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Exploratory Factor Analysis: Validity and Reliability of Technology Self-Efficacy Instrument

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Abstract

This study intends to establish the validity and reliability of the instrument for assessing the notion of teacher's technology self-efficacy. A quantitative method was employed in the cross-sectional survey research design with data from the pilot study collected from 100 secondary school teachers in Selangor, Malaysia. The samples were determined using a stratified random sampling approach. In this research, the teachers' technology self-efficacy instrument was utilized to assess the self-efficacy of teachers in using technology and the Digital Educational Learning Initiatives Malaysia (DELIMa) 2.0 in their teaching practice. The number of components and factor loading values for each item in the technology self-efficacy construct were determined using the Exploratory Factor Analysis (EFA). The EFA findings show five components for the construct of teachers' technology self-efficacy, each of which has an eigenvalue greater than 1.0. i.e, (based on ISTE-NETS standards) (1) Design & Develop Digital Age-Learning Experiences and Assessments, (2) Engage in Professional Growth and Leadership, (3) Promote and Model Digital Citizenship, (4) Model Digital-Age Work and Learning, (5) Engage in Professional Growth and Leadership. The reliability of component 1 is 0.942, of the component 2 is 0.932, of component 3 is 0.768, of component 4 is 0.842 and of component 5 is 0.682. The reliability for the overall construct of teachers' technology self-efficacy was 0.931. The complete construct of teachers' technology self-efficacy has met the criteria for construct validity and reliability. To sum up, other researchers can utilise the study's measures to assess the notion of teachers' technology self-efficacy in different circumstances.

Keywords: Exploratory Factor Analysis, Reliability, Technology Self-Efficacy, Secondary School Teachers.

Introduction

As technology evolves rapidly, leveraging technology to scale up learning quality in Malaysia has then become one of the core components devised in Education Blueprint 2013-2025. The scale ranged from (1) educating students to study in a digital environment to (2) upgrading infrastructure, (3) teacher training, (4) boosting student-to-device ratio, and (5) piloting ICT innovations (MOE, 2013). The Malaysia Education Blueprint 2013-2025 agenda is divided into three phases. Phase 1 is concentrating on the basis, such as infrastructure and competencies, Phase 2 is focusing on ICT innovations, and Phase 3 is maintaining the innovative and broader usage in the curriculum. To summarise, the techniques employed by the Ministry of Education (MoE) to improve ICT have a longstanding experience in Malaysia. With the exposure, instructors and students are likely to be familiar with the use of technology in the teaching and learning process, (MOE, 2013). Technology integration in the classroom has been proven to increase teaching and learning results. According to studies, the use of technology in education settings promotes learning and enriches the experience for both teachers and students in a classroom (Ammade et al., 2018). Therefore, building teachers' technology integration skills is crucial to effectively integrate technology into teaching and learning (Goldhaber, 2021).

Besides the advancement of learning and teaching, it is worthy to note that the conventional teaching methods are losing their functionality in the 21st century which is highly supported by the technological advancements. On the other hand, the online teaching as a method has gained attention in the recent years after the new norm introduced due to COVID-19. Under such circumstances the role of teachers becomes significant in application of the new technologies.

Accordingly, Tomczyk (2020) contended that the successful implementation of the technologies in education sector requires that teachers should have necessary skills of their integration. And it has emerged to be a significant concern of recent times. Moreover, (Rumengan et al., 2018), contended that the human component is significant to successfully implement the technologies. Being the key player in technology integration in the education field, it becomes necessary that teacher should be confident and ready to adopt the new technologies (Farjon et al., 2019).

