I.J. Modern Education and Computer Science, **2024, 1, 84-96**
Published Online on February 8, 2024 by MECS Press (http://www.mecs-press.org/)
DOI: 10.5815/ijmecs.2024.01.07

Design and Validity of an Instrument to Measure Digital Literacy among Pre-service Teachers involved in Inclusive Education

Wu Miaomiao
Department of Curriculum and Instructional Technology, Faculty of Education, University of Malaya, Kuala Lumpur, 50603, Malaysia
E-mail: s2026817@siswa.um.edu.my
ORCID iD: https://orcid.org/0009-0006-7091-1872

Dorothy De Witt
Department of Curriculum and Instructional Technology, Faculty of Education, University of Malaya, Kuala Lumpur, 50603, Malaysia
ORCID iD: https://orcid.org/0000-0003-3123-7150

Nor Nazrina Mohamad Nazry*
Department of Curriculum and Instructional Technology, Faculty of Education, University of Malaya, Kuala Lumpur, 50603, Malaysia
E-mail: nazrina@um.edu.my
ORCID iD: https://orcid.org/0000-0002-5900-2700
*Corresponding Author

Norlidah Alias
Department of Curriculum and Instructional Technology, Faculty of Education, University of Malaya, Kuala Lumpur, 50603, Malaysia
E-mail: drnorlidah@um.edu.my
ORCID iD: https://orcid.org/0000-0002-8299-2669

Lee Leh Hong
Planning, Research and Innovation Department, Institute of Teacher Education Ilmu Khas Campus, Kuala Lumpur, 50603, Malaysia
E-mail: sharonlee@ipgkik.edu.my
ORCID iD: https://orcid.org/0000-0001-8206- 6406

Alijah Ujang
Society of Community Rehabilitation Center, Selangor, 53100, Malaysia
E-mail: ujangalijah@gmail.com
ORCID iD: https://orcid.org/0009-0003-3507- 4173

Received: 06 July, 2023; Revised: 19 August, 2023; Accepted: 16 October, 2023; Published: 08 February, 2024

Abstract: Assessing pre-service teachers' digital literacy is challenging, particularly in inclusive education. Reliable and valid testing instruments are required to measure the digital literacy pre-service teachers possess in inclusive education. The entire research process comprises three phases. The first stage was to develop the assessment instrument, the second stage was to validate its content validity, and a pilot study was then conducted to test the reliability and construct validity of the instrument. The results of this study showed that item-level and scale-level content validity scores were both 1.0. The Kaiser-Meyer-Olkin is equal to 0.865. Five factors were extracted, explaining 54.40% of the total variance. The model fits were also all satisfactory. Standardized factor loadings of the instrument' s 28 items were above 0.5. The values of Cronbach's are higher than 0.7 for the five factors and the whole instrument. It can be summarized that the instrument had good reliability and validity and can be used to assess the digital literacy of pre-service teachers in inclusive education. There has been research into developing tools to evaluate the digital literacy of pre-service teachers. Still, few studies have addressed pre-service teachers of inclusive education, and this study fills this research gap. The subsequent phase involves evaluating it using a more extensive sample.

Index Terms: Digital literacy, inclusive education, pre-service teachers, validity, reliability

1. Introduction

Digital technologies are a necessary element of social and economic progress today. Furthermore, 90% of jobs require digital literacy(DL) [1]. Modern technological advances are accelerating the development of learning outcomes while improving education content, so educators in this era need to have digital literacies [2,3]. However, Covid-19 has challenged the adequacy of digital literacies among teachers [4]. Teachers need to acquire digital literacies as it has been noted that the higher the teachers' DL, the higher their pedagogical competence [5]. DL consists of three stages: digital competence, digital use, and digital transformation where digital competence is the foundational stage of DL [6]. Hence, DL for use in teaching practice should be a critical competency for pre-service teachers(PST) [7]. PST need to have a deeper understanding of the current social and educational work environment for them to successfully integrate into it, it is vital to have the greatest degree of DL which is transformational DL.

Although digital technology has permeated all aspects of people's lives, immersion in a digital society is not guaranteed for everyone as not all citizens have equal access to digital resources [8]. In inclusive education(IE), the needs of every person matter, and developing IE environments for all has implications for building a sustainable future. PST must have access to opportunities to increase their digital skills, and work within the framework of IE [9]. When used appropriately, digital technology may promote social and educational inclusion, ensuring that those with special needs are considered [10]. This is because technology has the potential to expand the possibilities available to disabled individuals and remove the obstacles they might face [11]. The importance of developing digital skills among PST has been mentioned by academics [12,13,14]. Through practical training in real-life scenarios, PST are able to develop their skills in inclusive teaching on time [15], which can be achieved through virtual reality to create the need for scenarios [16]. PST therefore need to have a certain DL. However, measuring PST' professional digital competence is problematic due to the complexity of the concept [17]. There does not seem to be any measure of DL for IE especially among PST who are at a critical stage of their training.

As mentioned above, IE is a new educational trend in global education, DL is a required competency for teachers in the new era, PST in IE need to be digitally literate, and measuring the DL of PST in IE is necessary. This study found through a brief literature review that there have been some instruments developed in the literature for assessing the DL of PST, and as for their theoretical frameworks containing the European Framework for the Digital Competence of Educators (DigCompEdu), the Technological and Pedagogical Content Knowledge (TPACK) model, as well as many more established instruments for measuring the DL of PST, Among these theories, inclusive ordinances are clearly presented in DigCompEdu, Therefore, DigCompEdu was chosen as the theoretical basis of this instrument for this study. With regard to the instruments using DigCompEdu as a theoretical basis, there are some that only measure some of the digital literacies covered by DigCompEdu, there are instruments that only examine PST' perspectives on DL, and there are instruments that only measure PST' mastery of the level of DL knowledge. While there are also instruments that specifically qualify PST in particular subjects, however, there are no extant instruments that measure PST' DL that address IE.

Based on this, the objectives of this study were: i) to develop an instrument that can assess the level of DL of PST involved in IE, and ii) to examine the reliability and validity of the instrument.

2. Review of Literature

In accordance with [18], Paul Gilster introduced the term DL in 1997, and its meaning has transformed over the years in response to changes in technologies and the knowledge and skills requirements of the labor force. The field of education is subject to the same trend. The DL of teachers have progressively garnered the interest of both national and state authorities. Furthermore, there is a growing demand within the educational sphere for teachers who possess expertise in the effective utilization of technology [19]. Assessments of educators' DL have been the primary focuses of research on the prevalence of DL in the educational system [20]. Existing research on DL assessment has focused on k12 students, college students, and educators [20]. While assessments can be found to assess the DL skills of K-12 students, for instance, [21] employed a particular assessment instrument to gauge various facets of DL in a sample of 151 primary school students. And there is some research assessing the DL of teachers, for example, [22] evaluated the self-assessment of DL among Spanish educators through the utilization of a questionnaire featuring a four-point Likert scale. However, there are few assessment programmes that are easily selectable to specifically assess the DL of teachers in IE [19].

