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Review Article

Science Competence Assessment at Middle School: Teacher's Perception and Practice

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Abstract: Science competence is one of the most vital learning outcomes of natural science subjects in general education. The research presents a guideline to develop assessment criteria/toolkits following the science competence components containing science awareness, science inquiry and scientific problem-solving. A topic titled "how to classify mixtures and separate the mixture" in natural science six is presented to illustrate the guideline. A deep interview method was applied with thirteen natural science teachers to gather information about teachers' perceptions and practices in teaching and assessing activities to support students in enhancing their science competence. Feedback from teachers about the proposed guidelines was also collected. The research results created a picture of implementing natural science subjects in secondary schools with information about the challenges and needs of teachers to improve the issues. This paper is expected to provide teachers with valuable tools in the innovation phase toward competence-based teaching and assessment.

Keywords: Science competence, natural sciences, middle school, assessment, challenging.

1. Introduction

The new general education program issued in 2018 is the first achievement of the comprehensive fundamental education and training reform in Vietnam. This program develops based on the qualifications and competencies approach instead of the content approach. The new orientation requires upgrading the entire education system, including teachers, who play an essential role in the quality of education and training. Mai and Brundrett [1] pointed out the importance of developing teachers as researchers to adapt well to competence-based teaching and assessment methods. In the current situation, with three kinds of textbooks and countless online teaching resources, they need to select and design teaching and assessment strategies actively to lead and organize students' learning activities that help achieve educational goals.

Natural science subject in the new general curriculum is designed with an integrated approach. This approach provides various

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opportunities for students to deeply understand nature and develop their science competence to solve real-life problems [2]. However, many challenges teachers have to face when teaching integration with a new curriculum can be listed, such as time preparation, facilities, and understanding of other subjects' knowledge [3, 4]. Among these factors, teachers' perception always plays a critical role in their practices. Some articles also mentioned these issues related to integrated teaching [5], intention to use technology in education [6], class size-based teaching methods [7], formative assessment [8], classroom-based assessment [9, 10] and assessment for learning [11]. In this paper, we also focus on 04 parts related to teachers' factors in finding out the challenges and needs teacher got when conducting new curricula: i) Facility and school regulations; ii) Teaching and assessment methods; iii) Students' attitudes, engagement, and interest in the new curriculum; and iv) Training activity.

The 2018 general curriculum has the orientation to form five qualifications (patriotism, empathy, hard work, honesty, responsibility) and ten core competencies, including general and specialized competencies. Natural competence is one of the specialized competencies expected to form through learning natural science subjects in school [12]. Scientific competence is the ability of learners to effectively apply scientific perceptions, skills, and attitudes to solve problems through scientific inquiry activities toward sustainable development [2]. In the nature science curriculum, secondary students explore the natural world through key learning topics: substance and transformation, energy and transformation, living things, earth and sky. This competence requires learning through active activities like doing experiments, doing research, observe phenomena; therefore, that leads to the need for teacher change in teaching and assessment. Assessment of students' scientific competence is an activity to collect data about students' achievement in learning activities. Implementing it takes more time than traditional assessment methods and requires support from policy, schools, and teachers' perceptions of advantages. So in this research, we also present teachers with a set of sample lesson plans expected to provide them with more ideas in assessing science competence. Based on these situations, the study is designed to answer two questions:

i) What are the challengings and needs of teachers when teaching the new curriculum following a competence-based approach?;

ii) Do teachers believe in the effectiveness and feasibility of the proposed competence-based teaching and assessment model?

2. Science Competence and Assessment

Science competence is a concept similar to science literacy which has been mentioned in many large-scale assessments and national general curriculums [13]. PISA 2018 presented a definition of science competence as a scientifically literate person who, therefore, is willing to engage in reasoned discourse about science and technology, which requires the competencies of explaining phenomena scientifically, evaluating and designing scientific inquiry, interpreting data and evidence scientifically [14]. This concept enhances the role of technology as a support tool for learning science. In Vietnam's general curriculum, science competence contains 03 primary parts: science awareness, science inquiry, and scientific problem-solving. While science awareness requires students to deeply understand scientific phenomena, concepts, and theories, two other components are related to students' ability to apply the knowledge to research or solve real-life issues [12]. The requirements offer changing teaching and assessment methods toward high-order thinking and skills to adapt well to learning outcomes.

