

Self-Determination and Technological Pedagogical Content Knowledge (TPACK): How Novice Teachers in Mathematics Education Surviving and Thriving in Disruption Era

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Abstract. The learning process has changed drastically from the face-to-face or classroom method to the one with technology utilization. One of the goals of mathematics education at school is to help students become smart citizens, namely, who can make decisions based on their needs, not others' encouragement. Within the literature of motivation, there is a theory known as self-determination. The teachers' efforts to develop students' self-determination are reflected in those teachers' capabilities in three ways: mastery of content, pedagogy, and technology, known as the TPACK. Mastery of both self-determination and TPACK is highly essential. This article discusses the instruments measuring both of them. In this study, we first arranged statements that correspond to both abilities' indicators. Subsequently, we tested the legibility and performed the face validity and content validity by the experts. The methodology used in this study is a quantitative approach. Data were descriptively and quantitatively analyzed with the help of IBM SPSS software version 21. The results indicate that several statements need to be revised. However, the instruments have met both face validity and content validity. This result is also supported by the evidence of a high-reliability value and validity score. The instruments in this study, therefore, can be developed in further research.

1. Introduction

The disruption era inevitably affects all aspects of life, including education. Teachers and students are required to keep following the changes and developments. High-order, critical, analytical, and out-of-the-box thinking are necessary to survive in this era. Learning in the disruption era faces many challenges. In the past, it could be conducted through face-to-face interaction, but now it is required to be conducted using technology-based learning media. Although we are now in the new normal era, face-to-face or classroom learning is still restricted. It should be conducted online. This online learning requires teachers to become more well prepared in order to get an optimum result.

According to Tosepu [1], there are five principles to which teachers should be adhered in facing the disruptive era: 1. pushing beyond comfort zone; 2. working toward well defined, specific goals; 3. focusing intently on impactful activities; 4. receiving and responding to high-quality impact; 5. developing mental model expertise. Those five principles need to be instilled by the teachers to become competitive and positively influence their students.

In realizing those five principals, teachers are required to be motivated to change themselves, so they have a high willingness to learn and accept changes. Personal desire or personal initiative is



termed as self-determination. The theory of self-determination is a motivation theory developed by Deci & Ryan in 1985 [2]. The theory distinguishes motivation into three forms, namely: (a) a motivation; (b) intrinsic motivation; and (c) extrinsic motivation. A motivation is the attitude of someone who has no motivation for something. The intrinsic motivation is more on someone's urge to do something because of internal impulses or inner interest. Alternatively, it is because that individual feels happy to do something. On the other hand, extrinsic motivation refers to someone's urge to do something because of outside factors or specific purposes, such as getting rewards and avoiding punishment.

Technological mastery has been one of the must-have skills in today's disruption era, including school teachers. In addition to content and pedagogical aspects, teachers are now demanded to master technology because it has become an integral part of assessing teachers' competence. These three integrated capabilities are called Technological Pedagogical Content Knowledge (TPACK). TPACK was first developed by Mishra & Koehler [3] as a result of developing a theory put forward by Shulman [4] which is related to Pedagogical and Content Knowledge (PCK). This TPACK theory was developed from the PCK theory since technology's role in the learning process became highly significant.

The teachers with the right self-determination and master TPACK will adapt to any changes in the current era. Consequently, it is essential to explore that issue by measuring those two capabilities among school teachers. In performing that study, the first thing to do is developing an appropriate instrument for measuring the two capabilities. According to Yusuf [5], an instrument is critical in any research because it plays a significant role in the data collection process. Some research on developing the instruments of self-determination and TPACK have been carried out. Kosko [6], in his dissertation, developed self-determination instruments for students in mathematics courses. Schmidt, Baran, Thompson, Mishra, Koehler, & Shin [7] were the first to develop the TPACK instrument for school teachers' candidates. Moreover, Zelkowski, Cox, Gelason, & Bismarck [8] developed the TPACK instrument for secondary school teachers' candidates. Both Schmidt et al. [7] and Zelkowski et al. [8] focused on developing the instruments for college students who would be school teachers.

Based on those previous studies, in this study, we attempt to develop the instrument of self-determination and TPACK by focusing on the school teachers. We focus the instrument on the novice teachers with the teaching experience of two to five years. We specifically focus our instrument on mathematic teachers. This present study is intended to create a valid and reliable instrument of self-determination and TPACK.

2. Method

The development of the instrument was started by reviewing previous studies on self-determination capability. Additionally, we developed several related indicators in order to result in measurable statements. The development was begun by adapting the instrument proposed by Kosko [6]. We made several adaptations by adjusting the language and omitting several statements, not in line with this study's purposes. This process resulted in 22 statements of self-determination for novice teachers.

