Validity and Reliability of the Postgraduate Self-Determined Learning Questionnaire (PSLQ)

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Abstract: Postgraduate students have to play active roles in self-determined learning, as major agent in their own learning and research activities. There is a lack of validated research instruments to measure self-determined learning among postgraduate students. The Postgraduate Self-Determined Learning Questionnaire (PSLQ) was specifically developed to fill in the gaps. This study aims to examine the validity and reliability of the PSLQ through exploratory factor analysis (EFA). The original version of PSLQ has 59 items and it was administered to a sample of 201 postgraduate students from a research-intensive university in Malaysia. The results of EFA revealed that PSLQ measures four distinct factors; learner-centered learning, interactive non-linear learning, double-loop reflection, and capacity development, which accounted for 54.22% of the variance in self-determined learning. The total number of items in PSLQ has been reduced to 42, after 17 items were removed. The instrument demonstrated excellent internal consistency, with a Cronbach's alpha value of α=.959. The findings suggest that PSLQ is a valid and reliable instrument that can be used to measure self-determined learning among postgraduate students. Implications of the research findings are discussed in this paper.

Keywords: Heutagogy, Postgraduates, Reliability, Self-determined learning, Validity

1. Introduction

Teaching and learning in higher education has undergone metamorphosis from pedagogy to andragogy and in the last decade to Heutagogy. Heutagogy or self-determined learning was introduced by Steward Hase and Chris Kenyon in 2000. This approach redefines learning and provides exciting opportunities for educators in higher education to improve teaching and learning practices. It is a novel approach to educational practice that was founded on key concepts like constructivism, andragogy, and autonomous learning (Hase & Kenyon, 2013). Self-determined learning shares certain key attributes with andragogy approach in learning such as self-directedness and learner autonomy, but it further extends the andragogical approach by encouraging students to decide on their own learning path and decide on what and how to learn while navigating through the non-linear learning environment. This highly autonomous learning approach advocates strong learner's agency. Self-determined learning

requires students to take charge of their own learning, think and reflect critically, engage in interactive non-linear learning and develop self-capacity in facing the challenges of the 21st century and fourth industrial revolution (4th IR) (Blaschke, 2012).

Self-determined learning is mostly witnessed in research environment (Uday, 2019), particularly among postgraduate students who are involved in research and innovative activities. Studies showed that self-determined learning can meet postgraduate students' unique learning needs and help them to achieve success in higher degree (Eicher & Dietz, 2013; Dietz & Eichler, 2013; Hase, 2016; Kerry, 2013; Tay & Hase, 2013). To promote self-determined learning among postgraduate students, there must be instruments that can be measured their application of the skills. However, there is currently a lack of suitable measures on self-determined learning (Hase, 2016), particularly among postgraduate students. As showed in Table 1, the existing instruments focused more on measuring heutagogical elements and practices (e.g., Mimi et al., 2020; Jailani et al., 2020) among undergraduate students (e.g., Mohaffyza et al., 2020; Rascón-Hernán et al.) and teachers (e.g., Miler et al., 2018; Glassner & Back, 2019). There were also instruments that measure self-directed learning and self-regulatory abilities, which has some similar attributes as self-determined learning (e.g., Rascón-Hernán et al. 2019; Torabi et al, 2013). However, as a whole, literature reviews show that there is no specific instrument that measure postgraduate students' self-determined learning.

Table 1. Examples of Measures related Self-Determined Learning and Heutagogy Approach

Name of Instrument	Year	Purports to Measure	Respondents	Author	Measure of postgraduate students' SDL
Questionnaire	2020	Heutagogical domain	Undergraduates	Muhffyza et al.	No
Questionnaire survey	2020	Heutagogical elements in learning	Undergraduates	Mimi et al.	No
Instrument of heutagogical teaching and learning activities	2020	Heutagogic design elements	University lecturers	Jailani et al.	No
Questionnaire	2019	Heutagogy framework	University learners and lecturers	Mohammad et al.	No
Survey	2019	Perceptions of Heutagogically professional learning	Primary school teachers	Miller et al.	No
Questionnaire survey	2019	Effectiveness of M-learning via heutagogy approach	Executive programme students	Kamrozzaman et al	No
Written blogs and students' products	2019	Innovative teacher education heutagogy	Student teacher	Glassner & Back	No
Self-directed Learning Readiness Scale	2019	Learning planning, desire for learning, self-confidence, self-management and self-evaluation	Undergraduates	Rascón-Hernán et al. (2019)	No
Self-directed Learning Readiness Scale	2013	Self-management, willingness to learn, self-regulatory abilities	School teachers	Torabi et al.	No

