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Validating Problem Solving Competency Instrument in the New General Education Curriculum

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Abstract

Problem solving is a crucial skill for students who experience learning and living in the 21st century. To enhance this skill, students need to face a situation setting problem, then students solve the problem. The 2018 general education curriculum has been developed according to the competency approach. As a result, the instructions and assessment system need to be adapted to align with requirements in the new curriculum. The purpose of present study is to develop and validate the problem solving competency (PSC) instrument based on general requirements of this competency in the general education curriculum in Vietnam. The results of Exploratory Factor Analysis (EFA) show that the instruments can be divided into three different components with good factor loadings to measure problem solving competency of Vietnamese students. The instrument is reliable and valid. Reliability analysis using Cronbach's alpha revealed satisfactory internal consistency for each factor, with values ranging from .670 to .812.

Keywords

problem solving, curriculum, competency, validation

1. Introduction

Problem solving has been always considered as one of the important goals in education. Researchers around the world have proposed various definitions and conducted many studies in different methods to have more understanding about the processes of problem solving as well as the way to develop problem solving for students (Gagne & Briggs, 1974). Researcher also proposed different phases of problem solving, various learning and teaching activities related to information processing (Chase & Simon, 1973), cognitive science (Paas & Van Merrienboer, 1994) and constructivism (Mayer & Wittrock, 2006). One of the famous work come from Polya (1957). He proposed that there are four steps for

problem solving, and students can follow those four steps to solve any problem they face. They are (1) understanding the problem; (2) devising a plan; (3) carrying out the plan; and (4) looking back at work. He also proposed many different strategies and questions for teachers and students in each step. It is noted that Polya's approach has played an important role in researching on problem solving. Following Polya's perspectives, Bransford and Stein (1984) developed a 5-stage problem-solving model, and Weir (1974) introduced the four problem solving levels. Although having different names, the work from Bransford and Stein, and Weir has been considered as the extension of Polya's work.

In terms of measuring problem solving, educational researchers have developed different types of instruments and tools. Although Adams and Wieman (2016) reviewed the literature, and they stated that there have been little focused on the students' problem solving skills with the published measurement, educational and psychological researchers have been encouraging to develop many instruments. They have different approaches to investigate problem solving. For instance, Heppner and Peterson (1978) measured problem solving using a Likert scale. The author developed an instrument, known as a questionnaire, based on the framework of different steps of problem solving. This questionnaire has been used widely afterward to have more understanding about students' problem solving. In another approach from writing context, Docktor and Heller (2009) proposed different types of writing requirements as well as proposed various writing problems, and ask students to solve those problems. Associated rubrics have been developed to assess the problem solving procedures and the ways students reason and explain things through their writing. Chang (2010) developed a test to measure problem solving ability using open-ended essay-questions based on the creative problem solving model of Osborn. Students took the test by answering the questions and provided their strategies to solve the problems in the test. Kruatong (2011) also developed a questionnaire to examine students' problem solving in Thailand. The focuses of the questionnaire are on the levels of students' abilities in solving problems including understanding a problem, identifying appropriate information and conceptions, sequencing of solving problem, constructing a solution, and evaluating the answer.

In Vietnam, the Ministry of education and Training has issued the new general education curriculum in 2018 (Vietnam Ministry of Education and Training, 2018), where the curriculum innovation has changed from content-based approach to competence-based approach. However, teachers and educators are still working with the traditional assessment focusing knowledge rather than competencies. They find it difficult to measure and assess the competencies as well as to monitor students' progress. In this new curriculum, problem solving has been considered as one of the key competencies that needs to develop for students in many different subjects and educational activities. Since competence-based approach and competence-based assessment are relatively new in Vietnam, the needs of developing an instrument to measure problem solving, by following the requirement in the new curriculum, are required to support teachers and students effectively implement the new curriculum. The purpose of present study is to develop and validate the Problem Solving Competency (PSC) instrument based on general requirements of this competency in the general education curriculum in Vietnam.

