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Exploratory Factor Analysis: Validity and Reliability of Teacher's Knowledge Construct Instrument

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Abstract

The study aims to determine the instrument's validity and reliability in measuring the construct of teachers' knowledge. The cross-sectional survey research design used a quantitative approach, with pilot study data obtained from 100 primary school teachers of the Trust School Programmed in Selangor, Malaysia. The selection of the samples was based on a two-stage random sampling strategy. In this study, the teacher's knowledge instrument was used to measure teachers' knowledge in implementing a cooperative learning structure. The Exploratory Factor Analysis (EFA) procedure was employed to identify the factor loading value of each item, as well as the number of components for the teacher's knowledge construct. The EFA results demonstrate three components for the construct of teacher knowledge with the eigenvalue of each component exceeding 1.0, i.e., content knowledge, pedagogical knowledge and technological knowledge. The reliability of the content knowledge component was 0.966, of the pedagogical knowledge component was 0.967 and of the technological knowledge component was 0.961. The total construct of the teacher's knowledge was 0.967. The entire construct of teachers' knowledge achieved the requirements for the validity and reliability of the construct. The study's instruments can be used by other researchers to measure the construct of teachers' knowledge in other contexts.

Keywords: Exploratory Factor Analysis, Reliability, Teachers' Knowledge, Trust School Programme

Introduction

The 21st century educational system requires that teachers adopt a method of instruction that enables pupils to explore knowledge and acquire 21st century skills. The 21st century skills of communication, collaboration, creativity and critical thinking are critical skills that students need to master (Glinel, 2020; Razali, 2021). Teachers as agents of change play an important role in developing these skills among pupils through a student-centered teaching approach. The Ministry of Education, Malaysia, in the Malaysian Education Blueprint 2013-2025 (Wave 3), aims to add a more comprehensive 21st century model of teaching innovation (MOE, 2013). Teaching approaches such as Inquiry-Based Learning, Problem Solving, Contextual Learning, Cooperative Learning, Project-Based Learning and STEM Approach are teaching and learning innovation strategies that need to be taken into consideration to drive students' well-being.

Along with the nation's development, the curriculum aspect was also enhanced. Therefore, the transformation of teachers' teaching from a teacher-centered to a student-centered method requires the strong support of teachers' knowledge in order to strengthen the delivery of the curriculum. Teachers' knowledge is the primary focus in applying teaching innovation. In line with Rogers (2003) Innovation Decision Making Process Theory, the knowledge aspect is the primary focus in implementing innovation. Teachers must thus be knowledgeable in order to deliver the curriculum effectively and implement student-centered teaching strategies that can benefit students.

Literature Review

According to Shulman (1987) there are seven categories of basic teachers' knowledge. Nevertheless, pedagogical content knowledge is a fundamental skill that must be mastered by teachers, since it explains the teacher's teaching knowledge in terms of understanding the teaching content and pedagogy. Furthermore, Mishra and Koehler (2006) introduced the Technological, Pedagogical Content Knowledge Model (TPACK), which is a continuation of the Shulman Model. In the TPACK Model, one element of basic knowledge is added to the pedagogical content knowledge, namely, technological knowledge. Modern educational innovations that integrate technology in teaching enable the TPACK Model's integration of technological knowledge components to be pertinent. In this study, teacher knowledge refers to three important aspects of the knowledge of teaching that are presented in the TPACK Model, namely, content knowledge, pedagogical knowledge and technological knowledge.

Content knowledge refers to teachers' knowledge of various technologies, ranging from low-level technology to high-level technology (Schmidt et al., 2009). Pedagogical knowledge, on the other hand, refers to the knowledge of teaching methods and processes covering classroom management, development of lesson plans and assessment of pupils (Schmidt et al., 2009) .Content knowledge refers to the teacher's knowledge of the subject taught covering the aspects of understanding facts, theories and procedures (Pamuk et al., 2015).