The theoretical basis of existing literature on PST' DL mainly comes from DigCompEdu [23], The TPACK model [24], as well as the adaptation or translation of some mature and verified scale [25]. The inclusive approach of DigComEdu is remarkable as it refers to the need to integrate techniques that cater to the needs of every learner among these theories [26], For example, [23] designed an instrument for assessing DL based on DigCompEdu, but it used fewer areas of DigCompEdu, and it only measured digital knowledge of PST. The instrument of [27] was also

DigComEdu-based, but it only assesses PST' perceptions of digital skills and their potential. Besides, [28] also designed an instrument based on A to assess DL of PST, but the DL it measures is relatively monotonous, and only focuses on the ability of PST to communicate and communicate with other people. [24] combined the theories of the TPACK model, DigCompEdu, and 21st century competences, using Maturity Questionnaire to detect the perception of DL ability of prospective teachers of secondary education in social studies in university. [29] examined preservice teachers' perspectives on technical, pedagogical, and content knowledge of the TPACK framework. [30] proposed a newly developed conceptual framework that added Knowledge based on the TPACK framework. [31] only referred to the four technology-related dimensions of the TPACK model, and only limited pre-service science teachers' self-assessment of their DL. [32] translated the original well-established instrument to measure the status of DL among PST. The instrument of [25] was also established by translating the original questionnaire, it paid attention to children with some disabilities, such as children with hearing, vision and cognitive impairments, but it does not refer to IE.

Existing instruments either only measure PST subjective cognitions of DL, or only partly involve DL capabilities, or do not involve IE, so it is easy to conclude from a brief review of the literature related to this research field, there is a strong need to develop a measure of DL among PST in IE.

3. Theoretical Foundation

With widespread digitization, many educational institutions and sectors have carried out studies on integrating digital technologies in education [33,34,35]. And in particular, regarding what digital skills and knowledge teachers need in today's digital age, many different writers, organizations, and institutions have come up with various definitions for specific criteria [36]. Among the many standards, the DigCompEdu stands out as an internationalized framework. The Joint Research Centre of the European Union released DigCompEdu in late 2017 [37]. As a reference framework, DigCompEdu provides an integrated vernacular and standpoint for crucial areas of digital competition throughout the European Union. In addition, it is an overview of local, national, European, and global research projects [37]. It is intended as an instrument for assessing and enhancing citizens' digital competence. Designed to aid in the formation of educational and economic policies that promote the growth of digital competencies and engaged citizenship. Additionally, the framework is descriptive rather than prescriptive, emphasizing the significance of all competencies, making it open to adaptation to specific goals and circumstances [38]. Furthermore, the inclusive strategy of DigComEdu is noteworthy because it alludes to the necessity of incorporating practices that are responsive to all learners [39]. what's more, according to [40] European Education and Culture Executive Agency & Eurydice (2019), most education systems emphasize all five facets of DL: information and data literacy (IDL), communication and collaboration literacy(CCL), digital content creation literacy(DCCL), problem solving literacy(PSL), and digital safety literacy (DSL). IDL deals with three main steps in dealing with data, information, and digital content, the first being browsing, searching, and filtering; the second being evaluating, and the last being managing [40]. CCL encompasses six digital skills: online etiquette, managing digital persona, utilizing digital tools for sharing, engaging in digital citizenship, and collaborating via digital platforms [40]. The quartet of proficients of DCCL relates to crafting digital content comprises generating digital materials, incorporating and refining digital resources, understanding copyright and licenses, and coding [40]. Addressing issues, recognizing requirements and solutions, innovatively harnessing technologies, and pinpointing gaps in digital proficiency constitute the four competencies of PSL [40]. DSL has been construed as safeguarding devices, ensuring the security of personal data and privacy, upholding health and welfare, and preserving the environment [40]. This study will build on that theory to construct the dimensions of the instrument in the context of IE.

The Universal Design for Learning (UDL) framework was developed in the 1990s by researchers at the Centre for Applied Special Technologies in the USA [41]. The UDL framework requires consideration of each learner in terms of curriculum design, resources, teaching methods, and environment [42], the UDL framework's fundamental principles include the following: A variety of different ways of engaging with learning are offered to stimulate interest in learning for all students; It is necessary to present the subject matter and material in a number of different formats to make it more understandable and approachable for the class as a whole; To adopt a variety of approaches and communication methods to enable students to express themselves fluently [43]. Hence, the UDL principles are applied to IE.

4. Methodology

The instrument development was carried out systematically, including three stages: the items' development, content validity, and evaluation of the pilot study. The instrument development process is shown in Fig.1. Content validity refers to the extent to which an instrument's items are pertinent and reflective of the aimed construct for specific evaluation purposes [44], which can be accomplished by using the results of a panel of experts who are from the domain being studied. The Content Validity Index (CVI) created by [45] is used to judge the content validity of this study. Based on [46], there were four main steps in the process of content validity in research: (a) Prepare evaluation form; (b) Identify experts; (c) Score each item by expert during evaluation; (d) Calculate the CVI. The expert rating form is partially shown in Fig.2. After obtaining the content validity of the instrument, the pilot study needs to be done to form a more stable instrument and achieve the research objectives, which can be continued using Exploratory Factor

Analysis (EFA) and Confirmatory Factor Analysis (CFA) methods to determine the validity and reliability of the instrument. The participants were PST involved in IE at a public university in Kuala Lumpur, Malaysia. Researchers employed a method of random sampling when selecting 179 participants. To avoid test bias, ten incomplete and invalid questionnaires were removed, resulting in 169 valid questionnaires being returned.

