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Psychometric Assessment of Teacher 4.0 Competencies (Teach4comp) among Pre-University Lecturers in Malaysia

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Abstract

Lecturers need to have high skills in the process of imparting knowledge and must be proficient in using the latest technology, so that the teaching and learning process can be carried out effectively and efficiently in line with Education 4.0 era. The term Teacher 4.0 was created to describe the characteristics of these educators. However, lecturer's required level of skill and competency is still questionable. Studies and instruments to measure Teacher 4.0 competency level are still limited. Thus, the aim of this study is to develop a new instrument named Teach4Comp, that can measure the level of competitiveness of Teacher 4.0 among lecturers. The instrument was developed based on adaptation of constructs from DigCompEdu model and Digital Literacy model. A questionnaire was administered to 60 Pre-University lecturers from Selangor. All items have been analyzed using the Rasch measurement model. The data were analyzed to identify that items were functional according to the aspect of items fit in measuring constructs, items polarity, unidimensionality, item functionality differences (DIF) and the reliability and separation of item and respondent. The instrument reliability showed good result with Cronbach Alpha of 0.97. All the pscyhomteric results have confirmed that the Teach4Comp is valid and reliable. This research can contribute as a solution for a comprehensive teacher 4.0 competency measurement tool in Higher Education Institutions.

Keywords: Teacher 4.0, Teaching Competency, Pre-University Lecturer, Rasch Model

IntroductionThe global issue of implementing smart technology based on Education 4.0 occurred during the outbreak of COVID-19 pandemic (Denisova et al., 2020; Birch et al. 2020; Abumalloh et al., 2021; Kamal et al. 2020; Selvanathan et al. 2020), the whole world had to rely on more efficient technology. Online communication was needed to connect family members who are separated by long distance, to hold meetings and to work from home (Birch et al., 2020; Kamal et al., 2020). Most lecturers were forced to master themselves in using various types of learning mediators to ensure that knowledge can be delivered effectively. Many lecturers who were not skilled to use smart technology faced many problems in

adapting to the new teaching transformation. This is where the importance of the Teacher 4.0 lies.

Teacher 4.0 is a concept coined to describe the characteristics of future educators who are able to handle new technology and use it efficiently in their teaching (Abdelrazeq et al., 2016). As educational tasks become more complex with various challenges, new teaching concepts parallel to changes related to technology should be considered. The ability of educators to go through the digital era in the educational process and their willingness to adapt to the frequently changing educational environment is an important issue to discuss (Peredrienko, Belkina & Yaroslavova, 2020).

The need to strengthen lecturers' competency with characteristics of Teacher 4.0 is an effort to provide the best input to students. Students in higher education institutions, are generally seen as more skilled in the use of technology (technology savvy) than lecturers. Therefore, it is important for lecturers to equipped themselves in using technology and become more competent to produce effective pedagogy (Mokhtar & Noordin, 2019; Bizami et al., 2023) so as not to fall behind. It can also provide a more personalized and differentiated learning styles that can suits students; ability (Din, 2015; 2016; Masdoki et al., 2021; Ginja & Chen, 2020). To ensure a continuity of creative and effective teaching and learning, lecturers has to make sure they are competitive and have an appropriate technology skills (Vlachopoulos, 2020; 2012; Cao's, 2023).

However, the use of the term Teacher 4.0 is still restricted and not widely used at the national or the international level. Therefore, issues related to skills and competencies of Teacher 4.0 are still being studied. Models and theories related to Teacher 4.0 are also limited. This is one of the important justification to conduct the study. Development for new instruments is important to help various stakeholders, especially the educational institutions, to identify their educators who have achieved the required level of skills. This is also important to ensure that educators have skills in line with the needs of Technology 4.0 (Masdoki et al., 2021; Yu et al., 2023). Limited measurement tools will also make it difficult to get good reference of resources that can help in the provision of training resources and appropriate programs that can be prepared to strengthen the skills of educators. Thus, more research is needed to expand the knowledge about psychometric properties of Teacher 4.0 competency scale specifically in Education 4.0 context. Hence, Teacher 4.0 Competency Assessment (Teach4Comp) instrument was developed. It is necessary to study the validity and reliability of the instrument to ensure and sustain the precision of the instrument. Thus, the study had examined the psychometric properties of Malaysian version of Pre-University lecturers skills in Education 4.0 using Rasch measurement Model.