Previous studies have employed components of pedagogical content knowledge to assess teachers' subject-specific knowledge for courses such as the Malay Language Yatim et al (2020) and Mathematics (Mahendran et al., 2021; Patric & Rosli, 2020). This study measure the knowledge of teachers based on the elements of content knowledge, pedagogical knowledge and technological knowledge. Thus, this study places a strong emphasis on the validity and reliability of the instrument used to measure the construct of teachers' knowledge, before it is transformed into the planning and execution of student-centered teaching. The objectives of the study are:

- To determine the construct validity of the teachers' knowledge instrument.
- To determine the reliability of the teachers' knowledge construct.

Methodology

This study used a cross-sectional survey research design with a quantitative approach. The researchers used questionnaire forms for data collection. The study population comprised primary school teachers of the Trust School Program in the Selangor (N=546). The selection of the study location was based on the highest population of primary school teachers of the

Trust School Programme in the state of Selangor compared to other states. There are eight primary schools of the Trust School Programme in Selangor. A two-stage randomized sampling strategy was applied for school and teacher selection. One hundred teachers from two primary schools of the Trust School Programme were selected as respondents for this study. Prior to distributing the online questionnaire via Google Forms to the respondents, the researchers obtained permission to conduct research from the Educational Policy Planning and Research Division, Ministry of Education Malaysia, as well as from the Selangor State Education Department. Researchers appoint teacher representatives at each school and respondents answer self-administered questionnaires through their schools.

Instrument

The questionnaire was adopted from Pamuk et al. (2015) to measure teacher content knowledge, while the questionnaire was adopted from Schmidt et al. (2009) to measure teacher pedagogical knowledge and technological knowledge. There are 22 interval-scale items in the range of 1 (strongly disagree) to 10 (strongly agree). An interval scale between 1 to 10 was used to make the data size more precise and meet the needs of parametric statistics (Awang et al., 2016, 2018). Content validity for the assessment of the suitability of the instrument content includes aspects of the suitability of the language used and the suitability of the instrument content with studies carried out by four experts (Fraenkel & Wallen, 2012; Idris, 2013).

Exploratory Factor Analysis (EFA)

Exploratory Factor Analysis (EFA) is a procedure used to identify solely the items that represent questionnaire-specific constructs (Mindrila, 2017). EFA can be implemented with a minimum number of 100 respondents (Hair et al., 2010; Mindrila, 2017). Before running a factor analysis, the Kaiser-Meyer-Olkin sample adequacy test (KMO) and the Bartlett's Test of Sphericity must be performed to ensure the data are suitable.

The EFA procedure provides information on the factor loading value for each item of the instrument. Items with a factor loading of < 0.5 need to be deleted. In addition, items also need to be deleted if the factor loading > 0.50, unless they appear in two or more components. In this study, researchers referred to the goodness of fit index for the assessment of EFA as proposed by (Hair et al., 2010). A summary of the goodness of fit index is shown in Table 1.

Table 1
Goodness of Fit Index

EFA index	Suggested value*
Bartlett’s test of sphericity/ (sig<0.05)	<0.05
Kaiser-Meyer-Olkin (KMO) of sampling adequacy	>0.50
Factor loading each item	≥0.50

*Hair et al (2010)

Reliability

The instrument's consistency in producing reliable results across measurement executions is referred to as the reliability of the instrument (Hair et al., 2010). The Cronbach's alpha value was calculated for each item to assess the internal consistency of the instrument (McMillan & Schumacher, 2014). According to Sekaran and Bougie (2016) Cronbach value was less than

0.60, acceptable if the value was in the range of 0.60 - 0.70, and good if the value exceeded 0.80.

Findings

Descriptive statistic

The mean and standard deviation for each item that measures the construct of the teacher's knowledge are provided in Table 2 as descriptive statistical results.