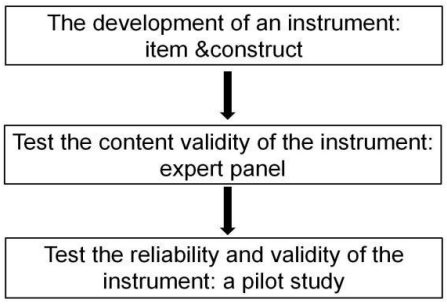
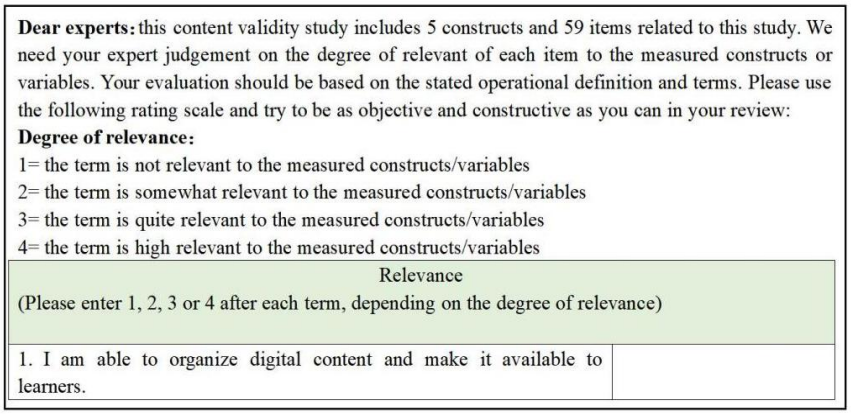


Fig.1. Diagram of the study' s procedure



Dear experts: this content validity study includes 5 constructs and 59 items related to this study. We need your expert judgement on the degree of relevant of each item to the measured constructs or variables. Your evaluation should be based on the stated operational definition and terms. Please use the following rating scale and try to be as objective and constructive as you can in your review:

Degree of relevance:

1= the term is not relevant to the measured constructs/variables
2= the term is somewhat relevant to the measured constructs/variables
3= the term is quite relevant to the measured constructs/variables
4= the term is high relevant to the measured constructs/variables

	Relevance (Please enter 1, 2, 3 or 4 after each term, depending on the degree of relevance)
1. I am able to organize digital content and make it available to learners.	

Fig.2. Screenshot of expert assessment form

The research design of this study was quantitative in nature and data was collected through the distribution of questionnaires, hence the need to ensure the validity of the data. If study participants respond to all survey questions in one session, the validity of the results may be susceptible to the impact of Common Method Variance (CMV) [47]. [48] hypothesized that the core concept behind this assessment is that CMV becomes apparent when either a) a solitary factor is present and captures all the extracted variances, or b) the predominant portion of covariance among the measurements can be attributed to a single factor. In cases where the total variance explained by a sole factor falls below the 50% threshold, it indicates that CMV does not exert an influence on your data [48]. The data was tested and the overall correlation was interpreted as 31.18% (less than 50%), which ensures the quality of the data collected and more credibility in the results of the data analysis.

5. Results

This section presents the results of the study across the following three domains: development of the initial instrument items and constructs, and analysis of the initial instrument's content validity, analysis of the target instrument' s reliability and validity.

5.1 The development of an initial instrument

The theoretical basis of this instrument is the DigCompEdu. The instrument, which was used to measure DL of PST in Malaysia employed a five-point Likert scale involving five constructs (information and data literacy in inclusive classroom(IDLIC), communication and collaboration in inclusive classroom(CCLIC), digital content creation literacy in inclusive classroom(DCCLIC), problem solving literacy in inclusive classroom(PSLIC), digital safety literacy in inclusive classroom(DSLIC)) and 59 items, each of which was scored from 1 (strongly disagree) to 5 (strongly agree). Details of the constructs and items are shown in Table 1.

Table 1. Details of the constructs and items

Constructs	Item	No. of Items
IDLIC	1-19	19
CCLIC	20-35	16
DCCLIC	36-44	9
PSLIC	45-54	10
DSLIC	55-59	5

The instrument was made available in both English and Malay in order to eliminate problems in the understanding among the respondents. The original instrument, after translation by the researchers, was examined and assessed by relevant language experts to ensure the quality of the translation while eliminating inconsistencies in meaning.

5.2 Content validity

Prior to testing, an initial discussion on the relevance of each item of the instrument in the form of an expert symposium was conducted, and some items were modified and removed. The choosing of domain-specific specialists must be based on criteria like expert knowledge, specialized training, or relevant professional experience [49]. Afterwards, three experts(two IE experts and one instructional technology expert) were selected to assess the content validity of the instrument, which was in line with the requirement as a minimum of two experts was sufficient as suggested by [50]. Then, the calculation method of Item-Content Validity Index (ICVI) and Scale-Content Validity Index (SCVI) based on [46,51] was adopted to calculate CVI in this study. Before the CVI could be calculated, the scores given by the experts needed to be reassigned, replacing 3 and 4 with 1 and 0 for scores 1 and 2 [46]. When CVI = 1, the item is acceptable; ICVI < 1, the item will need to be adjusted or simply deleted [46,51]. SCVI value minimum is 0.80; when SCVI≧0.90, the instrument is excellent. After calculating, ICVI and SCVI for the instrument were equal to 1, which indicated that there was no problem with the instrument's content validity.

5.3 Reliability of the initial instrument

Reliability is an evaluation of the consistency of multiple measurements of an attribute [52]. Cronbach Alpha value of 0.7 and above is satisfactory [53]. It is considered acceptable when it is between 0.60 and 0.80 [54]. In addition, according to [34], the it should be higher than 0.7. This study used SPSS software to analyze the reliability of the constructs of the instrument. The reliability values of IDLIC, CCLIC, DCCLIC, PSLIC, DSLIC were 0.919, 0.904, 0.856, 0.899, 0.829, respectively. The Cronbach Alpha score of the entire instrument was 0.96. The results demonstrate that the instrument as a whole and its five constructs have achieved an adequate degree of dependability.

5.4 Validity

EFA is a procedure that can be executed in SPSS software for validating the scales of instrument items [55]. Therefore, using IBM SPSS 26.0, the researchers did EFA via principal component analysis with the varimax rotation. Before conducting the EFA, the results of the two-variate correlation matrix should be analyzed for each item [56]. And [57] recommended the removal of one item from a pair when their bi-variate correlation ratings exceeded 0.80. After testing, the correlation of both items for the instruments in this study did not exceed 0.8. Meanwhile, [55] proposed to eliminate all items with communalities below 0.2. The communalities values in this instrument are all above 0.2, so there is no need to delete items either. Based on [58], when the sample size is below 300, the mean communality of the preserved elements must be determined, for studies with sample sizes between one hundred and two hundred, a mean 0.5 ~ 0.6 is appropriate; for studies with sample sizes smaller than 100, a mean of 0.6 or higher is acceptable. The number of respondents to this study was 169 and the mean communality was 0.501, which is also in line with the criteria. And the EFA results showed Bartlett's test of Sphericity of the tool was significant ($p<0.05$), and the Kaiser-Meyer-Okin value was 0.865(> 0.60). These values demonstrate that sample size was adequate and that factor analysis is allowed to continue [59, 60]. According to [55], The percentage of the total variance explained by the retained factors is at minimum 50%. This study also met this requirement. the total variance explained is 50.081% when five factors are extracted.

