Analytic Hierarchy Process with Rasch Measurement in the Construction of a Composite Metric of Student Online Learning Readiness Scale

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ABSTRACT

This paper developed the Online Learning Readiness Composite Scale (OLRCS), a composite measure of student online learning readiness based on five dimensions, namely (1) computer/internet self-efficacy; (2) self-directed learning; (3) learner control; (4) motivation for learning; and (5) online communication self-efficacy. A single metric of online learning readiness has its advantage over its disaggregated dimensions. For one, it allows a summative description of each student which school administrators can use for an effective student targeting toward flexible learning. Rasch Analysis (RA) was performed to come up with an objective measure for each dimension while Analytic Hierarchy Process (AHP) was applied to aggregate the computed Rasch scores of the five dimensions. Three OLRCS have been constructed using weights generated by (1) teacher participants, (2) student participants, and (3) combined student and teacher participants. Results showed that motivation for learning consistently received the highest weight while online communication self-efficacy and computer/internet self-efficacy got low weights among the three OLRCS. Research findings also showed that student participants gave more importance to learner control than self-directed learning, unlike the teacher participants. The difference in the teacher and student perspectives merits detailed attention to optimize the online learning environment and enable individual support. Nevertheless, using cluster analysis, the distribution of students who are ready, undecided, or not ready for online learning is similar to the three constructed OLRCS.

Keywords: *multidimensional latent variable; multi-criteria decision analysis; linear aggregation*

1. Introduction

The benefits of online learning in formal education are highlighted due to the current worldwide situation. Horton (2006) defined online learning as the use of information and computer technologies and systems to build and design learning experiences. It covers a range of technologies such as the world wide web, email, chat, new groups and texts, and audio/video conferencing delivered over computer networks to impart education. Thus, it relies on the learner's own pace, according to their own convenience (Dhull and Sakshi, 2017).

A wide variety of literature states that online learning has various critical success factors (CSF). Identification of these CSF plays a huge role to boost the successful implementation of

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an online learning system. Some researchers identified student characteristics as a major success factor of online learning, above and beyond the teacher and the institution (Selim, 2007; Rohayani and Kurniabudi, 2015; Alhabeeb and Rowley, 2018). A recent study by Reyes et al. (2021) focuses on assessing students' online learning readiness, which is an important student characteristic to consider in online learning. The student's readiness for online learning must be assessed to improve content quality (Cigdem and Yildirim, 2014) and to predict the student's success in online learning (Doe et al., 2017).

Extensive literature reviews agreed that students' online learning readiness is a multidimensional metric. Kirmizi (2015) considered five dimensions which include computer/internet self-efficacy, self-directed learning, learner control, motivation for learning, and online communication self-efficacy. Motivation for learning is defined as the student's learning attitude while learner control refers to a student's control over learning efforts to direct his/her learning. Moreover, computer/internet self-efficacy refers to a student's ability to demonstrate proper computer and internet skills while self-directed learning refers to the student's responsibility for learning context to reach learning outcomes. Lastly, online communication self-efficacy defines the student's adaptability to ask questions, respond, give insights, and participate in discussions online. Using the Online Learning Readiness Scale (OLRS), which was developed and validated by Hung et al. (2010), it was found that motivation for learning is the most important predictor of success, followed by learner control. On the other hand, six dimensions were used by Yilmaz (2017) to determine the online learning readiness of students. His research applied the OLRS developed by Demir and Yurdugül (2015) which consists of six dimensions, similar to Hung et al. (2010) but separated online self-efficacy from computer self-efficacy. Moreover, the study by Watkins et al. (2004) assessed the readiness for online learning by using their developed self-assessment instrument. This instrument has six dimensions namely, technology access, online skills and relationships, motivation, online audio/video, internet discussions, and importance to success. Although the developed instrument was deemed reliable based on Cronbach's alpha coefficient, there was no validity measure used to assess the readiness for online learning. Dray et al. (2011) also developed a tool to assess student readiness for online learning. Unlike the previously mentioned research, student readiness was defined by only two dimensions namely learner characteristics and technology capabilities. There are also two dimensions, such as self-management of online learning and comfort with online learning, which were considered by Smith (2005) to develop a tool that was both reliable and valid by using Cronbach's alpha and factor analysis (FA), respectively, for online learning readiness. Moreover, in the study of Ascari et al. (2005), online learning readiness has two dimensions, namely perceived ease of use and perceived usefulness.

