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EXPLORING EDUCATION IN THE DIGITAL AGE: INNOVATIONS, INTERSECTIONS AND INSIGHTS

PREFACE

Dear esteemed readers and contributors,

It is with great pleasure and excitement that I extend a warm welcome to you all to this special edition of our journal, dedicated to exploring the diverse and dynamic themes shaping the landscape of education in the digital era. As we embark on this journey of discovery, each theme serves as a guiding beacon, illuminating the innovative intersections of technology and pedagogy.

Our first theme, Teaching based on Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT), sets the stage for our exploration by delving into the transformative potential of intelligent technologies in education. From personalized learning experiences to predictive analytics, AI, ML, and IoT hold the promise of revolutionizing traditional teaching methods and unlocking new pathways to knowledge acquisition.

Theme 2 invites us to immerse ourselves in the realm of 360 Learning, Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). Here, we witness the fusion of physical and digital worlds, as learners embark on immersive journeys that transcend the confines of the traditional classroom. Through experiential learning and interactive simulations, VR, AR, and MR technologies redefine the boundaries of education, offering unprecedented opportunities for engagement and exploration.

In Theme 3, we explore the power of Collaborative Teaching, Global Learning, and innovative practices such as Gamification, Maker-Space, and Maker Lab initiatives. This theme underscores the importance of collaboration, cultural exchange, and hands-on experimentation in fostering creativity, critical thinking, and problem-solving skills among learners worldwide.

Theme 4 sheds light on the paradigm shift towards Open and Distance Learning (ODL), Self-Instructional Materials (SIM), and the utilization of Big Data Analytics in Learning. Here, we witness the democratization of education, as learners gain access to high-quality resources and personalized learning experiences irrespective of geographical constraints. Big Data analytics further enhance the educational landscape by providing insights into learner behavior and preferences, enabling educators to tailor instruction to individual needs.

In Theme 5, we explore the evolving role of Social Media Learning as a catalyst for knowledge dissemination, collaboration, and community building. From online forums to multimedia platforms, social media offers a dynamic space for peer-to-peer learning, digital literacy development, and the cultivation of virtual learning communities.

Theme 6 invites us to embrace Design Thinking for new Learning Delivery, emphasizing the importance of user- centered design principles in creating innovative and inclusive learning experiences. Through empathetic design, educators can reimagine learning environments that foster creativity, adaptability, and lifelong learning skills.

In Theme 7, we delve into Andragogy in technology-based learning, Instructional Design, and Best Practices in e-learning. This theme highlights the importance of learner-centered approaches, effective instructional design strategies, and the dissemination of evidence-based practices to optimize learning outcomes in the digital age.

Finally, Theme 8 explores the Development of e-learning systems, materials, and mobile technologies, including the emergence of MOOC-based mobile learning materials. Here, we witness the evolution of educational technologies, as mobile devices and online platforms redefine the boundaries of access and engagement in education.

As we navigate through these diverse themes, let us embrace the spirit of inquiry, collaboration, and innovation that defines our scholarly community. I extend my deepest gratitude to all the contributors who have enriched this journal with their insights and expertise. May this edition inspire new ideas, spark fruitful discussions, and contribute to the ongoing dialogue surrounding the future of education.

Thank you for your dedication and commitment to advancing the frontiers of knowledge in the field of education.

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Theme 1: Teaching based on Artificial Intelligence (Ai)/ Machine Learning (ML)/ Internet of Things (iOT)

Theme 2: 360 Learning/Virtual Learning Virtual Reality/Augmented Reality & Mixed Reality

Theme 3: Collaborative Teaching or/and Global Learning/A.D.A.B in Teaching and Learning/ Gamification in Teaching and Learning/Maker-Space/ Maker Lab

Theme 4: Open and Distance Learning (ODL)/Self Instructional Materials (SIM)/Big Data Analytics in Learning

Theme 5: Social Media Learning

Theme 6: Design thinking for new Learning Delivery

Theme 7: Andragogy in technology-based learning/Technology in learning/Instructional design in learning/Best practices in e-learning

1. Challenges and Innovations: Adapting Practical Culinary and Foodservice Subjects for Distance Learning during COVID-19
2. Exploring Tertiary Education ESL Learners' Dependency on the Internet, Internet Sources, and Internet Source Reliability

