

Research Article

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Development of Learning Environment Instruments in Distance Education at the Open University

Lisa Dwi Ningtyas , Yuli Rahmawati , Riyadi

Abstract

Background/Objective. This study uses distance learning theory-based learning environment instrument development research with a unique design for culturally sensitive factors in the learning environment as the grand theory used. Therefore, the planning of this learning environment instrument requires a relationship that refers to the three dimensions of social organization from Moos (1979) and the fourth dimension from Geert Hofstede and Michael H. Bond (1984). This study aims to develop a distance education learning environment instrument for Open University that can be used in universities in Indonesia that provide distance education.

Materials/methods. This type of research is instrument development research with a sequential mixed methods exploratory research approach using a sample of 912 students spread throughout Indonesia.

Results. The results of this study obtained a level of reliability which shows that this instrument can reliably measure the real conditions of the learning environment in distance education at the Open University.

Conclusion. It is expected that the results of this study can contribute to maintaining the quality of the distance learning environment in higher education in Indonesia through the development of distance learning environment instruments for the Open University as a form of reflection by Open University students on teaching materials and their evaluation for the Open University academic community.

1. Introduction

Education in Indonesia needs to be evenly distributed in every region (Utomo Priyambodo, 2022; Wulandari, 2021). According to Koes (2021) and Putra (2021), factors that cause the uneven distribution of education in Indonesia include the low quality of teachers, low achievement, and lack of facilities and infrastructure for learning. Overcoming the educational gap in various regions of Indonesia is a serious concern for the Ministry of Education, Culture, Research and Technology.

The educational gap is not spared by students who take lectures in various regions in Indonesia. To overcome this, the Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 109 of 2013 Article 2 explains that Distance Education is a solution to expand access and facilitate higher education services in the education and learning process in various regions of Indonesia (Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 109 of 2013 Concerning the Implementation of Distance Education in Higher Education, 2013). Distance education in higher education is student-centred learning that is carried out independently with tutors as facilitators in answering student questions and providing challenges to be able to develop innovation, personality, and independence in finding new knowledge or solving authentic problems to achieve the desired target (Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 109 of 2013 Concerning the Implementation of Distance Education in (Higher Education, 2013; Moore et al., 2011; Polianovskyi et al., 2021; Spencer, 2003; Wasson & Kirschner, 2020).

In its operation, it is not uncommon for distance education problems to occur due to the lack of quality of distance learning regarding technical failures or the lack of effectiveness of distance learning followed by students (Borisova et al., 2006). Meanwhile, the learning activity process must meet the implementation of the learning process according to Minister of Education, Culture, Research and Technology No. 53 of 2023 CHAPTER II Article 14 to maintain its quality (Minister of Education, Culture, Research and Technology Regulation No. 53 of 2023 concerning Quality Assurance of Higher Education, 2023). To see the implementation of the distance education learning process, it is necessary to assess the learning environment. Assessment of the learning environment plays a significant role in improving student achievement and forming attitudes (Yu, 2022). This is because the learning environment can be interpreted as the physical, social, psychological, and pedagogical context in which students learn (Kirschner et al., 2004; Mäkelä & Helfenstein, 2016). Assessment of the learning environment in education in Indonesia requires a representative learning environment instrument.

The Indonesian government's learning environment instrument already covers students' social, physical, pedagogical, and psychological aspects, as seen from its dimensions (Junior High School Directorate Manager, 2022). However, the instrument is limited to a survey of the learning environment in early childhood education units up to secondary schools. Therefore, no learning environment instrument in universities in Indonesia implements distance education.

Several previous instruments regarding learning environments in higher education institutions that implement distance education worldwide exist, including (Walker & Fraser, 2005), the Distance Education Learning Environments Survey (DELES) (Walker & Fraser, 2005), the Attitude Towards Computers and Computing Courses questionnaire (ACCC) (Newby, 1998), and the Online Learning Environment Survey (OLES) (Pearson & Trinidad, 2005).

Unlike previous learning environment instruments, this study uses distance education theory with a unique design on culturally sensitive factors in its learning environment, which is the grand theory used. The learning environment instrument was developed in Indonesia, which has a rich and diverse culture (Informatika, 2013). Therefore, the design of this learning environment instrument

requires a relationship that refers to the three social organization dimensions of Moos (1979) and the four dimensions of Geert Hofstede and Michael H. Bond (1984).

Universities in Indonesia that implement distance learning processes include the Open University, Asia Cyber University, Muhammadiyah Cyber University, and Merdeka University of Surabaya (Univ. Merdeka Surabaya, 2021; Universitas Siber Asia, 2023; Universitas Siber Muhammadiyah, 2021; Universitas Terbuka, 2023). However, the university that pioneered distance learning in Indonesia is the Open University (UT) (Terbuka, 2023). One of the services for Open University students is the Distance Learning Program Unit, which has 39 offices spread throughout Indonesia. With the development of learning environment instruments in distance learning at the Open University, these learning environment instruments can be used at other universities that implement distance learning in Indonesia.

Research on instrument development is currently being carried out, including research conducted by Ningtyas et al. (2020) and Riyadi et al. (2023). In recent decades, instrument development has been increasingly explored in the student learning environment (Ningtyas et al., 2020; Rahayu et al., 2020; Rahmawati et al., 2020, 2017; Riyadi et al., 2023; Sheffield et al., 2018). After the Covid-19 Pandemic hit the world, the learning environment in distance education began to be explored (Al-Jarf, 2021; Al-mawee et al., 2021; Aristeidou & Cross, 2021; Bork-Hüffer et al., 2021; de la Peña et al., 2021; Demetriou et al., 2021; Hlib et al., 2019; Ismaili, 2020; Masalimova et al., 2021; Tsarapkina et al., 2021; Virtič et al., 2021). However, other researchers, including Walker and Fraser (2005), studied the distance education environment (Walker & Fraser, 2005) before initiating DELES. DELES has 34 items allocated to six scales. Furthermore, Özkök et al. (2009) also developed a different DELES instrument by adding one dimension of student enjoyment. In addition, the DELES instrument developed by Fernández-Pascual et al. (2015) differs from the DELES developed by Walker & Fraser (2005) in adding one dimension of satisfaction. Furthermore, there is research on developing other learning environment instruments in the university area (Dorman, 1999; Treagust & Fraser, 1986). Therefore, the state of the art in this study is that the development of instruments for assessing the learning environment in distance education has been intensively carried out in recent years. In addition, there has been no development of learning environment instruments in distance education with a unique design on culturally sensitive factors in universities in Indonesia, which is a novelty in this research. The findings of this study can be the forerunner of research on the development of learning environment instruments both in secondary schools and universities in Indonesia. In addition, with the results of this study, learning environment instruments can be developed again that can be applied to universities throughout Indonesia that implement distance education.