Since dimensions related to online learning readiness vary across various types of research, Demir and Yurdugül (2015) explored a reference model by desk reviewing various studies which developed tools for assessing student readiness for online learning. The created model includes six dimensions, namely competency of technology usage, self-directed learning, access to technology, confidence in prerequisite skills, motivation, and time management. This research adopted the OLRS by Hung et al. (2010) in measuring student readiness for online learning since their instrument wholly captured Demir and Yurdugül's (2015) reference model. Some studies which applied OLRS were those by Kaymak and Horzum (2013), Cigdem and Yildirim (2014), Kirmizi (2015), Buzdar et al. (2016), Kayaoglu and Akbas (2016), Elnakeeb and Khalifa (2016), Engin (2017), Cavusoglu (2019), Mutambik et al. (2018), Fearnley and Malay (2021), and Reyes et al. (2021).

Although student online learning readiness is a multidimensional metric, aggregation of its dimensions to come up with a composite measure has an intuitive appeal, especially for policy or decision-makers (Phelps et al., 2018). A composite measure provides a summary picture of the multiple facets or dimensions of complex, multidimensional phenomena in a way that facilitates evaluation and comparison (Becker et al., 2017). This composite measure serves as an overall measure or assessment that has not been fully established in online learning readiness yet. In the case of an overall measure of online readiness, the capabilities of the higher education system were assessed to introduce and implement online learning readiness programs. The low value of the overall online readiness of a university suggested a serious deficit of some e-readiness factors (Darab and Montazer, 2011). This paper, however, aims to construct a composite measure of student readiness for online learning which takes into account all five dimensions in OLRS (Hung et al., 2010), namely (1) computer/internet self-efficacy; (2) self-directed learning; (3) learner control; (4) motivation for learning; and (5) online communication self-efficacy.

In constructing a composite measure, a multi-criteria decision analysis (MCDA) such as the Analytic Hierarchy Process (AHP) is used so that the relative importance of each dimension of a characteristic/variable can be established (Kil et al., 2016; Blagojevic et al., 2019). A composite measure provides decision-makers with an explicit view of the dimensions that should be prioritized. Moreover, knowing the degree of student readiness through a single metric provides school administrators valuable insights for effective student targeting. Several kinds of literature related to education applied the AHP technique. Sael et al. (2019) implemented AHP in profiling students. Their objective was to detect and classify the most important factors that increase Moroccan students' dropout and failure. Further, Anis and Islam (2015) reviewed the AHP application in higher learning institutions. Their systematic analysis found that AHP was often applied to measure quality education, evaluate faculty members, measure performance, strategically plan, and choose a university and select university students. The AHPs in their study were applied together with other methods according to the objectives of the study. One example was measuring the quality of education by Yeşim and Ortaburun (2011). They applied AHP together with the Spearman Rank Correlation test to redesign the undergraduate curriculum of one of the faculties of Marmara University. On the other hand, in the case of using AHP in strategic planning, Begičevič et al. (2007) applied AHP together with factor analysis in modeling the systematic implementation of e-learning and online education distance education at a university in Croatia. Their study concluded that organizational readiness, which includes the university framework and faculty strategy for development and financial readiness served as the most influential criterion in implementing online learning in this institution. In this paper, AHP was used along with Rasch analysis.

Rasch measurement was performed to come up with an objective measure for each of the five dimensions wherein a linear transformation of the ordinal raw score was obtained and expressed in logits. These scores can be used for parametric analyses given that distributional assumptions are met. Hence, this research is an attempt to combine the five dimensions of Hung et al.'s (2010) OLRS using AHP with Rasch scores. The resulting composite metric can be used to assess the factors that contribute to students' readiness for e-learning. Moreover, the procedure demonstrated in this paper can be replicated to apply to future investigations related to the construction of composite metrics for other multidimensional latent variables.

2. Methodology

2.1 Data source

This study made use of the data collected by Reyes et al. (2021) using Hung et al.'s (2010) OLRS. This scale has five dimensions, namely (1) internet/computer self-efficacy; (2) self-directed learning; (3) learner control; (4) motivation for learning; and (5) online communication self-efficacy. Online learning readiness was measured through a series of statements rated on a Likert scale with a score of 1 for a strong disagreement and 5 for a strong agreement. In the study by Reyes et al. (2021), the results showed that the overall Cronbach's alpha coefficient is 0.89. This suggests that the OLRS has a high level of interaction between Filipino higher education students and items. Further, Fearnley and Malay (2021) confirmed the OLRS' reliability in the local context wherein Cronbach's alpha coefficient in each dimension ranged from 0.727 to 0.871 with an overall internal consistency of 0.889. Hence, OLRS is highly reliable and can be adopted in studies involving Filipino higher education students.