[61] highlighted 0.50 or greater as a reasonable for the lowest loading of an item. A construct with lesser than three elements is typically feeble and unreliable [62]. Therefore, this study chose to run EFA with factor loading less than 0.5 not displayed. [55] proposed a minimum of three non-cross-loading items per factor with an acceptable loading score. If there are problematic items (low loading, cross loading or standalone items), deleting and rerunning the analysis can solve the problem [62]. Those items with issues should be deleted one by one until all conditions are satisfied. The results after the first rotation are shown in Table 2. It is a need to delete some items that do not belong to any factor in turn, such as IDL2, IDL9, IDL10, etc.

Table 2. The rotated factor matrix after the first rotation

Item	Component				
	1	2	3	4	5
IDL1	0.655				
IDL2					
IDL3	0.669				
IDL4	0.593				
IDL5	0.664				
IDL6	0.570				
IDL7	0.756				
IDL8	0.586				
IDL9					
IDL10					
IDL11	0.572				
IDL12	0.600				
IDL13					
IDL14	0.549				
IDL15					
IDL16					
IDL17					
IDL18					
IDL19			0.546		
CCL1					0.638
CCL2					0.636
CCL3					0.517
CCL4					0.557
CCL5					0.657
CCL6					0.502
CCL7					
CCL8					0.701
CCL9					0.676
CCL10					
CCL11					
CCL12				0.595	
CCL13				0.647	
CCL14				0.551	
CCL15					
CCL16					
DCCL1			0.539		
DCCL2			0.665		
DCCL3			0.768		
DCCL4			0.548		
DCCL5			0.610		
DCCL6				0.540	
DCCL7				0.526	
DCCL8				0.621	
DCCL9				0.538	
PSL1		0.510			
PSL2		0.519			
PSL3		0.581			
PSL4		0.523			
PSL5		0.574			
PSL6		0.667			
PSL7		0.569			
PSL8		0.642			
PSL9		0.517			
PSL10		0.617			
DSL1		0.602			
DSL2		0.556			
DSL3		0.690			
DSL4		0.759			
DSL5		0.662			

After sixteen rotations, all items are attributed to a specific construct, and there are no cross-factor items. The factors were renamed (IDLIC, PSLIC, DCCLIC, CCLIC, DSLIC) according to the original dimensions of the instrument(Table 3).

Table 3. The rotated factor matrix after sixteen rotations

	Component				
	IDLIC	**PSLIC**	**DCCLIC**	**CCLIC**	**DSLIC**
IDL1	0.652				
IDL3	0.679				
IDL4	0.638				
IDL5	0.711				
IDL6	0.562				
IDL7	0.738				
IDL9	0.582				
IDL10	0.534				
IDL11	0.568				
IDL12	0.612				
IDL14	0.553				
CCL1				0.737	
CCL2				0.694	
CCL3				0.637	
CCL4				0.604	
CCL5				0.679	
CCL8				0.638	
CCL9				0.641	
CCL16			0.552		
DCCL1			0.580		
DCCL2			0.716		
DCCL3			0.796		
DCCL4			0.646		
DCCL5			0.691		
DCCL7			0.569		
DCCL8		0.587			
DCCL9		0.526			
PSL1		0.690			
PSL2		0.731			
PSL3		0.602			
PSL4		0.584			
PSL5		0.714			
PSL6					0.518
PSL8		0.587			
PSL10		0.523			
DSL1					0.653
DSL2					0.656
DSL3					0.789
DSL4					0.745
DSL5					0.661

From Table 3, we need to assign CCL16 to the construct DCCLIC, DCCL8, and DCCL9 need to be assigned to the construct PSLIC, and PSL6 belongs to the construct DSLIC. And these remaining 40 items had satisfactory factor loading (> 0.50). The percentage of the total variance explained by the retained factors is 54.40%, which is still acceptable. Therefore, these items were crucial and related to the instrument's construct, which could be employed to assess DL among PST in IE.

To assess construct validity, factor analysis was conducted in this study, which includes EFA and CFA, CFA undertakes EFA to further verify the validity of the instrument. This study uses AMOS v26 software to do CFA. The researchers evaluated the CFA using several models of fit indices, including the Chi-Square Test of Model Fit value(< 3) [63], CFI (Comparative Fit Index) value(>0.9) [64], RMSEA (Root Mean Square Error of Approximation) value (<0.08) [65], GFI (Goodness of Fit Index) value (>0.8) [66]. After removing some items, the CFA results of this instrument are shown in Fig.3: ChiSq/df=1.578(<3), GFI=0.824(>0.8), CFI=0.902(>0.9), RMSEA=0.059(<0.08). The results imply that the instrument's model demonstrated a favorable fit, signifying that the theoretical framework corresponds with the empirical observations.