Theme 8: Development of e-learning system/Development of e-learning materials/Development of mobile systems in Learning/Development of MOOC-based mobile learning materials

1. Student Acceptance with the Usage of Padlet in Guiding Research Statistics Analysis
2. MOOC Courses Development: Guidelines for GLAM MOOC

Guest Editors

Programme Outcomes Attainment towards Psychomotor Skill Development during Open Distance Learning in Engineering Laboratory Courses

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ABSTRACT

Open distance learning (ODL) has faced an enduring challenge in delivering programs associated with psychomotor skills caused by the COVID-19 pandemic. The teaching, learning, and assessment related to psychomotor development during ODL have often been less effective than traditional methods due to the absence of technical skills like hands-on equipment handling, which are challenging to implement in remote learning environments. This paper focuses on attaining programme outcomes or graduate attributes related to developing psychomotor skills in laboratory courses during ODL within the context of engineering education. A quantitative research approach was used to gather insights, using a questionnaire survey administered to engineering students engaged in laboratory courses via ODL. The findings revealed that engineering students perceive three significant program outcomes attained during ODL, which were the ability to determine the correct methods and procedures, including experiment design, the capacity to synthesise information to devise practical solutions for challenging issues, and the ability to propose valid conclusions and solutions for given problems. However, it is crucial to note that the ability to collect data accurately, primarily through tool usage, remains a fundamental psychomotor skill ranked as the least attained programme outcome during ODL. This highlights the unique challenges faced when teaching and assessing practical skills in remote environments. Furthermore, the study showed that using engineering laboratories during ODL was perceived as the least effective method for addressing psychomotor skill development. These findings suggest the need for innovative strategies and technology-enabled solutions to bridge the gap between theoretical knowledge and hands-on practice in engineering education during ODL. It also demonstrates the urgent requirement to enhance the delivery of practical skills in ODL, particularly within engineering laboratory courses. Further research should focus on innovative methodologies for remote psychomotor skill development, such as virtual labs and simulation technologies, to provide a more comprehensive and practical learning experience for engineering students engaged in these programs.

Keywords: Laboratory courses; Open distance learning; Programme outcomes; Psychomotor skill development

INTRODUCTION

The World Health Organization (WHO) declared that COVID-19 is a global pandemic on 11 March 2020. This scenario continued until July 2022. As a result, an unprecedented academic disruption occurred worldwide (UNICEF, 2023). The widespread COVID-19 outbreaks caused a sudden change in the learning process from face-to-face (F2F) to ODL, introducing various platforms for lecturers and students. Consequently, teaching approaches and delivery methods must also be realigned to ensure the Programme Outcomes (P.O.) can be achievable and measurable during open distance learning. According to the Board of Engineers Malaysia, engineering graduates should acquire 12 Washington Accord attributes, which are mapped to three main learning domains, namely cognitive(knowledge), psychomotor (motor skills), and affective (emotion) upon graduation. Novak-Pintarič and Kravanja (2020) found that programs associated with motor skills, especially for Science, Technology, Engineering, and Mathematics (STEM), were less suited for remote learning even before the COVID-19 pandemic. Additionally, a recent study done by Bali and Musrifah (2020) and Plummer et al. (2021) viewed that teaching, learning, and assessment (TLA) for the psychomotor domain during ODL is less effective than traditional methods due to a lack of technical skill such as handling equipment in a laboratory which cannot easily be implemented during remote learning. Meanwhile, Chiew et al. (2022) found that psychomotor skill assessment for engineering programmes only meets the minimum level of addressing learning outcomes at the initial stages of ODL in Malaysia for the undergraduate level. Hence, this study aims to monitor the development of the psychomotor learning domain, specifically in engineering laboratory courses, via ODL from engineering students' perspectives. An online survey was distributed among 256 respondents within local universities in Malaysia. Data was gathered and analysed using the Rasch Model. Hopefully, the findings will help realign the TLA for practice-oriented components during remote learning at the undergraduate level.