Literature Review

There is substantial evidence that the extent to which teachers actual use and implement technology in the classroom is influenced by their beliefs about their ability to do so. As such, self-efficacy is a personal belief in one's own ability to perform a given action or attainment or mastery (Bandura, 1997; Denzine et al., 2005). Beliefs in one's own efficacy have been proven to influence enthusiasm, decision-making processes, instructional conduct and resilience (Thurm & Barzel, 2020). Therefore, self-efficacy in the context of integrating technology in the classroom is concerned with a teacher's perceived capacity to integrate technology into classroom lessons as well as facilitate meaningful instruction using suitable digital tools. Recent researchers have found that self-efficacy has been identified as an important component in influencing people's readiness to embrace and use new technologies (Lew at al., 2020). As a result, teachers' ability to make technological and pedagogical decisions on ways to employ technological tools in improving teaching and learning promotes the successful integration of technology in the classroom.

Some teachers are required to boost their technological self-efficacy to be more efficient in the classroom (Gentry et al., 2014). However, as Gentry pointed out, the specific initiatives for improvements need to be recognized well before best fitting methods in school districts and education programs for aspiring teachers could be implemented. In the sections that follow, methods for enhancing teachers' technological skill sets and all-around teaching abilities will be discussed after a discussion of the literature on teachers' technological self-efficacy. In the literature on technology acceptance, self-efficacy has been viewed as either a general or a specific concept. In general, self-efficacy refers to teachers' self-perceptions of their ability to implement effective pedagogical activities with the assistance of technology (Tondeur et al., 2020).

This viewpoint holds that self-efficacy refers to teachers' overall ICT competencies rather than a specific technology. For instance, research on the Technological Pedagogical and Content Knowledge framework emphasizes the significance of teachers' general ICT competencies in their instructional practices (Mishra & Koehler, 2006). From a specific standpoint, self-efficacy refers to teachers' beliefs about the ability to use a customized educational technology (Kemp et al., 2019). Teachers' technology self-efficacy, whether general or targeted, has been found to influence their technology acceptance and use of technology in general (Hong et al., 2020). Therefore, this research focuses a major emphasis on the validity and reliability of the instrument used to assess teachers' technology self-efficacy in incorporating technology into their teaching and professionalism. The study objectives are:

- To determine the construct validity of the teachers' technology self-efficacy instrument.
- To determine the reliability of the teachers' technology self-efficacy construct.

Methodology

In this study, a cross-sectional survey research methodology and a quantitative technique were utilised. The researcher collected data using questionnaire forms. The target population of this study consisted of secondary school teachers in Selangor (N=25,522). Selangor was chosen as the study location by the virtue of having the highest number of secondary school teachers in service and a large percentage of the District Education Office that has the highest number of DELIMa 2.0 logins among secondary school teachers are in Selangor, i.e., Hulu Langat, Petaling Perdana, Klang and Gombak. The determination of sample employed the Stratified Random Sampling of schools and teachers' selection. There is a total amount of 100 secondary school teachers from two secondary schools had been chosen as the respondents for the study. The researcher first acquired permission from both Educational Policy Planning and Research Division, Ministry of Education Malaysia and Selangor State Education Department to conduct the research before delivering the online questionnaire using Google Form to the respondents. A teacher representative which is the school's digital and technology coordinator was appointed through their schools, participants completed self-administered surveys.

Instrument

The questionnaire to assess teachers' technology self-efficacy was adopted from (Gentry et al., 2014). There are 34 interval-scale items in the range of 1 (strongly disagree) and 5 (strongly agree). The content validity of this instrument is determined by examining if the material contained in the instrument is sufficient to the sample of the domain of content it is designed to represent. The instrument's format is also an important part of content validation. This encompasses aspects like the legibility of the orienting, the size of the type, the suitability of the language, and the conciseness of the directions (Fraenkel et al., 2018).

Exploratory Factor Analysis

Factor analysis has been adopted across many academic fields as result of advancements in computer technology, including behavioural and social sciences, medicine, and economics. Exploratory Factor Analysis (EFA) is one of the most often used factor analysis approaches, with the primary goal of determining the underlying organization of the research variables (Hair et al., 2010). EFA is frequently the first stage in the construction of new scales or measurements. Factor analysis works by applying statistical techniques to limit the number of variables that can be evaluated to a lesser variable that cannot be seen; a process known as lowering the dimensionality of data (Bandalos & Finney, 2018). It is common practice to test validity using EFA, which suggests that the variables viewed or scored have a smaller number of latent variables or constructs (Leech et al., 2015).