The subjects involved a stratified random sample of 290 students from the University of the Philippines Los Baños (UPLB). The sample size was determined using a margin of error of ± 0.04, a confidence level of 0.95, and a design effect of 0.50. Proportional allocation was implemented wherein the sample students were stratified according to program classification with 80% undergraduate and 20% graduate students.

The weights for the composite measure of online learning readiness were obtained by asking the AHP participants, who were four faculty members and seven students, to rank the dimensions in terms of what they perceived as relatively more important to the scale. This was done by pairwise comparisons of the five dimensions with the more important dimension given a higher rating than the others. At the end of the process, two sets of ratings were collected, one from the teachers, and another from the students. These AHP participants were chosen based on their length of experience in online education. The teacher and student participants were from different institutions and fields of study, with an average of three years of experience in online teaching and learning, respectively. Since inputs in AHP are obtained from experts, it does not need a statistically significant sample size to generate robust results (Dias and Ioannou, 1996; Doloi, 2008). Aside from simplicity and a high level of consistency, one of the well-known reasons for using AHP is its applicability for small sample sizes even a judgment from a single expert is already a representative (Darko et al., 2019). In this research, from the list of identified participants, the final number of experts, which is 11 participants, was determined based on their willingness to participate in the study.

2.2 Construction of a composite metric for OLRS

A. Rasch analysis

The Rasch model measures a latent trait based on the functional trade-off between a person's trait and item difficulty in a series of questions. This study specifically used the following Rasch-Andrich (RA) Rating Scale model:

$$B_n - T_j - F_k = ln\left(\frac{P_{njk}}{P_{nj(k-1)}}\right) \tag{1}$$

where it specifies the probability, P_{njk}, that student n of online readiness B_n is observed in category k of a rating scale applied to item j of difficulty T_j as opposed to the probability $P_{nj(k-1)}$ of being observed in category (k–1). Moreover, F_k is the Rasch-Andrich threshold. Since Rasch analysis is capable of transforming the ordinal responses into interval measures (expressed in logits), it can then be used in the parametric analysis. In this paper, the online learning readiness score D_i for each dimension (where i = 1, 2, 3, 4, 5) was generated by the RA model. The higher the logit score D_i, the more ready the student is for the i^{th} dimension. One logit or one natural log of odds ratio refers to the distance along the line of the online readiness scale that increases the odds of being ready that is specified in the measurement model by a factor of 2.718. For example, an item with a logit score of +1.0 means that this item increases the odds of a student being in the k^{th} level of readiness as compared to being in the

(k-1)th level of readiness multiplicatively by $e^{+1.0} = 2.178$. A logit unit of zero means a neutral response. Data processing was done using WINSTEPS 4.5 and AHP Software (Goepel, 2018).

B. Analytic Hierarchy Process

An important part of the construction of composite metrics for OLRS is the assignment of weights, W_i to be used in aggregating the five dimensions. This research recruited inputs of participants from the field of online education, four teachers and seven students, to generate these dimension weights using the Analytic Hierarchy Process (AHP). The process starts with participants establishing a pairwise priority among the five dimensions. Using these pairwise priorities, a matrix of pairwise comparisons of the five dimensions was constructed, with whole odd numbers from 1 to 9 given to those with higher priorities and its inverse to its less prioritized partner. The even numbers in between were assigned as a compromise. The scale of comparisons is presented in Table 1.

Table 1. The scale used for the comparison of each dimension (Saaty and Vargas, 1991)

Scale	Degree of importance
1	Equal importance
3	Moderate importance of one dimension over another
5	Strong or essential importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values
Reciprocals	Values for inverse comparison

The resulting matrix was normalized by dividing each cell by its corresponding column total. The average scores in the rows are the resulting weights. These series of comparisons produced the normalized principal eigenvector (or priority vector) from which weights of each dimension were obtained. Higher weight, W_i, means greater importance of the dimension as perceived by the participants. To check if the assumption of matrix consistency is satisfied, the consistency ratio (CR) was computed and checked. A CR of at most 0.10 is considered acceptable; otherwise, the judgments often need reexamination, that is, the ratings should be revisited by transforming them (Saaty, 1987; Teknomo, 2006; Franek and Kresta, 2014). Reducing the square root of the 1 to 9 scale gives higher consistency.