LITERATURE REVIEW

Engineering is a technical programme that requires motor skills, which is one of the attributes of graduate students in Malaysia. These outputs were determined as part and parcel of tertiary education stipulated by the Board of Engineer Malaysia (BEM) to ensure engineering graduates are market-ready for employability (Engineering Technology Accreditation Council, 2020). Hence, measuring the psychomotor domain became the focus of institutions of higher learning (IHL) in Malaysia that offer engineering programmes.

Psychomotor domains relate to the physical ability to handle and manage software, equipment, or tools. The psychomotor domain is associated with modern tools usage and investigation attributes in implementing the Civil Engineering Degree Programme (EC220) curriculum in UiTM Shah Alam, as shown in Table 1 (Chiew et al., 2022). These attributes will be developed in the curriculum structure through laboratory courses, final-year projects, and studio-based courses.

Table 1. Programme Outcomes (P.O.) mapped to Learning Domains for EC220 (Chiew et al., 2022)

PO	Washington Accord Attributes	Dominant Learning Domains
PO1	Engineering Knowledge	Cognitive
PO2	Problem Analysis	Cognitive
PO3	Design development of solution	Cognitive
PO4	Investigation	Psychomotor
PO5	Modern tool usage	Psychomotor
PO6	The engineer and society	Cognitive
PO7	Environment and sustainability	Cognitive
PO8	Ethics	Affective
PO9	Individual and teamwork	Affective
PO10	Communications	Affective
PO11	Project management and finance	Cognitive
PO12	Lifelong learning	Affective

Simpson taxonomy Programme Outcomes (P.O.) for EC220 (Chiew et al., 2022) were adopted to evaluate student performance related to the psychomotor domain during the assessment period. Simpson (1972) proposed seven (7) tier levels of difficulties in assessing psychomotor domains, starting from perception, set, guided response, mechanism, complex overt response, adoption, and origination. This difficulty level is a gold method to evaluate students during the physical mode of the evaluation process but not for ODL sessions (Eroğlu et al., 2022). Wati et al. (2020) stated that the biggest challenge in delivering practicum work during ODL is to recreate the laboratory environment at home with online supervision. Ibrahim et al. (2023) found that students perceived trouble with internet accessibility during TLA and a non-conducive home environment for study as the main reasons that resulted in a decremental motivation level during ODL. However, Rahim et al. (2023) viewed that not all laboratories can be recreated in a home environment due to the apparatus needed and materials used to conduct the test, such as harmful chemical reagents that must be handled with proper safety guidelines in the laboratory. In addition, Mayuze et al. (2023) and Noor et al. (2023) discuss the evaluating process for laboratory courses at the diploma civil engineering programme in UiTM Pasir Gudang needs to be realigned to fit the ODL mode of delivering and evaluating process.

Some findings show that student performance during ODL has not significantly changed compared to F2F learning due to the adaptation of assessment methods for remote learning in laboratory courses. However, Lee et al. (2023) revealed that ODL has decreased student performance on the use of modern tools compared to F2F sessions. Similarly, Chiew et al. (2021) found that students face difficulties adapting to and understanding engineering software during remote learning. Rahim et al. (2023), Noor et al. (2023), and Mayuze et al. (2023) agreed that motor skills can be introduced to students by providing demonstration videos for each learning outcome. Students should be able to give feedback verbally during the practical test or through home-based video, which imitates accurate procedures in laboratory work. However, there are limitations in analysing P.O. related to developing psychomotor skills during ODL. Therefore, this study aims to examine the development of the psychomotor domain in engineering laboratory courses via ODL from students' perspectives based on programme outcome attainment.

METHODOLOGY

A quantitative approach was utilised for the research design in this study, and the online survey was adopted to collect data from the respondents. Two steps of the research are involved: (1) data collection and (2) analysis of the data to determine the trends, patterns, and relationships between the variables. In this study, the Rasch Model was used to analyse the data. Purposive sampling was used to target the respondents who were engineering students. They were chosen based on their experience in open distance learning (ODL). The questionnaire survey was made available for three months, and the respondents were only allowed to submit their responses once. The questionnaire survey was designed based on five (5) sections outlined in Table 2.