Note: SDL = self-determined learning

To fill in the research gaps, this study has developed an instrument to measure self-determined learning of postgraduate students. The items in PSLQ were developed based on three comprehensive literature reviews. The first reviews aimed to unveil the underlying theories of self-determined learning, with focus on agency theory (Milgram, 1974), humanism (Rogers, 1980), and constructivism (Piaget, 1980; Vygotsky, 1978). The second reviews aimed to identify its relevant framework, model, assessment's components and items (e.g., Blaschke, 2012; 2018, Blaschke & Marín, 2020; Blaschke & Hase, 2016; Cheng et al., 2010; Hase & Kenyon, 2001, 2007, 2013; Kember et al., 2000; Macaskill and Taylor, 2009; Teo et al., 2010; Williamson. 2007) while the third reviews focused on self-determined learning in higher education context, particularly among postgraduate students, to confirm the validity of the questionnaire framework (e.g., Alias et al., 2019; Hamdan et al., 2021; Mohaffyza et al., 2020; Rathakrishnan & Raman, 2021; Yusof et al., 2021). Fig.1 shows the questionnaire framework that was used to develop the items for PSLQ.

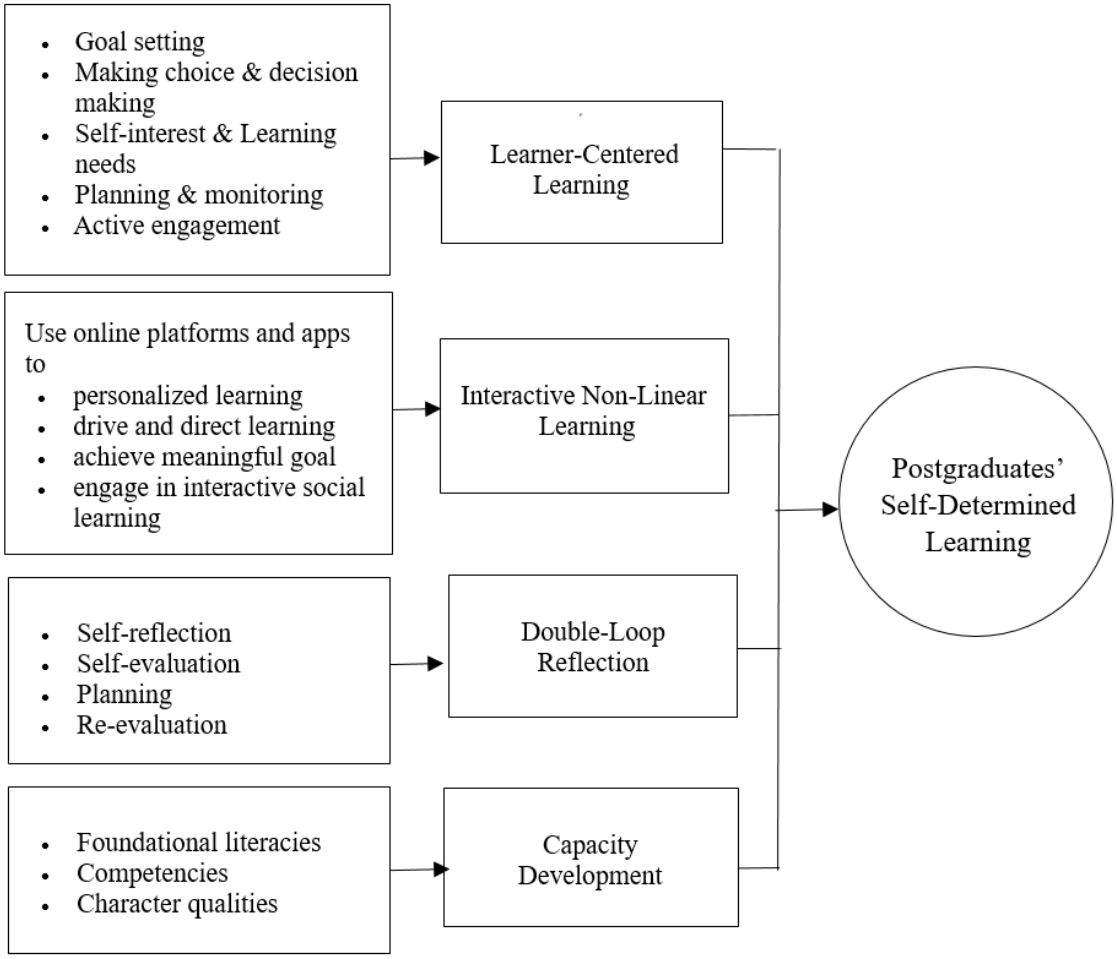

Fig. 1 Framework for Postgraduate Self-Determined Learning Questionnaire (PSLQ)

The first dimension of PSLQ is learner-centered learning. As proposed by the agency theory (Blaschke, 2018), learners are the key agent of learning and are placed at the centre of the learning processes (Li et al., 2021). This is founded on the basis that humans perceive themselves as origins of their behaviour and act as agent to self-direct their learning to construct knowledge, which is supported by humanism (Rogers, 1980) and constructivism (Piaget, 1980; Vygotsky, 1978). Past theories suggest that a highly autonomous, interactive, and non-linear learning environment is ideal for self-determined learning. It is in line with the notion of personalized and autonomous learning in higher education (Macaskill & Taylor, 2009).

The second dimension of PSLQ is interactive non-linear learning. Non-linear learning allows learners to choose their learning path autonomously rather than a linear path set by their lecturers (Gillaspy & Vasilica, 2021). Postgraduate students get to decide what and when to learn as well as their preferred learning styles and pace (Robberecht, 2007; Teo, et. al, 2010). With the support of digital technologies and Web 2.0, learning