Methodology

This study used a survey technique with a set of questionnaires (Teach4Comp) adapted from the previous research of DigCompEdu (Redecker, 2017; Ismail and Jarrah, 2019). This adapted questionnaire containts 71 items of five-point rating scale reflecting seven main constructs. The constructs are, Technology 4.0 literacy, professional engagement, Technology 4.0 resources, teaching and learning, assessment, student empowerment and facilitating students' 4.0 Technological competence. Teach4Comp was used to assess the seven constructs representing the independent variables. The dependent variable is the

competency itself. Items are quantitatively examined using WINSTEPS version 3.71 to assess the suitability of items.

Teach4Comp was administered to a total of 60 lecturers from Pre-University institution which is Kolej MARA Banting in Selangor. Rationale of the selection of lecturers from Selangor was because of the known heterogeneity of backgrounds among lecturers in this institution. The questionnaire was administered to the teacher involved in groups by the researcher. Respondents were given 20 minutes to answer the questionnaire before being collected by the researcher. There were 65 questionnaires being distributed. However, 5 questionnaires were rejected as a result of incomplete and invalid responses. Respondents for this research consisted of 40 (66.7%) females and 20 (33.1%) males.

Results and Discussion

This section discusses about five main findings. Initially the discussion will be on fit statistics. This is followed by item polarity, unidimentionality and item functionality differences. Finally, reliability and separation will be presented and discuss.

a. Fit Statistics

Fisher (2006) asserted that the first procedure to be done is to identify items that do not meet the Rasch model (not fit) with MNSQ values or uniform fit statistics (Zstd) for each item. In this study, the MNSQ infit value is used to determine item compatibility by seeing that the perfect expected value is 1.00 logits. Bond and Fox (2007) assert that the MNSQ outfit value is not weighted because it is more easily influenced by respondents who feel that an item is too easy or too difficult to agree on. It also does not provide useful information about the majority of respondents. Thus, researchers pay more attention to the infit value of the MNSQ because it can better identifies the items quality in majority of respondents.

Findings show that the MNSQ (mean square) infit value is recorded to be between 0.64 to 1.42. This value conforms to the measurement quality by Bond and Fox (2007), taking the determination of the compatibility range of items with a value of 0.5 logits to 1.50 logits. A total of 4 items were dropped in the item compatibility test by looking at the MNSQ infit values that were out of the range.

b. Item Polarity

The polarity values of the items ranged from 0.31 logits to 0.78 logits. The item polarity value (PTMEA) obtained should have a positive value and exceed 0.3 logits (Bond & Fox, 2007; Nunnally & Bernstein, 1994; Wu & Adams, 2007). This shows that this value meets the logits value of a good instrument and proves that the item measures the construct perfectly and that all items move towards the measurement of a single sub-construct (Bond & Fox, 2007).

c. Unidimensionality

The following table reports unidimensionality analysis for each construct in the Teach4Comp instrument. The Principal Component Analysis of Residual procedure shows that the gross variance explained by the measurement is 41.3% compared to the model's expectation of 42.1 percent. This variance explained by the measures was way above 40%, therefore indicates a strong principal measurement dimension (Bond & Fox, 2015).

The next step is to look at the level of measured interference or unexplained variance in the first contrast. The interference level or tha noise measured shows a percentage of 7.4%. This value is categorized as good i.e less than 15% (Fisher, 2007). The Eigenvalues of 6.7 also

indicates that there is no significant second dimension in the item (Azrilah et al., 2015). All those values are classified as good (Azrilah et al. 2015) and sufficient if the value is less than 15 percent (Azrilah et al., 2013; Fisher, 2007). Since all other important tests have been passed thus this instrument is acceptable with the following dimensions and items.