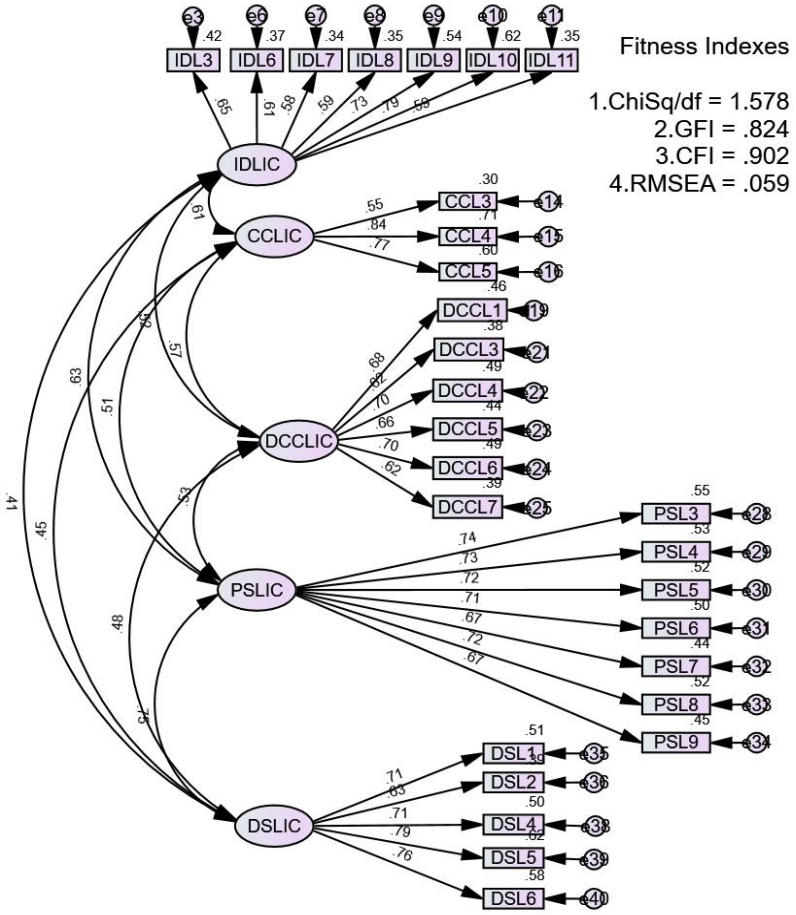


Fig.3. Results of the confirmatory factor analysis

Table 4. Factor loading, AVE, CR, Cronbach Alpha value after CFA

Construct	Item	Factor loading	No. of Items	AVE	CR	Cronbach Alpha value
IDLIC	1	0.647	7	0.427	0.837	0.835
	2	0.612				
	3	0.583				
	4	0.590				
	5	0.732				
	6	0.790				
	7	0.587				
CCLIC	8	0.550	3	0.537	0.772	0.755
	9	0.842				
	10	0.774				
DCCLIC	11	0.681	6	0.442	0.826	0.823
	12	0.619				
	13	0.699				
	14	0.661				
	15	0.702				
	16	0.624				
PSLIC	17	0.745	7	0.502	0.876	0.875
	18	0.727				
	19	0.720				
	20	0.711				
	21	0.665				
	22	0.719				
	23	0.671				
DSLIC	24	0.713	5	0.520	0.844	0.843
	25	0.628				
	26	0.708				
	27	0.788				
	28	0.759				

Convergent validity evaluates the agreement level among various indicators of the same construct. To establish convergent validity, it's necessary to compute the factor loading of items, Composite Reliability (CR), and Average Variance Extracted (AVE) [67]. In this investigation, CR and AVE were calculated for the derived factors to assess the convergent validity of the instrument. The results of composite reliability for each construct revealed that all five elements exceeded the recommended minimum reliability threshold of 0.70, as advocated by [68]. To further assess convergent validity, AVE was examined for each factor. Although Table 8 indicated that the AVE for two of the five components fell below the suggested threshold of 0.50, it was noteworthy that if the CR of these factors was above 0.7, a slightly lower AVE, as outlined by [68], can still be acceptable. Hence, the domains of the instrument and the associated items remained unchanged. After CFA, the factor loading of each item was higher than 0.5, the reliability value of each construct was still excellent (see Table 4), and the whole instrument' s Cronbach alpha value was 0.922, which shows that the instrument is reliable and effective.

6. Discussion

This research provides a tool that may evaluate the degree of DL of PST in IE, based on the theoretical foundations of DigCompEdu and the UDL framework. The instrument consists of five constructs and 59 items that address five dimensions that measure the level of DL. The emphasis on engaging all students in IE makes it imperative to change traditional mindsets and practices in innovative and accessible ways to equalize and include education [69]. In the context of education, DL is described as the skills and knowledge that teachers need to carry out their pedagogical practices [6]. The instrument has been designed with care to emphasize the pre-service teacher's focus on all students, assessing their literacy in terms of skills, knowledge, and pedagogy, which is consistent with the literature mentioned above. Although literature exists on tools to evaluate DL of PST [8], but little research has focused on PST of IE. Besides, the fundamental truth is that the majority of the methods used to gauge competence still need more efficiency, which is because the equipment that was used to obtain the measurements needs to meet the requirements to be considered accurate [70]. This study is plausible and feasible for developing an instrument for PST of IE.

As a way to guarantee the integrity of the survey used in the study, content validity was checked. The content validity of this instrument is excellent, and it can pinpoint the problem areas of the instrument, reduce the burden of comprehension on the respondent, and decrease the measurement error of the instrument. [54] mentioned that the coefficient's reliability increases as it approaches the value of 1.00. The Cronbach Alpha value is above 0.9 for the entire instrument and a reliability value of 0.7 or more for each dimension. These outcomes proved that the measurement tool was valid and that all items matched within the instrument. These results bolster the theory that the instrument has an outstanding level of internal reliability. EFA may assess the sufficiency of the number of items that adequately explain an analyzed construct [71]. After determining the five dimensions of the instrument through EFA in this study, CFA was conducted after EFA and validated the proposed model identified during the EFA stage. CFA is commonly performed subsequent to establishing the correlation matrix or factor structure. It entails testing a theory and conjecture concerning the specified factor structure. In this investigation, multiple frequently employed goodness-of-fit models were scrutinized, taking into account established criteria. In short, regarding the data examined in this research, evaluations of the instrument's reliability in terms of internal consistency, as well as its content validity and construct validity, all exceed acknowledged benchmarks.

7. Conclusion

DL is a prospective competency for the professional development of instructors in e-learning settings confronted by the worldwide market [72]. In response to the continuing international calls for a strengthened approach to inclusive policies within education systems, there is a real need for PST to clarify and even grow their DL in this area to help them meet the challenges of dealing with diverse learners. Although some scholars have developed instruments to assess the DL of PST, few instruments measure the DL level in IE. This study developed and validated a tool to assess DL among PST involved in IE based on the internationalization framework DigCompEdu. The reliability and validity of the items in this instrument were determined when the instrument was administered to PST who have had exposure to digital technologies and inclusive pedagogies during their pre-service training. The source of our data is this group, and CMV's screening guarantees the quality of the data. These data were then statistically analyzed for content and construct validity, and the results show that the 5-dimensional, 28-item instrument is valid and reliable. The results of this research will fill a research gap while promoting the development of teacher education. In future studies, further sample size expansion is needed. The instrument can also be extensively implemented for in-service teachers, and subsequent studies will deepen research in this area.

Acknowledgements

This research is supported by the Ministry of Higher Education, Name of Grant: Fundamental Research Grant (FRGS), Project Code: FRGS/1/2021/SSI0/UM/02/7.

References

[1] Brugia, M., & Zukersteinova, A. 2019. Continuing Vocational Training in EU Enterprises. Publications Office of the European Union.

[2] Hassan, M. M., & Mirza, T. 2021. The Digital Literacy in Teachers of the Schools of Rajouri (J&K)-India: Teachers Perspective. International Journal of Education and Management Engineering, 11(1), pp. 28-40.

[3] Ilina, I., Grigoryeva, Z., Kokorev, A., Ibrayeva, L., & Bizhanova, K. 2019. Digital Literacy of the Teacher as a Basis for the Creation of a Unified Information Educational Space. International Journal of Civil Engineering and Technology, 10(1), pp. 1686-1693.