can take place anytime and anywhere, thus, learning becomes more personalised, interactive and dynamic (Hase & Kenyon, 2013; Oliver, 2016). Students in higher education can also share and exchange their ideas as well as obtain feedbacks from others through online platforms (e.g., Facebook, Research Gate, learning management system) and social apps (e.g., Facebook, Twitter, WhatsApp).

The third dimension of PSLQ is double-loop reflection. Double-loop reflection stresses the importance of developing students' metacognitive abilities, which include self-reflection, self-evaluation, self-planning, and re-evaluation skills (Blaschke, 2012; Hase & Kenyon, 2013). In single-loop learning, students focus on correcting their errors without questioning the underlying assumptions and learning goals set. In double-loop learning, students will engage in deeper thinking and ponder hard about what, why, and how they learn. Double-loop reflection occurs when learners question and test their own values with the aim to improve learning. These metacognitive processes prompt postgraduate students to think critically and challenge their existing values and beliefs (Hase & Kenyon, 2013), which advances their learning and research.

The fourth dimension of PSLQ is capacity development. Capacity development refers to the process in which learners increase their capability to apply knowledge, competencies, and character qualities during the learning processes. Students' capacity development is a process of developing and strengthening own skills, abilities, process, and resources to survive, adapt and thrive in the fast changing world of technology. It is the efforts gear towards improving the level of knowledge, skills and qualities possessed by an individual for proficiency in a given task or job (Oviawe et al., 2017). It is important to develop postgraduate students' capacity to enable them thrive in the 21st century and serve as the future work force (Kereluik et al., 2013). The emphasis on capacity development (Hase & Kenyon, 2001) is also in line with outcome-based learning in higher education (Ministry of Education, 2015). Specifically, students need to develop their capacity in terms of foundational literacies (e.g., digital skills), competencies (e.g., interpersonal skills) and character qualities (e.g., taking initiative) (World Economic Forum, 2015; Jose, 2021) to meet the increasingly complex job demand in the 21st century.