Table 2. Design of Questionnaires Survey

Section	Item	No.	Measurement
A	Demographic Profile of Respondents	6	Choice
B	General information related to ODL	4	Multiple choices
C	How psychomotor skills contribute to students' abilities during ODL	7	5-point Likert Rating
D.1	Effectiveness of related to teaching, learning and assessment (TLA) activities in addressing the psychomotor domain during ODL	4	5-point Likert Rating
D.2	Type of assessment used to measure psychomotor domain for the laboratory-based course during ODL	6	Multiple choices (May choose more than one type)
D.3	Programme outcome development in laboratory courses during ODL	7	5-point Likert Rating
E	Challenges faced in undertaking laboratory activities during ODL	6	5-point Likert Rating
F	Suggestions to improve the laboratory courses during ODL	10	5-point Likert Rating

Data Collection

The data collection involved an online questionnaire survey distributed using Google Forms based on purposive sampling, which involved a total of 272 students from various levels of engineering courses at public and private universities in Malaysia.

Data Analysis

Demographic results were presented as percentages to illustrate the distribution of respondents. Subsequently, the Rasch model was employed using WINSTEPS version 3.69.1.16 software to analyse the data collected from the questionnaire survey. Rasch's analysis focuses on examining how well the data fits the model instead of the traditional statistical approach of evaluating how well the model fits the data. Additionally, the study assessed the validity and reliability of the completeness scale using the Rasch Model technique. The Rasch Model was chosen because it shifts the focus from fitting a model to building a reliable measurement instrument (Bond & Fox, 2012). It creates a hypothetical unidimensional line that positions objects and individuals based on their difficulty and ability assessments, as demonstrated in the Person Item Distribution Map (PIDM) (Bond & Fox, 2012). To achieve a good fit, data points that demonstrated misfits were systematically removed (Scholten, 2011). Within this model, logic values represent measurements at an interval level rather than ordinary numbers, and summary statistics are used to assess the validity and reliability of respondents. Further investigation was conducted when the item reliability value equals or exceeds 0.7 (Bond & Fox, 2012). Additionally, an item characteristic curve scalogram was employed to provide an overall analysis of persons and items, while the study of the PIDM illustrates the distribution of respondents and items along a single continuum (Bond & Fox, 2012). The Rasch Model analysis transforms ordinal data into ratio data using a ruler of probability events, thereby generating an equal interval measurement ruler with its unit referred to as the "Logit" (log-odd-unit) scale.

RESULTS ANALYSIS AND DISCUSSION

Based on the 272 respondents' feedback, the following sub-section discusses the analysis of the results based on Section A (Respondents' Profile & Information) using descriptive analysis and the analysis of the results for Sections D1, D2 and D3 based on Rasch Analysis.

Table 3. Respondents' Profile & Information

Characteristics of Respondents		**Percentage**
1. Gender	Female	61%
	Male	39%
2. Age	18-21	71.8%
	22-25	22.5%
	More than 25 years	5.6%
3. University	Universiti Teknologi MARA	69%
	Other Universities	31%
4. Programme Level	Degree	73.2%
	Diploma	26.8%
5. Current CGPA	3.50 – 4.00	30.3%
	3.00 - 3.49	42.3%
	2.50 – 2.99	25%
	Less than 2.50	2.5%
6. Residency during ODL	Rural Area	11.4%
	Village	17.7%
	Small Town	27.6%
	Large Town	16.9%
	City/Metropolitan	26.4%
7. Social Class based on Household Income	B40 (Less than RM4850/month)	55.3%
	M40 (Between RM4850 - RM10950/month)	33.6%
	T20 (More than 10950)	11.1%
8. Access to devices used during ODL	Yes	98%
	No	2%

10. Type of device used during ODL.	Smart Phone	87.3%
	Tablet	14.8
	Laptop	94.4%
	Personal Computer	12%

As indicated in Table 3, most respondents (71.8%) are between 18 and 21 years old at the start of the study. Additionally, 73.2% of the participants were pursuing a bachelor's degree. The student's academic background was based on their CGPA, where most students fall under the Second Upper-Class honours category (42.3%). The respondents come from various geographical locations, including cities, metropolitan areas, large towns, small towns, villages, and rural areas, with the majority (70.9%) residing in cities and towns during ODL. The socioeconomic status of the students was based on their family household income, with 55.3% of the students coming from B40 families (earning less than RM4850 per month), 33.6% from M40 families (earning between RM4850 and RM10959 per month), and 11.1% from T20 families (earning more than RM10959 per month). Among the 256 students, 98% have access to devices during ODL, with smartphones and laptops being the most used devices, while less than 15% use tablets or personal computers.

