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A Framework Design for Developing and Validating Virtual Test to Assess Science Process Skills in Chemistry

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Abstract.
Technological advancements and the demands of the pandemic around the world forced educators to think of solutions in the teaching and learning process so that there were no obstacles in the assessment process. Although the focus of learning assessment in Indonesia focused on literacy and numeracy assessment, the assessment of science process skills is still carried out because the science process skills are the core key to developing children's knowledge in science, including chemistry. The present assessment process used more online platforms or virtual tests. This study aimed to describe the virtual test design framework that is suitable for assessing science process skills in chemistry. The method used was a literature review. We collected journal articles in accordance with the theme, and then the journal article was reviewed and arranged into several discussion sections. The framework design for developing and validating virtual test had four phases: planning, developing, validating, trial and data processing. Discussions include an overview of virtual tests, assessing the skills of chemical-specific science processes with virtual tests and how the virtual test design framework assesses science process skills on chemistry that qualify on assessment characteristics (validation, reliability, objectivity, and practicality).

Keywords: assessment, virtual test, science process skills

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1. INTRODUCTION

Science process skills are essential in understanding science that students must possess because producing a good literacy depends on the science process carried out [1, 2]. Understanding science can be done by identifying problems, proposing hypotheses, designing experimental procedures, making observations, and simulations, collecting and processing data, applying theory, and explaining the results of experiments [3]. All these activities are science processes that must be passed to understand science itself. Science process skills are essential for students in scientific inquiry activities to solve various science problems [4, 5].

In science, especially chemistry, two related things are chemistry as a product and chemistry as a process [4]. Chemistry as a product includes a set of knowledge consisting of facts, principles, concepts, theories, and chemistry principles. Chemistry as a process includes the skills and attitudes possessed by scientists to acquire and develop chemical knowledge [6]. Teachers should not only focus on the introduction of science concepts but also introduce how to acquire and develop such concepts [7]. A learning process would be meaningful if students could find their concepts from the material being studied and one of them is implementing science process skills in learning [5].

There were many types of research to assess science process skills in chemistry, such as; the acid-base titration material [8], the solubility material and the results of solubility [9], salt hydrolysis material [10] and colloidal system material [11]. However, in its implementation, the assessment of the skills of the scientific process is still not implemented optimally, because teachers don't have a concrete concept to develop virtual test in assessing science process skills [12]. The assessment of the skills of this scientific process is still reluctant to be carried out by teachers in elementary and secondary schools for various reasons, including the national testing system, which is still dominated by science as a product, not science as a process. Whereas in terms to get science as a product, the process has an important role [7, 13].

The implementation of online learning is required due to the spread of Covid-19 [14]. Online learning that is no longer an obstacle to many educational institutions in Indonesia makes many possibilities for online learning to be carried out massively [15, 16]. Whether it is entirely online or even blended learning [17], this changing learning process affects the assessment process, one of which is the process of assessing the skills of the science process [18]. Teachers have difficulty assessing students' science process skills directly because learning is not done face-to-face. So, online assessment must also be prepared so that the learning process can run optimally [2]. One of the efforts to assess the skills of the scientific process that can be done is a virtual test [2, 19], where the test is conducted online, and the assessment is carried out objectively, through multiple-choice questions [18]. In order to develop a virtual test that can evaluate students' science process skills in chemistry subjects, a suitable framework is needed to make it easier for researchers to develop assessment instruments. This framework contains the stages of developing virtual tests to become a product that can evaluate the skills of chemical science processes. The study aims to describe the virtual test design framework that is suitable for assessing science process skills on chemistry.

2. RESEARCH METHOD

This research is qualitative research using the Literature Review method [20, 21]. Literature research or literature review is research that reviews or critically reviews the knowledge, ideas, or findings contained in the body of literature oriented and formulating theoretical and methodological contributions to a particular topic [22]. The stages are to collect journal articles, textbooks and handbooks that follow the theme. Then the journal article is given a review and arranged into several discussion sections. The result of the literature review that has been conducted is a virtual test design framework that is suitable for assessing science process skills in chemistry.

3. RESULT AND DISCUSSION

3.1. Indicators of Science Process Skills in Chemistry

Science Process Skills (SPS) need to be taught following the level of cognitive development of participants. SPS will be the driving wheel of the discovery and development of facts and concepts and the growth and development of attitudes, insights, and values. Thus, students are expected to master various types of SPS without having to master all the facts and concepts gathered in the science group [7]. Experts do not have a unified view concerning the type of SPS, as shown in the following Table 1.