Prior to this study, the 59-item PSLQ have undergone context validation. Content validation is the process of determining whether the items in the instrument adequately cover the measured construct and this is done with the help of experts in the field (Nur Farhana et al., 2020). In this study, the content of PSLQ was assessed by a panel of practitioners who are lecturers in higher education and experts in relevant fields, which includes educational psychology, information technology, business studies, digital education, STEM, as well as applied psychometric and statistics. The relevance, clarity, comprehensiveness and significance of each item in PSLQ were assessed. Interviews with postgraduate students were also carried out to establish the face validity of the instrument. However, to evaluate the construct validity and reliability of PSLQ, further analyses are required. This study has formulated two research objectives to guide this study.

Research Objectives

1. To determine the construct validity of PSLQ on postgraduate students.
2. To determine the reliability of PSLQ on postgraduate students.

2. Method

A cross-sectional quantitative research design was carried out to achieve the objectives of this study. The study was conducted at a research-intensive university in Malaysia. The PSLQ was uploaded and administered online. Due to the pandemic Covid-19 situation in Malaysia, physical surveys were not permitted at the university, hence, data collection was carried out fully online. This study has obtained ethical approval from the Human Research Ethics Committee (JEPeM USM Code: USM/JEPeM/19090509) to collect the required data.

2.1 Sample

A pilot test was carried out to trial run the online survey and to obtain the initial reliability of the instrument. The survey invitation link was sent to 90 postgraduate students from three different schools in the university. A total of 43 postgraduate students have responded to the survey (response rate=47%). Findings from the preliminary study showed that PSLQ could be administered online and the instrument has yielded high reliability (α=.84-.95). Next, the survey invitation link was sent to postgraduate students from 12 schools at the institution. A total of 201 students have responded to the survey. The response rate was 50.52%, which is considered good for online questionnaire survey (Fosnacht, 2017). The sample size for this study was adequate for running exploratory factor analyses (Zeynivandnezhad, et al., 2019; MacCaullum et al., 1999).

2.2 Instrument

The Postgraduate Self-Determined Learning Questionnaire (PSLQ) was used to measure postgraduate students' self-determined learning. The original version PSLQ consisted of 59 items. It was designed as a four-point Likert scale, with responses ranged from (1) strongly disagree, (2) disagree, (3) agree to (4) strongly agree. There was no mid-point response or neutral choice in this instrument in order to prompt the respondents to 'get off the fence' and made a more decisive choice when answering. The four-point likert scale also allowed more specific responses to be gathered and the scores to be distributed to other options (Chyung, et al., 2017). More genuine responses could also be encouraged among the respondents since a four-point likert scale is among the most preferred scale type (Taherdoost, 2019).

As showed in Table 2, PSLQ was designed to measure learner-centered learning (16 Items), interactive non-linear learning (15 Items), double-loop reflection (16 items) and capacity development (10 Items).

Table 2. Item-specification of PSLQ

No	Dimensions	No. of Items
1	Learner-centered learning (LC)	16
2	Interactive non-linear learning (NL)	15
3	Double-loop reflection (DL)	16
4	Capacity development (CD)	10
Total		**59**

Items on learner-centered learning measure student-centred learning among postgraduate students. In student-centred learning processes, students are autonomous and independent learners who can decide what they want to achieve and take charge of their own learning processes (Norhafezah et. al., 2020). At the postgraduate level, they are given the autonomy to choose how and what they want to learn. The subscale consists of 10 items that gauge postgraduates' autonomy in setting own learning goals, making choices such as choosing research topics and making decisions in learning and research work to ensure that their learning needs are met. It also measures their self-directedness in planning and monitoring as well as engagement and discussions with others (e.g., supervisors, researchers, peers) to promote self-learning. Items on interactive non-linear learning, on the other hand, measure postgraduate students' non-linear learning. When postgraduate students learn in a highly personalized learning environment, they are expected to self-direct own learning processes and research activities. With the support of Web 2.0 technologies, learners actively engage in social learning by getting feedbacks, inputs and information from others through online platforms and apps to achieve their individual learning goals (Blaschke & Hase, 2016; Bartscht, 2016; Peters, 2002). Items on non-linear learning covers postgraduate students' use of online platforms and apps to personalize, drive and direct own learning, achieve meaningful goals, and engage in social learning through discussions with others (e.g., supervisor(s), researchers, librarians, peers, relevant stakeholders) and disseminate their research work to a wider audience. This is in line with Oparinde (2021)'s findings that it is utmost important for

postgraduate students to constantly engage with their supervisors to co-create new knowledge through master or doctoral research. The use of ICT and online platforms, thus, allows academic discourse to take place between postgraduate students and their supervisors in a non-linear and flexible manner.

