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A SEM-PLS Approach: Teacher 4.0 – Are You Competent Enough?

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Abstract: *Teacher 4.0 is a concept of future educators created to explain the characteristics of educators who can handle various technologies with effective teaching in parallel with the transformation of Education 4.0. Readiness and acceptance of the use of various smart technologies, better known as Technology 4.0 experienced a large-scale shift in the national education system, especially in teaching and learning methods. This includes all levels from primer to higher education institutions. The transformation of 4.0 requires improvement in teachers' competency to enhance teaching and to ensure it is in line with the country's objective in producing highly competitive, innovative educators and students in the era of 4.0. The need for a measurement tool is important due to the lack of research conducted to test the competence of Teacher 4.0. Thus, this study was conducted to measure the competence of Teacher 4.0 by creating a new instrument adapted from the DigCompEdu model. Appropriate constructs were validated and hypotheses were tested using PLS-SEM approach to evaluate the contribution of each construct towards Teacher 4.0 competency. The sample used in this study involves 274 among MARA teachers' pre-university institutions across Malaysia. A total of three formative constructs were identified, namely teaching and learning, assessment and facilitating students' Technology 4.0 competence. Questionnaires were distributed to respondents using purposive sampling and the data obtained was analyzed using SEM-PLS software. The results of the analysis show that all constructs have passed sufficient convergent validity. Hypothesis verification analysis shows that all constructs have a positive contribution towards Teacher 4.0 competency. Overall, this study has created a new measurement instrument that can measure the competence of Teacher 4.0 and improvised the DigCompEdu model. Findings can be a reflection indicator for teachers to improve teaching methods and strategies in addition to developing existing competencies. The problems arising from this study can be indicators for educational institutions to ensure that the facilities and infrastructure required for Technology 4.0 can be expanded in line with their needs as an educational support tool.*

Keywords: *Teacher 4.0; teacher competency; pre-university; 4.0 measurement.*

1. INTRODUCTION

Teacher 4.0 is a concept first introduced by Abdulrazeq et al. (2016) to describe the characteristics of future educators who are able to handle new technologies and use them efficiently in their teaching. Peredrienko et al. (2020) explain that Teacher 4.0 is a concept that was created in response to the needs of the 4.0 Industrial Revolution that is taking place, and it is easier to describe the characteristics of teaching and learning by educators based on this revolution. As teachers' tasks become more complex with various challenges, new teaching concepts in line with technology-related changes should be considered. Teachers' ability to navigate the digital era in the educational process and their readiness to adapt to the ever-changing educational environment are important issues to discuss.

Puncreobutr (2016) states that teachers need to help meet the educational needs of society in the "innovative era". This is in line with the teaching and learning process that supports students' ability to use new technologies and can help them develop better skills (Nguyen et al., 2024; Malik et al., 2024). The need to strengthen the competence of lecturers

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to have the characteristics of Teachers 4.0 is an effort to provide the best input to students. For students in higher education institutions, they are generally seen as more skilled in the use of technology (technology savvy) than the teachers. Therefore, it is important for a teacher to master the use of technology and become more competent to produce effective pedagogy (Nguyen et al., 2024; Mahmud et al., 2023; Mokhtar & Noordin, 2019) so as not to be left behind.

2. LITERATURE REVIEW

Teacher 4.0 is a concept recommended in support of past research such as that of Shenkoya & Kim (2023) and Fisk (2017) who stated that teaching and learning based on Education 4.0 provides a positive shift to the education system. Teaching methods are no longer entirely dependent on the experience skills and knowledge of teachers. Teachers need to be skilled and competent in using various technologies to produce more effective teaching outputs in line with the characteristics required by Teacher 4.0. This requirement applies to all levels of educators, namely primary school teachers, secondary school teachers and lecturers in higher education institutions.