Table 1
Standard Residual Variance (in Eigenvalue units) Educator Competence 4.0

		Empirical			Modeled
Total raw variance in observations	=	90.2	100.0%		100.0%
Raw variance explained by measures	=	37.2	41.3%		42.1%
Raw variance explained by persons	=	19.5	21.6%		22.1%
Raw Variance explained by items	=	17.7	19.6%		20.0%
Raw unexplained variance (total)	=	53.0	58.7%	100.0%	57.9%
Unexplned variance in 1st contrast	=	6.7	7.4%	12.6%	
Unexplned variance in 2nd contrast	=	6.2	6.9%	11.7%	
Unexplned variance in 3rd contrast	=	5.0	5.6%	9.5%	
Unexplned variance in 4th contrast	=	4.1	4.5%	7.7%	
Unexplned variance in 5th contrast	=	3.7	4.1%	6.9%	

Item Functionality Differences

Bond and Fox (2007) suggest three indicators of differential item functioning (Differential Item Functioning, DIF) which are (i) t values between -2 to +2, (ii) contrast DIF values which are between – 0.5 to + 0.5 and (iii) p values less than 0.05. A review showed that there were gender-biased responses to some items. The items involved are item 19 under the awareness sub-construct (Technology 4.0 literacy construct), items 20, 21, 22, 24 and 25 under the professional involvement construct and items 28 and 30 under the Technology 4.0 resource construct. Other than that are items 32, 34, 36, under the teaching and learning construct, item 42 under the evaluation construct, items 43, 45 and 46 under the construct of student empowerment, items 47, 51 and 55 under the construct of facilitating students' Technology 4.0 competence and items 59, 60 and 61 under the competency construct. Table 3.19 shows the items that have gender-biased responses. Positive contrast DIF values are more easily agreed by female respondents while negative contrast DIF values are more easily agreed by male lecturers.

Table 2
List of Gender Bias Items by Construct

Construct	Item	S.E	DIF Contras	t
Awareness (Technology Literacy 4.0)	19	0.65	-2.01	-2.29
Professional Engagement	20	0.79	-3.25	-2.90
	21	0.69	-2.58	-2.55
	22	0.82	2.76	2.76
	24	0.72	-2.68	-2.63
Technology 4.0 Resources	28	0.68	-2.11	-2.08
	30	0.78	2.37	2.15
Teaching and learning	32	0.85	-2.49	-2.04
	34	0.81	-2.51	-2.13
	36	0.83	-2.66	-2.15
Assessment	42	0.54	-2.51	-2.65
Student Empowerment	43	0.89	2.70	2.23
	45	0.76	2.85	2.76
	46	0.72	-2.24	-2.20

Facilitating Students' Technology Competency	4.0	47	0.68	-1.97	-2.15
		51	0.75	2.82	2.67
		55	0.77	2.19	2.19
Competency		59	0.76	2.37	2.53
		60	0.64	-2.32	-2.69
		61	0.76	-.2.42	-2.32

Reliability and Separation Index

The reliability of individual abilities was recorded 0.96 and the reliability of item difficulty was recorded 0.81. The recorded Cronbach Alpha value is 0.97. This finding shows that these items are reliable. The obtained individual separation index was 4.87 and the item separation index recorded 2.07. This value is categorized as good referring to Fisher (2007). This also shows that individual ability and item difficulty are well spread and item ranking on the logits scale has high reliability. Fisher (2007) also stated that an isolation index between 3 and 4 is good and an index above five is excellent.