Items on double-loop reflection measure postgraduate students' engagement in double-loop reflection during the learning processes. There are a total 14 items that gauge postgraduate students' self-reflection, self-evaluation, self-planning and re-evaluation of own progress and learning. In specific, the scale measures students' self-refection about their own learning approaches, progress and problem solving. It also measures their self-evaluation of own learning goals, self-beliefs, and commitment. These metacognitive processes are important to help students overcome their weaknesses and challenges in learning (Blaschke & Hase, 2015; Eberle, 2013). Lastly, items on capacity development were designed to measure postgraduate students' capacity development according to the 21st century framework. It gauges students' capacity development in terms of foundational literacies (how students apply the core skills to tasks), competencies (how students approach complex challenges) and character qualities (how students approach the changing environment) (World Economic Forum, 2015; Jose, 2021). The mastery of these skills enhances students' capacity to thrive in the 21st century and promote their lifelong learning skills. Items on foundational literacies measure students' knowledge relevant to their field of study, digital skills, and numeracy skills. Capacity development on competencies, on the other hand, measure students' application of transferrable skills such as communication skills, cognitive skills, interpersonal skills, and practical skills when dealing with complex learning and research problems. Finally, postgraduate students' character qualities are gauged through their initiative to seek feedback, persistency, curiosity and adaptability, which are crucial for learning and research at the postgraduate level and also for lifelong learning in the 21st century (World Economic Forum, 2015). These knowledge, competencies and character qualities are the desired learning outcomes of postgraduate education (Ministry of Education, 2015).

3. Results

3.1 Validity of PSLQ

Validity refers to whether an instrument actually measure what it is designed to measure (Knekta, et al., 2019). Validity is the most fundamental consideration in instrument development. In this study, validity of PSLQ indicates to which extent it measures postgraduate students' self-determined learning. An exploratory factor analysis (EFA) was run. EFA is a multivariate statistical method that has become a fundamental tool in developing and validating psychological measurements (Watkins, 2018), including instruments in the field of educational psychology (Laher, 2010). This analysis is suitable to be run during early stages of instrument development (Knekta et al., 2019). In this study, EFA was run on the 59-item PSLQ to (a) determine the underlying structure and correlations among the items, (b) identify the items that load onto a particular factor, and (c) possibly removing items that do not load onto any of the extracted factors or were wrongly loaded (Thompson, 2004). Prior to this analysis, the Kaiser-Meyer-Olkin (KMO) was run to determine the sampling adequacy of the data set for EFA and the factorability of PSLQ. The result of KMO was .942, which was deemed superb to conduct EFA (>.90) (Field et al., 2012). The Bartlett's Test of Sphericity was also carried out to compare the observed correlation matrix to the identify matrix. A significant statistic (χ^2= 8387.72, $p<.05$) indicated that factor analysis could be sufficiently performed on the data set. Overall, there were no multicollinearity issues and the data set was approximately normal (Pallant, 2013). The inspection of the anti-image correlation for all the items were above 0.5 (Tabachnick & Fidell, 2007), which was suitable for factoring.

3.2 Construct Validity

The principal component analysis (PCA), a recommended preliminary solution, was used to extract the factors (Pett et al., 2003) and to reduce the number items (Netemeyer et al., 2003) in PSLQ. The varimax rotation method was performed to assist with the interpretation of the factors to yield meaningful item groups. Varimax rotation enlarged the sum of the variance of the squared loadings, making a small number of main variables valuable (Mirzaei et al., 2019). Eigenvalues greater than one

were accepted for the latent root criterion, as it indicates more common variance than unique variance explains by a single factor (Verma, 2013). Results of extraction of common factors in PSLQ showed that a total of four factors were extracted, which accounted for 54.22% of the variance in postgraduate students' self-determined learning (Table 3). The total variance explained is considered good in social science and education research since the percentage explained was over 50% (Hair et al., 2010; Williams, 2010). Factor I was found to be predominant, it explained 23.76% of the variance and had an eigenvalue of 14.02. Factor II accounted for 11.55% of the variance and had an eigenvalue of 6.81. This was followed by Factor III that explained 10.77% of the variance, with an eigenvalue of 6.35%. Lastly, Factor IV accounted for 8.12% of the variance and had an eigenvalue of 4.79. This finding was supported by the scree plot results in which four points were found to be above the inflection point. This results showed that PSLQ measures four distinct factors.