2. Method

Table 1. Participants

Grade	Gender		Total
	Male	Female	
6	206	184	390
7	311	310	621
Total	**517**	**494**	**1,011**

A sample of 1,011 students participated in the present research. Grade 6 and grade 7 students were invited because in Vietnam, the new curriculum has been only implemented for students in those grades. There are 517 male students and 494 female students in the sample. Table 1 shows the details of the sample.

2.1 Instruments

The new general education curriculum has requirements for problem solving competency, these requirements are set for students after the end of each level of education. Table 2 shows the requirements for students when they finished their lower secondary education level.

Table 2. Requirements of Problem Solving Competency for Lower Secondary School Students

No	Standards
1	Know how to identify and clarify information; know how to analyze and summarize relevant information from many different sources.
2	Analyze learning situations; Detect and raise problematic learning situations.
3	Identify and know how to find out information related to the problem; propose solutions to solve the problem.
4	Assess the suitability or non-suitability of plans, solutions and the implementation of plans and solutions.

It can be seen that those requirements are too general, and it is difficult to measure students' competency of problem solving. Based on suggestions from Griffin et al. (2018) on developing indicators for measuring a construct, Table 3 shows 22 statements that reflect the above four requirements. These statements were used to develop the instruments to measure students' competency of problem solving by using 5-point Likert scale of the frequency they can perform each statement.

Table 3. Statement about Students' Problem Solving Competency

No	Statement
C01	I'm worried I won't be able to do it if I encounter obstacles as soon as I start solving a problem
c02	After solving a problem, I don't analyze what's right or wrong
c03	After trying to solve a problem in some way, I often compare the actual outcome with what I think should have happened
c04	I have the ability to solve most problems even though I can't imagine/think of a way to solve them at first
C05	Many of the problems I encounter are too complex for me to solve
C06	I will not continue if I feel incapable of solving the problem
C07	I often look at the chances of success of each solution to assess its feasibility
C08	When faced with a problem, I stop and think about it before deciding on the next step
C09	When it comes to deciding which option to take, I usually weigh the consequences of each option and compare them to each other
c10	When I make a plan to solve a problem, I make sure I can implement it
c11	I usually predict the end result after performing a specific sequence of actions
c12	When I try to think of possible solutions to a problem, I don't think of many solutions
c13	With enough time and effort, I believe I can solve most of the problems I face
c14	While solving problems, I am confident that I can handle problems that may arise
c15	Even though you're solving a problem, sometimes you feel like you're groping or wandering around and not getting into the real problem
c16	I believe I have the ability to solve new and difficult problems
c17	I compare different options and make decisions based on a system of criteria
c18	After making a decision on how to solve the problem, the results I expect often match my actual results
c19	I assessed the suitability of the plan and solution given
c20	When I have a problem that needs to be solved, I can summarize and state the problem easily
C21	I can clarify the information of the problem to be solved
c22	I usually identify the process that needs to be taken to solve the problem I encounter

2.2 Statistical Analysis

Since 22 statements were newly developed based on the requirements of problem solving competency in the new curriculum in Vietnam, the Exploratory Factor Analysis (EFA) was used for the analysis (Hair et al., 2019). This EFA procedure is one of the most commonly used in social and behavioral

sciences. In studies seeking evidence about the internal structure of a test, each factor should be defined by a high number of items, as a single item is usually a variable with low reliability. It is recommended to carry out a preliminary analysis of the metric quality of the items to subject the most adequate items to EFA. For this purpose, it is recommended to analyze and report the mean, standard deviation, and item-test correlation of each one of the items, as well as the Cronbach's alpha of the scales of the test. The researcher should decide whether to eliminate certain items and, if so, the EFA should be repeated in their absence because it may modify the initial solution. It is also appropriate to obtain different measures of sampling adequacy, such as KMO and Bartlett's sphericity test.

3. Results and Discussion

Table 4 shows the results of KMO and Bartlett's Test for the EFA analysis. It can be seen from this table that Kaiser-Meyer-Olkin Measure of Sampling Adequacy is .896, above the commonly recommended value of .6, and the Bartlett's Test of Sphericity is significant ($\chi 2$ (231) = 4267.028, $p < .05$). This result indicates that the EFA analysis is valid.