Table 3
Summary Statistics for individuals

	Total Score	Count	Measure	Model Error	Infit		Outfit	
					MNSQ	ZSTD	MNSQ	ZSTD
Mean	264.4	63.0	1.06	0.25	1.02	-0.3	1.06	-0.2
Standard Deviation	22.7	0.0	1.39	0.05	0.61	2.9	0.67	2.9
Max	309.0	63.0	4.42	0.44	3.92	9.9	3.40	8.4
Min	197.0	63.0	-2.31	0.21	0.22	-5.8	0.23	-5.5
Real RMSE	0.28	True SD	1.36	Separation	4.87	Person Reliability		0.96
Model RMSE	0.25	True SD	1.36	Separation	5.34	Person Reliability		0.97

Person Raw Score – To – Measure Correlation = 0.99
Cronbach Alpha (KR-20) Person Raw Score "Test" Reliability = 0.97

Table 4
Summary Statistics for Items

	Total Score	Count	Measure	Model Error	Infit		Outfit	
					MNSQ	ZSTD	MNSQ	ZSTD
Mean	251.9	60.0	0.00	0.26	1.00	0.0	1.06	0.0
Standard Deviation	13.1	0.0	0.62	0.03	0.20	1.1	0.38	1.2
Max	289.0	60.0	1.42	0.36	1.44	2.3	2.58	3.1
Min	226.0	60.0	-1.30	0.19	0.65	-2.1	0.60	-2.2
Real RMSE	0.27	True SD	0.55	Separation	2.07	Person Reliability		0.81
Model RMSE	0.26	True SD	0.56	Separation	2.18	Person Reliability		0.83

Umean = 0.0000 Uscale = 1.0000
Item Raw Score – To – Measure Correlation = -0.62

Conclusions

This paper aimed to report on the design and development of a Rasch-based instrument measuring Teacher 4.0 competency. The respondents involved lecturers in Pre-University institutions in Malaysia and to discuss its use for research and teaching purposes. The instrument consists of six constructs measuring competency adapted from DigCompEdu (Redecker, 2017) with one new construct which is literacy Technology 4.0 developed by adaptation from Digital Literacy Theory (Hovde & Renguette, 2017). This new construct consists of three sub-construct which are knowledge, awareness and familiarity. The instrument uses authentic biological contexts which facilitates the presentation of age-adequate items for the Pre-University lecturers.

Overall, this study had shown the strength of the Rasch measurement model. It is established on the Item Response Theory in assessing the psychometric properties of Teach4Comp. Different diagnosis procedures were applied to assess the psychometric properties of the Teach4Comp. With the examination through Rasch analysis, it was discovered that eight out of 71 items were unfit, leaving only 63 items remaining in the Teach4Comp. Further analysis with the remaining items concluded that the validity and reliability of the instrument are acceptable for measuring Teacher 4.0 competency among Pre-University lecturers. Additionally, the result showed that the instrument has also fulfilled other psychometric properties required for an acceptable instrument. These indicate that Teach4Comp is indeed an instrument appropriate to measure the level of Teacher 4.0 competency among Pre-University lecturers in Malaysia.

Limitations of the Study

In our opinion, as this assessment is being used, and added data sets are collected, there will be additional analyses conducted as well as possible new versions of the items developed. Some of the issues outlined below are those which we plan to consider as added analyses with the present instrument in a range of settings. Some of the study limitations concern analysis steps which were taken.

One requirement of the Rasch model is what is termed independency (Wright & Stone, 1979; Wright & Masters, 1982; Andrich, 1988). Independency can be understood when a respondent attempts to solve an item on a test. The interaction of respondent and item should not impact the chance that the same respondent solves another item on the test. It is possible as a respondent attempts to solve some items, there might be an impact upon the chances of that same respondent solving other items.

Further studies should also explore in more detail the issue of individual item mapping. The calibration process of this instrument can be done involving two stages, the first stage is the difficulty of the item and the second stage is the estimation of individual ability. This process is carried out until a determination of the item parameter estimate (item difficulty) and the individual parameter in the instrument (ability) is estimated where they are placed in a single scale. In addition, scalogram analysis can also be done to see the respondent's ability to answer each question item and identify if there is data negligence from the respondent. As for future research, it is also recommended that different studies should be organized by using a bigger scope particularly in different education institutions, different education levels and various samples to generate a much better, detailed, and comprehensive information which can be represented more extensively.

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