Mokhtar & Noordin (2019) explain that teachers need to function as facilitators who help students learn in a self-learning method. Teacher 4.0 does not become the main presenter who provides information conventionally but functions as facilitator. Teachers encourage students to explore information from various technological mediums while helping students filter out invalid information. This is to prevent students from misusing the medium provided and accessing incorrect information. The teaching atmosphere is more flexible (Khotimah et al., 2024; Ingaldi et al., 2023; Hutson & Patel, 2023).

Teachers 4.0 are also able to use augmented reality technology, information and communication technology optimally, using smart alarms (smart sensors) and others (Khotimah et al., 2024; Peredrienko et al. 2020; Hutson & Patel, 2023). Specifically, Teacher 4.0 in this study refers to teachers who master the skills of various technologies including smart technology and apply these technologies in developing teaching strategies, used in the teaching and learning delivery process and post-teaching evaluation.

Smolyaninova and Bezyzvestnykh (2019) explain that Teacher 4.0 should always strive for the development of creative thinking and action, and then transform these creative actions into innovative results in the context of educational digitalization. Different teaching scenarios are produced to face the current technological revolution in the context of Industry 4.0. In these scenarios, innovative technologies have been used to introduce new methods to support teaching. The Teachers 4.0 scenario introduced by Abdelrazeq et al. (2016) as an analysis of

traditional teaching methods in the form of a scenario analysis method aims to identify the main challenges and needs for future educators. The three categories focused on are (i) human-based teaching (ii) didactic teaching, and (iii) technology-based and organizational teaching.

DigCompEdu Model

This study adapts the DigcompEdu model by using its three main formative constructs, namely teaching and learning, assessment and facilitating students' technology 4.0 competence. The European Framework for the Digital Competence of Educators (DigCompEdu), published in 2017, describes digital competences specific to the teaching profession (Redecker, 2017). The DigCompEdu model is a comprehensive framework that explains the meaning and concepts of educators more efficiently based on digital usage.

The framework is based on expert consultation and aims to structure existing insights and evidence into a more comprehensive model, applicable to all educational contexts. This model has complemented the main area of focus, namely education, by prioritizing the elements of digital technology competency for teachers and monitoring every logical development related to teaching competency.

The selection of the DigCompEdu model coincides with this study which seeks to measure the level of competence and competency of teachers related to the use of technology in education. However, the DigCompEdu model only measures the ability to use digital technology in a basic way. This study also measures the use of Technology 4.0. Therefore, the DigCompEdu model is adapted to build items and instruments to measure the competence of Teacher 4.0 which is in line with teaching skills based on Technology 4.0.

Problem Statement

There are studies conducted to see the effectiveness of technology or digital impact on a particular subject, but the studies reported are more focused on student achievement results, the effectiveness of student understanding levels and student examination results (Khotimah et al., 2024; Jima'ain et al., 2020; Sin Ying Tan et al., 2019 & Saputri, 2019). There are also studies conducted to see the level of readiness and acceptance of Education 4.0-based technology (Saud et al., 2018; Taherdoost, 2018; Kopcha, 2012; Rameli et al., 2018; Yunos & Din, 2019). However, there are still limited studies conducted to test the level of competence and skills of Teacher 4.0 among teachers.

The extent to which teachers have mastered the skills and competence in handling smart technology, utilizing existing facilities and remaining positive through each phase of technological transformation in teaching still lacks clear empirical evidence (Jamhari et al. 2020). Therefore, it is important for researchers to conduct this study in order to be able to

report a study that can serve as a reference in line with the aims of the Educational Institutions in producing quality teachers. Figure 1 below illustrates the conceptual framework of the three formative indicators tested in the study.