EFA was used in the study for two key reasons. First, it allows the researcher to have direct control over minimizing the number of variables. Secondly, EFA is presented as the first multivariate method since it could be particularly useful in putting additional multivariate approaches into practice. The researcher conducted EFA on the technology self-efficacy construct of the sample using IBM-SPSS 26.0. Prior to carrying out a factor analysis, the Kaiser-Meyer-Olkin sample adequacy test (KMO) and Bartlett's Test of Sphericity must be completed to guarantee that the data is appropriate. The pilot research collected 100 respondents, which corresponded with the sample size suggested by Tabachnick and Fidell (2019) which is 100 to 200 respondents for the study to conduct factor analysis. Following the application of the EFA approach, the author suppresses the value of the threshold at 0.6 or higher as suggested by Hair et al. (2010). High factor loading scores suggest that the constructs are better able to describe the dimensions of the factors (Yong & Pearce, 2013). As shown in Table 1, This study employed the goodness of fit index to measure EFA as recommended by (Hair et al., 2010)

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	$\geq$0.50

Reliability

Reliability is the capacity to produce consistent results across time, samples, and locations by maintaining the consistency of scores in particular variables (Awang, 2015). An accurate representation of the whole population in the study is demonstrated by a dependable instrument, which consistently produces consistent data (Mohajan et al., 2018). An instrument's reliability is often evaluated using the alpha coefficient approach in educational research (Cresswell, 2014). The consistency of all responses to the items used to evaluate a construct is gauged by Cronbach's alpha coefficient (Fraenkal et al., 2018). It is suggested by Hair et al (2010) that the fitting threshold of the reliability is 0.7 or higher for achieving adequate instrument reliability.

Findings

Descriptive statistics

Table 2 provides descriptive statistical data for the mean and standard deviation for each question that evaluates the concept of the TSE.

Item Code	Items	Mean	S.D
TSE 1	I empower my students to demonstrate their creative thinking by using digital tools.	3.61	.869
TSE 2	I am able to develop technology-enriched learning environments that enable all students to pursue individual curiosities in an active setting.	3.52	.876
TSE 3	I am able to involve my students in activities where they use digital tools to manage projects that is focused on real-life events.	3.56	.874
TSE 4	I am able to instruct my students to use digital tools that I myself feel comfortable with.	3.67	.873
TSE 5	I am sure of how to set up a classroom where students can express themselves using technology.	3.34	.895
TSE 6	I can help my students to use digital tools to solve real-world problems.	3.45	.863
TSE 7	I know how to work with students, colleagues in face-to-face environments to model the collaborative knowledge construction process.	3.64	.793
TSE 8	I am aware of digital tools that allow students to manage their own learning in terms of setting learning goals.	3.64	.781
TSE 9	I am confident with my ability to analyze data on my students' performance in order to improve my own instruction.	3.64	.798
TSE 10	I am confident in customizing learning activities to address students' diverse learning styles using digital tools.	3.57	.850
TSE 11	I feel confident when asked to integrate digital tools to promote students' learning.	3.47	.841
TSE 12	I share with students how to use digital tools to independently manage their own learning objectives.	3.42	.826
TSE 13	I share with students how to use digital tools to independently assess their own results.	3.50	.865
TSE 14	I struggle to provide students with varied assessments that are aligned with the technology standards.	2.98	.856
TSE 15	I am confident in my ability to design authentic learning experiences that incorporate contemporary tools and resources.	3.50	.818
TSE 16	I feel a sense of satisfaction when adapting learning experiences that incorporate digital tools to promote students' learning	3.74	.783
TSE 17	I have prior knowledge on how to use digital tools in my teaching.	3.77	.773
TSE 18	I feel that I have more time to communicate effectively with students using digital age media.	3.54	.897
TSE 19	I value the use of digital tools to analyze in supporting research.	3.81	.754
TSE 20	I tell students that it's important to use resources from digital tools in their own learning	3.85	.813
TSE 21	I am confident that the technology skills I have today will help me acquire new skills for the future.	3.91	.822
TSE 22	I feel confident in my ability to communicate relevant information to students using digital age media.	3.56	.863
TSE 23	I struggle to provide equitable access to digital tools.	2.79	1.056
TSE 24	I routinely integrate digital communication tools for my students to engage with students from other cultures.	3.49	.805
TSE 25	I frequently model digital etiquette	3.41	.837
TSE 26	I am continually addressing different student needs such as access to online resources.	3.45	.816
TSE 27	I actively teach the ethical use of online information.	3.52	.841
TSE 28	I feel confident in my ability to communicate relevant information to parents using digital age media.	3.37	.889
TSE 29	I consistently engage in professional development that enables me to be confident in demonstrating effective use of digital tools in my classroom.	3.52	.841
TSE 30	I discuss educational technology tools with my colleagues.	3.72	.837
TSE 31	I take some time to integrate a new tool into my teaching until I have seen the evidence of the effectiveness.	3.29	.907
TSE 32	I participate different informal learning communities in which I seek out to learn new digital tools.	3.50	.887
TSE 33	I discuss with my colleagues the effective use of digital resources to improve student learning.	3.67	.825
TSE 34	I continually evaluate research trends on the practical effectiveness of current digital tools for teaching.	3.33	.916