Competence assessment is developed based on the outcome-based model of education [15]. The education with competence approach needs to define complex behaviors of competencies. Then assessments are designed aligned to these outcomes to gather evidence of students' behaviors [16]. Various competence methods

can be used to measure students' competence, especially in science [17]. Kuo, Wu, Jen, and Hsu [18] built and validated a computer-based test that used questions to measure students' science inquiry. The results confirm the ability of test questions in science competence assessment. Large-scale assessments like TIMSS and PISA also use test questions like multichoice questions and short answers in competence assessment. However, this test requires the teacher's ability to design and validate the question. While projects are one of the popular methods of teaching integrated and experimental subjects, Prather, et al., [19] suggested that many of the participants can not understand projects' knowledge or concept if teachers don't have a suitable assessment method. Moreover, both computer-based tests and performance-based assessments in projects require time and facility to conduct. Therefore, this paper also measures teachers' perception of competence assessment methods.

3. Research Design

The research used the deep interview method to collect the data to determine the perception and practice of natural science teachers in the new general curriculum. This paper is part of a project that studies student science competence. The initial research has proved the framework and scale of measuring students' science competence [20]. A lesson plan sample was also designed and experimented with to develop students' science competence. The results showed the effectiveness of that model [21]. In this paper, we introduced the lesson plan to 13 teachers and asked them to comment on the possibility of the lesson plan being deployed in the classroom and their need to train these methods. The research also gathered information about their schools' integrated status of natural science subjects.

First, all participants joined courses related to competency-based assessment. In this course, they are introduced to science competence, competence-based assessment principles, and methods of assessing students' science competence using some assessment tools. A sample lesson plan used to measure students' competence using inquiry-based teaching methods and performance-based assessment is also presented.

After the courses, they are invited to be interviewed following the question:

i) Introduce yourself, your experience, and the school you are teaching;

ii) What is the current situation of teaching Natural Sciences at the secondary school you teach;

Facility and school regulations.

Teaching and assessment methods.

Students' attitude, engagement, and interest in the new curriculum.

Training activity.

iii) Do you have any comments on the attached toolkit and sample lesson plan?

Suitability.

Effectiveness and increase students' interest, competence, or not.

Challenges when applied in schools.

Need of training or providing sample lessons.

Recommendations

The data collected are analyzed using Atlis software. Some common themes are proposed.

3.1. Lesson Plan Sample

The lesson plan sample is published in the book "Assessing science competence of 6^{th}-grade students in Natural Science" [22].

The lesson's name is "how to classify mixtures and separate the mixture". This lesson teaches students about Mixtures, Methods of separation of substances: Extraction, filtration, and distillation. An inquiry project with the 5E model is used. The objectives and assessment criteria are created based on the science competence framework [20] and learning outcomes in the general curriculums published by the Minister of Education and Training.

The plan contains two main lessons, following the graph below (Figure 1):

Students were asked to work in teams, propose questions, collect data, and do

experiments to answer the inquired questions. Besides some simple activities, students also have to do a big assignment in lesson 2. In this mission, they have to solve one of three missions, they are:

Group 01: The eastern sea is experiencing a shipwreck accident waiting for oil. The consequences lead to daily living in the ocean being harmed. Suggest oil treatment spilled seawater save marine life in the laboratory and practice.

Group 02: People on the island in the middle of the sea often spend time and money transporting fresh water from the mainland. Do experiments and propose methods to remove salt in seawater so islanders can save money.

Group 03: Due to negligence in the repair process, a large amount of sand and gravel fell into the water tank of Minh's family. Do experiments and propose treatments so that you can purify the water and research to present an effective water filtration system that removes many impurities.