SPS must be developed in students starting from the most specific ability: observing, measuring, up to the highest ability, namely conducting investigations [23]. Each type of SPS is a remarkable intellectual skill used by all scientists and can be applied to understand any phenomenon. These indicators are adjusted to the content of the material that was wanted to measure the skills of the science process [7]. As in chemistry, measurable indicators of science process skills include; observation, interpretation, classification, prediction, communication, hypothesizing, planning experiments, applying concepts, and asking questions [7, 26]. Each indicator has a sub-indicator to compile the science process skills assessment. Science process skills problems are developed following scientific process skills indicators tailored to the chemistry material content that they want to assess [7, 26].

Table 1: Views on the indicators of science process skills according to experts.

Expert	Year	Indicators of Science Process Skills
Good, R.	1997	Observing, classifying, using number, measuring, using space/time relationships, communicating, predicting, inferring [23].
Abruscato, J.	1982	Observing, classifying, using space/time relationships, using numbers, measuring, communicating, hypothesizing, experimenting, controlling variables, interpreting data, defining operationally [24].
Harlen, W.	1992	Observing, hypothesizing, predicting, investigating, interpreting, finding and drawing conclusions, communicating [1, 23].
Gega, P.	1995	Observing, classifying, measuring, communicating, inferring and predicting, experimenting [23].
Ramig, et al.	1995	Observing, inferring, identifying and manipulating variables, predicting, hypothesizing, organizing and interpreting data, investigating: experimenting and surveys [23].
Semiawan, C.	1992	Observing (measuring, calculating, classifying, connecting), hypothesizing, planning, variable controlling, interpreting data, predicting, applying, communicating [25].
Rustaman, N.	1992	Observing, interpreting, classifying, predicting, communicating, hypothesizing, planning, defining operationally, asking question [23].

3.2. Characteristics of The Development of Science Process Skills Question in Chemistry

The characteristics of SPS questions are very different from the question points that will be used to measure the understanding of science concepts and their applications. In the matter of SPS, students are given information in verbal or visual form; tables, diagrams, or graphs that must be processed first in order to answer the given question. The general characteristics contains things to consider when planning to compile the details of the SPS problem, including the following [2, 7, 26]:

1. It should not be burdened with concepts so as not to be confused with the measurement of mastery of the concept. The concepts involved must be believed by the preparation of questions already learned by students or familiar to students (close to the state of everyday students).
2. Contains a certain amount of information that students must process. It can be a picture, diagram, graph, and in a table or description or the original object
3. The aspect to be measured must be clear and contain only one aspect.
4. We recommend that images be displayed to help present objects, the exception of information that is clearly presented with words.

In addition to general characteristics, the special characteristics of science process skills are: [7, 26]

1. Observation: attempted from the actual object/event or the original image.
2. Interpretation: must present a certain amount of data to show a pattern.
3. Classification: there must be an opportunity to find/find similarities and differences, or given certain criteria to group or determine the number of groups that must be predicted.
4. Prediction: must be a clear pattern or tendency to propose conjectures or predictions.
5. Communicating: there must be a specific serving form to be changed to another serving form, for example, a description of form to a chart shape or a table shape to a graph shape.
6. Hypothesizing: can formulate conjectures or answers temporarily or test existing statements and contain relationships of two or more variables, usually containing a way of working to test or prove.
7. Planning an Experiment or Investigation: should provide an opportunity to propose ideas with regard to the tools/materials to be used, the order of procedures to be taken, determine variables, control variables/changes
8. Applying Concepts/Principles: must contain concepts/principles that will be applied without mentioning the name of the concept.
9. Asking Questions: must bring up something surprising, impossible, unusual, or contradictory in order for respondents or students to be motivated to ask questions

3.3. A Framework for Developing and Validating Virtual Test to Assess Science Process Skills in Chemistry

The assessment of science process skills can be done by written, oral, and observational tests [27]. Although it can be done with several tests, a written test with the form of multiple-choice questions is the right choice because the multiple-choice test includes objective tests [18]. The judgment from the scoring system, the objective test will produce the same score. Like the name he uses, the objective question is a matter of objective truth. Therefore, an objective test is a test that, in its examination, can be done objectively and overcome the weaknesses of subjective tests [28]. In addition to including objective tests, multiple-choice tests are carried out so as not to burden teachers in conducting assessments, saving time, and minimizing the use of tools and materials [27].

