Identification of Multiple Representation Abilities Using C3TMC Instrument: Needs Analysis in Chemistry Learning

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Abstract. Chemistry learning plays a significant role in producing pupils whom both mastered the cognitive aspect and multiple representative aspects (contextual learning). Evaluation instrument used by the teacher for measuring cognitive aspect is common, but those for measuring multiple representation ability is rare. The proper instrument is needed to measure multiple representations. This study aims to describe the analysis of the needs of the Computerized Three-Tier Multiple choice (C3TMC) Instrument to measure student’s multiple representational abilities in chemistry learning. Qualitative descriptive is the research method chosen by conducting a qualitative survey. The sampling technique was purposive sampling. The participants consisted of 17 chemistry teachers in the Surakarta area. This research used 13 items of the survey that aimed to reveal teachers' needs on the learning evaluation process had been validated by two experts. The results obtained show that the analysis of computerized and needed an assessment instrument that was able to measure students' multiple representational abilities has a high utilization category in chemistry learning, namely 88.2%. By considering the results, the teachers tremendously need a good instrument to measure pupils' multiple representation abilities in Chemistry learning.

1. Introduction
Chemistry studies the structure of matter and the changes that matter undergoes both in natural processes and in planning and conducting experiments [14]. Chemistry learning is currently required to generate students not only mastering theory but also be able to collaborate on multiple representation abilities for problem-solving in everyday life [14]. The human physical environment is influenced and filled with chemical products, helps in public debate, and understands the daily environment, this shows the importance of understanding chemistry [7][3]. Education in real-world scenario applications is an effective strategy and process so that students can more easily understand the material so that the learning process is more enjoyable [10]. In the last 20 years, education development has shifted towards ICT which is used as one of the education management strategies, including institutional governance and human resources. This is in line with the Ministry of Education and Culture's explanation regarding the characteristics of 21st-century learning, namely the availability of information anytime and anywhere (information), the implementation of machine use (computerization), and it can be done anywhere and from anywhere (communication).

One of the learning activities at school is chemistry learning. Mastery of ICT by chemistry learners is very important to support the achievement of the vision and mission of learning in the 21st century. The importance of chemistry in the souls of students, namely that individual students are required to be able to solve problems critically and contribute to the scientific decision, making regarding technology
and science issues that occur in public debate [6]. Competence “Partnership 21st Century Learning” is built with education, where the learning process will require students or learners to have life preparation which includes knowledge, skills in technology, media and information, learning skills, and innovation. Many of the multi-representative computer-based learning environments used in classrooms today support a variety of learning activities.

The chemistry curriculum must explain learning in both concept and context. Representation is a form that can describe a certain material concept. Where students can understand chemistry at the macroscopic and microscopic levels: the symbol level and the process level by having strong representational abilities include: verbal, image, mathematical, and graphic representations [2]. Chemical phenomena can be explained by representing three different levels of phenomena, namely microscopic, sub-microscopic, and symbolic [8][9]. The ability to understand every aspect of both microscopic, submicroscopic, and symbolic aspects in solving a problem is required for mastery of chemistry in secondary schools. So that an evaluation of the mastery of three aspects of multiple representations needs to be done.

The three-tier multiple-choice test instrument is an instrument with questions divided into 3 levels. The first level is a simple question of multiple choice, the second part is the reason for choosing the first level answers, and the third level is the confidence questions for answers to levels one and two [5]. Thus, the three-tier multiple-choice test instrument is considered suitable to be combined with the implementation of the use of machines (computerization) to measure students' multiple chemical representation abilities and as an effort to support the achievement of the 21st-century learning vision and mission.

The chemistry curriculum must explain learning in concepts and contexts so that the ability of multiple representations is very important for students. Chemistry learning plays a significant role in producing pupils whom both mastered the cognitive aspect and multiple representational aspects (contextual learning). Evaluation instrument used by the teacher for measuring cognitive aspect is common, but those for measuring multiple representation ability is rare. The proper instrument is needed to measure multiple representations.