[4] Li, M., & Yu, Z. 2022. Teachers' Satisfaction, Role, and Digital Literacy During the COVID-19 Pandemic. Sustainability, 14(3), p. 1121. https://doi.org/10.3390/su14031121

[5] Rapanta, C., Botturi, L., Goodyear, P., Guàrdia, L., & Koole, M. 2020. Online University Teaching During and After the Covid-19 Crisis: Refocusing teacher presence and learning activity. Postdigital science and education, 2, pp. 923-945. https://doi.org/10.1007/s42438-020-00155-y

[6] Martin, A., & Grudziecki, J. 2006. Dig Eu Lit: Concepts and Tools for Digital Literacy Development. Innovation in teaching and learning in information and computer sciences, 5(4), pp. 249-267. https://doi.org/10.11120/ital.2006.05040249

[7] Corona, A. G.-F., Martínez-Abad, F., & Rodríguez-Conde, M.-J. 2017. Evaluation of Digital Competence in Teacher Training. 20. pp, 1-5. Proceedings of the 5th International Conference on Technological Ecosystems for Enhancing Multiculturality. https://doi.org/10.1145/3144826.3145367

[8] Cabero Almenara, J., Barroso Osuna, J. M., Gutiérrez Castillo, J. J., & Palacios-Rodríguez, A. d. P. 2020. Validación del Cuestionario de Competencia Digital para Futuros Maestros Mediante Ecuaciones Estructurales. SOCIEDAD ESPAÑOLA DE PEDAGOGÍA. 72 (2), PP. 45-63. https://doi.org/10.13042/Bordon.2020.73436

[9] Cretu, D. M., & Morandau, F. 2020. Initial teacher education for inclusive education: A bibliometric analysis of educational research. Sustainability, 12(12), p. 4923. https://doi.org/10.3390/su12124923

[10] Medina-García, M., Higueras-Rodríguez, L., García-Vita, M. d. M., & Doña-Toledo, L. 2021. ICT, Disability, and Motivation: Validation of a Measurement Scale and Consequence Model for Inclusive Digital Knowledge. International Journal of Environmental Research and Public Health, 18(13), p. 6770. https://doi.org/10.3390/ijerph18136770

[11] DeWitt, D., Alias, N., Ibrahim, Z., Shing, N. K., & Rashid, S. M. M. 2015. Design of a Learning Module for the Deaf in a Higher Education Institution Using Padlet. Procedia-Social and Behavioral Sciences, 176, pp. 220-226. https://doi.org/10.1016/j.sbspro.2015.01.464

[12] McGarr, O., & McDonagh, A. 2021. Exploring the Digital Competence of Pre-service Teachers on Entry onto an Initial Teacher Education Programme in Ireland. Irish Educational Studies, 40(1), pp. 115-128. https://doi.org/10.1080/03323315.2020.1800501

[13] Reisoğlu, İ., & Çebi, A. 2020. How Can the Digital Competences of Pre-service Teachers be Developed? Examining a Case Study through the Lens of DigComp and DigCompEdu. Computers & Education, 156, p. 103940. https://doi.org/10.1016/j.compedu.2020.103940

[14] Varela-Ordorica, S. A., & Valenzuela-González, J. R. 2020. Use of Information and ommunication Technologies as a Transversal Competence in Teacher Training. Revista Electrónica Educare, 24(1), pp. 172-191. https://doi.org/10.15359/ree.24-1.10

[15] Walton, E., & Rusznyak, L. 2020. Cumulative Knowledge-Building for Inclusive Education in Initial Teacher Education. European Journal of Teacher Education, 43(1), pp. 18-37. https://doi.org/10.1080/02619768.2019.1686480

[16] Stavroulia, K. E., Christofi, M., Baka, E., Michael-Grigoriou, D., Magnenat-Thalmann, N., & Lanitis, A. 2019. Assessing the Emotional Impact of Virtual Reality-based Teacher Training. The International Journal of Information and Learning Technology. 36(3), pp. 192-217. https://doi.org/10.1108/IJILT-11-2018-0127

[17] Tveiterås, N. C., & Madsen, S. S. 2022. From Tools to Complexity?—A Systematic Literature Analysis of Digital Competence Among Pre-service Teachers in Norway. Digital Literacy for Teachers, pp. 345-389. https://doi.org/10.1007/978-981-19-1738-7_18

[18] Falloon, G. 2020. From digital literacy to digital competence: the teacher digital competency (TDC) framework. Educational Technology Research and Development, 68(5), pp. 2449-2472. https://doi.org/ 10.1007/s11423-020-09767-4

[19] De León, L., Corbeil, R., & Corbeil, M. E. 2023. The development and validation of a teacher education digital literacy and digital pedagogy evaluation. Journal of Research on Technology in Education, 55(3), pp. 477-489. https://doi.org/10.1080/15391523.2021.1974988

[20] Magassa, L. 2020. " I am not computer savvy": A look into the everyday digital literacy levels of formerly incarcerated people using a novel holistic digital literacy framework. University of Washington.

[21] Lazonder, A. W., Walraven, A., Gijlers, H., & Janssen, N. 2020. Longitudinal assessment of digital literacy in children: Findings from a large Dutch single-school study. Computers & Education, 143, p. 103681. https://doi.org/10.1016/j.compedu.2019.103681

[22] García-Vandewalle García, J. M., García-Carmona, M., Trujillo Torres, J. M., & Moya Fernández, P. 2021. Analysis of digital competence of educators (DigCompEdu) in teacher trainees: the context of Melilla, Spain. Technology, Knowledge and Learning, pp. 1-28. https://doi.org/10.1007/s10758-021-09546-x

[23] Lázaro-Cantabrana, J., Usart-Rodríguez, M., & Gisbert-Cervera, M. 2019. Assessing teacher digital competence: The construction of an instrument for measuring the knowledge of pre-service teachers. Journal of New Approaches in Educational Research (NAER Journal), 8(1), pp. 73-78. https://doi.org/ 10.7821/naer.2019.1.370

[24] Miguel-Revilla, D., Martínez-Ferreira, J. M., & Sánchez-Agustí, M. 2020. Assessing the digital competence of educators in social studies: An analysis in initial teacher training using the TPACK-21 model. Australasian Journal of Educational Technology, 36(2), pp. 1-12. https://doi.org/10.14742/ajet.5281