For the TPACK, the instrument development was begun by reviewing and studying some statements from the previous study conducted by Zelkowski et al. [8]. We also made some adjustments in terms of language and omitted some statements not related to mathematics learning. Furthermore, we developed 42 statements of the TPACK components, namely, TK, PK, CK, PCK, TPK, TCK, and TPACK, focusing on mathematics contents.

In general, the instrument development of the two capabilities consists of six stages, namely:

1. Creating instrument grids based on indicators;
2. Carrying out a legibility test for students of Master of Mathematics Education;
3. Judging the instrument conducted by the experts through testing the face validity and content validity;
4. Revising the validation results related to the feedbacks of expert judgment;
5. Testing the instrument on students of Master of Mathematics Education outside the population for

empirical validity;

6. Analyzing the test results of the instrument;

7. Revising the test results of the instrument in order to obtain the validity and reliability of the statements.

The legibility test was also carried out on two students of Master in Mathematics Education. They were given the statements to see whether the questions could be understood or not. Two statements were considered ambiguous, and after they were corrected, we asked the experts to obtain their judgments by validating the correction results.

Two lecturers carried out the validation of expert judgment. The first lecturer has a doctoral background in mathematics education, and the other has a master's degree in education background, an expert in the Guidance and Counseling field. The face validity and content validity were performed to see the editorial readability of the research instrument. The assessment results were then tested to see the uniformity of the validation results. The proposed hypothesis is as follows:

H_0 : Validators give uniform consideration

H_1 : Validators give non-uniform consideration

The above hypothesis test uses the Q-Cochran statistic with the test criteria of accepting H_0 if the probability value (Asymp.Sig.) is larger than = 0.05, while in the other circumstance, H_0 is rejected. We obtained seven statements to be corrected. After correcting them according to the suggestions of the experts, we then performed the empirical test.

To conduct this empirical validity, we distributed the instruments to the master students in mathematics education outside the population, but represent the research sample. The number of those students is eleven students who are novice teachers.

3. Results and Discussion

This section discusses the process of validating both the instruments of self-determination and TPACK. In the process of face validation and content validation of the expert judgment, we performed the Q-Cochran test because there are statements with a value of less than one. The following Table 1 shows the summary of the test:

Table 1. Summarizes of Face and Content Validity of Self-determination& TPACK

Test of Validity	Self-determination			TPACK	
	<i>N</i>	<i>df</i>	<i>Sig.</i>	<i>df</i>	<i>Sig.</i>
Face validity	11	2	0.001	2	0.000
Content validity	11	2	0.000	2	0.012

Table 1 shows that Asymp. Sig values for the face validity and content validity are less than 0.05. It means the **null hypothesis is rejected**, or the validators give a non-uniform consideration. Nonetheless, some of the statements were revised, as suggested by the experts.

The next step was performing empirical validity. It is the final validating step we conducted for developing the representative instruments of self-determination and TPACK. To conduct the validity and reliability tests, we utilized the SPSS software version 21. Validity and reliability tests were performed to determine the consistency or reliability of a statement and determine the support of the whole test statements by correlating the statement scores with the questions' overall score. The formula used to test the validity in this study is the Pearson Product Moment formula. The criterion of the test is if the Sig. Value is larger than 0.05; the statement is categorized as valid, vice versa. The reliability calculation was performed using the Cronbach Alpha formula [9] because the statements are the descriptions.

3.1 Self-determination

The validity calculation results show three invalid statements, namely numbers 4, 6, and 8. The following Table 2 is the summary:

Table 2. Summaries of Empirical Validity of Self-determination

Statement	Sig. (2-tailed)	Information	Statement	Sig. (2-tailed)	Information
1	0.012	Valid	12	0.004	Valid
2	0.002	Valid	13	0.000	Valid
3	0.004	Valid	14	0.000	Valid
4	0.836	Not Valid	15	0.010	Valid
5	0.001	Valid	16	0.000	Valid
6	0.853	Not Valid	17	0.003	Valid
7	0.000	Valid	18	0.002	Valid
8	0.302	Not Valid	19	0.003	Valid
9	0.002	Valid	20	0.001	Valid
10	0.000	Valid	21	0.002	Valid
11	0.001	Valid	22	0.000	Valid

Those three invalid statements are part of autonomy. It is an aspect of self-determination measuring how the students can control themselves when starting and maintaining their different behavior from students in general in the lectures during the pandemic. The complete portrayal is shown in the following Table 3.