Validity and Reliability

The Rasch Model analysis presents "summary statistics" to determine the validity and reliability of the measured items and persons. An appraisal of data fit to the strategies chosen by the respondents was carried out to observe the extent to which the respondents' responses to each stated strategy are consistent with the responses to other factors on the same assessment (Fisher, 2005). Figure 1 shows the summary statistics items (survey instrument) for the 11 measured items (D1 & D3 sections) generated from 272 persons. It reports the reliability, quality, and validity of the items in Section D on teaching, learning, and assessment activities carried out during ODL, as agreed upon by the respondents.

```
     SUMMARY OF 11 MEASURED (NON-EXTREME) Item
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT        OUTFIT    |
|          SCORE      COUNT     MEASURE  ERROR      MNSQ   ZSTD  MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN     943.6      280.0         .00    .09        .97    -.4   .93    -.7 |
| S.D.      81.0         .0         .64    .00        .19    2.2   .28    2.6 |
| MAX.    1016.0      280.0        1.59    .10       1.30    2.9  1.44    3.8 |
| MIN.     747.0      280.0        -.56    .09        .64   -4.4   .52   -4.8 |
|-----------------------------------------------------------------------------|
| REAL RMSE    .09 TRUE SD     .63  SEPARATION  6.91  Item    RELIABILITY  .98 |
|MODEL RMSE    .09 TRUE SD     .63  SEPARATION  7.15  Item    RELIABILITY  .98 |
| S.E. OF Item MEAN = .20                                                     |
-------------------------------------------------------------------------------
UMEAN=.0000 USCALE=1.0000
Item RAW SCORE-TO-MEASURE CORRELATION = -1.00
2992 DATA POINTS. LOG-LIKELIHOOD CHI-SQUARE: 5066.05 with 2707 d.f. p=.0000
Global Root-Mean-Square Residual (excluding extreme scores): .6743
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Figure 1. Summary of 11 measured items

It shows an item reliability of 0.98 (model = 0.98), greater than 0.7 and indicates the sufficiency of the items spread along the continuum (Fisher, 2005). Hence, the instrument is suitable for not being dependent on the respondents. It also indicates that the probability of the difficulty levels of every item remains the same if the instrument is given to a different group of students of the same size (Bond & Fox, 2012). The table also shows that the instrument has a good measurement model error of + 0.11 logit (Fisher, 2005).

Figure 2 shows the summary statistics for 272 persons measured for TLA activities during ODL. The person reliability statistic of 0.90 is an excellent measure of the consistency of the responses given by the 272 participants. A high level of personal reliability indicates that the instrument used in the study is effective in categorising and distinguishing the level of strategies selected by the respondents. It means that if the same set of survey instruments is given to a different group of participants, the likelihood of obtaining a similar pattern of ability in the person-measure order table and the location of these students on the person-item distribution map would be identical (Azrilah, 2011). The high personal reliability suggests that the study's findings are likely reliable and accurate in reflecting the participants' perspectives regarding TLA activities during ODL.

SUMMARY OF 272 MEASURED (NON-EXTREME) Person

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	37.0	11.0	1.04	.46	.90	-.3	.93	-.3
S.D.	8.5	.0	1.62	.08	.80	1.6	.88	1.6
MAX.	54.0	11.0	4.62	1.04	4.78	5.0	5.60	5.1
MIN.	12.0	11.0	-5.78	.35	.09	-3.6	.09	-3.4

REAL RMSE .52	TRUE SD 1.53	SEPARATION 2.96	Person RELIABILITY .90
MODEL RMSE .47	TRUE SD 1.55	SEPARATION 3.31	Person RELIABILITY .92

S.E. OF Person MEAN = .10

MAXIMUM EXTREME SCORE: 5 Person
MINIMUM EXTREME SCORE: 3 Person

Figure 2. Summary of 272 Persons

Figure 3 shows the standardised residual variance. The analysis demonstrates the reliability and unidimensionality of the instrument used to assess the programme outcomes attainment to develop the psychomotor skills during ODL, meeting the minimum 20% unidimensionality requirement as outlined by Reckase (1979) and the Rasch cut-low point of 40%.

Table of STANDARDIZED RESIDUAL variance (in Eigenvalue units)