[25] Masalimova, A. R., Erdyneeva, K. G., Kislyakov, A. S., Sizova, Z. M., Kalashnikova, E., & Khairullina, E. R. 2022. Validation of the Scale on Pre-Service Teachers' Digital Competence to Assist Students with Functional Diversity. Contemporary Educational Technology, 14(4). https://doi.org/10.30935/cedtech/12301
[26] Brazal, I. K., Monje, P. M. M., & Urrutxi, L. D. 2022. Teachers' digital competence and inclusive education at school: An analysis of teacher attitudes. https://doi.org/10.18844/cjes.v17i9.7031
[27] Hidayat, M. L., Astuti, D. S., Sumintono, B., Meccawy, M., & Khanzada, T. J. 2023. Digital Competency Mapping Dataset of Pre-service Teachers in Indonesia. Data in Brief, p. 109310. https://doi.org/ 10.1016/j.dib.2023.109310
[28] Rodríguez-García, A.-M., Cardoso-Pulido, M.-J., De la Cruz-Campos, J.-C., & Martínez-Heredia, N. 2022. Communicating and Collaborating with Others through Digital Competence: A Self-Perception Study Based on Teacher Trainees' Gender. Education Sciences, 12(8), p. 534. https://doi.org/10.3390/educsci12080534
[29] Luik, P., Taimalu, M., & Suviste, R. 2018. Perceptions of technological, pedagogical and content knowledge (TPACK) among pre-service teachers in Estonia. Education and Information Technologies, 23, pp. 741-755. https://doi.org/10.1007/s10639-017-9633-y
[30] Deng, G., & Zhang, J. 2023. Technological pedagogical content ethical knowledge (TPCEK): The development of an assessment instrument for pre-service teachers. Computers & Education, 197, p. 104740. https://doi.org/10.1016/j.compedu.2023.104740
[31] Kotzebue, L. v., Meier, M., Finger, A., Kremser, E., Huwer, J., Thoms, L.-J., Becker, S., Bruckermann, T., & Thyssen, C. 2021. The framework DiKoLAN (Digital competencies for teaching in science education) as basis for the self-assessment tool DiKoLAN-Grid. Education Sciences, 11(12), p. 775. https://doi.org/10.3390/educsci11120775
[32] Bitemirova, S., Zholdasbekova, S., Mussakulov, K., Anesova, A., & Zhanbirshiyev, S. 2023. Pre-service TVET Teachers' Digital Competence: Evidence from Survey Data. TEM Journal, 12(2). https://doi.org/10.18421/TEM122-64
[33] Cattaneo, A. A., Antonietti, C., & Rauseo, M. 2022. How Digitalised Are Vocational Teachers? Assessing Digital Competence in Vocational Education and Looking at its Underlying Factors. Computers & Education, 176, p. 104358. https://doi.org/10.1016/j.compedu.2021.104358
[34] Su, J., & Yang, W. 2022. Artificial Intelligence in Early Childhood Education: A Scoping Review. Computers and Education: Artificial Intelligence, p. 100049. https://doi.org/10.1016/j.caeai.2022.100049
[35] Viberg, O., Grönlund, Å., & Andersson, A. 2023. Integrating Digital Technology in Mathematics Education: a Swedish Case Study. Interactive Learning Environments, 31(1), pp. 232-243. https://doi.org/10.1080/10494820.2020.1770801
[36] García-Valcárcel Muñoz-Repiso, A., Casillas Martín, S., & Basilotta Gómez-Pablos, V. M. 2020. Validation of an Indicator Model (INCODIES) for Assessing Student Digital Competence in Basic Education. https://doi.org/10.7821/naer.2020.1.459
[37] Redecker, C., & Punie, Y. 2017. Digital Competence of Educators. Joint Research Centre-JRC: Luxembourg, p. 95. https://doi.org/10.2760/159770
[38] Cabero-Almenara, J., Romero-Tena, R., & Palacios-Rodríguez, A. 2020. Evaluation of Teacher Digital Competence Frameworks through Expert Judgement: The Use of the Expert Competence Coefficient. Journal of New Approaches in Educational Research (NAER Journal), 9(2), pp. 275-293. https://doi.org/10.7821/naer.2020.7.578
[39] Brazal, I. K., Monje, P. M. M., & Urrutxi, L. D. 2022. Teachers' Digital Competence and Inclusive Education at School: An Analysis of Teacher Attitudes.s. Cypriot Journal of Educational Science. 17(9), pp. 3314-3326. https://doi.org/10.18844/cjes.v17i9.7031
[40] European Commission/EACEA/Eurydice. 2019. Digital Education at School in Europe. Eurydice Report. Luxembourg: Publications Office of the European Union.
[41] Griful-Freixenet, J., Struyven, K., & Vantieghem, W. 2021. Exploring Pre-service Teachers' Beliefs and Practices about Two Inclusive Frameworks: Universal Design for Learning and Differentiated Instruction. Teaching and Teacher Education, 107, p. 103503. https://doi.org/10.1016/j.tate.2021.103503
[42] Rose, D. H., & Meyer, A. 2002. Teaching Every Student in the Digital Age: Universal Design for Learning. Association for Supervision and Curriculum Development, 1703 N. Beauregard St., Alexandria, VA 22311-1714 (Product no. 101042: $22.95 ASCD members; $26.95 nonmembers).
[43] Rao, K., & Meo, G. (2016). Using Universal Design for Learning to Design Standards-based Lessons. Sage Open, 6(4), pp. 1-12.https://doi.org/10.1177/2158244016680688
[44] Haynes, S. N., Richard, D., & Kubany, E. S. 1995. Content Validity in Psychological Assessment: A Functional Approach to Concepts and Methods. Psychological assessment, 7(3), p. 238. https://doi.org/10.1037/1040-3590.7.3.238
[45] Waltz, C. F., & Bausell, B. R. 1981. Nursing Research: Design Statistics and Computer Analysis. Davis Fa.
[46] Yusoff, M. S. B. 2019. ABC of Content Validation and Content Validity Index Calculation. Education in Medicine Journal, 11(2), pp. 49-54. https://doi.org/10.21315/eimj2019.11.2.6
[47] Burton-Jones, A. 2009. Minimizing method bias through programmatic research. MIS quarterly, pp. 445-471. https://doi.org/10.2307/20650304
[48] Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. 2003. Common method biases in behavioral research: a critical review of the literature and recommended remedies. Journal of applied psychology, 88(5), p. 879. https://doi.org/10.1037/0021-9010.88.5.879
[49] Baharuddin, M. F., Masrek, M. N., & Shuhidan, S. M. 2020. Content Validity of Assessment Instrument for Innovative Work Behaviour of Malaysian School Teachers. International Journal of Scientific and Technology Research, 9(4), pp. 1940-1946.
[50] Lynn, M. R. 1986. Determination and Quantification of Content Validity. Nursing Research, 35(6), pp. 382-386. https://doi.org/10.1097/00006199-198611000-00017
[51] Polit, D. F., Beck, C. T., & Owen, S. V. 2007. Is the CVI an Acceptable Indicator of Content Validity? Appraisal and Recommendations. Research in nursing & health, 30(4), pp. 459-467. https://doi.org/10.1002/nur.20199
[52] Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. 2019. When to Use and How to Report the Results of PLS-SEM. European business review, 31(1), pp. 2-24. https://doi.org/10.1108/EBR-11-2018-0203
[53] Coolican, H. 2018. Research Methods and Statistics in Psychology. Routledge.
[54] Sekaran, U., & Bougie, R. 2016. Research Methods for Business: A Skill Building Approach. john wiley & sons.