In addition to the form of the science process, skills developed are a matter of multiple choices; this question is also presented in a virtual test [2, 13]. This virtual test will help reveal macroscopic, microscopic, and subs-microscopic chemical problems [17]. Because by using virtual tests, problem makers can use images, graphics, animations, and videos to create questions to clarify the meaning of the test principal statement [2]. The use of visual forms in test questions would be able to help evaluators measure students' higher cognitive abilities compared to using only statements or questions, and the use of visual forms can also train and measure the ability of the student's science process. The development of this virtual test is an innovation to improve the quality of learning measuring instruments by utilizing the development of *Information and Communication Technology* (ICT) [13, 15, 17].

Several research models /designs can be used to develop virtual tests that can measure the skills of science processes in chemistry as developed by Benson and Florence, which developed 4 phases of assessment development, namely the planning phase, development phase, quantitative evaluation phase, and validation phase [29]. McIntire also developed assessment development steps; 10 test development steps must be passed, namely: (a) defining the test's audience, and purpose, (b) developing a test plan, (c) composing the test items (d) writing the administration instructions (e) conduct piloting test (f) item analysis (g) revising the test (h) validation the test (i) developing norms (j) complete test manual [30]. Finally, the development and validation method from Adams & Wieman develops four main phases, namely the planning phase, the development phase, the validation phase, and the trial and processing phase of research data [31]. Of the three development and validation methods mentioned above, the framework is prepared with four main phases: the planning phase, development phase, validation phase, and trial and data processing phase of research results. These phases can be shown in the Figure 1**.**

3.4. Planning phase

This phase aims to build a conceptual framework; this phase is focused on literature study activities. The steps in the development of the test at this phase are defining the test, audience, and purpose [31]. At this phase, identification of research problems, analyzing chemistry content, and analyzing aspects (indicators) in science process skills are carried out.

3.5. Development phase

This phase aims to obtain information related to things that need to be done in developing virtual tests to measure the skills of science processes in chemistry. At this stage, several steps are carried out, namely developing the design of the problem, making question items, and compiling instructions for solving the problem. The development of the problem design starts by making a grid design as a reference to develop question points. This grid contains sub-materials and indicators connected with science process skills. Furthermore, the question points are arranged based on indicators that have been adjusted to the science process skill indicators. This development phase must also be prepared storyboard; the purpose is to make it easier to convert written question items into virtual tests. The storyboard created must consider the technicality of writing, color, virtual shape, the layout of question points, and answers to questions. Finally, at this phase of development, instructions for solving the problem must also be prepared to facilitate it at the trial phase.

3.6. Validation phase

The steps that will be taken at the validation phase are conduct piloting test, revising the test and validating the test. At this phase, all research instruments that have been developed, then will be validated by experts (expert judgement) in order to obtain valid research instruments before being tested. After being validated by experts, the measuring instruments developed are revised in accordance with expert input and suggestions, then the revision results are ready to be tested. The improvements of the virtual test developed include improving the construction of the problem, clarity of the language that is arranged, improving the suitability of perceptual visual ability indicators with problems, writing inappropriately, questions that do not lead whatever things need to be improved.

3.7. Trial phase and data processing of research results

After being declared worthy of being tested by experts, the virtual test to measure the science process skills that have been completed is made next in the trial. This