This research material aims to complete the study on the development of learning environment instruments in distance education in universities in Indonesia and evaluation for the academic community of the Open University. Therefore, the formulation of the problem that can be raised in this study is (1) How is the development of learning environment instruments in distance education in open universities? (2) How to maintain the quality of the learning environment in distance education in open universities?

2. Literature Review

This study uses the theory of distance learning with a special design on culturally sensitive factors in the learning environment as the grand theory used. The meaning of culturally sensitive here is the psychological characteristics with "culture", namely the state of the surrounding social system (Geert Hofstede & Michael H. Bond, 1984). This is because the learning environment instrument was developed for use in Indonesia, a country with a rich and diverse culture (Informatika, 2013). Therefore, the design of this learning environment instrument requires a relationship that refers to the three social organization dimensions (Moos, 1979), namely relationships, personal development,

and system maintenance and system change. Moos (1979) describes From this conceptual perspective, Moos describes what has long been established as the domain of environmental systems in social ecology that can describe different environments without boundaries in three dimensions: 1) Relationship Dimension, 2) Personal Growth Dimension, and 3) System Maintenance and Change Dimension Moos (1979). Through subsequent research, Moos demonstrated the enduring quality of these dimensions in the context of family, work, school, health, military, prison, and community settings. The Relationship dimension distinguishes the nature and strength of personal relationships. This is "the degree to which individuals are involved in the environment and the degree to which they tend to support and help each other" (Moos, 1979). This dimension includes cohesion, expression, support, affiliation, and involvement. The Personal Development dimension is characterized by personal growth and self-improvement opportunities the environment offers. Aspects associated with this dimension include independence, achievement, task orientation, self-discovery, anger, aggression, competition, autonomy, and personal status (Moos, 1979). The System Maintenance and Change dimension considers the degree of environmental control, orderliness, clarity of expectations, and responsiveness to change. This dimension's aspects include organization, control, order, clarity, innovation, physical comfort, and influence (Moos, 1979). Moos also suggests that the System Maintenance and Change Dimensions are suitable for cross-cultural comparisons of social organizations. In addition, it is also necessary to refer to the four dimensions of Geert Hofstede & Michael H. Bond (1984), namely power distance, uncertainty avoidance, individualism versus Collectivism, and masculinity versus femininity.

Based on several previous studies and the grand theory used, this study will develop distance learning environment research at an Open University with a special design on Indonesian cultural factors using several dimensions of the DELES instrument (Walker & Fraser, 2005), ACCC from (Newby, 1998), and OLES from (Clayton, 2007). The dimensions that will be used in this study are instructor support; student interaction and collaboration, personal relevance, authentic learning; active learning; and student autonomy from DELES (Walker & Fraser, 2005), usefulness of course from ACCC (Newby, 1998), and equity and asynchronicity from OLES (Clayton, 2007).

3. Methodology

3.1. Study Design

This type of research is instrument development research with an exploratory sequential mixed methods research approach. The exploratory sequential mixed methods research approach is used because, in this study, qualitative data are first collected and analyzed, and themes are used to drive the development of quantitative instruments to explore further the research problem (Creswell, 2012; Onwuegbuzie et al., 2009; Teddlie & Tashakkori, 2009). As a result of this design, the analysis stage is carried out after the primary qualitative phase, the secondary quantitative phase, and the integration phase that connects the two data sets and expands on the initial qualitative exploration findings (Creswell, 2012).

3.2. Instrument Development Procedure

In this study, Recker and Rosemann (2010) developed a five-stage instrument development procedure (Recker & Rosemann, 2010). The following is a model of the development procedure used in this study;

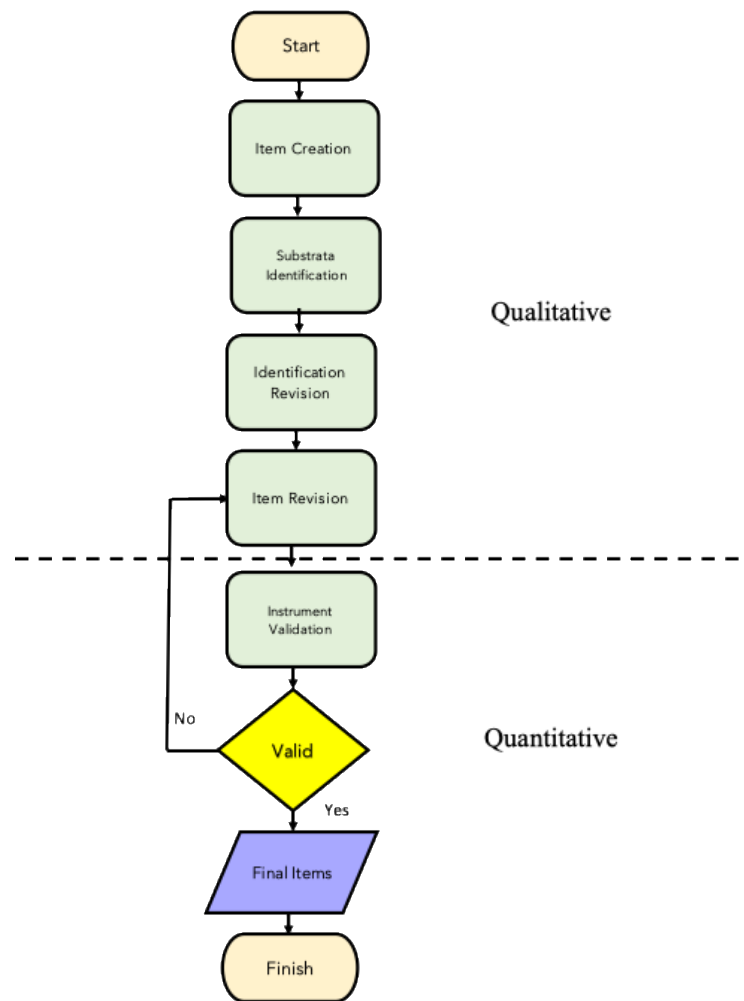


Figure 1. Instrument Development Procedure Model

The first stage of item creation contains an analysis of relevant literature that will determine the theoretical construction of the measurement items to be developed to obtain candidate items for each construction. In the second stage of substrata identification, a panel study was conducted with three experts who have experience and expertise in the field of study, the type of involvement in the field (e.g., education, consulting, management, or actual fieldwork), and the level of training/education background in the field of distance learning and learning environments. This is because the experts used to provide input to sort candidate items into several construct categories so that statements in a category have the most similar meaning to each other and the most different meaning from statements in other categories. A panel of three measurement experts carries out the third stage of item identification to identify a collection of candidate items from a set of items that show good potential for high content validity. The fourth stage of item revision is carried out by a panel of practitioners consisting of three Open University lecturers to provide assessments and correct the wording of items that must indicate the target population of the final field study. This aims to determine the measurement items that are most likely to be well understood in the final field test. The results of all expert responses were analyzed using Fleiss Kappa to calculate the probability of agreement between assessors. The fifth stage of instrument validation was conducted using a survey method to obtain sufficient responses from the study's target population. The population used in this study was all Open University students in Indonesia. According to Geert Hofstede & Michael H. Bond (1984), sampling must differ in the same population, not necessarily representative, and must be adjusted from one culture to another.