The compatibility of the weighing method is considered in deciding the suitability of the aggregation method. According to Nardo et al. (2008), AHP as a weighing method is compatible with either linear or geometric aggregations. The simplest and most widely used linear aggregation was used to combine the five dimensions since it preserves the relative importance of the dimension as reflected by the generated weights. The constructed composite metric satisfies the preferential independence condition of a linear aggregation, i.e., the composite metric permits the assessment of the marginal contribution of each dimension separately (Munda, 2012). Further, since linear aggregation possesses a full compensability property, this means that a student with a low readiness score in some dimensions can still be compensated by sufficiently high scores in other dimensions to tweak his/her composite score. The formula to compute the composite metric of OLRS (OLRCS) is:

$$OLRCS = \sum_{i=1}^{5} W_i D_i \qquad (2)$$

where W_i and D_i are the weight and Rasch scores of the i^{th} dimension, respectively.

Finally, cluster analysis was done on the OLRCS to classify students into three groups namely, (1) not ready for online learning; (2) undecided; (3) ready for online learning.

2.3 Evaluation of the constructed composite metric for OLRS (OLRCS)

A perceived overall student readiness was also obtained during the survey done by Reyes et al. (2021). To assess the relationship between the OLRCS and the perceived overall student readiness, the Spearman correlation coefficient was obtained. A positive correlation between the two scores indicates the same direction, i.e., as the perceived overall student readiness rating increases, OLRCS also increases. A low correlation, however, suggests that overall online readiness cannot be measured through personal perception but requires an objective measure like the OLRCS.

The robustness of the OLRCS is assessed by sensitivity analysis, deleting one dimension at a time and recomputing the OLRCS for each deletion (Dating, 2019). The result of each OLRCS re-computation was compared with the original OLRCS. A low percentage of matched results in the resulting confusion matrix will indicate sensitivity to that particular dimension.

3. Results and Discussion

3.1 Reliability and validity of OLRS

The OLRS by Hung et al. (2010), which this study adopted, was tested for reliability and validity as administered to higher education students in the Philippines. Rasch principal components analysis of residuals was used to check the construct validity of the instrument. This was done by weighing the index of raw variance explained by the instrument over the total raw variance of the sampled responses. Using all the 18 questionnaire items, Table 2 showed that 50% of the index of raw variance is more than 40%, the standard set by Fisher (2007) and Adams et al. (2018). However, when all 18 questionnaire items were pooled together, the unidimensionality property of the construct was not achieved since the eigenvalue in the first contrast is equal to 2.52, exceeding the threshold of less than 2 (Raîche, 2005). On the other hand, the index of raw variance in each dimension ranges from 56% to 68% and their eigenvalues in the first construct are all within the threshold value. This means that each dimension exhibited a good unidimensional scale to effectively measure the online readiness of the students.

Table 2. Standardized Residual Variance in Eigenvalue Units

Dimension	Eigenvalue	Observed
All		
Raw variance explained by measures	17.99	50.00%
Unexplained variance in 1st contrast	2.52	7.00%
Computer/Internet Self-Efficacy		
Raw variance explained by measures	5.21	63.50%
Unexplained variance in 1st contrast	1.67	20.30%
Self-directed Learning		
Raw variance explained by measures	6.20	67.40%
Unexplained variance in 1st contrast	1.62	17.60%
Learner Control		
Raw variance explained by measures	6.39	56.10%
Unexplained variance in 1st contrast	1.52	13.30%
Motivation for Learning		
Raw variance explained by measures	5.33	57.10%
Unexplained variance in 1st contrast	1.50	16.10%
Online Communication Self-Efficacy		
Raw variance explained by measures	4.47	59.90%
Unexplained variance in 1st contrast	1.54	20.50%

Further, Table 3 shows the item reliability of each OLRS dimension. With all item reliabilities having a value of at least 0.90 (or separation index of at least 3.00), the sample is large enough to confirm the construct validity of OLRS (Linacre, n. d.). This means that the set of items in each dimension is well-targeted (Wright and Stone, 1999; Linacre, 2012). These results supported the results of the studies made by Kirmizi (2015), Hung et al. (2010), and Yilmaz (2017) that student readiness for online learning is a multidimensional measure. Table 3 also summarized the person reliability of all dimensions which are all below 0.80 (or separation index below 2.00). This implies that OLRS is not sensitive enough to distinguish between more or less-ready students. Though the person reliability of the four dimensions ranged from 0.71 to 0.76, which is somewhat close to the standard, additional survey items can be included to improve the OLRS (Linacre, n. d.), particularly in the learner control dimension (person reliability = 0.56).