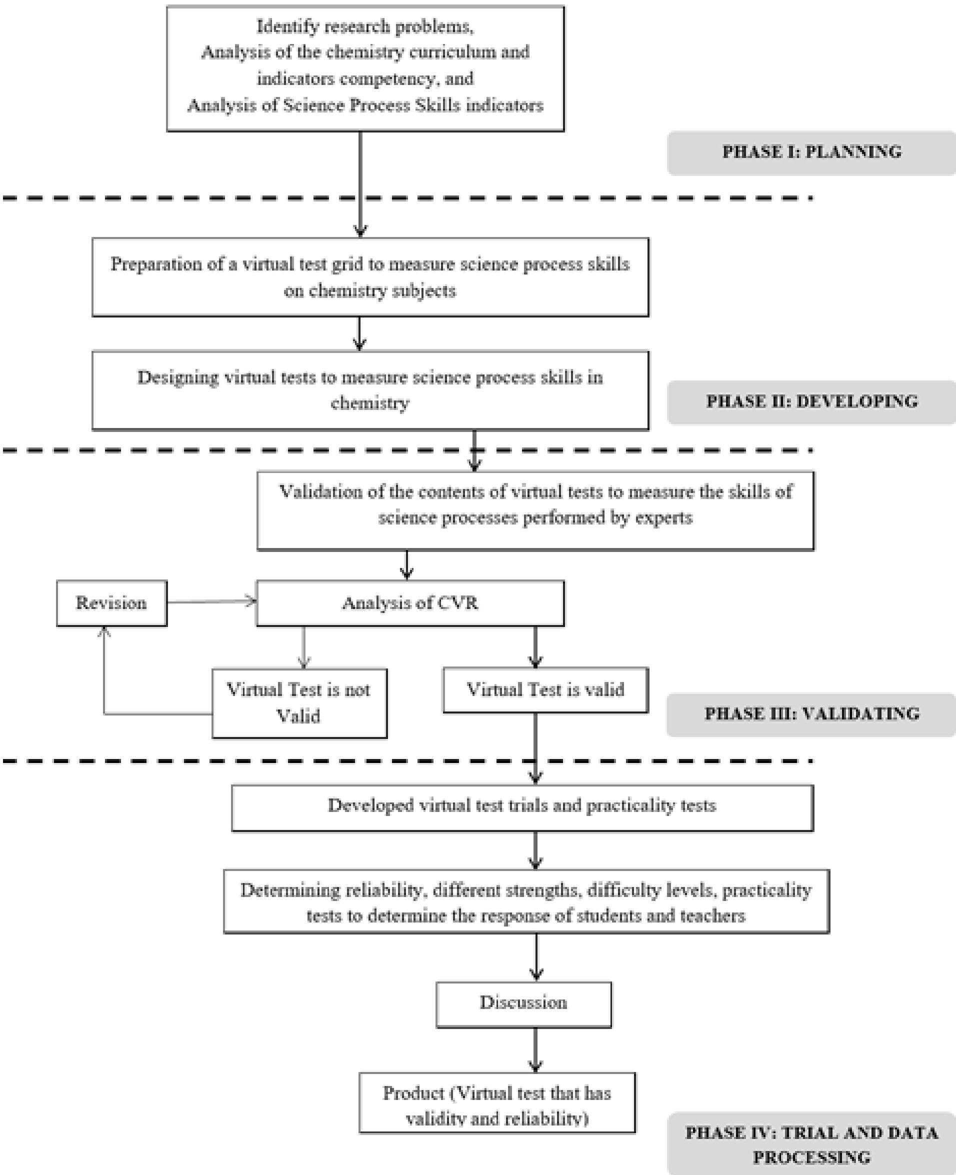

Figure 1: A framework for developing and validating virtual test to assess science process skills in chemistry.

phase aims to determine the feasibility of test tests (reliability, distinguishing power, and difficulty level) and practicality tests using practicality test questionnaires [13, 27, 32]. This practicality test should be done because, in the selection of tests and other assessment instruments, practical considerations cannot be ignored [33]. There are several aspects of practicality tests, namely: 1) use, including easy to manage, store, and can be used at any time, 2) the time required in the implementation should be short, fast and precise, 3) the attractiveness of the device to the interests of learners, 4) easily interpreted by teachers, experts and learners, and 5) have the exact equivalence so that it can be used as a substitute or variation [34].

4. CONCLUSION

Science process skills need to be taught and evaluated because science process skills will be the driving wheel of discovery and development of facts and concepts and the growth and development of attitudes, insights, and values. Especially when considering chemistry, which consist of chemistry as a product and chemistry as a process, it is essential to teach and evaluate the skills of science processes in chemistry. This evaluation process is not necessarily done by observing students but can also use the form of multiple-choice questions so that they are more efficient and objective assessments. The development and validation of virtual tests to measure the skills of science processes in chemistry can follow the development and validation through the phases of planning, development, validation, and trials. There are several general characteristics that should be considered when planning to compile the details of the SPS problem, which are, it should not be burdened with concepts so as not to be confused with the measurement of mastery of the concept. The question should contain a certain amount of information that students must process. The aspect to be measured must be clear and contain only one aspect. Displaying images is recommended, to help present objects, the exception of information that is clearly presented with words.

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