Table 3. Results of Extraction of Common Factors in PSLQ

Factors	Eigenvalues	Percentage of Variance	Cumulative Percentages
I	14.023	23.767	23.767
II	6.819	11.557	35.324
III	6.357	10.775	46.100
IV	4.795	8.128	54.227

Table 4 shows the rotated component matrix of PSLQ. A total of 14 items have loaded onto Factor I, which was labelled as "Double-loop Reflection". For Factor II, 10 items have loaded onto this factor, which was labelled as 'Learner-centered Learning'. Factor III also has 10 items and it was labelled as 'Interactive Non-Linear Learning'. Lastly, eight factors have loaded onto Factor IV, which were all related to capacity development of postgraduate students. Seventeen items were deleted from the original scale because the items failed to meet the minimum item loading of .30 (Arifin & Yusof, 2016).

Table 4. Rotated component matrix of PSLQ

Items	**Components**			
	1	**2**	**3**	**4**
Item 32	**.761**			
Item 37	**.752**			
Item 36	**.726**			
Item 33	**.716**			
Item 39	**.713**			
Item 38	**.705**			
Item 35	**.680**			
Item 34	**.672**			
Item 45	**.636**			
Item 40	**.621**			
Item 47	**.554**			
Item 41	**.517**	.381		.382
Item 44	**.517**		.369	
Item 46	**.516**	.365		.362
Item 11		**.761**		
Item 9	.368	**.558**		
Item 13	.394	**.550**		
Item 14		**.541**	.362	
Item 7	.406	**.526**		
Item 8	.382	**.508**		
Item 1	.316	**.479**		
Item 12		**.478**	.307	

Items	Components			
	1	**2**	**3**	**4**
Item 15	.324	**.474**	.434	
Item 3		**.367**		
Item 24			**.806**	
Item 20			**.737**	
Item 23			**.714**	
Item 29			**.692**	.338
Item 28		.323	**.626**	
Item 30	.394		**.550**	
Item 25	.384	.421	**.517**	
Item 18	.403		**.505**	
Item 31		.363	**.490**	
Item 22			**.467**	
Item 54	.306		.326	**.631**
Item 59	.302	.422		**.570**
Item 51	.363			**.562**
Item 53			.436	**.545**
Item 52	.377			**.539**
Item 49	.450			**.454**
Item 48	.394	.325		**.408**
Item 43	.361	.352	.302	**.400**

After EFA, the number of items in PSLQ has been reduced to 42. As showed in Table 4, items under Factor I, which was labelled as double-loop reflection, has displayed strong data. Majority of the items have uniformly high communalities without cross loadings. A number of cross-loadings, however, were observed for Factor IV, capacity development. Since PSLQ was designed to measure self-determined learning, it is likely that the extracted factors were somewhat related. This suggests that capacity development is a very complex factor. The results of the rotated component matrix also showed that Item 43, which was designed for double-loop reflection, has the high cross-loading on capacity development. An inspection on this item shows that it measures students' self-initiative to get feedback, which is an important character quality under the 21st century skills framework (World Economic Forum, 2015). Founded on this reason, Item 43 was retained and moved to Factor IV, as it measures postgraduate students' capacity development in self-determined learning.

3.3 Reliability of PSLQ

Reliability is defined the accuracy and consistency of an instrument's results (Taherdoost, 2016). An instrument is considered highly reliable when the scale was re-administered to the same samples, the scores obtained are essentially consistent. In this study, the Cronbach's alpha analysis, which is based on the average correlation of items within a test, was run to test the internal consistency of PSLQ. As showed in Table 5, the 42-item PSLQ has a Cronbach's alpha value of α=.959, which demonstrates excellent reliability (Hair et al, 2015). The four dimensions of PSLQ have also yielded high reliability (ranged from .866 to .942).