Table 3. Statements of Self-determination

	Indicator of self-determination	Statement
1	Able to conduct and anticipate the consequences taken during lectures.	<i>Without repeating the material in the LMS makes me more comfortable to understand the material from my lecturers.</i> <i>Taking distance lectures gives me difficulties in understanding the material.</i>
2	Able to take responsibility for decisions made to complete assignments or discussions.	<i>I get confused when asked to give my opinion during an online discussion.</i>

Under the expert judgment and results of the in-depth analysis regarding the statement's suitability as a description of the self-determination indicator, statements 4, 6, and 8 were further corrected in terms of language and were still used as part of the self-determination instrument. From the calculation of reliability, we found that $r = 0.881$. This result shows that the instrument of self-determination has high reliability [9]. Therefore, for self-determination capability, the number of total statements that can be used is 22 items. As stated by Taylor, et. al [10], there have been many instruments that measure the relationship of self-determination and its achievements, as well as this instrument is expected to be an option to see the relationship of novice teacher self-determination and its achievements.

3.2 Technological Pedagogical and Content Knowledge (TPACK)

The results of validation calculation for the TPACK instrument are shown in the following Table 4.

Table 4. Summarize of Empirical Validity of TPACK

Statement	Sig. (2-tailed)	Information	Statement	Sig. (2-tailed)	Information
1	0.001	Valid	23	0.002	Valid
2	0.000	Valid	24	0.937	Not Valid
3	0.001	Valid	25	0.002	Valid
4	0.000	Valid	26	0.001	Valid
5	0.007	Valid	27	0.005	Valid

Statement	Sig. (2-tailed)	Information	Statement	Sig. (2-tailed)	Information
6	0.016	Valid	28	0.548	Not Valid
7	0.006	Valid	29	0.202	Not Valid
8	0.016	Valid	30	0.134	Not Valid
9	0.019	Valid	31	0.000	Valid
10	0.016	Valid	32	0.031	Valid
11	0.001	Valid	33	0.001	Valid
12	0.028	Valid	34	0.034	Valid
13	0.000	Valid	35	0.030	Valid
14	0.005	Valid	36	0.030	Valid
15	0.000	Valid	37	0.034	Valid
16	0.028	Valid	38	0.007	Valid
17	0.001	Valid	39	0.404	Not Valid
18	0.828	Not Valid	40	0.007	Valid
19	0.001	Valid	41	0.004	Valid
20	0.132	Not Valid	42	0.004	Valid
21	0.001	Valid			
22	0.132	Not Valid			

From the total of 42 statements, there are seven invalid statements, which will be shown in more detail in Table 5.

Table 5. Statements of TPACK

Aspect	TPACK Indicator	Statement
CK (Content Knowledge)	Able to master various basic mathematical abilities	I have a limited understanding of calculus
PCK (Pedagogical Content Knowledge)	Able to master various delivery strategies for difficult materials	Different teaching approaches are not required to explain basic mathematical concepts
TCK (Technological Content Knowledge)	Able to master various mathematical applications	I have difficulty in teaching advanced mathematics Technological knowledge is not necessary for basic mathematics My knowledge regarding the use of technology for advanced mathematics is limited The technologies which can be used in mathematics are limited
TPACK (Technological Pedagogical Content Knowledge)	Able to integrate technology in teaching specific mathematics topics	Integrating technology in mathematics teaching is difficult and takes a long time

After analysing student answers for the invalid instruments, we discussed them again with the experts. There are several considerations, especially regarding the TCK indicator, which are not represented if all statements are omitted. The result of the reliability calculation shows that $r = 0.912$. It indicates that the TPACK instrument also has high reliability [9]. Thus, for the TPACK capability, the number of total statements used is 42 items. The development of this valid and reliable instrument developed is different from other TPACK instruments because it focuses more on teacher attitudes and

technology integration in teachers [11]. Although it is different from other developers who focus on implementing TPACK in the learning process through observation, other TPACK instruments specifically focus on the teacher as the subject and thoroughly evaluate their development capabilities in the TPACK domain, which needs to be developed.

The development of this instrument that was developed is indeed different from other TPACK instruments because it focuses more on teacher attitudes and technology integration in teachers. Although it is different from other developers who focus on implementing TPACK in the learning process through observation, the development of other TPACK instruments that specifically focuses on the teacher as the subject, and thoroughly evaluates their development capabilities in the TPACK domain, needs to be developed as stated by Anthony & Paidi [12-13].

4. Conclusions

This preliminary research related to the self-determination instrument and TPACK is still in the early stages and development. However, from the results and discussion, it can be seen that the existing instruments are valid and reliable. The need for a good instrument to capture how self-determination and TPACK of prospective teachers is a necessity today and in the future. This is because good teachers need to be prepared from the beginning to help students who are ready to face the era of disruption, which is related to intrinsic motivation and the ability to master technology.

The new instruments which can measure the capabilities of self-determination and TPACK of the novice teachers have gone through adequate and accountable validity and reliability tests. Therefore, those two instruments can be used to conduct further research, especially novice teachers, as the research subject.

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