		-- Empirical --			Modeled
Total raw variance in observations	=	28.2	100.0%		100.0%
Raw variance explained by measures	=	17.2	61.0%		59.8%
Raw variance explained by persons	=	10.4	37.0%		36.3%
Raw Variance explained by items	=	6.8	24.0%		23.5%
Raw unexplained variance (total)	=	11.0	39.0%	100.0%	40.2%
Unexplned variance in 1st contrast	=	3.4	12.0%	30.8%	
Unexplned variance in 2nd contrast	=	1.4	4.9%	12.6%	
Unexplned variance in 3rd contrast	=	1.1	4.0%	10.2%	
Unexplned variance in 4th contrast	=	1.1	3.9%	9.9%	
Unexplned variance in 5th contrast	=	.9	3.1%	8.1%	

Figure 3. Standardised Residual Variance

The measures account for 61.0% of the raw variance, closely aligning with the expected value of 59.8%. This distribution comprises 24.0% of the raw variance explained by the items and 37.0% explained by the students' responses. Furthermore, the unexplained variance by the first contrast stands at 12.0 %, falling comfortably below the 15% cut-off point suggested by Fisher (2005). These findings collectively affirm the instrument's reliability in effectively assessing the programme outcomes attainment and discerning variations in respondents' chosen proficiency levels. Figure 4 shows 11 item statistics based on measure order for Section D1 and Section D2.

Item STATISTICS: MEASURE ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Item
1	747	280	1.59	.10	1.30	2.9	1.44	3.8	.65	.72	48.9	58.6	D1a
3	858	280	.65	.09	1.06	.7	1.20	1.9	.70	.73	59.6	54.6	Dic
2	884	280	.45	.09	1.10	1.1	1.09	.9	.70	.74	51.8	55.9	D1b
4	916	280	.20	.09	1.01	.2	1.08	.8	.71	.74	50.7	55.6	D1d
8	959	280	-.12	.09	1.17	1.8	1.07	.7	.76	.75	56.6	56.9	D3d
7	986	280	-.33	.09	.85	-1.7	.68	-3.0	.79	.76	65.4	58.4	D3c
9	990	280	-.36	.09	.78	-2.5	.64	-3.5	.80	.76	66.2	58.6	D3e
5	1005	280	-.48	.09	1.08	.9	1.03	.3	.75	.76	63.2	60.1	D3a
11	1009	280	-.51	.09	.73	-3.1	.58	-4.0	.80	.76	67.3	58.9	D3g
10	1010	280	-.52	.09	.64	-4.4	.52	-4.8	.83	.76	68.4	58.9	D3f
6	1016	280	-.56	.09	.99	-.1	.95	-.4	.77	.76	62.9	59.0	D3b
MEAN	943.6	280.0	.00	.09	.97	-.4	.93	-.7			60.1	57.8	
S.D.	81.0	.0	.64	.00	.19	2.2	.28	2.6			6.7	1.7	

Figure 4. Item Statistics: Measure Order

Effectiveness of time flexibility, delivery, assessment and usage of engineering laboratories during ODL to address the psychomotor domain

Table 4 shows four (4) statements from Section D1 on the effectiveness of time flexibility, an online platform used for delivery, assessment and usage of laboratories to measure the psychomotor domain during ODL. The statements were ranked according to the respondents' level of agreement with each statement using logit values.

Table 4. Effectiveness of time, delivery, assessment and usage of laboratories during ODL

Item	Effectiveness	
D1d	Time flexibility effectively improves the psychomotor domain during ODL	0.20
D1b	Online meetings, such as Google Meet, with the provision of notes. and recordings contributed to the effective delivery of laboratory courses during ODL	0.45
D1c	The effectiveness of assessment designed during the pandemic is equivalent to the assessment conducted before ODL	0.65
D1a	Using remote engineering laboratories during ODL is an effective method for measuring the psychomotor domain.	1.59

The positive logit values indicate disagreement by the respondents on all four (4) statements. The respondents' disagreement with these statements highlights some insights and challenges related to open distance learning (ODL) in engineering laboratories, particularly concerning the psychomotor domain.

For statement D1d (0.2logit), the respondents might be skeptical about whether time flexibility, a hallmark of ODL, truly enhances psychomotor skills. Time flexibility in learning is hardly reflected in the development of psychomotor skills as the students may believe that specific hands-on skills require structured and in-person sessions. Thus, it is crucial to acknowledge that while time flexibility can be a significant advantage in ODL, the growth of specific practical skills still requires synchronous, real-time engagement between students and lecturers, which can be challenging in a flexible online environment (Bali & Musrifah, 2020).

