepts [15]. Learning difficulties are important for both teaching and learning, both science educators and cognitive researchers agree that efforts to understand and improve science education should be focused on fundamentally important knowledge domains [4].
4. Conclusion
It can be concluded that the computer-assisted TAI used to diagnose students’ difficulties in learning chemistry in the chemical bond subject matter is found in stem 8 which not all students can answer correctly and only 4% of students can answer correctly. This TAI can determine the consistency of students in answering questions and can detect student difficulties in learning chemical bonds. There are several factors that cause students unable to answer questions presented in the form of testlets. One of them is due to a lack of understanding of the basic concepts of students, where the ability to describe bonds is still low because it is difficult to find in real life. therefore, the teacher needs an evaluation tool that can be used to evaluate students’ level of understanding. one of them is the teacher can use the computer-assisted TAI as an evaluation tool and also as an alternative concept that will be delivered to students so that they become more aware of the material delivered.

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