Furthermore, the tool for conducting construct validity of the distance education learning environment assessment instrument at Open University using MIRT and comparing which MIRT model is most suitable for use. This is because the distance education learning environment assessment instrument at Open University uses a scale with polytomous categories and wants to see the level of distance education application at the Open University (Samejima, 2016). This stage aims to obtain statistical evidence regarding the reliability and validity of the measurement items developed.

3.3. Sample Collection Techniques

The population of this study was all students of Open University in Indonesia. The selection of samples and population was done using purposive sampling. Purposive sampling was chosen because, in this study, the researcher assumed that he knew about the population and could assess whether the selected sample was representative (Jack et al., 2008). In this study, the researcher assumed that by taking samples representing Indonesia's Western, Central, and Eastern regions, the sample reached more than 630 samples. This is based on at least 10 participants for each item; the ideal ratio of respondents to items is 10:1 (Nunnally & Bernstein, 1994). Data collection was carried out with the help of Google Forms, which was distributed to Open University students who met the sampling criteria. After data collection using purposive sampling, 916 students were obtained as research samples from 31 Regional Open Universitys from 40 Regional Open Universitys throughout Indonesia. Furthermore, by using the Slovin formula (Williams, 2024) with the number of Open University students being 671967 students, the minimum sample size is as follows:

$$n = \frac{N}{1 + N(\alpha)^2}$$

$$n = \frac{671967}{1 + 671967(0.05)^2}$$

$$n = 399,76 \approx 400 \text{ samples}$$

Based on the calculation above, the results obtained are 400 samples that are at least representative of the population. Thus, 916 samples are considered to be representative of the population of this study. Furthermore, the representativeness of the research sample was tested using Kaiser-Meyer-Olkin (KMO). The results of the KMO calculation in this study obtained 0.97 (KMO value between 0.8 - 1.0), which means that the sampling in this study is sufficient for quantitative analysis with analysis factors and MIRT (Guttman, 1954; Tabachnick & Fidell, 1989).

3.4. Sample

The sample of this study was 916 Open University students for quantitative data. Respondents who can fill out this research questionnaire must meet the following requirements: (a) Active undergraduate students of Open University; (b) Taking lectures in at least the 3rd semester; (c) Choosing tutorial learning assistance, either online tutorials, webinars, or face-to-face. Based on sampling, it can be concluded that the samples in this study mostly came from UT Bogor (24.78%), the second came from UT Pontianak (19.87%), and the rest came from 31 regional UTs out of 40 regional UTs spread throughout Indonesia. The following is a map of regional Open Universities used in this study:



Figure 2. Distribution of Research Samples Throughout Indonesia

Based on the data above, the quantitative research samples in this study are distributed throughout Indonesia, including Western, Central, and Eastern Indonesia.

3.5. Data Analysis Techniques

Tools to conduct construct validity of distance education learning environment assessment instruments at Open University and its application level using the best model analysis for polytomous data with multidimensional item response theory (MIRT). The MIRT models compared to find the best model in this study are the Graded Response Model (GRM), Generalized Partial Credit Model (GPCM), Partial Credit Model (PCM), and Nominal Response Model (NRM). This study will review three critical assumptions: monotonicity, unidimensionality, and local independence (Nguyen et al., 2014).

4. Results

This is instrument development research with an exploratory sequential mixed methods approach through five stages of instrument development from Recker & Rosemann (2010). This research starts from a qualitative approach, namely at the stages of item creation, substrata identification, item identification, and item revision. The final stage is ended by a quantitative approach, namely at the stage of instrument validation. In this first stage, namely item creation, various literature studies were reviewed, so it was decided that the development of the learning environment instrument in distance education at Open University refers to the dimensions of the learning environment itself, namely the three social organization dimensions from Moos (1979), namely relationships, personal development, and system maintenance and system change. In addition, because this study examines Indonesia, which is rich in culture, it is necessary to refer to the four dimensions of Geert Hofstede & Michael H. Bond (1984): power distance, uncertainty avoidance, individualism versus Collectivism, and masculinity versus femininity. Based on that, another thing is to continue to review several previous studies and the grand theory used; it was decided to use several dimensions of the DELES instrument from Walker & Fraser (2005), AC from Newby (1998), and OLES from Clayton (2007). The dimensions that will be used are instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, and student autonomy from DELES (Walker & Fraser, 2005), usefulness of course from ACCC (Newby, 1998), and equity and asynchronicity from OLES (Clayton, 2007).

Furthermore, instrument items are developed from the theoretical construction that has been determined and will enter the next stage. The second stage is the identification of substrata by three experts with experience and expertise in the field of study. Items that have been identified according to whether or not they are by the already available dimensions enter the next stage, namely item identification. At the item identification stage, two measurement experts were selected to review

the instrument items determined to be in accordance with the scale used and to review the five points in each item. After this, the next stage was carried out, namely item revision.

Three experienced senior lecturers at Open University carried out the item revision stage. At this stage, they reviewed the instrument items that had been agreed upon from the previous stages to see whether they were in accordance with the language commonly used or familiar to Open University students.

Furthermore, the development of learning environment instruments in distance education has 63 items with nine dimensions that are reviewed based on the stages of item creation, substrata identification, item identification, and item revision. The next step is to calculate the strength of the agreement of the experts in this study using the Fleiss Kappa analysis (Fleiss, 1971). Feiss Kappa is used because it can perform calculations that include agreement values in assessment studies with more than two assessors (Banerjee et al., 1999; Tong et al., 2020). The assessment for experts in this study is on a scale of 0 and 1, which was analyzed by Fleiss Kappa and assisted by JASP ver. 0.18.3 software. The following are the results of the Fleiss Kappa analysis in this study:

Table 1. Fleiss Kappa Analysis Results

Ratings	Fleiss' kappa	SE	95% CI	
			Lower	Upper
Overall	0.742	0.024	0.695	0.788
0		0.024		
1		0.024		

Note. 63 subjects/items and eight raters/measurements. Confidence intervals are asymptotic.