Table 3. Person and Item Reliability Measures

Dimension		Student	Item
	Separation	1.55	7.33
Computer/ Internet Self-Efficacy (CS)	Reliability	0.71	0.98
	Separation	1.70	7.15
Self-directed Learning (SL)	Reliability	0.74	0.98
	Separation	1.14	15.00
Learner Control (LC)	Reliability	0.56	1.00
	Separation	1.79	7.48
Motivation for Learning (ML)	Reliability	0.76	0.98
	Separation	1.57	5.60
Online Communication Self-Efficacy (OS)	Reliability	0.71	0.97

The results of the rating scale analysis presented in Table 4 revealed that the 5-rating scale, from strongly disagree to strongly agree, was used approximately as modeled, based on the fit statistics having values close to 1 (Fisher, 2007; Adams et al., 2018). However, some categories were overly improbable, particularly those in dimensions of computer/internet self-efficacy (category: strongly disagree) and learner control (category: strongly agree). A few students expressed poor levels of readiness on items in the computer/internet self-efficacy dimension that they were expected to be ready for. Similarly, some students expressed high levels of readiness on items in the learner control dimension that they were expected to be less ready for. Both the Rasch-Andrich thresholds and the average measures exhibited the desired monotonically ascending pattern across categories indicating that the categories represent advancing levels of online learning readiness (Linacre, n. d.).

Overall, the OLRS showed a considerable ability to measure student readiness for online learning. In particular, the instrument may be improved by adding items that can measure student readiness in the learner control dimension.

Table 4. Results of the Rating Scale Analysis

Dimension/Category Label	Average Measure	Infit MNSQ	Outfit MNSQ	Andrich Threshold
Computer/Internet Self-Efficacy (CS)				
1	-2.42	1.53	1.44	NONE
2	-1.44	0.78	0.65	-3.77
3	0.42	1.14	1.13	-0.69
4	2.26	0.90	0.86	-0.39
5	4.72	0.99	0.89	4.85
Self-directed Learning (SL)				
1	-2.02	0.99	0.98	NONE
2	-0.75	0.99	1.05	-2.49
3	0.14	1.01	1.23	-0.51
4	1.17	0.84	0.84	0.01
5	2.36	1.10	1.06	2.99
Learner Control (LC)				
1	-2.53	0.97	0.98	NONE
2	-1.48	0.78	0.94	-2.51
3	-0.12	0.78	0.94	-0.71
4	1.26	0.82	1.00	0.01
5	1.94	1.55	1.35	3.21
Motivation for Learning (ML)				
1	-2.46	1.25	1.12	NONE
2	-0.80	0.94	1.00	-3.14
3	0.34	0.86	0.78	-0.99
4	2.10	0.84	0.94	-0.06
5	4.03	1.16	1.10	4.19
Online Communication Self-Efficacy (OS)				
1	-2.56	1.18	1.11	NONE
2	-1.25	0.99	1.08	-3.34
3	0.11	0.78	0.75	-0.39
4	1.25	0.97	0.96	0.33
5	2.40	1.12	1.08	3.40

3.2 Five dimensions of OLRS using Rasch Score

From the paper by Reyes et al. (2021), Table 5 shows that students were found to be quite ready in the computer/internet self-efficacy (mean = +2.3 logit) and motivation for learning (mean= +2.06) dimensions, while students were not ready in terms of controlling their learning program and the environment under the learner control (mean= -0.08 logit) dimension. For the self-directed learning and online communication self-efficacy dimensions, a neutral response was obtained. For each dimension, the following are the items where students felt least ready based on item difficulty: (1) not being distracted by other online activities while learning online (LC); (2) having confidence in knowledge and skills of how to manage online learning platforms (CS); (3) managing time well (SL); (4) having the motivation to learn (ML); and (5) feeling confident in posting questions in online discussions (OS). On the other hand, the following are the items where students were most ready in each dimension: (1) repeating the online instructional materials based on their needs (LC); (2) being open to new ideas (ML); (3) having confidence in performing the basic functions of Microsoft Office programs or their counterparts (CS); (4) seeking assistance when facing learning problems (SL); and (5) improving from their mistakes.