Table 2
Descriptive statistics of items

Item Code	Items	Mean	S.D
b1pk	I have sufficient knowledge in my field	8.52	1.184
b2pk	I know basic concepts such as formulas and definition in my fields.	8.60	1.119
b3pk	I understand the structure (organizations) of topic of content I teach	8.63	1.001
b4pk	I can present the same subject matter at different levels.	8.26	1.078
b5pk	I can explain background details of concepts, formulas, and definitions in my field.	8.35	.913
b6pk	I have adequate knowledge in explaining relation among different concepts on the subject matter.	8.26	1.115
b7pk	I can explain why specific topic is important.	8.65	.932
b8pk	I can make connections with content I teach and daily life.	8.64	.951
b9pp	I can adapt my teaching based upon what pupils currently understand or do not understand.	8.53	.935
b10pp	I can adapt my teaching style to different learners.	8.37	.943
b11pp	I can use a wide range of teaching approaches in a classroom setting.	8.39	1.110
b12pp	I can assess student learning in multiple ways.	8.50	.912
b13pp	I know how to assess student performance in a classroom.	8.57	.925
b14pp	I am familiar with common student understandings and misconceptions.	8.35	1.048
b15pp	I know how to organize and maintain classroom management.	8.51	.926
b16pt	I keep up with important new technologies.	7.91	1.008
b17pt	I frequently play around with the technology.	7.83	1.068
b18pt	I know about a lot of different technologies	7.45	1.009
b19pt	I have the technical skills I need to use technology.	7.34	1.060
b20pt	I know how to solve my own technical problems.	7.15	1.033
b21pt	I can learn technology easily.	7.49	1.010
b22pt	I have had sufficient opportunities to work with different technologies.	7.50	1.066

S.D=standard deviation

Exploratory Factor Analysis

The EFA procedure used pilot study data and was analyzed using IBM SPSS 25 software. In this study, the EFA analysis used the Principal Component Analysis (PCA) extraction method to extract items into components. The rotation method used was varimax (variation maximum). Table 3 shows a summary of the SPSS output for the EFA procedure. Based on the

SPSS output, the Kaiser-Meyer-Olkin test score was 0.926, i.e., it complies with the reserved threshold value (>0.50). The KMO value indicates that the sample used for EFA analysis was sufficient. In addition, Bartlett's test results were also significant ($\chi^2 = 2895.715$, $p < 0.05$), and further analysis can be conducted.

Table 3
KMO and Bartlett's Test for Teachers' Knowledge Construct

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.926
Bartlett's Test of Sphericity	Approx. Chi-Square	2895.715
	df	231
	Sig.	.000

Furthermore, according to Hair et al (2010), the number of components for measuring constructs in a questionnaire can be determined in three ways, namely, with an eigenvalue over 1, cumulative variance over 60%, or by referring to the scree plot. Based on Table 4, there are three components that have an eigenvalue exceeding 1. Component 1 contributed 30.37% variance, component 2 contributed 27.58%, and component 3 contributed 24.79%. These three components accounted for 82.73% of the overall variance change, and complied with a cumulative variance of over 60%.

Table 4
Total Variance Explained for Teachers' Knowledge Construct

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	13.793	62.696	62.696	13.793	62.696	62.696	6.680	30.365	30.365
2	3.210	14.593	77.289	3.210	14.593	77.289	6.067	27.576	57.941
3	1.196	5.438	82.727	1.196	5.438	82.727	5.453	24.786	82.727
Extraction Method: Principal Component Analysis									

Aside from that, the scree plot for the teachers' knowledge construct split 22 items into three components (Figure 1). An evident point of inflation was seen after the third factor, according to an analysis of the scree plots (Chua, 2009). In a nutshell, based on the eigenvalue, cumulative value and scree plot, there are three components for the teachers' knowledge construct.