From these problems, it is necessary to conduct a needs analysis of an assessment instrument that can be used as an evaluation tool, namely the Computerized Three-Tier Multiple Choice (C3MC) Instrument to measure students' multiple representational abilities in chemistry learning.

2. Research methodology
This research is qualitative descriptive research. Qualitative analysis techniques are divided into three components, namely data reduction (summarizing), display (presentation), and concluding. This study aims to determine the needs analysis of the Instrument Computerized Three-Tier Multiple Choice (C3TMC) to measure students' multiple representational abilities in chemistry learning. The subjects in this study were 17 chemistry teachers in the Surakarta area, divided into 17 questionnaire subjects and 3 subjects who were interviewed again. The selection of research subjects for conducting back interviews was based on the school level which included high, medium, and low school categories. The sampling technique was carried out by purposive sampling. Purposive sampling research is sampling based on certain considerations aimed at making the data obtained more representative.

The data in this study were obtained from the analysis of the chemistry teacher's needs questionnaire and interviews with the Computerized Three-Tier Multiple Choice (C3TMC) instrument to measure students' multiple representational abilities in chemistry learning. The questionnaire on the needs of the chemistry teacher for the instrument Computerized Three Tier Multiple Choice (C3TMC) instrument to measure the multiple representation abilities of students consisting of 13 questions and followed by interviews to deepen the analysis of the questionnaire questions. The questions asked were related to the implementation of the use of machines (computerization), the three-tier multiple-choice test instrument, and the ability of multiple representations. The collected data is then tabulated. Data analysis is done by analyzing data/information, then describing the data obtained, and restating it in a qualitative narrative.
3. Results and Discussion
Analysis of the needs of the Instrument Computerized Three Tier Multiple Choice (C3TMC) to measure the ability of multiple representations of students in chemistry learning was carried out using a questionnaire analysis and the results of interviews with the needs of chemistry teachers in the Surakarta area. The needs analysis questionnaire is based on the chemistry teacher’s knowledge of three-tier multiple-choice, multiple representations and the implementation of machine use (computerization) in the chemistry learning process carried out by the teacher.

The needs analysis questionnaire contains 13 questions with details: 10 questions in the form of a closed answer questionnaire and 3 in the form of an open answer questionnaire. The use of two open answer questionnaires is intended to explore the depth of the use of evaluation instruments and the extent to which multiple levels of representation are applied in the learning process.

The results of the needs analysis research using questions in the form of a closed answer questionnaire are summarized in table 1. which explains the percentage of answers to chemistry teachers in Surakarta.

Table 1. Percentage of closed questionnaire results for the analysis of the needs of the chemistry teacher C3TMC instrument

| Question Number | Question                                                                 | Answer Percentage (%) |
|-----------------|--------------------------------------------------------------------------|-----------------------|
| 3               | Are you familiar with the three-tier multiple-choice assessment instrument? | 70.6 29.4             |
| 4               | Have you used the three-tier multiple-choice assessment instrument in your assessment? | 11.8 88.2             |
| 5               | Do you know about multiple representations in chemistry lessons?          | 64.7 35.3             |
| 6               | Do you think that the ability of multiple representations is important for students? | 82.4 17.6             |
| 7               | Do you apply multiple representation-based learning in classroom learning? | 41.2 58.8             |
| 8               | Do you refer to multiple representations chemistries on based learning in the learning process? | 52.9 47.1             |
| 9               | Are the assessment instruments used by you able to measure students' multiple representational abilities? | 29.4 70.6             |
| 10              | Do you need an assessment instrument that can measure students' multiple representation abilities? | 88.2 11.8             |
| 11              | Do you use computer-based assessment instruments?                        | 88.2 11.8             |
| 12              | Do you think it is necessary to develop a Computerized Three-Tier Multiple Choice (C3TMC) assessment instrument to measure students' multiple representation abilities of chemistry? | 88.2 11.8             |

Note:  
<33.3% = low  
33.4%-66.6% = moderate  
> 66.7% = high [10]

The analysis of the results of the closed questionnaire presentation will be detailed in sections 3.2 to 3.5

3.1. Type of evaluation instrument questions the teacher uses
Chemistry learning that has been carried out by the teacher has used a variety of questions. The results of the research need analysis using questions in the form of an open answer questionnaire with question number 1 containing the questions:
"What grading system do you use in assessing student learning?"