S.D standard deviation

Exploratory Factor Analysis

The researcher conducted EFA on the technology self-efficacy construct of the sample using IBM-SPSS 26.0. The Principal Component Analysis (PCA) was employed as the extraction method and the Varimax (Variation Maximization) was used as the rotation method. The SPSS output for the EFA method is shown in Table 3. According to the SPSS result, the EFA achieved Kaiser-Meyer-Olkin (KMO) value 0.000, which represents the sample adequacy, which ought to be greater than the threshold value of 0.6 (Hoque et al., 2018). Furthermore, the results of Bartlett's test were significant ($x^2 = 0.00000$, $p < 0.05$), allowing for additional analysis.

Table 3
The KMO and Bartlett's test score

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.905
Bartlett's Test of Sphericity	Approx. Chi-Square	3041. 088
	df	561
	Sig.	.000

Additionally, there are three techniques to determine how many components are needed to measure a construct in a questionnaire, which is using an eigenvalue greater than 1, a cumulative variance greater than 60%, or using the scree plot. It is shown in table 4 that there are five components that have eigenvalue greater than 1. The variation explained by component 1 is 21.088%, component 2 is 20.491 %, component 3 is 11.347%, component 4 is 10.769%, component 5 is 6.378%. This construct's total variance that was explained was 70.073%. Given that it exceeded the minimal threshold of 60%, the overall variance explained is adequate.

Table 4
Total Variance Explained for Technology Self-Efficacy 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	17.516	51.516	51.516	17.516	51.516	51.516	7.170	21.088	21.088
2	2.074	6.101	57.617	2.074	6.101	57.617	6.967	20.491	41.578
3	1.640	4.824	62.441	1.64	4.824	62.441	3.858	11.347	52.926
4	1.509	4.438	66.879	1.509	4.438	66.879	3.662	10.769	63.695
5	1.086	3.194	70.073	1.086	3.194	70.073	2.168	6.378	70.073
Extraction Method: Principal Component Analysis									

The scree plot for the technology self-efficacy construct, meanwhile, divided 34 elements into five components (Figure 1). The analysis of the scree plot revealed that there was a clear point of inflation after the fifth factor (Chua, 2009). The technology self-efficacy construct, in brief, has five components based on the eigenvalue, cumulative percentage and scree plot.