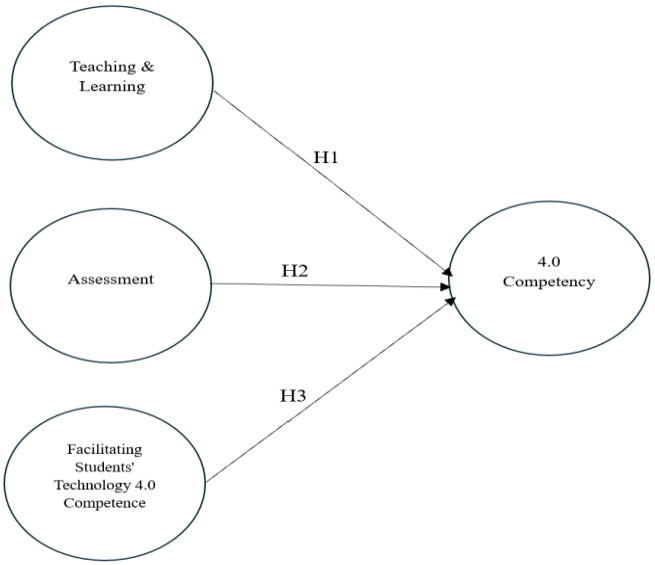

Figure 1: Conceptual Framework of Formative Indicators Tested

Hence, three hypotheses were developed:

H1: Teaching and learning has a positive impact towards Teacher 4.0 competency

H2: Assessment has a positive impact towards Teacher 4.0 competency

H3: Facilitating students' technology 4.0 competency has a positive impact towards Teacher 4.0 competency

3. METHODS

This study involves the implementation of a quantitative study where the analysis is carried out at the individual level in MARA (Majlis Amanah Rakyat) higher education institutions in Malaysia. Data is collected through the distribution of questionnaires using physical and virtual mediums. This study involved 274 respondent teachers at MARA pre-university. SEM-PLS measurement analysis was used to test three formative indicators which are professional engagement, teaching and learning, assessment and facilitation of Technology 4.0 student competencies. Analysis involves convergent validity testing and hypothesis testing by referring to Hair et al. (2017).

4. RESULTS

The evaluation of formative measurement constructs is carried out through their statistical significance, that is, by looking at the weights indicator. The weights indicator is obtained from the results of regression tests for each construct measured formatively for the

related indicators. It represents the relative importance of each indicator to form the construct. The significance test for the weight indicator relies on a bootstrapping procedure to obtain the standard error of the data without relying on any assumptions (Hair et al. 2017). The bootstrapping procedure produces t-values for the weight indicator (and other model parameters). These t-values are compared with critical values from the standard normal distribution to decide whether the coefficient is significantly different from zero. The critical values for the significance levels of 1% ($\alpha = 0.01$), 5% ($\alpha = 0.05$) and 10% ($\alpha = 0.10$) with error probabilities are 2.576, 1.960 and 1.645 (two-tailed), respectively (Hair et al. 2017). Based on the assumption of a 10% significance level, a t-value exceeding 1.645 (two-tailed test) indicates that the weight indicator is statistically significant.

Table 1 reports the convergent validity and significant relationship of indicators for the constructs of teaching and learning, assessment, and facilitating student Technology 4.0 competence. All formative indicators for each construct have values that meet the set standard values. This includes significant t-values for all indicators. This proves that all indicators make sufficient absolute contributions to form their respective constructs.

Table 1: Convergent validity report

Formative Indicators	**Item**	**Convergent Validity**	**Weights**	**VIF**	**t-value for Weights**	**Sig.**	**t-value for Loadings**	**Sig.**
Teaching & Learning								Yes
	PDP26	0.731	0.033	1.635	0.256	No	6.625	
	PDP27		0.251	2.04	2.726	Yes	11.997	Yes
	PDP28		-0.106	2.499	0.993	No	10.197	Yes
	PDP29		0.149	1.871	1.219	No	7.719	Yes
	PDP30		0.354	2.19	3.126	Yes	13.665	Yes
	PDP31		0.522	1.785	3.665	Yes	19.615	Yes
						Yes		
Assessment	PN32	0.712	0.578	1.985	3.963	Yes		
	PN33		0.378	1.514	2.041	Yes		
	PN34		0.21	1.836	1.878	Yes		
Facilitating Students' Technology 4.0 Competence	MKT41	0.881	0.045	1.6	0.514	No	8.188	Yes
	MKT42		-0.032	3.137	0.320	No	3.964	Yes
	MKT43		-0.063	3.350	0.898	No	2.651	Yes
	MKT44		0.018	3.536	0.211	No	3.732	Yes
	MKT45		0.039	3.230	0.707	No	2.805	Yes
	MKT46		0.148	1.491	2.117	Yes	5.156	Yes
	MKT47		0.899	1.495	15.039	Yes	64.557	Yes
	MKT48		0.075	1.516	1.640	No	8.520	Yes