Table 4. The Results of KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.896
Bartlett's Test of Sphericity	Approx. Chi-Square	4267.028
	df	231
	Sig.	0.000

Figure 1 shows the results of scree plot. From this result, it can be seen that all the indicators of problem solving competency can be divided into three components. the results revealed a three-factor structure that accounted for 40.960% of the overall variation.

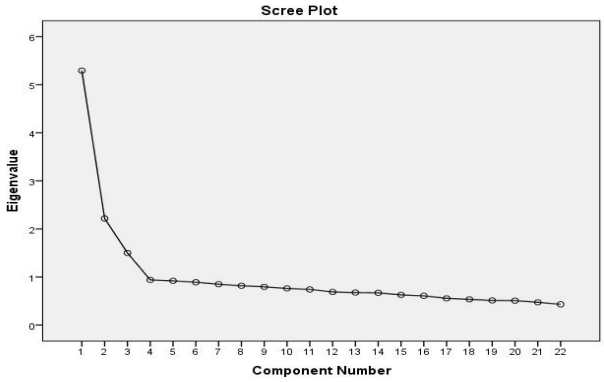

Figure 1. Scree Plot from EFA Analysis

Table 5 shows the results of EFA for 22 PSC items using varimax rotations. It can be seen that all factor loadings of the statements were above 0.4 in both three components. The Cronbach Alpha coefficient for the whole instrument is .753 which is relatively high. Reliability analysis using Cronbach's alpha revealed satisfactory internal consistency for each factor, with values ranging from .670 to .812.

Table 5. The Results of EFA and Reliability Analysis

Item	Statement	Component			Cronbach Alpha
		1	2	3	
c14	While solving problems, I am confident that I can handle problems that may arise	.718			
c16	I believe I have the ability to solve new and difficult problems	.689			
C21	I can clarify the information of the problem to be solved	.673			
c04	I have the ability to solve most problems even though I can't imagine/think of a way to solve them at first	.605			
c10	When I make a plan to solve a problem, I make sure I can implement it	.603			0.812
c20	When I have a problem that needs to be solved, I can summarize and state the problem easily	.591			
c13	With enough time and effort, I believe I can solve most of the problems I face	.581			
c18	After making a decision on how to solve the problem, the results I expect often match my actual results	.481			
c22	I usually identify the process that needs to be taken to solve the problem I encounter	.459			
C09	When it comes to deciding which option to take, I usually weigh the consequences of each option and compare them to each other		.705		
C07	I often look at the chances of success of each solution to assess its feasibility		.672		0.741
c17	I compare different options and make decisions based on a system of criteria		.618		
C08	When faced with a problem, I stop and think about it before deciding on the next step		.608		
c03	After trying to solve a problem in some way, I often		.541		

	compare the actual outcome with what I think should have happened				
c19	I assessed the suitability of the plan and solution given	.405	.485		
c11	I usually predict the end result after performing a specific sequence of actions		.401		
C05	Many of the problems I encounter are too complex for me to solve			.706	
C01	I'm worried I won't be able to do it if I encounter obstacles as soon as I start solving a problem			.653	
c12	When I try to think of possible solutions to a problem, I don't think of many solutions			.619	
c15	Even though you're solving a problem, sometimes you feel like you're groping or wandering around and not getting into the real problem			.617	0.67
C06	I will not continue if I feel incapable of solving the problem			.564	
c02	After solving a problem, I don't analyze what's right or wrong			.468	

4. Conclusion

The PSC is an instrument to measure secondary school students' problem solving competency in Vietnam following the requirements in the new general education curriculum. This instrument provides teachers with a valuable resource for assessing students' problem solving competency within specific subjects. Based on the responses of students, teachers can also monitor the development of students' problem solving competency as a whole as well as three different sub-components of students' problem solving competency. This information will help teachers and students improve their teaching and learning toward to developing students' problem solving competency. The present study has some limitations. The sample of the study were formed in only two schools. Moreover, additional types of invariance testing (e.g., temporal, cross-cultural, and sport type), as well as other ongoing construct validity evaluation, needs to be considered in future research to gather new evidence on problem solving abilities. Hence, continued evaluation of the PSC is necessary.

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