Based on the results of the Fleiss Kappa analysis, it was 0.742. This indicates that the results of the Fleiss Kappa analysis show between 0.61 - 0.80, which means it is included in the substantial agreement category (Landis & Koch, 1977). Therefore, the results of this qualitative word can proceed to the next stage, namely instrument validation. After there is an agreement, it enters the instrument validation stage. At this instrument validation stage, the instrument in distance education at Open University, which has gone through 4 qualitative stages, is distributed with the help of a Google form to Open University students who meet the criteria. Furthermore, 916 Open University students were obtained throughout Indonesia. The following is a descriptive data analysis of each item in this data:

Table 2. Item Descriptive Statistics

	Mean	Std. Deviation	Item Total Correlation
X1	4.66	.608	.468
X2	4.48	.731	.528
X3	4.50	.705	.413
X4	4.46	.690	.491
X5	3.55	1.247	.486
X6	4.32	.853	.540
X7	4.31	.757	.590
X8	4.57	.612	.506

	Mean	Std. Deviation	Item Total Correlation
X9	4.40	.846	.304
X10	1.95	1.005	-.398
X11	4.23	.929	.572
X12	4.48	.734	.531
X13	4.68	.577	.309
X14	3.43	1.360	.495
X15	4.09	1.012	.643
X16	4.39	.724	.607
X17	4.33	.797	.539
X18	4.51	.702	.256
X19	3.67	1.522	-.179
X20	4.26	.862	.625
X21	4.32	.807	.602
X22	4.73	.507	.368
X23	3.87	1.111	.480
X24	3.94	1.004	.637
X25	4.38	.711	.722
X26	4.44	.690	.669
X27	4.35	.748	.479
X28	4.48	.670	.669
X29	4.30	.852	.705
X30	4.22	.863	.582
X31	3.84	1.132	.555
X32	4.14	1.106	.558
X33	4.22	.860	.698
X34	4.44	.689	.684
X35	4.34	.746	.686
X36	4.40	.813	.363
X37	2.31	1.306	-.249
X38	4.41	.744	.631
X39	4.45	.667	.635
X40	4.41	.750	.367
X41	2.99	1.340	.426
X42	4.35	.774	.659

	Mean	Std. Deviation	Item Total Correlation
X43	4.12	.887	.630
X44	4.06	.843	.651
X45	4.27	.731	.670
X46	4.34	.734	.744
X47	4.43	.711	.630
X48	4.40	.712	.640
X49	4.30	.766	.506
X50	4.30	.763	.701
X51	4.27	.825	.625
X52	4.23	.781	.702
X53	4.23	.754	.646
X54	4.51	.649	.495
X55	4.22	.782	.674
X56	4.18	.855	.566
X57	4.33	.761	.650
X58	4.35	.753	.392
X59	3.74	1.205	.552
X60	4.25	.768	.711
X61	4.26	.729	.682
X62	4.13	.821	.620
X63	4.33	.829	.449

Based on the table above, the item-total correlation of the items in this instrument is good, except for items 10, 19, and 37. This indicates that these items cannot form a good learning environment instrument in distance education at Open University. Therefore, items 10, 19, and 37 are dropped from this instrument. However, the reliability coefficient results on this instrument obtained good results, namely 0.955. The following is a table of the statistical results of the reliability of this instrument:

Table 3. Reliability Coefficient Results

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.955	.963	63

The overall reliability coefficient results indicate a high intercorrelation between the items (Adams & Farmer, 2022). Next, quantitative data analysis is continued. This quantitative data analysis is based on the results of the instrument validation stage. The calculation of quantitative data analysis in this study was assisted by R software ver 4.4.1 for macOS 11 and RStudio. The result of this final stage is the analysis of instrument validation data using the most appropriate multidimensional item

response theory polytomy model. Before looking for the most appropriate multidimensional item response theory polytomy model, three critical assumptions were checked: unidimensionality, local independence, and monotonicity (Nguyen et al., 2014).

4.1. Unidimensionality Assumption

The parallel analysis results based on minimum rank factor analysis prove that the instrument subscales are unidimensional. Based on the Bartlett test, the results of $T = 31707.98$, $p < 0.001$, and the Kaiser-Meyer Olkin (KMO) test = 0.97 support the suitability of the correlation matrix for conducting factor analysis. The cumulative proportion of variance for the first variable is 0.51. These results are supported by several unidimensional proximity indices $\text{UniCo} = 0.96$. $\text{UniCo} > 0.95$, indicating that the measurement is unidimensional (Ferrando & Lorenzo-Seva, 2018). Furthermore, the ECV is seen in this analysis to explain the general variance. The ECV in this study was obtained at 0.87. Where this ECV is more than 0.85, the measurement is unidimensional (Ferrando & Lorenzo-Seva, 2018).

4.2. Assumption of local independence

Judging from the subscale of the learning environment instrument in distance education at the Open University, no local dependence (LD) statistic is greater than 10. This indicates no excess covariance among item responses when θ is constant (Baker & Kim, 2017).

4.3. Monotonicity Assumption

In this assumption, the Mokken scalability coefficient is seen. The results of the Mokken instrument items range from 0.310 (SE = 0.022) to 0.436 (SE = 0.014), with the H coefficient for the total scale being 0.504 (SE = 0.010). These results prove that the H scalability coefficient per item is greater than or equal to 0.30 and 0.50 for the total scale. This means that support for the scale's monotonicity is found (Mokken, 2011).

4.4. Fit Model

To see the fit model in this study by calculating with the M2 statistic (Maydeu-Olivares, 2013). The results obtained in this study were $M2 = 7192.148$, $df = 1531$, $p\text{-value} < 0.001$. Based on the results of M2, the model in this study is adequate. In addition, the RMSEA is also seen with a limit of less than or equal to 0.08 (Hu & Bentler, 1999; Xu et al., 2017). The RMSEA results obtained in this study were 0.06. This indicates that in terms of RMSEA, this research model is adequate (fit). In addition, the CFI and TLI in this study obtained 0.9107 for CFI and 0.9135 for TLI. According to Bentler & Bonett (1980), $\text{CFI} > 0.9$ and $\text{TLI} > 0.9$ indicate that the model is fit.

4.5. MIRT Model Selection

The following are the results of the ANOVA analysis of the four models:

Table 4. ANOVA MIRT Model

Model	AIC	SABIC	HQ	BIC	logLik
GRM	93357.40	93842.42	93900.12	94779.30	-46383.70
GPCM	94898.46	95383.48	95441.18	96320.37	-47154.23
PCM	97582.91	97972.57	98018.92	98725.25	-48554.45
NRM	93369.82	94105.86	94198.17	95604.87	-46192.91

*Note: AIC= Akaike Information Criterion; SABIC= Sampel-Size Adjusted BIC; HQ= Hannan-Quinn; BIC= Bayesian Information Criterion; logLik= Log-Likelihood

Based on the table, it can be seen that from various models, the one that gets the smallest value is the GRM model (Snipes & Taylor, 2014). Therefore, the instrument in this study uses GRM analysis.