Based on the needs questionnaire data, 100% of the 17 teachers answered student learning assessments not only through texts but also through non-tests. The question in the form of an open answer questionnaire with question number 2 containing questions:

"What kinds of questions do you use in assessing student tests?"

In this question, the teacher's response explaining the percentage of question types that you use in conducting test assessments of students is summarized in table 2.

Table 2. Percentage of the types of questions that you use in conducting test assessments of students

| types of questions       | Percentage (%) |
|--------------------------|----------------|
| Multiple Choice and Essays | 35.4           |
| Multiple choice          | 29.4           |
| Essays                   | 17.6           |
| Combination              | 5.9            |
| Test-let                 | 5.9            |
| Two-tier multiple choice | 5.9            |

Based on table 2, it can be seen that 35.4% of the teachers revealed that the questions types of multiple choice and essays were the most widely used. The questions type of multiple-choice was widely used by the teacher with a percentage of 29.4%, the type of essay question was widely used by the teacher with a percentage of 17.6%, and the use of the type of combination test, test-let, and two-tier multiple-choice had a percentage of 5.9%. As for the results of the interview, one in three teachers revealed that daily tests usually using essay questions, but for the midterm exam and annual final exams it is usually a combination of the questions types of multiple-choice and essay questions. Meanwhile, the assessment of the skills aspect is only carried out through presentations and student folio assignments. Two teachers added that the teacher assessment also used the assessment when implementing practicum and the presentation of the results of the practicum and discussion. Assessment of the practicum implementation and the presentation of the results of the practicum and discussion is carried out to assess aspects of student skills.

3.2. Use of Machines (Computer) in chemistry learning evaluation instruments

The competency of "Partnership 21-st Century Learning" is built, where the learning process requires students or students to have life preparation, one of which is skills in technology, media and information, learning skills, and learning innovation. The Ministry of Education and Culture explained that 21st-century learning is closely related to the availability of information anytime and anywhere (information), the implementation of machine use (computerization), and it can be done anywhere and from anywhere (communication). This shows that the use of computerized instruments can be applied to the generation of students in the 21-st century or better known as millennial generation students to increase student interest in learning.

Several research instruments have been developed on a computer basis, including two-tier computerized instruments on the chemical bonding material and chemical equilibrium [17].

Analysis of the use of machines (computerization) in chemistry learning conducted by teachers in the Surakarta area is shown in questionnaire question no. 11. Based on the questionnaire, it can be seen that the implementation of computer-based instruments in chemistry learning is high. This is evidenced by the percentage of use of computer-based assessment instruments by chemistry teachers of 88.2%. Meanwhile, 11.8% of chemistry teachers stated that they had not used computer-based assessment instruments. Based on the results of interviews conducted with three chemistry teachers, it was stated that the use of technology in chemistry learning was very helpful and was able to increase student interest and focus. This is consistent with a survey conducted of three-quarters of U.S. teachers show that they use technology in the classroom to help motivate their students, increase peer interaction by connecting students with other students, including students with disabilities [15][16].
3.3. Teacher's Knowledge of Three-Tier Multiple Choice and Multiple Representation Instruments

Three-tier multiple choice is an instrument test of multiple-choice with a reasoned question pattern so that it can measure students' abilities more deeply than the question of the instrument of multiple choice in general [5]. By using this instrument, students can get feedback in the form of students' abilities based on the results obtained. This question instrument has been developed to determine the level of understanding and misconceptions of students [12][13]. The analysis of the teacher's knowledge of the three-tier multiple-choice test instrument is shown in the questionnaire question no.3. Based on the questionnaire, it can be seen that the teacher's knowledge of the three-tier multiple-choice test instrument is high and it is proven by the percentage of teachers' knowledge of the three-tier multiple-choice instrument by 70.6%. Meanwhile, 29.4% of chemistry teachers stated that they did not know the three-tier multiple-choice test instrument.