Table 5. Student Readiness for online learning in Rasch scores in each dimension with their corresponding minimum and maximum values of item difficulty

Dimension	Mean	Standard Deviation (SD)	Item Difficulty	
			Minimum	Maximum
Computer/ Internet Self-Efficacy (CS)	2.30	2.67	-1.11	1.10
Self-directed Learning (SL)	0.65	1.52	-0.75	1.09
Learner Control (LC)	-0.08	1.53	-1.42	1.72
Motivation for Learning (ML)	2.06	2.44	-1.13	1.03
Online Communication Self-Efficacy (OS)	0.08	2.01	-0.49	0.68

3.3 A composite metric for OLRS using Analytic Hierarchy Process

Table 6 shows that all identified participants in the field of online learning gave ratings with acceptable consistency ratios (CR) of less than 0.10. The lowest CR are 0.031 and 0.017 for teacher participants and student participants, respectively.

Table 6. Consistency Ratio (CR) of each participant

Number	Participants	CR
1	Teacher	0.071
2	Teacher	0.076
3	Teacher	0.031
4	Teacher	0.087
5	Student	0.090
6	Student	0.017
7	Student	0.073
8	Student	0.037
9	Student	0.022
10	Student	0.062
11	Student	0.088

Table 7 shows the weights of each dimension for teacher participants, student participants, and combined student and teacher participants (overall). In the case of combined participants, the dimension of motivation for learning has the highest weight (0.317) followed by self-directed learning (0.228), and learner control (0.200). On the other hand, online communication self-efficacy and computer/internet self-efficacy have low weights of 0.147 and 0.108, respectively. The weights of teacher participants were consistent with that of combined participants. Meanwhile, the weights for dimensions of learner control and self-directed learning have different orders of magnitude for student participants. The CRs for teacher participants, student participants, and combined participants are acceptable.

Table 7. AHP weights and its Consistency Ratios

Dimension	Weights Teacher	Weights Student	Weights Combined
Computer/Internet Self-Efficacy (CS)	0.086	0.122	0.108
Self-directed Learning (SL)	0.282	0.200	0.228
Learner Control (LC)	0.171	0.217	0.200
Motivation for Learning (ML)	0.311	0.317	0.317
Online Communication Self-Efficacy (OS)	0.150	0.144	0.147
Consistency Ratio	**0.028**	**0.004**	**0.005**

The perceived online readiness rating is moderately and positively correlated with Online Learning Readiness Composite Scale (OLRCS) as shown in Table 8, implying that as the perceived readiness score increases, OLRCS also increases. Moreover, there is an almost perfect direct correlation among OLRCS for teacher participants, student participants, and combined participants.

Table 8. Spearman's Rank Order Correlation Coefficient of perceived online readiness rating with OLRCS

	Perceived	Teacher	Student	Combined
Perceived	1.0000			
Teacher	0.5217*	1.0000		
Student	0.5243*	0.9958*	1.0000	
Combined	0.5223*	0.9982*	0.9993*	1.0000

*Significant at 5% level

Table 9 shows cluster analysis results to classify students according to their online learning readiness. Using OLRCS, the majority of the students (68%) are undecided on their online learning readiness having cluster centroids ranging from 0.66 to 0.70. Only one-fourth of the students are ready for online learning. The predetermined three clusters were justified since they gave the lowest variation within clusters.

Table 9. Cluster Analysis with Cluster Centroids and Cluster Sizes

	Classification		
OLRCS	**Not Ready**	**Undecided**	**Ready**
Teacher	-2.6136	0.6571	2.9146
	(19)	(197)	(74)
Student	-2.6520	0.7000	2.9883
	(19)	(198)	(73)
Combined	-2.6397	0.6818	2.9545
	(19)	(197)	(74)

Table 10 shows that the students who are similarly classified by their perception and OLRCS based on combined/teacher participants are 10, 75, and 46 for not ready, undecided, and ready, respectively. These comprise 45% of the students. However, 117 students (40%) perceive themselves as not ready for online learning. This is contrary to the results of OLRCS where only 19 students (7%) are classified as not ready.