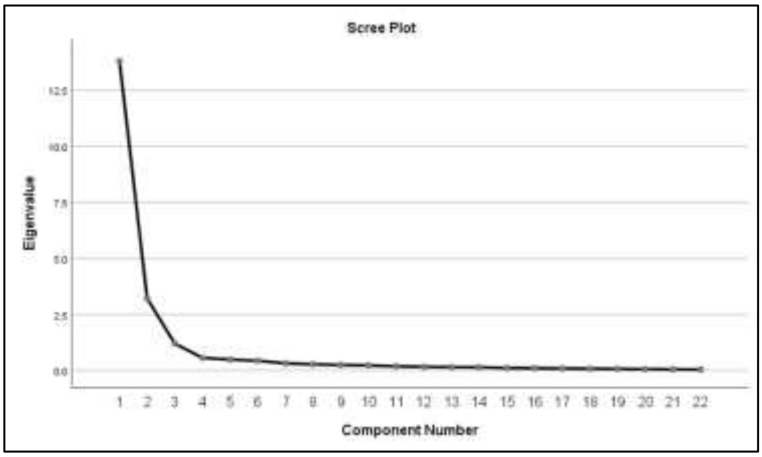

Figure 1: Scree Plot for Teachers' Knowledge Construct

The item code was divided into its three basic components in accordance with the EFA results based on a rotatable component matrix (Table 5). Components 2 and 3 each have seven items, whereas Component 1 has eight items. Each item's factor loading was over 0.5, and there was no cross loading of the items amongst the three components. Hence, the researchers retained all the items in the study.

Table 5
EFA of each component items

	Rotated Component Matrix		
	Component		
Item code	1	2	3
b1pk	.853		
b2pk	.854		
b3pk	.823		
b4pk	.749		
b5pk	.805		
b6pk	.808		
b7pk	.781		
b8pk	.704		
b9pp			.698
b10pp			.789
b11pp			.720
b12pp			.817
b13pp			.776
b14pp			.697
b15pp			.797
b16pt		.802	
b17pt		.793	
b18pt		.928	
b19pt		.874	
b20pt		.874	
b21pt		.898	
b22pt		.812	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser

Reliability

Table 6 shows that, the analysis of the reliability of items for the teacher's knowledge construct has an alpha Cronbach value equal to 0.967 for the 22 questionnaire items. Thus, the items in the construct of the teacher's knowledge offer consistent results.

Table 6
The Cronbach's alpha for each component and construct

Component	No of Items	Cronbach's Alpha
Content knowledge	8	0.966
Technological knowledge	7	0.961
Pedagogical knowledge	7	0.967
Teachers' knowledge as a construct	22	0.967

Conclusion

This study explored questionnaire items to measure the construct of teachers' knowledge. In total, the EFA procedure provides the output of three components to measure the construct of the teacher's knowledge, namely, content knowledge, technological knowledge and pedagogical knowledge. The items in each component have a good factor loading value of over 0.50. Additionally, the reliability level of the questionnaire items was also good, with a Cronbach's alpha value exceeding 0.80. Thus, this study can confirm the validity of the construct and the reliability of the instruments used to measure the construct of the teacher's knowledge. However, the findings of this study are limited to the questionnaire instruments used, and only involve primary school teachers of the Trust School Programme in Selangor. Therefore, further studies can be carried out by involving other teachers from different categories of schools. This instrument of teachers' knowledge can be beneficial for other researchers to measure the knowledge of teachers, especially in performing teaching and learning tasks.

Contribution

The validated scale of the teachers' knowledge instrument was useful to measure the implementation of innovation teaching in various fields, especially the student-centred teaching approach. This scale is crucial for assessing teachers' content, pedagogical, and technological knowledge, since they need to be efficient in all the three areas to adopt a 21st century teaching strategy. The instrument is also helpful for practitioners, since it raises their awareness on how to better apply the student-centred teaching method.

Recommendation

It is recommended that a lengthy study involving Confirmatory Factor Analysis (CFA) be conducted in order to further validate the presence of the teachers' knowledge instrument. Additionally, researchers can add more items to the teachers' knowledge construct to enable the instrument to measure teachers' knowledge more thoroughly. Finally, the study could be conducted in a different location with a different population.

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