Table 5. Item-specification of Postgraduate Self-Determined Learning Questionnaire (PSLQ)

No	Dimensions	Items No.	Cronbach's Alpha (α)
1	Double-Loop Reflection	14	.942
2	Learner-Centered Learning	10	.866
3	Interactive Non-Linear Learning	10	.878
4	Capacity Development	8	.872
	Total	42	.959

Table 6 revealed that the results of item-total correlation, which ranged from .475 to .771. All the values were above .40. The results suggest that items in PSLQ have very good discriminant (Olofsson et al., 2015). The reliability of learner-centered learning and capacity development could be improved slightly by α=.016 and α=.006 respectively if Items 3 and Item 53 were deleted. However, the improvements on Cronbach's alpha were too small, with no significant impact on the internal consistency, which suggests that both items should be retained. Further inspections on Item 3 shows that it measures postgraduate's autonomy in making decision on their research topic while Item 53 measures postgraduate students' capacity development in foundational literacy, specifically their research knowledge. As the two items measure important aspects of learner-centered learning and capacity development, it provides further justification for the items to be retained.

Table 6. Item-Total Statistics of PSLQ

Items	Scale Mean if Item Deleted	Correlated Item-Total Correlation	Cronbach's Alpha if Item Deleted
Double-loop Reflection			
Item 32	42.47	.727	.938
Item 37	42.48	.730	.938
Item 36	42.43	.709	.938
Item 33	42.48	.745	.937
Item 39	42.50	.762	.937
Item 38	42.53	.736	.937
Item 35	42.52	.771	.937
Item 34	42.55	.721	.938
Item 45	42.57	.712	.938
Item 40	42.63	.729	.938
Item 47	42.48	.650	.940
Item 41	42.55	.697	.939
Item 44	42.73	.624	.941
Item 46	42.48	.655	.940
Learner-Centered Learning			
Item 11	28.66	.687	.844
Item 9	28.65	.668	.847
Item 13	28.53	.629	.849
Item 14	28.64	.639	.848
Item 7	28.60	.684	.844
Item 8	28.61	.620	.850
Item 1	28.46	.469	.861
Item 12	28.72	.572	.854
Item 15	28.67	.633	.848
Item 3	28.77	.475	.882
Interactive Non-Linear Learning			
Item 24	26.39	.748	.854
Item 20	26.64	.622	.865
Item 23	26.31	.650	.863
Item 29	26.57	.579	.869
Item 28	26.58	.564	.870
Item 30	26.15	.642	.864
Item 25	26.04	.640	.864
Item 18	26.04	.475	.875
Item 31	26.08	.576	.869
Item 22	26.00	.550	.870
Capacity Development			
Item 54	21.35	.691	.849

Items	Scale Mean if Item Deleted	Correlated Item-Total Correlation	Cronbach's Alpha if Item Deleted
Item 59	21.23	.714	.847
Item 51	21.26	.659	.853
Item 53	21.76	.459	.878
Item 52	21.26	.677	.852
Item 49	21.28	.672	.852
Item 48	21.21	.616	.858
Item 43	21.26	.585	.861

4. Discussion and Conclusions

The PSLQ is specifically designed to measure postgraduate students' self-determined learning. The preliminary version of the instrument has 59 items that covers four dimensions of self-determined learning namely (a) learner-centered learning, (b) interactive non-linear learning, (c) double-loop reflection and (d) capacity development. The items and dimensions of this instrument were developed based comprehensive reviews of past studies and theoretical discussions. Through content validation, face validation and pilot test processes, few rounds of improvement have been made on PSLQ. To test the construct validity and internal consistency of this instrument, the PSLQ was uploaded and administered online on a sample of postgraduate students in a research-intensive university. The EFA analysis was run to determine the underlying structure and corrections among the items, identify items that load onto particular factors, and remove items that do not load onto any of the extracted factors. The results of the analysis showed that PSLQ is a valid and reliable instrument and it can be used to measure postgraduates' self-determined learning. The findings also revealed that PSLQ is a four-factor instrument that gauges self-determined learning as a multidimensional construct. These factors could explain more than half of the variance in postgraduate students' self-determined learning, which is considered good in social science and education research (Hair et al., 2010; Williams, 2010). Overall, PLQ demonstrated good psychometric properties.