This study model produced three hypotheses that were tested using path analysis. The bootstrapping method was used to test the constructed hypotheses. The bootstrapping method is a non-parametric method to determine the accuracy of PLS estimates (Ngah 2016). The PLS and bootstrapping methods are recommended in the structuring model using an estimated 5000

samples through replication to examine the study hypotheses. This includes tests to determine the f2 value, VIF and P value for the internal model (Chin 2010; Hair et al. 2017). Table 2 shows the results of the bootstrapping procedure for testing the hypotheses of this study. All hypotheses are supported as reported.

Table 2: Hypothesis Testing

Hyp.	Relationship	Beta	Standard Deviation Error	t-value	p-value	LL	UL	VIF	f^2	Results
H1	Teaching & Learning → COMPETENCY	0.152	0.065	2.349	0.009	0.044	0.256	2.465	0.033	Supported
H2	Assessment → COMPETENCY	0.236	0.051	4.633	0	0.153	0.321	1.937	0.102	Supported
H3	Facilitating Students' Technology 4.0 Competence → COMPETENCY	0.271	0.046	5.864	0	0.193	0.346	1.248	0.208	Supported

5. DISCUSSION

All convergent validity analyses were met as reported. This shows that this study was able to confirm all three constructs as proposed. All constructs used have been validated to build a three-dimensional measurement instrument model based on the adaptation of the DigCompEdu model (Redecker 2017). Although these models and theories were originally used in different cultural environments and educational systems, they are capable of measuring the required educator competencies.

Next, based on Table 2, this study can confirm that there is a positive contribution ($\beta > 0$, t-value > 1.645 and p-value < 0.05) between the three constructs used, namely teaching and learning, assessment and facilitation of students' Technology 4.0 competence towards Teacher 4.0 competence (Hair et al., 2017). In other words, when the constructs of teaching and learning, assessment and facilitation of students' Technology 4.0 competence increase, the level of Teacher 4.0 competence also increases.

6. CONCLUSION

The results show that the SEM procedure supports the conceptual framework. The majority of constructs show positive and significant contributions to Teacher 4.0 competencies. Teacher 4.0 emphasizes the function of future educators which must be in line with the requirements of technological developments. Teachers must be sensitive and always ensure that they remain skilled in conveying knowledge to students in accordance with the rapid

development of smart technology, especially Technology 4.0 (Khotimah et al., 2024; Abdelrazeq et al. 2016; Ingaldi et al., 2023; Hutson & Patel, 2023). Therefore, this Teacher 4.0 competency instrument can meet the criteria of self-reflection as suggested by the theory of reflection by Dewey (1933), namely emphasizing concern and teaching goals, monitoring, determining levels of competence, responsibility, resource-based assessment, collaboration and innovation.

This study has contributed to literacy research in the field of Education 4.0 in Higher Education Institutions. Suggestions for further research are discussed as a result of the continuation of this study that are considered appropriate to be implemented by future researchers. These suggestions include aspects of expanding the context of the study, statistical analysis, adding items, testing with other variables and aspects of competence. It is suggested that further research needs to be conducted to expand the scope of the study across countries and replicate the concept of educator competence using variations in samples, variables and measurement techniques.

LIMITATION

This study on the validity of the measurement instrument and competency model of Teacher 4.0 requires a rather challenging process due to the constraints of the Covid-19 pandemic phase. The implementation of online data collection makes it difficult to monitor respondents to answer transparently and the lack of response in answering the distributed questionnaires. However, this situation does not affect the overall results of the study.

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