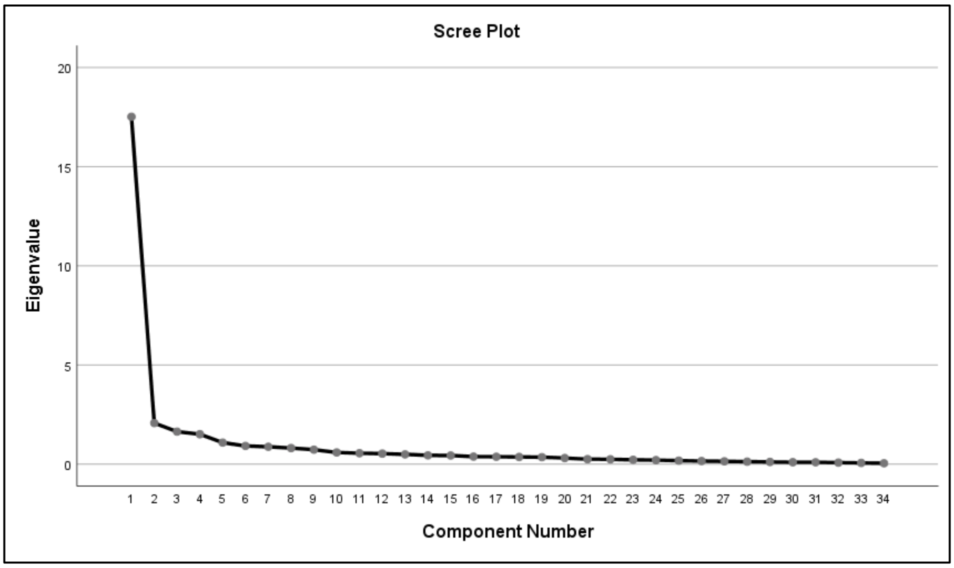

Figure 1: Scree Plot for Technology Self-Efficacy Construct

Table 5 listed the components, the corresponding items that belong to each component, and the factor loading for each item. In order to keep an item, the item factor loading must be larger than 0.6; otherwise, the item must be removed from the actual research instruments (Awang, 2015).

Table 5
The Rotated Component Matrix for Technology Self-Efficacy Construct

Item code	**Rotated Component Matrix**				
	Component				
	1	**2**	**3**	**4**	**5**
TSE 1	.773				
TSE 2	.631				
TSE 7	.672				
TSE 8	.693				
TSE 11	.704				
TSE 12	.628				
TSE 13	.654				
TSE 10		.600			
TSE 21		.638			
TSE 26		.735			
TSE 28		.635			
TSE 29		.726			
TSE 30		.605			
TSE 32		.677			
TSE 33		.790			
TSE 24			.720		
TSE 25			.647		
TSE 16				.630	
TSE 19				.794	
TSE 20				.756	
TSE 14					.708
TSE 23					.762
TSE 31					.782

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

Reliability

As a result, five components were developed from the EFA process for analysing the measuring items for technological self-efficacy. There are 7 items in Component 1, 8 items in Component 2, 2 items in Component 3, 3 items in Component 4, and 3 items in Component 5. Out of the 34 items that were proposed, only 23 items that were ultimately retained. Computing Cronbach Alpha in the manner suggested by Nunally and Berstein (1994), yields information on the scale's internal dependability. The internal reliability for the 23-item technology self-efficacy construct is 0.931. This result is outstanding since it exceeds 0.7, the suggested value by (Sekaran and Bougie, 2010).