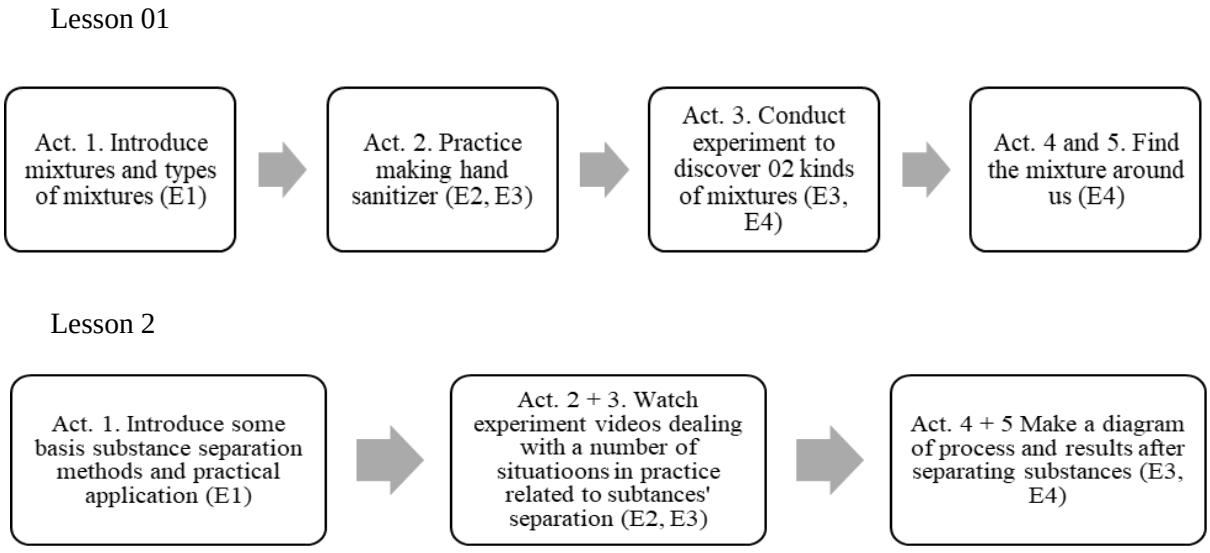

Figure 1. Lesson plan.

During the lesson, the Self-assessment/Observation Form, Student Task Form, Presentation/group review/Observation Form, Student Task Form, and rubrics to assess product and presentation were used to collect data about students' science competence.

Each lesson plan contains a lesson plan, student's book, PowerPoint, and mission form that teachers will be provided in word format so they can adapt to suitable with their context.

3.2. Research Subjects

Thirteen teachers who are teaching natural science in middle school are invited to join the research. They all have bachelor's degrees and are studying for Master's degrees. They are interviewed after being introduced to competence-based assessment, science competence, and the sample lesson plan. They had one week to read and study the sample lesson plan before joining the interview round.

Table 1. Participants' Demography

Gender	
Male	02
Female	11
Age	
Min	23
Max	34
Average	25
School	
Public	06
Private	05
International	02

The table below shows the demography of the participants. There are 02 male teachers and 11 female teachers. They are from 23 to 34 years old. 06 of them are working in public schools, and the number of teachers working in private and international schools are 05 and 02, respectively.

3.3. Data Analysis

Atlis software is used to analyze the data collected from interviewing participants. Some themes are created following the participants' opinions. The shared view of participants is counted and listed in Table 2. Based on the results, some recommendations are proposed.

Table 2. Coding categories and frequencies of participants discussing each topic

Code	Number
Practices	
Three teachers teach natural science separately	11
STEM lessons or STEM contest	09
Focus on active learning strategies like project-based learning, guild students to discover the knowledge	08
Only use traditional teaching methods because of lack of time and facility	03
Teacher's training activities organized by schools, districts, MOET (STEM, assessment, students' charisteristics,…)	12
Teachers' Self-training by Canvas courses	01
Facility: Enough experiment labs, tools, and modern devices to apply the new general curriculum	06
Lack of facility	05
Advantages	
Increase students' science competence	11
Students' interest increase	05
Disadvantages	
Class size is not suitable for active learning	02
Lack of time for preparation and implementation	07
Teaching oriented the testing contents	03
One teacher does not have enough qualifications to teach all components	06
Fee for preparing teaching tools	05
Need	
Sample lessons to save time	05
Training to create lessons by themselves	04
Both sample and training	03
Funding from the school to implement	04

4. Results

In the following sections, we describe the results of this study in terms of context, teachers' practice, their perception of the advantages and disadvantages of implementing new curriculums, and their need for training and support activities (sample lesson plan, facility, funding).

4.1. Teaching Practices

i) Teaching and assessment practices

Almost teachers (11/13) said that the three components "of physics, chemistry, and biology" are taught separately in their schools. The integration is only applied in STEM lessons or projects (07/13). However, these

projects are conducted by individual teachers in different disciplines. Some reasons are listed as *"students have to learn separately to prepare for classification exam to select students in a special class that training to enter gifted high school"*, teacher 13 replied. Or teachers don't have enough deep understanding of all three components to teach integrated (6/12). Teachers also wonder which way of integration is suitable for their context. Regarding these problems, we will provide some international experiences in the discussion part.

In terms of facility, teachers mention various textbooks their schools choose. In some schools, they use diverse kinds of textbooks for different grades. Because of the new curriculum, teachers said they needed to read all textbooks and other references to find examples. There is a difference in facility support for the new curriculum of schools. Nearly 50% of teachers approved that their schools provide enough tools, devices, and laboratories for conducting active learning activities. In comparison, others complain that the lack of services impacts their teaching process. Teacher 10 shared, "*I need a laboratory assistant to support me in preparing for experiment tools"*.