Table 10. Distribution of respondents based on their perceived online readiness rating and OLRCS for teacher participants and combined participants

	OLRCS Teacher Participants/ Combined Participants			
Perceived	**Not Ready**	**Undecided**	**Ready**	**Total**
Not Ready	10	93	14	117
Undecided	6	75	14	95
Ready	3	29	46	78
Total	19	197	74	290

Similar distributions were obtained using OLRCS based on student participants except for one student who shifted from ready to undecided. This is shown in Table 11.

Table 11. Distribution of respondents based on their perceived online readiness rating and using OLRCS for student participants

	OLRCS Student Participants			
Perceived	**Not Ready**	**Undecided**	**Ready**	**Total**
Not Ready	10	93	14	117
Undecided	6	75	14	95
Ready	3	30	45	78
Total	19	198	73	290

Figure 1 shows the results of the sensitivity analysis. If the dimension of online communication self-efficacy is removed from the OLRCS model, at least 96% of the students are consistently classified as ready, undecided, and not ready by both models. This high percentage indicates that the model with four dimensions still provides almost the same predictions compared to the model where all five dimensions are present. On the other hand, if the dimension of motivation for learning is removed from the OLRCS model, at least 85% of the students are consistently classified as ready, undecided, and not ready by both models. This relatively low percentage implies that the model without the dimension motivation for learning provides around 15% prediction inconsistency against the model where all five dimensions are present.

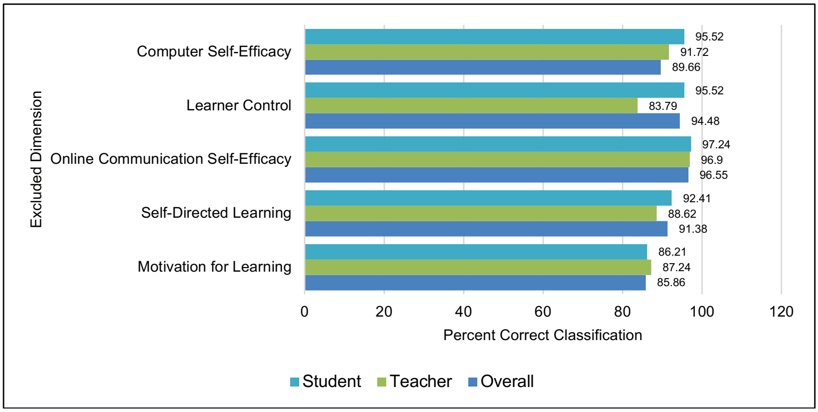

Figure 1. Distribution of students who are similarly classified using the original OLRCS model and with one dimension excluded

4. Conclusions and Recommendations

The research findings prove that personal perception cannot effectively quantify a student's overall online learning readiness. It requires an objective measurement through the use of the OLRS, whose reliability and validity have been supported by numerous literature. Most students perceive themselves as not ready while OLRCS classified the majority of them as undecided. The results differ because OLRCS considered the multidimensionality of the construct, unlike the perceived online readiness rating. Further, the classification of a student using OLRCS also accounted for the readiness of other students in the group.

The Rasch analysis (RA) model was used to generate scores per dimension while the Analytic Hierarchy Process (AHP) was utilized to assign weights to aggregate the five dimensions. Three composite metrics of OLRS (OLRCS) have been constructed using weights generated by (1) teacher participants, (2) student participants, and (3) combined student and teacher participants. The weights generated by the teacher participants ranked the dimensions in the following order: (1) motivation for learning; (2) self-directed learning; (3) learner control; (4) online communication self-efficacy; and (5) computer/internet self-efficacy. The student participants ranked the five dimensions similarly except for learner control and self-directed learning. Student participants gave more weight to learner control than self-directed learning. Students feel that they need to be more prepared in learner control than in self-directed learning. This resulting difference in the teacher and student perspectives merits detailed attention to optimize the online learning environment and enable individual support. Nevertheless, combining the two gave rankings similar to that of the teacher participants, with weights across different dimensions not varying too much from each other. Generally, the results of classifying a student as whether s/he is ready, undecided, or not for online learning are similar regardless of the OLRCS used.