After running EFA, the number of items in PSLQ has been reduced from 59 to 42. Seventeen items have been deleted. The most dominant factor that measures self-determining learning was double-loop reflection. It has a total of 14 items that gauges students' self-reflection, self-evaluation, self-planning and re-evaluation of their own learning and progress. Double-loop reflection explained 23.75% of the variance in self-determined learning. This shows that it is very important for students to engage in self-reflection to identify what and how to learn and constantly get feedback to improve their research and performance. Postgraduate students also need to reflect their learning goals, self-beliefs, commitments and progress in studies. As such, double-loop reflection also enhances students' personalized learning as it promotes their higher order thinking skills, opens up more learning opportunities and help them to attain meaningful progress in academic and research work. The second important factor was learner-centered learning. This factor consisted of 10 items that explained 11.55% of the variance in self-determined learning. At the postgraduate level, the locus of control in learning lies within the learner. Postgraduate students need to self-direct and self-determine own learning and research activities (Hase & Kenyon, 2007). They play the central role in making decisions concerning their learning and research directions. During self-determined learning, postgraduate students will chart their learning path, set own learning goals, plan and monitor own progress and engage with others (e.g., supervisors, researchers, peers) to get feedbacks for improvement (Qadri & Pasha, 2021).

The third factor was labelled as interactive non-linear learning. This 10-item factor accounted for 10.77% of the variance in self-determined learning. It is an important principle of self-determination particularly in non-linear learning environment (e.g., Blaschke & Hase, 2016; Bartscht, 2016; Peters, 2002). With the support of digital technologies, learning processes is more self-driven, personalised, and interactive. In non-linear learning environment, learning is more personalised as the learning goals are set by the students to meet their individual learning needs, interest and abilities, thus, the attainment of these goals are more meaningful (Köse, 2010; Ribière, Haddad, & Wiele, 2010; Uday, 2019). Interactive non-linear learning is evident when postgraduate students engaged in multi-directional

interactions using online platforms and apps to interact with supervisors, experts and researchers in the field, peers, as well as relevant stakeholders to access resources and feedback to help them learn and conduct research independently. The last factor was capacity development. This factor was found to be a complex variable as many cross-loadings were observed. The eight-items on this factor accounted for 8.12% of the variance in self-determined learning. Capacity development in self-determined learning enables postgraduate students to be more prepared for the challenges and uncertainty in the 21st century (Hase & Kenyon, 2001; Oviawe et al., 2017). Students have to be self-determined learners in order to develop foundational literacies (e.g., digital skills), competencies (e.g., interpersonal skills) and character qualities (e.g., taking initiative) effectively (World Economic Forum, 2015; Jose, 2021). The development of these capacities are line with the emphasis on 21st century skills, lifelong learning skills and outcome-based learning in higher education (Ministry of Education, 2015).

In conclusion, PSLQ is a valid and reliable instrument that measures postgraduate students' self-determined learning. The 42-item instrument is designed to a brief instrument that can be administered either online or in paper-and-pencil form. It can be used to measure the level of self-determined learning among postgraduate students and to identify aspects that require improvement so that intervention can be carried out. This study also found that to promote self-determined learning, the most important factor that should be taken into account is double-loop reflection. It is important for postgraduate students to engage in constant self-reflection, self-evaluation and self-planning for self-improvement in learning and research. There are also needs to provide them with autonomy and opportunity to optimize ICT in learning for capacity development. Inevitably, a few limitations also exist. Generalisation might be a problem, further analyses on a larger population of postgraduate students should be conducted to further confirm the validity and reliability of PSLQ. Confirmatory factor analysis (CFA) can be carried out to assess its convergent validity, discriminant validity, and reliability. There are also needs to test the validity of PSLQ on postgraduate students from different disciplines and mode of studies (e.g., fully by research, mixed mode) to determine its psychometric properties across different groups of postgraduate students.

5. Authors' Contributions

The authors affirmed that there is no conflict of interest in this article. MNLY conceived and designed the research protocol and wrote the paper. AFO and TAP performed the data collections and reviewed drafts of the paper. TCC helped in data collection and data analysis.

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