[55] Samuels, P. 2017. Advice on Exploratory Factor Analysis. URL: https://www.researchgate.net/publication/319165677_Advice_on_Exploratory_Factor_Analysis
[56] Rockwell, R. C. 1975. Assessment of Multicollinearity: The Haitovsky Test of the Determinant. Sociological Methods & Research, 3(3), pp. 308-320. https://doi.org/10.1177/004912417500300304
[57] Field, A. 2013. Discovering Statistics Using IBM SPSS Statistics. sage.
[58] MacCallum, R. C., Widaman, K. F., Zhang, S., & Hong, S. 1999. Sample Size in Factor Analysis. Psychological methods, 4(1), p. 84. https://doi.org/10.1037/1082-989X.4.1.84
[59] Ehido, A., Awang, Z., Halim, B. A., & Ibeabuchi, C. 2020. Establishing Valid and Reliable Measures for Organizational Commitment and Job Performance: An Exploratory Factor Analysis. International Journal of Social Sciences Perspectives, 7(2), pp. 58-70. https://doi.org/10.33094/7.2017.2020.72.58.70
[60] Muda, H., Baba, Z. S., Awang, Z., Badrul, N. S., Loganathan, N., & Ali, M. H. 2020. Expert Review and Pretesting of Behavioral Supervision in Higher Education. Journal of Applied Research in Higher Education, 12(4), pp. 767-785. https://doi.org/10.1108/JARHE-02-2019-0029
[61] Brugia, M., & Zukersteinova, A. 2019. Continuing Vocational Training in EU Enterprises. Publications Office of the European Union. https://doi.org/10, 704583.
[62] Costello, A. B., & Osborne, J. 2005. Best Practices in Exploratory Factor Analysis: Four Recommendations for Getting the Most from Your Analysis. Practical assessment, research, and evaluation, 10(1), p. 7. https://doi.org/10.7275/jyj1-4868
[63] Bentler, P. M., & Bonett, D. G. 1980. Significance tests and goodness of fit in the analysis of covariance structures. Psychological bulletin, 88(3), p. 588. https://doi.org/10.1037/0033-2909.88.3.588
[64] Hu, L. t., & Bentler, P. M. 1999. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural equation modeling: a multidisciplinary journal, 6(1), pp. 1-55. https://doi.org/10.1080/10705519909540118
[65] MacCallum, R. C., Browne, M. W., & Sugawara, H. M. 1996. Power analysis and determination of sample size for covariance structure modeling. Psychological methods, 1(2), p. 130. https://doi.org/10.1037/1082-989X.1.2.130
[66] Seyal, A. H., Rahman, M. N. A., & Rahim, M. M. (2002). Determinants of academic use of the Internet: a structural equation model. Behaviour & Information Technology, 21(1), pp. 71-86. https://doi.org/10.1080/01449290210123354
[67] Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. 2021. A primer on partial least squares structural equation modeling (PLS-SEM). Sage publications.
[68] Fornell, C., & Larcker, D. F. 1981. Evaluating structural equation models with unobservable variables and measurement error. Journal of marketing research, 18(1), pp. 39-50. https://doi.org/10.1177/002224378101800104
[69] Messiou, K. 2017. Research in the Field of Inclusive Education: Time for a Rethink? International journal ofinclusive education, 21(2), pp. 146-159. https://doi.org/10.1080/13603116.2016.1223184
[70] Wesnawa, I. G. A., Kartowagiran, B., Jaedun, A., Hamdi, S., Hadi, S., Susantini, E., Sunendar, D., Laliyo, L. A. R., Christiawan, P. I., & Gede, D. 2022. Content Validation of Digital Instrument for Measurement of Pedagogic Competence for Social Science Teacher Candidates in the Industrial Revolution 4.0 Era in Indonesia. International Journal of Information and Education Technology, 12(12). https://doi.org/10.18178/ijiet.2022.12.12.1767
[71] Zainol, M. S., Hamzah, M. I. M., & Alias, B. S. 2022. Validity and Reliability of Principal Authentic Leadership Instrument. Journal of Pharmaceutical Negative Results, pp. 4232-4248. https://doi.org/10.47750/pnr.2022.13.S07.530
[72] Jenson, J., Tomin, B., & Terzopoulos, T. 2018. Making Space for Innovation: Teacher Perspectives on a Wearable Technology Curriculum. ICERI2018 Proceedings. https://doi.org/10.21125/iceri.2018.1979.

Authors' Profiles

Wu Miaomiao is a PhD candidate at the Curriculum and Instructional Technology Department, Faculty of Education, Universiti Malaya. She is interested in research areas including digital technologies, new pedagogies, and inclusive education.

Dorothy De Witt is currently a Research Fellow at the Faculty of Education, Universiti Malaya. She is a retired Associate Professor at the Curriculum and Instructional Technology Department, Faculty of Education, Universiti Malaya. Her research interests are in digital technologies and new pedagogies for learning.

Nor Nazrina Mohamad Nazry, PhD, is a Senior Lecturer at the Curriculum and Instructional Technology Department, Faculty of Education, Universiti Malaya. Her research interests are serious games, virtual reality, and ICT in education.

Norlidah Alias, PhD, is a Associate Professor at the Curriculum and Instructional Technology Department, Faculty of Education, Universiti Malaya. Her research interests are in curriculum development and technical vocational education and training.

Lee Leh Hong, PhD, is currently a Head of Department, Planning, Research and Innovation Department, Institute of Teacher Education Ilmu Khas Campus. Her research interest is in educational measurement and evaluation.

Dr Alijah Ujang is currently a vice chairman in Society of Community Rehabilitation Center in Gombak. She is a retired head of special education department in Teachers Training Institute, Ilmu Khas Kuala Lumpur. Her research interest is in education for special needs pupils.

How to cite this paper: Wu Miaomiao, Dorothy De Witt, Nor Nazrina Mohamad Nazry, Norlidah Alias, Lee Leh Hong, Alijah Ujang, "Design and Validity of an Instrument to Measure Digital Literacy among Pre-service Teachers involved in Inclusive Education", International Journal of Modern Education and Computer Science(IJMECS), Vol.16, No.1, pp. 84-96, 2024. DOI:10.5815/ijmecs.2024.01.07