Sensitivity analysis validated the results of AHP on the weights of each dimension on the OLRCS. The dimension motivation for learning gave the largest alteration to the result once removed from the computation of OLRCS. This result validates that this dimension has the highest weight in the OLRCS model. Interestingly, the dimension computer/Internet self-efficacy displayed the second largest change in the percentage of similar classifications when removed from the OLRCS despite having been ranked last by the participants. In addition, the dimension of online communication self-efficacy remains to be the least important among the dimensions. In the face of increasing familiarity with computers and the Internet, self-efficacy in its usage continues to be a requisite for online learning. As a result, students can develop the confidence to effectively communicate online.

The OLRCS is useful in flexible learning specifically for planning and policy-making post-pandemic, such that school administrators can perform initial assessments of students to identify those who are ready or not for online learning. They may treat students who were classified as not ready and undecided to be both unprepared and find ways to make them ready for online learning. However, considering resource constraints such as time, budget, and labor, those who were not ready should be given priority. Moreover, a high proportion of undecided students requires further investigation like holding dialogues/consultations with such students. School administrators should provide a support structure for students' specific needs (Brooks, 2003), especially for those who are not ready and undecided. This may include devices and technological support and connectivity, financial assistance, and psychological support and guidance (Zincirli, 2021). Also, they should offer students with forthright information and proper advising (Brooks, 2003). For instance, schools may organize seminars and lectures to help these groups of students overcome the challenges they face during online learning and encourage them to seek assistance once they experience difficulty in online learning. In addition, school administrators should train and equip their teachers with the necessary skills to support and handle students in online learning (Murray, 2021). The training should include how to communicate more openly with students who have such limitations and consider individual differences between students and their capacities to adapt to the online learning environment.

Moreover, the resulting weights of individual dimensions of online learning readiness can help teachers design and manage classes effectively. For instance, a module might be designed to increase a student's motivation for learning to stimulate and sustain student interest. Ease and confidence in computer use also play a vital role in deciding whether a student is ready for online learning. School administrators should create programs or activities that would support students with their ability to direct and control their learning. For instance, the school can invest in programs and activities for training teachers on various approaches to create interesting and engaging activities, which target lifelong learning and empower students to choose alternatives, and then assess the student's progress.

Finding associations and modeling relationships among critical factors can be constructed using the OLRCS instead of using individual dimensions. Such a model can help identify the extent of influence of key factors on online learning readiness and subsequently, its outcomes such as student performance, drop-out rate, etc. Combining Rasch analysis with AHP may lead to constructing composite metrics for other multidimensional latent variables like happiness, anxiety, and stress.

5. Limitations and Future Directions

This paper focused only on constructing a composite measure of student readiness for online learning which takes into account all five dimensions of the OLRS (Hung et al., 2010). It must be noted that this study adopted the OLRS without the intention of changing it. In addition, the study focused on higher education students; thus, similar research can be done to assess the online learning readiness of primary and secondary education students.

This study used the Rasch logit scores to come up with a measure of online learning readiness per dimension. The possibility of converting the OLRCS from Rasch logit score to positive interval scores can also be done. This will allow geometric aggregation which can be compared to the results of this study. Given the OLRCS, conducting concrete validation is recommended to further verify the scores.

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APPENDIX: List of items in OLRS per dimension

Dimension
Computer/ Internet Self-Efficacy (CS)
CS1. I feel confident in performing the basic functions of Microsoft Office programs or their counterparts.
CS2. I feel confident in my knowledge and skills of how to manage online learning platforms
CS3. I feel confident in using the Internet to find or gather information for online learning.
Self-directed Learning (SL)
SL1. I carry out my own study plan.
SL2. I seek assistance when facing learning problems.
SL3. I manage time well.
SL4. I set up my learning goals.
SL5. I have higher expectations for my learning performance.
Learner Control (LC)
LC1. I can direct my own learning progress.
LC2. I am not distracted by other online activities while learning online.
LC3. I repeat the online instructional materials on the basis of my needs.
Motivation for Learning (ML)
ML1. I am open to new ideas.
ML2. I have motivation to learn.
ML3. I improve from my mistakes.
ML4. I like to share my ideas with others.
Online Communication Self-Efficacy (OS)
OS1. I feel confident in using online tools (e.g., email, discussion) to effectively communicate with others.
OS2. I feel confident in expressing myself (e.g., emotions and humor) through text.
OS3. I feel confident in posting questions in online discussions.