4.6. Fit Items

The calculation to see the suitability of each item with the evaluated model is with the $S-\chi^2$ index and is considered appropriate to GRM if $p > 0.01$ and $RMSEA < 0.06$ (Reise & Waller, 2009). This calculation gets all p-values above 0.01. This shows that the item-level suitability of this instrument is suitable (good item-level fit). Furthermore, if viewed from the $RMSEA S-\chi^2$, all items are < 0.06 . This shows adequate suitability, and the estimation of the GRM model can continue.

4.7. Graded Response Model Analysis

The Graded Response Model (GRM) analysis in this study was assisted by R software ver 4.4.1 for macOS 11 and RStudio. The following is a table of the results of the calculation of learning environment instruments in distance education at Open University using GRM:

Table 5. Graded Response Model IRT Parameters

Items	a	b_1	b_2	b_3	b_4	$b_4 - b_1$
X1	3.056	-2.671	-2.254	-1.212	-0.109	2.562
X2	1.570	-4.212	-3.149	-1.830	-0.412	3.800
X3	1.223	-5.464	-4.117	-2.196	-0.520	4.944
X4	1.572	-4.901	-4.001	-1.812	-0.314	4.587
X5	1.027	-2.750	-1.616	-0.245	0.934	3.684
X6	1.494	-3.914	-2.738	-1.428	-0.176	3.738
X7	2.018	-3.693	-2.522	-1.405	-0.001	3.692
X8	1.684	-4.222	-3.654	-2.282	-0.495	3.727
X9	1.028	-4.139	-3.786	-2.308	-0.373	3.766
X11	1.881	-2.682	-2.076	-1.241	-0.051	2.631
X12	1.864	-3.321	-2.843	-1.705	-0.419	2.902
X13	1.024	-5.962	-5.455	-3.528	-1.181	4.781
X14	1.094	-1.984	-1.344	-0.191	0.917	2.901
X15	2.002	-2.361	-1.839	-0.960	0.092	2.453
X16	2.258	-3.422	-2.549	-1.453	-0.160	3.262
X17	1.798	-2.932	-2.674	-1.553	-0.058	2.874
X18	0.854	-7.026	-6.207	-2.891	-0.698	6.328
X20	2.318	-2.567	-2.062	-1.203	-0.057	2.510
X21	2.177	-2.934	-2.362	-1.262	-0.099	2.835
X22	1.420	-5.304	-4.514	-3.213	-1.072	4.232
X23	1.231	-3.003	-1.977	-0.860	0.490	0.490
X24	1.882	-2.724	-1.822	-0.703	0.350	3.074
X25	3.690	-2.487	-2.198	-1.251	-0.139	2.348

Items	a	b₁	b₂	b₃	b₄	b₄ – b₁
X26	3.311	-2.803	-2.285	-1.354	-0.256	2.547
X27	1.632	-3.877	-3.042	-1.670	-0.082	3.795
X28	3.215	-2.809	-2.334	-1.450	-0.307	2.502
X29	2.998	-2.369	-1.823	-1.124	-0.146	2.223
X30	2.002	-2.908	-2.177	-1.217	0.047	2.955
X31	1.643	-2.272	-1.713	-0.699	0.383	2.655
X32	1.650	-2.314	-1.834	-1.151	-0.097	2.217
X33	2.583	-2.484	-1.962	-1.099	0.017	2.501
X34	3.393	-2.580	-2.341	-1.389	-0.248	2.332
X35	3.056	-2.671	-2.254	-1.212	-0.109	2.562
X36	1.354	-3.580	-3.078	-1.902	-0.291	3.289
X38	2.582	-3.011	-2.155	-1.453	-0.238	2.773
X39	2.931	-2.899	-2.497	-1.477	-0.233	2.666
X40	1.134	-5.810	-4.007	-2.092	-0.307	5.503
X41	0.961	-1.775	-0.892	0.559	1.801	3.576
X42	2.773	-2.778	-2.013	-1.310	-0.128	2.650
X43	2.411	-2.597	-2.065	-0.900	0.136	2.733
X44	2.401	-2.912	-2.094	-0.872	0.320	3.232
X45	3.016	-2.770	-2.346	-1.162	0.059	2.829
X46	3.750	-2.483	-1.990	-1.227	-0.083	2.400
X47	2.525	-3.034	-2.478	-1.457	-0.246	2.788
X48	2.784	-2.896	-2.344	-2.393	-0.176	2.720
X49	1.708	-3.915	-3.024	-1.420	0.011	3.926
X50	3.001	-2.694	-2.218	-1.166	-0.041	2.653
X51	2.261	-2.866	-2.170	-1.225	-0.044	2.822
X52	3.177	-2.477	-2.153	-1.047	0.063	2.540
X53	2.736	-2.875	-2.322	-1.113	0.129	3.004
X54	1.822	-4.332	-3.240	-1.939	-0.378	3.954
X55	2.800	-2.755	-2.284	-1.047	0.096	2.851
X56	2.112	-2.864	-2.171	-1.150	-0.129	2.735
X57	2.724	-2.658	-2.204	-1.315	-0.088	2.570
X58	1.248	-4.613	-3.895	-1.907	-0.070	4.543
X59	1.524	-2.083	-1.538	-0.704	0.567	2.650
X60	3.107	-2.560	-2.038	-1.153	0.061	2.621

Items	a	b_1	b_2	b_3	b_4	$b_4 - b_1$
X61	3.018	-3.146	-2.400	-1.133	0.061	3.207
X62	2.268	-2.917	-2.269	-1.019	0.251	3.168
X63	1.558	-3.407	-2.978	-1.442	-0.150	3.257

The table above shows the estimated graded response IRT parameters for the learning environment instrument items in distance education at Open University. The items in this instrument cover most of the latent traits at -7.026 to 1.801. The difference between the threshold parameter values ($b_4 - b_1$) indicates the ease of students changing their assessments from one category to another. Therefore, if there is a slight difference between the b values, then a small difference in the trait will cause a change in student assessments.

The discrimination parameter (a) values range from 0.854 to 3.75. In this instrument, the item discrimination power varies; some are included in the moderate category ($0.65 \leq a \leq 1.34$), good items ($1.35 \leq a \leq 1.69$), and very satisfying/very high items ($a \geq 1.70$) (Baker, 2001). This means that the ability of the response category to distinguish between different levels of the construct being assessed (Adams & Farmer, 2022).