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

Component	No of items	Cronbach's Alpha
1	7	.942
2	8	.932
3	2	.768
4	3	.842
5	3	.682
Technology Self-Efficacy as a construct	23	.931

Conclusion

This study has investigated a significant number of items for evaluating the construct of Technology Self-Efficacy. Specifically, constructs 1, 2,3, 4 and 5 together make up the outcome of the EFA process, which measures the construct of technology self-efficacy. Besides, a good factor loading value of above 0.5 may be found in the items for each component. On top of that, the reliability of the items was outstanding, with a Cronbach's alpha value exceeding 0.60. According to Nunnally and Bernstein (1994), the acceptable internal consistency is α => 0.6. As a result, this study can attest to the accuracy of the instruments employed to evaluate the construct of technology self-efficacy as well as its validity. The conclusions of this study, however, are confined to the instruments utilised and involve only secondary school teachers in Selangor. Thus, more research can be done by enlisting the help of other instructors from other types of educational institutions. Finally, other researchers may find it useful to test how capable instructors are of incorporating technology into their lessons using this technology self-efficacy tool. As a result, the conclusion that may be derived from this study are outlined in the table below.

Table 7
Conclusions

Conclusion	Importance/ Siginificance
Validity and reliability of the instrument	The accuracy of the instrument employed to evaluate the construct of technology self-efficacy can be verified by this study due to the outstanding and accepted threshold of reliability and validity of the items. As a result, future researchers may find it advantageous in employing a technology self-efficacy assessment to assess how competent teachers are at incorporating technology into their lessons.
Technology self-efficacy in teaching and education.	This study shows that technology self-efficacy has been found critical in teaching and education. Teachers' confidence in their ability to effectively use technology will eventually affect their usage of technology in the classroom, which has ramification on students' engagement in lessons and their learning outcome.

Contribution
The validated scale of the technology self-efficacy assessment is effective for gauging how confident teachers are in their capacity to integrate technology into their teaching. Since teachers in the digital age need to be proficient with their 'teachnology' and 'technogogy' in the 21st century teaching method, this scale is essential for determining how technology self-efficacious they are. This tool is beneficial to practitioners as well since it increases their understanding of how to effectively use the 21st century teaching strategy and approach.

Also, this study makes a contribution by investigating the impact of technology self-efficacy on teachers' technology integration and usage of learning management system (LMS) which is the Digital Educational Learning Initiatives Malaysia (DELIMa). The theoretical framework leverages on the Technology Acceptance Model (TAM) and self-efficacy theory to explore the correlation between technology acceptance, self-efficacy, and the use of technology in education. According to the TAM, the ease of use and perceived usefulness impact teachers' adoption and usage of technology. On the other hand, the self-efficacy theory places a strong emphasis on teachers' perceptions of their own skills to complete a particular task (Pan, 2020).

Moreover, the research also investigates the contextual elements which have an effect on teachers' technology self-efficacy. It recognizes the significance of elements such as teachers' technology integration knowledge, behaviour, and experiences with technology in influencing teachers' self-efficacy in incorporating technology into their teaching practice. The study suggests that incorporating technology into teachers' education will improve self-efficacy in technology use.

The study further adds to the literature by analysing the connection between teachers' self-efficacy in integrating technology and their technological pedagogical content knowledge (TPACK). It is discovered that TPACK has a significant impact on teachers' self-efficacy and usage of ICT in teaching practice (Andyani et al., 2020). This emphasizes the significance of teachers' knowledge and abilities in successfully incorporating technology into their teaching practice.
In summary, this study provides beneficial knowledge into the theoretical and conceptual framework of the impact of technology self-efficacy on technology integration and usage of DELIMa among teachers. In addition, administrators and educators could utilize the validated instrument to measure technology self-efficacy among practitioners. Thus, understanding the factors that contribute to teachers' technology self-efficacy and attitudes towards technology-based teaching and learning allows educational policy makers as well as educators to establish strategies to improve technology integration in teaching and students' learning outcome.

Recommendation
In order to further validate the existence of instructor's technological self-efficacy measure, further investigation incorporating CFA is advised. In addition, researchers may also add more items to the construct so that the instrument can be more accurately assess teachers' technology self-efficacy. In conclusion, a different demographic and site might be used for this research.

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