Based on interviews conducted with teachers, there was an opinion from the teacher who revealed that 2 out of 3 teachers already knew the instrument with the three-tier multiple-choice model, but there was one teacher who did not. The ignorance meant by the teacher was related to knowledge about the preparation of questions and assessors' analysis. The teacher feels that it is still very difficult to arrange the questions because the teacher feels that these questions require extra time to prepare them. Meanwhile, the teacher has a very limited time.

The chemistry curriculum must explain learning in both concept and context. Where students can understand chemistry at the macroscopic and microscopic levels: the symbol level and the process level by having strong representational abilities include: verbal, image, mathematical, and graphic representations. The analysis of teacher knowledge on the ability of multiple chemical representations is shown in questionnaire question number 5. Based on this questionnaire, it can be seen that the teacher's knowledge of the ability of multiple representations of chemistry is moderate as evidenced by the percentage of teacher knowledge on the ability of multiple chemical representations of 64.7%. Meanwhile, 35.3% of chemistry teachers stated that they did not know the ability of multiple representations.

Based on the results of the needs analysis questionnaire in question number 6, 82.4% of the 17 chemistry teachers revealed that the ability of multiple representations is important for students. Meanwhile, 17.6% felt that the ability of multiple representations of chemistry was not important enough for students at senior high school level and far more important for students with university education levels.

3.4. Application of Three-Tier Multiple Choice and Multiple Representation Instruments in Learning

The importance of education in the 21-st century requires that students are not only smart in terms of knowledge but must have 3 skills which include life and career skills, skills in learning and innovation (learning and innovation skills), and skills in utilizing media information and technology (information media and technology skills). These skills are needed by students to adapt and as provisions to deal with the times and the development of increasingly advanced and complex systems.

In the process of implementing chemistry learning, based on the analysis of questionnaire answers, it shows that the application of the three-tier multiple-choice instrument in learning is still very low. However, it is different from the application of the multiple representation ability instruments in learning that is already at a moderate level in its use. This is evidenced by the percentage of the results of the application of the three-tier multiple-choice instrument in learning by 11.8% and the application of multiple representation abilities by 41.2 As many as 88.2% of the 17 chemistry teachers stated that they had not implemented the three-tier multiple-choice instrument and 58.8% had not implemented multiple representation-based learning.

In the application of multiple representation abilities, the teacher revealed that in the chemistry learning process 52.9% of 17 teachers had referred to chemistry based on multiple representations. However, 47.1% of the 17 teachers stated that they had not done multiple representation-based learning. The low application of multiple representations in learning at the medium level results in the low ability of students to have multiple representations. This is consistent with the findings showing that although
the majority of students come to the university with non-scientific ideas for the concept of energy, in some representations it has a positive effect on improving non-scientific students' ideas [1]. The results of the needs analysis research using questions in the form of an open answer questionnaire with question number 13 containing the questions:

"What of level do you apply multiple representations on chemistry learning?"

In this question, the teacher's response which explains the percentage level of multiple representation ability applied in chemistry learning is summarized in Figure 1.

![Figure 1. The percentage diagram of multiple representation ability levels applied in chemistry learning](image)

Based on the diagram in Figure 1, it can be seen that 54% of teachers stated that they had implemented multiple representation-based learning at the macroscopic level. In implementing multiple-based learning, the sub-microscopic level representation is 14%. While at the symbolic level, applying multiple representation-based learning achieved a percentage of 32%.