Next, the category response curves (CRC) are seen for each item of the distance learning environment instrument at the Open University. CRC in GRM is a graphical representation of the probability of ranking various options on a particular item across the range of assessed properties (Adams & Farmer, 2022; Falk, 2020; LaHuis et al., 2011). In this study, the X-axis on the CRC shows the basic level of student assessment of the distance learning environment at the Open University measured on a standardized regular scale (θ). Theoretically, its value can range from $-\infty$ to ∞ (Adams & Farmer, 2022). The CRC clearly illustrates for each item ranking option (1) never to (5) always, and a relatively sharp decline in the probability of each response option occurring. Each curve shows the probability of choosing one response alternative as a function of ability (Mateucci & Stracqualursi, 2006). The following are category response curves for the learning environment instrument items in distance education at Open University:

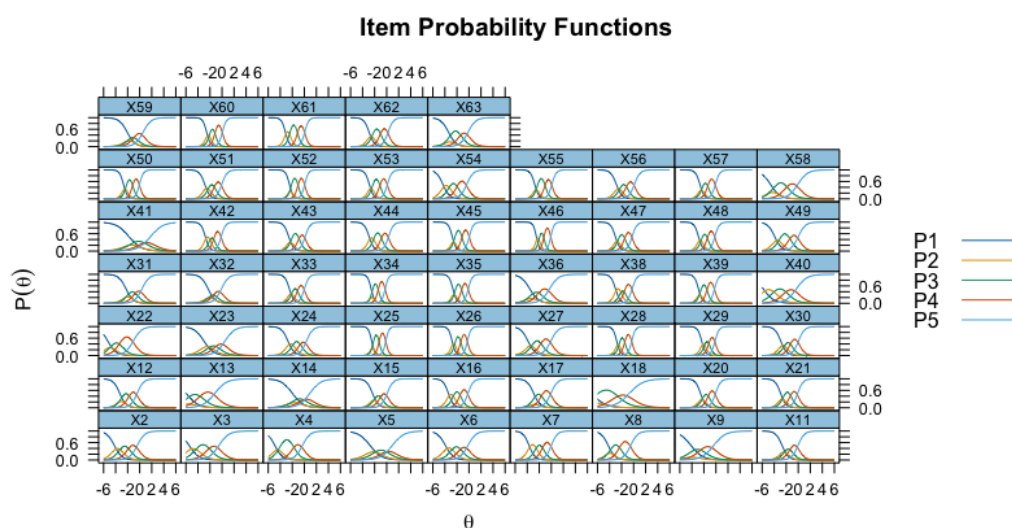


Figure 3. Category Response Curves for All Items

*Note: $P(\vartheta)$ = Represents the probability of a sample with latent ability ϑ answering the question correctly.

Based on the image above, it can be seen that the curve associated with option 5 has a monotonic increase. This means that the probability of choosing option 5 (always) increases along with the increase in students' assessment ability towards their learning environment. Judging from

all the items on the distance learning environment instrument at the Open University, it has a primarily pessimistic threshold estimate, which means that students who give very high ratings must complete the questions thoroughly. However, this could cause difficulty in estimating the results of the learning environment evaluation on this instrument for students who give very high ratings. According to Mateucci and Stracqualursi (2006), this could be due to the low frequency of category selection. Therefore, further research is needed regarding this instrument's best frequency for category selection.

Furthermore, all items on this instrument for other response alternatives, namely numbers 2 (rarely), 3 (sometimes), and 4 (often), have a non-monotonic trend. This increases in students who tend to have low and medium ability levels but decreases in students with relatively high ability levels. As the students' ability level is high, they should tend to complete the instrument items perfectly. Therefore, it is necessary to analyze the information on the instrument items to assess each instrument item's informative power and discrimination power (Mateucci & Stracqualursi, 2006). The following is information for the entire set of items, namely the test information curve (solid line), along with the respondent measurement error curve (circle line):



Figure 4. Test Information and Standard Errors for All Items

Based on the image above, it can be seen that the test information (in blue) and standard errors (in red dashed lines) are conditional from the measurement function for the overall scale of items from the learning environment instrument in distance education at the Open University. This is seen because, in IRT, there needs to be information that refers to the ability of an item and a scale (combined score) to accurately estimate the level of the construct being measured (i.e., the point at 0) (LeBuffe et al., 2018), where test information is inversely proportional to standard errors (LeBuffe et al., 2018). Where when test information increases, item reliability also increases. At $-4 \leq \theta \leq +2$ on this instrument, test information is approximately at or above 4, corresponding to reliability at or above 0.80 (Adams & Farmer, 2022). The scale shows good reliability between two standard deviations from the mean.

Furthermore, a qualitative analysis incorporated the Open University students' perception scale of the learning environment in their distance education.

Table 6. Scale Means, Standard Deviation, Internal Consistency Reliability, and Discriminant Validity for the Learning Environment Instruments in Distance Education at the Open University

Scale	Mean	SD	Alpha Reliability	Mean Correlation
Usefulness of course	4.424	0.535	0.916	0.841**
Equity	4.327	0.589	0.917	0.817**
Asynchronicity	4.387	0.520	0.917	0.828**
Active learning	4.396	0.451	0.925	0.714**
Student interaction and collaboration	3.715	0.896	0.943	0.583**
Instructor support	4.206	0.666	0.917	0.815**
Personal relevance	4.304	0.569	0.914	0.867**
Authentic learning	4.299	0.549	0.916	0.843**
Student autonomy	4.395	0.513	0.929	0.607**

N = 916, ***p* < 0.01

5. Discussion

5.1. Usefulness of Course

During the interview process, students were asked to describe how useful they found their Open University courses. The qualitative data from Open University students showed that they believed the courses they attended had benefits for their present and future lives ($UC \bar{X} = 4.424$). This indicates that the learning environment in distance education at the Open University provides an overview of the purpose of tutorials for students. This is explained by the results of interviews with Open University students, as follows:

Yes, I feel confident that the tutorials I follow in every lecture can definitely help me in developing knowledge and even mindset about my life (interview, student 5, accounting study program, February 8, 2025).

I really feel the benefits of participating in the tutorial, I am free to ask the tutor directly about the material I want to learn and it is directly related to my work as an elementary school teacher (interview, student 2, elementary school teacher education study program, February 1, 2025).

This is in accordance with research conducted by (Gupte et al., 2021; Polman et al., 2021) which states that learning should make students feel meaningful and should encourage students to actively choose to incorporate new concepts into their existing knowledge framework.

5.2. Equity

Almost all Open University students stated that they felt they received care and were treated equally in the lecture process by tutors ($E \bar{X} = 4.327$). Students who were interviewed also stated that their tutors in every tutorial always motivated and gave them appreciation so that they felt that they were always being paid attention to by the tutors in the tutorials. In addition, tutors always gave

equal opportunities to all students to express their opinions or to ask questions to the tutors. Open University students also felt that tutors in every tutorial they attended always gave responsive and balanced responses to all students who attended the tutorials. The following is one of the results of student interviews that have been conducted regarding the equity dimension:

I always get my turn when I want to ask the tutor questions about material that I don't understand (interview, student 5, accounting study program, February 8, 2025).