Facilities also impact teachers' teaching and assessment practices. 100% of teachers who have satisfaction with the school's resources said that they use various active teaching strategies and assessments in class, such as performance assessments, formative assessment applications, project-based learning, and problem-solving. While others argued that because they lack facilities and time, they only use traditional teaching methods. *"Facilities are limited, so I face difficulties designing active lessons for children to experience and experiment*", teacher 04 shared;

ii) Training activities

All teachers have attended training activities to adapt well to the new curriculum. Some training activities are related to textbooks, STEM teaching, specialist teaching sample, and assessment skills. Especially teacher 12 shared that her school hasn't opened training courses but providing teachers accounts to self-study in the Canvas platform. Teachers can choose which topics they really need to train. However, 05/13 teachers think that training activities are not practical and effective, *"Training is hardly useful. I often self-study on the internet without any specific guidance"* (Teacher 11*).*

4.2. Teacher's Perception and Needs

In this part, we asked the teacher to share about advantages and disadvantages of conducting new curriculums with the lesson plan sample and their need to improve the quality of teaching.

First, 11/13 teachers agreed that the sample plan is suitable to nurture students' science competence because of some reasons, such as *requires students to discover new knowledge in various ways; broaden knowledge outside the textbook; show many skills to solve problems, related to the real life, high-level thinking, increase students interest.*

On the other hand, some challenges when conducting these activities were mentioned. 02 teachers said about the class size. It is so difficult to assess 40 - 50 students in these activities. Time for preparing and conducting is also revealed. Teacher 13 said that natural science teachers in her school have to teach 10 - 12 classes per semester; therefore, they don't have enough time to develop the curriculum like that. Similarly, more than 50% shared the same problems. Teachers also fear that they must confirm the content knowledge in the general curriculum and testing for students, so they can't spend too much time doing experience or involving students in too many activities.

Then, we gather information about teachers' need to conduct active learning activities. While 05/13 teachers want to be provided sample lessons with completed and detailed material, 04/13 teachers want to join the training courses to guild them on how to design the lessons. The others share that they would like both sample lessons and training activities, then they can adapt the lesson plan to suit their students and contexts. 04 teachers also refer to funding

problems. They need support to prepare teaching materials.

5. Discussion and Conclusion

In this part, we will discuss the issues teachers mentioned in the interview round. The problems with facility and funding for experiments depend on each school's financial situation, so we focus on teaching and assessment methods and support activities.

Many articles have shown that teachers' ability, beliefs in effectiveness, and supports are the critical factors that impart their practice of new teaching methods [23-25]. In this study, teachers also shared these factors in their practices. While teachers showed their beliefs that the activities in the sample lesson could help develop students' science competence (11/13) and engage students in science lessons (05/13), they had worried about teachers' ability when teaching integrated (06/13). Shernoff, et al., [26]. also indicated the problems of "Lack of understanding disciplinary content and standards" when conducting integrated subjects because teachers don't know how to teach in that way. The other reason is that each teacher is trained intensely in one subject, which makes them feel unconfident when teaching other subjects (teacher 04).

Regarding solutions to improve in-service professional development, training activity is one way that proves efficacy [11, 27]. However, the content and training methods impact the activities' quality. *"Some training activity contains a lot of theories that are not suitable for the problem of teachers", teacher 13 mentioned.* Therefore, conducting a need assessment before training courses is vital to make the activities more meaningful. Furthermore, letting teachers freely choose online courses like Canvas and Coursera that fit their needs is one solution. In the future, other scholars can research more about the demand for online guidelines and resources for teacher development.

Some other solutions to improve teachers' understanding are also listed in some studies, such as "giving opportunities to see video recordings/productions of experienced teachers, sample lesson plan and assessment tools, create a supportive community, talk shows with professional experts" [26, 28]. These activities also fit with teachers' needs in the interview results. The managers or policymakers can flexibly apply the actions to help teachers increase their ability to conduct new curricula successfully. Moreover, the timetable is the most critical aspect in organizing in-service professional development courses.

The limitation of this research is that teachers don't have enough time to experiment with these lesson plans, and the samples are 100% of teachers in urban areas. In the next step, we will try to apply the lesson model in both urban and rural areas to compare the effectiveness and impacts of context on teachers' implementation. The research results expect to give some recommendations for training and improving teaching activity following the competence approach in new natural science subjects.

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