Based on the results of interviews conducted with chemistry teachers, 2 teachers revealed that the level of macroscopic ability was learning based on content, context at the sub-microscopic level. Meanwhile, two other teachers explained that the purpose of context-based learning was learning at the macroscopic level, at the sub-microscopic level showing students' understanding of the content, while at the symbolic level the teacher revealed that it contained mastery of formulas, language, images, and symbols. Based on the results of the interview, it shows that teachers' understanding of chemical representations is still low, in distinguishing the macroscopic and sub-microscopic levels. The teacher also revealed that the reason for the teacher's lack of understanding of multiple representations was the teacher's low understanding of the current development of education science, while the aspects developed were too many. Teachers feel the need for training and assistance in presenting learning tools and evaluation instruments that follow the development of the world of education as an effort to achieve the vision and mission of 21st-century learning so that the learning presented is not left behind. This is in line with how the understanding of the meaning of all representations should be supported in maximizing learning outcomes and the information that must be gathered from empirical evaluation to determine the effectiveness of a multi-representational learning environment.

3.5. The Need for Using Instruments to Measure the Multiple Representation Ability of Students

The assessment that is usually used by teachers in learning is in the form of tests multiple choice and or descriptions to assess students' abilities. However, in the 21st century, we need an assessment that can measure students' abilities in the learning process. Students' understanding related to macroscopic and submicroscopic aspects shows a deep understanding of chemical material, while at the symbolic level students can develop HOTS abilities so that students' understanding of macroscopic, submicroscopic, and symbolic aspects affects students' conceptual understanding [7]. The results of the assessment to measure student learning outcomes are expected to not only have an impact on students,
but can also be used as a source of information for teachers, schools, and can also be used for government and national levels and can measure students' ability to solve problems, think critically, and ability. other needs students in the 21st century.

Based on the results of the needs analysis questionnaire in question number 9, 70.6% of the 17 chemistry teachers revealed that the assessment instruments used had not been able to measure the multiple representation abilities of students. Meanwhile, 29.4% felt that the assessment instruments used had not been able to measure students' multiple representation abilities. This shows that the instrument's ability to measure multiple student representations is still low.

In the results of the needs analysis questionnaire on questions number 10 and 12, most of the teachers felt they needed an assessment instrument that was able to measure students' multiple representational abilities. So that the teacher felt the need to develop a Computerized Three-Tier Multiple Choice (C3TMC) assessment instrument to measure students' multiple chemical representation abilities. This is evidenced by the fact that 88.2% of the 17 teachers answered that they needed instruments and it was important to develop a Computerized Three-Tier Multiple Choice (C3TMC) assessment instrument to measure students' multiple chemical representation abilities. However, there were 2 teachers with a percentage of 11.8% who felt that they did not need to develop this instrument. According to two correspondents who expressed that it was not necessary, this was because the teacher himself felt that he did not understand multiple representations so that in the learning process in the class multiple representations were not included in the learning process. As a chemistry teacher educator, I often find prospective teachers either not critical of the existence of "triplets" or confused by the different ways in which the main components are described in their course of reading (levels of description, levels of representation, levels of thinking, different worlds. Students have difficulty translating the macroscopic and "representation level" of the material. This means they have problems translating between experience and submicroscopic model, between the macroscopic model and submicroscopic model, between experience or macro model and submicroscopic visualization, or between all. The development of a three-tier multiple-choice instrument is expected to be able to support 21st-century education and evaluate students by integrating the skills needed by students in the 21st century, such as the ability to solve HOTS questions, critical thinking, and so on. the development of assessment instruments is needed because this is an effort to improve teacher competence in the field of student assessment and evaluation [4][11].

4. Conclusion
Based on the research results it can be concluded that the analysis of computerized use has a high category of use in chemistry learning. Teachers use computers as learning media and evaluation instruments on school final exams. Evaluation instrument used by the teacher for measuring cognitive aspect is common, but those for measuring multiple representation ability is rare. Thus, we recommend that further research be carried out to develop the C3TMC instrument because of its widely applied computerized use, the need for an assessment instrument to measure the ability of multiple representations, and the development of a three-tier multiple choice that can reduce the possibility of student guessing.

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