The tutor who taught me always gave us students motivation in every tutorial, namely at the beginning and end of the tutorial and often the tutor always gave us appreciation when we were able to help the tutor in answering questions that other students asked (interview, student 2, elementary school teacher education study program, February 1, 2025).

Initially there were several studies conducted by (Friedman & Mare, 2019; Richards et al., 2008) stated that distance learning can widen the gap of vital inequalities for each student. The wide gap of vital inequalities can be caused by gender, culture, race, class, and geopolitical factors (Czerniewicz et al., 2020). However, research conducted by (Hodges et al., 2022; Williamson et al., 2020) stated that a well-prepared design in the distance learning system will make all learning activities at the university equal from the start. Based on this, it can be concluded that the equality felt by Open University students when taking tutorials is due to the mature distance learning system at Open University.

5.3. Asynchronicity

Open University has a platform that can help students understand the material more concisely, add material, get to know the tutors who teach the courses better, and communicate through discussion forums on the platform. The platform is called e-learning. On this occasion, students were asked to give their opinions regarding the performance of e-learning itself. The results obtained were that most students stated that e-learning could encourage them to think reflectively and the material contained in e-learning could be easily accessed anytime and anywhere by students ($A \bar{X}=4.387$). The following is a statement from the results of an interview with Open University students regarding the e-learning platform:

With e-learning, I can easily contact the tutor if I still have questions about material outside the tutorial (interview, student 5, accounting study program, February 8, 2025).

The discussion forums in e-learning are easy to access at any time and I can study them again for exams (interview, student 1, management study program, February 1, 2025).

As a student who finds it difficult to communicate directly by speaking, the discussion forums in e-learning help me to communicate directly by typing (interview, student 3, educational technology study program, February 4, 2025).

The tutors in every course I take always provide additional material that we can use to increase our insight into related material in e-learning and I can access it easily (interview, student 4, biology education study program, February 5, 2025).

I can find out about tutors and contact them further in the discussion forum, I can even find out the tutor's mobile phone number and email address in e-learning, where our course tutors always fill in the tutorial introduction forum in e-learning (interview, student 2, elementary school teacher education study program, February 1, 2025).

Based on these results, it states that distance education at the Open University which is carried out asynchronously is greatly assisted by the existence of e-learning or other social technologies to help the learning process run effectively and optimally. This is supported by one of the research results obtained by (Joyner et al., 2020) which states that most students tend to be more comfortable

doing asynchronous learning compared to traditional learning. Where even though learning is done asynchronously, learning at Open University can still be done well and optimally because it is supported by mature facilities and systems.

5.4. Active learning

Open University students are consciously aware that lectures at Open University are conducted with a distance learning system. Where with a distance learning system, students are required to study independently. Therefore, most Open University students are also consciously exploring themselves independently and are more independent in finding learning resources related to their learning topics ($AL \bar{X}=4.396$). The following are the results of interviews with Open University students regarding this dimension:

When I chose Open University to obtain my bachelor's degree, I knew the way I had to study, where I was required to study independently to be able to graduate from Open University (interview, student 3, educational technology study program, February 4, 2025).

There are indeed obstacles in the independent learning that I have been doing up to now, but I can overcome this by seeking help from other student friends or asking tutors during tutorials or in discussion forums (interview, student 2, elementary school teacher education study program, February 1, 2025).

(Ludwig-Hardman & Dunlap, 2003) stated that distance learning in universities is said to be successful largely due to the ability of educational institutions to personalize the teaching and learning process. One of these is by creating an active learning system that can facilitate learning by utilizing ideas from both students and tutors.

5.5. Student interaction and collaboration

Students during tutorials in lectures, in addition to being required to work independently, Open University tutors develop assignments by collaborating with other students. Most students feel that even though learning at Open University is done remotely, they feel they can still collaborate with other students ($SIC \bar{X}=3.715$). The results of student interviews regarding this dimension are as follows:

Most of the assignments given by the tutor are group assignments, which makes it easier for us to complete the assignments on time (interview, student 5, accounting study program, February 8, 2025).

Discussions that take place during tutorials are not only limited to students asking questions and answering with tutors, but sometimes there are also discussions that take place in groups with other students (interview, student 1, management study program, February 1, 2025).

Although the Open University implements a distance education system, it does not rule out the possibility that with a distance education system students can still interact and collaborate with each other. This is supported by research conducted by (Joyner et al., 2020) that the distance education system, although online, distributed, and asynchronous, still displays characteristics that emerge from traditional education programs such as student social communities. This can be due to the development of social media and some people feel more comfortable interacting online (Joyner et al., 2020).

5.6. Instructor support

The distance learning process does not hinder the connection between students and lecturers or make it difficult for tutors to help with difficulties experienced by students. Open University students feel that the distance between students and tutors does not affect their interaction (IS

$\bar{X}=4.206$). Tutors at Open University always help and answer every difficulty and also help students. In addition, Open University students also stated that in every tutorial, tutors always provide feedback on what they are studying that day, be it assignments or feedback on answers to every question in their class. The following is one of the results of an interview with Open University students regarding this dimension:

Even though the class I am taking is an online tutorial, the tutor always provides feedback on our assignments and questions, both in the tutorial and in e-learning (interview, student 1, management study program, February 1, 2025).

Our class during the tutorial was never quiet and silent. Maybe this was because the tutor could always enliven the atmosphere of our class by giving questions that made us think to answer them. In addition, the tutor was also able to make us always enthusiastic in answering the questions asked (interview, student 2, elementary school teacher education study program, February 1, 2025).

Research conducted by (Derakhshandeh & Esmaeili, 2020) stated that the role of tutors in a good distance learning program is that tutors still have adequate but not too much interaction with students, so that tutors can still manage their time as they wish, and help students avoid feelings of lack of interaction. Where with existing facilities such as e-learning, students are also given the opportunity to decide to what extent they need direct contact with tutors or not. Furthermore, to make tutors what is desired in Open University learning, Open University provides training to all tutors who will participate in tutorial activities each semester. This is in line with research conducted by (Nestulya & Shara, 2023) that to overcome the lack of “direct communication” in distance education, universities can provide practical training from specialists, namely mandatory training regarding the tutorials provided.

5.7. Personal relevance

Although learning at the Open University implements distance learning, Open University students can still apply the experiences they gain during tutorials and lecture materials that they study independently to their daily lives ($PR \bar{X}=4.304$). This may be due to the Open University policy, namely that out of eight tutorial meetings that students need to attend in each course they take, they are required to attend at least five tutorials. So, from this policy, students can really benefit from tutorial activities that they can apply in their daily lives. In addition, Open University students mostly consist of people who are already working, so they can easily relate understanding the material and cases given to their daily work. The following are the results of interviews with Open University students from the personal relevance dimension:

The tasks given by the tutor are tasks that are well packaged in case analysis in everyday life, so that in doing these tasks we can easily imagine them (interview, student 3, educational technology study program, February 4, 2025).

Many of my friends (other university students) in the tutorial asked the tutor questions about their experiences with problems they often encounter in their work (interview, student 2, elementary school teacher education study program, February 1, 2025).

Research conducted by (Daroedono et al., 2020) stated that when tutors provide educational materials or assignments in various formats such as video, audio, or text and students are free to choose the most convenient way for them to learn or do their assignments, it is very important to acquire and develop their practical skills that they can use in their lives. At the Open University, tutors are also asked to provide materials in the form of video, audio, or text in e-learning in addition to the materials in the module. Students have the right to choose one. Therefore, Open University students can easily apply their experiences in lectures to their daily lives because of this.

5.8. Authentic learning

Open University students admit that they can learn their learning materials well because they remember that what they learn from the lecture materials will be useful for them in their daily lives (AL $\bar{X}$ =4.299). Therefore, before studying the learning materials, they always look at the learning objectives stated in their lecture modules. In the Open University modules, they always provide cases that illustrate things that might happen in everyday life with the materials they learn. The following are the results of interviews with Open University students:

Yes, I feel the benefits that I get when I apply what I learn in lectures. One of them is in the learning evaluation material, the knowledge that I get from understanding the material in the lecture is very useful for me to assess the students I teach objectively (interview, student 2, elementary school teacher education study program, February 1, 2025).

Even though I have not yet become a teacher directly, the knowledge that I have learned in the student development course has really helped me understand my own child's growth and development and how I respond to my child's growth and development (interview, student 4, biology education study program, February 5, 2025).

One of the supporting tools for distance learning at Open University is a module that is packaged with the delivery of material through sentences and cases that are adjusted to the life or work that is appropriate for the students of the study program. where this is a form of authentic learning support in distance education at Open University. According to (Herrington et al., 2010) authentic learning framework in distance learning requires situated learning theory. Where situated learning is learning that is based on real-world contexts that are relevant to students (Chang et al., 2010). This will encourage students to engage in ongoing dialogue and share multiple perspectives if the assignments and materials presented are authentic to the students (Anderson & Dron, 2011; Chin et al., 2018).

5.9. Student autonomy

Open University students understand the learning system implemented at Open University. Students are faced with independent learning where students are aware of their demands, one of which is being able to manage themselves to determine their achievement targets for each outcome of the learning they go through (SA $\bar{X}$ =4.395) Among their self-management, Open University students are expected to be able to make decisions about choosing learning to being able to determine their own study time. The following are the results of interviews with Open University students regarding the dimensions of student autonomy:

Of course, I understand when it is time for me to study the material in the module (interview, student 5, accounting study program, February 8, 2025).

I study the material in the module at night when I have finished my work assignments from school (interview, student 2, elementary school teacher education study program, February 1, 2025).

The material I studied first was the material I considered the most difficult, then the other material (interview, student 3, educational technology study program, February 4, 2025).

I like to study before the tutorial starts. Because with this I understand better when listening to the questions asked during the tutorial and I understand what I don't master in the material, so I can ask questions about it to the tutor (interview, student 4, biology education study program, February 5, 2025).

According to research conducted by (Lazorak et al., 2021) increasing students' sense of responsibility for their own learning, one of the supporting factors is tutors who focus on students' ability to use language for communication in real-life situations. This proves that from students understanding the meaning of their learning, it can ultimately maintain a greater level of their

autonomy as individuals. In addition, from their desire to take independent action also depends on the level of motivation and self-confidence of students, while the ability to act independently assumes their level of knowledge and skills (Hinkel, 2005). Based on this, it can be concluded that Open University students can form their autonomy because the Open University learning system is comprehensive, good and mature.

6. Conclusion

The development of learning environment instruments in distance education at the Open University derived from the DELES instrument from Walker & Fraser (2005), ACCC from Newby (1998), and OLES from Clayton (2007) through the stages of instrument development from Recker & Rosemann (2010), which ultimately have nine dimensions, namely instructor support, student interaction and collaboration, personal relevance, authentic learning, active learning, student autonomy, course usefulness, equity, and asynchronicity. The development of this instrument can be used as a form of reflection by Open University students regarding their learning environment and evaluation material for the Open University academic community in maintaining the quality of the Open University distance education learning environment.

Overall, the level of reliability in the range of $-4 \leq \theta \leq +2$ is associated with an estimated reliability between 0.80 and 0.95. This shows that this instrument can steadily measure the actual state of distance education teaching and learning environment at Open University. The results of the identification per item show that the curve associated with the 5th option experiences a monotonic increase. This means that the chance of choosing the 5th option (always) increases along with the increase in students' assessment abilities towards their learning environment. This study examines the development of teaching and learning environment instruments in distance education at Open University. This study uses the population of all Open University students spread throughout Indonesia. It is hoped that the results of this study can also be used in other universities in Indonesia and even the world that implement distance learning in their education system. However, this study did not reach that point, so further research is needed to determine whether the results can be used validly in other universities in Indonesia and even the world that implement distance learning.

In addition, seen from all the items on the learning environment instrument in distance education at the Open University, it has a threshold test that is mostly negative, which means that students who give very high ratings are not required to complete the item questions completely. However, this can cause difficulties in estimating the results of the learning environment evaluation on this instrument for students who give very high ratings. According to Mateucci & Stracqualursi (2006), this can be caused by the low frequency of category selection. Therefore, further research is needed regarding this instrument's best frequency for category selection.

7. Suggestion

Based on the results of qualitative research on student perceptions of learning at the Open University also stated that the results obtained explained that distance education at the Open University had been prepared and carried out carefully, so that it could optimally support the objectives of distance education. In addition, the distance education system carried out by the Open University can also minimize things that are feared to reduce the objectives of learning, one example is that due to distance education there is a geographical distance between students and students or students and tutors, this will lead to lack of collaboration between students or lack of assistance that tutors can provide. The learning system at the Open University can dispel these things very well.

Declarations

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Ethical Approval. This study has been approved by the ethics committee of the Institute for Research and Community Service, State University of Jakarta No: 331/UN39.14/PT.01.05/IV/2025. All participants agreed to participate in this study and the participants' personal data was kept confidential.

Data Availability Statement. This research data is available at 10.6084/m9.figshare.28758866.

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