Next, statement D1b (0.45 logit) indicates the respondents' disagreement, suggesting that they may not find these approaches entirely compelling for laboratory course delivery during ODL despite online meetings and supplementary materials like notes and recordings. Hence, the effectiveness of online meetings and supplementary materials can vary widely depending on factors like the quality of instruction, student engagement, and the nature of the laboratory activities. Further investigation may be required to understand specific concerns. Similarly, Bali and Musrifah (2020) found that online learning mainly strengthens fundamental knowledge but lacks the motor aspect, which results in lower attainment of psychomotor skills (only reaching imitation level).

The third statement, D1c (0.65 logits), shows that the respondents believe that assessments designed in response to the pandemic lack the rigour and effectiveness of traditional in-person assessments. The rapid shift to online learning forced educators to adapt quickly, spending more time learning the technology rather than designing good assessments, which may have affected the quality of evaluations. It is essential to continuously improve online assessment methods and ensure they align with learning outcomes.

Finally, the last statement, D1a (1.59 logit), indicates the most significant disagreement among respondents, which suggests a notable skepticism about the effectiveness of using engineering laboratories for psychomotor skill assessment in ODL. This skepticism might stem from challenges in replicating the hands-on experience of a physical lab in a remote setting. It raises questions about the suitability of virtual labs or remote experimentation as alternatives for psychomotor assessment. Learning processes can become more engaging when online applications or remote-control mechanisms simulate actual experiments.

Overall, these disagreements emphasise the complexities and challenges associated with ODL in engineering, particularly regarding hands-on skills in the psychomotor domain. Hence, addressing these concerns may require innovative pedagogical approaches, robust online resources, and enhanced communication between educators and students to bridge the gaps in understanding and expectations. Additionally, ongoing research and adaptation of instructional methods in response to feedback are essential to improve the effectiveness of ODL in engineering laboratory courses.

Table 5 shows the ranking of seven (7) statements from Section D.3 relating to programme outcome attributes acquired by the students during ODL based on the level of agreement toward developing their psychomotor skills. The ranking was based on Rasch analysis using logit values.

Table 5. Ranking of Programme Outcomes or Graduate Attributes Attained towards Psychomotor Development based on Logit

Item	Programme Outcomes or Graduate Attributes	Login
D3b	Ability to determine the correct methods and procedure, including design of experiment (Application of knowledge) (WK1-WK4)	-0.56
D3f	Ability to synthesise information towards providing relevant solutions to overcome problematic conditions (Design for solutions) (WK5)	-0.52
D3g	Ability to propose valid solution and conclusion for the given problem (Design for Solution) (WK5)	-0.51
D3a	Ability to investigate complex engineering problems using research-based knowledge for laboratory courses (Investigation) (WK8)	-0.48
D3e	Ability to understand, analyse and interpret experimental results to discuss significant findings (Problem Solving) (WK1-WK4)	-0.36
D3c	Ability to create, select and apply appropriate techniques, resources and modern engineering and I.T. tools to carry out the relevant experiment (Modern tool usage) (WK5)	-0.33
D3d	Ability to collect data from experiments accurately (Modern tool usage – WK6)	-0.12

The following discussion is based on the top three and the last ranked P.O. development aligned with the psychomotor domain to emphasise how they relate to hands-on technical skills, practical application of theoretical knowledge, problem-solving, and experimentation. The top three ranked P.O. development related to psychomotor skill are (1) the ability to determine the correct methods and procedure, including design of experiment, (2) the ability to synthesise information towards providing relevant solutions to overcome problematic conditions and (3) the ability to propose valid conclusions for the given problem.

The first ranked statement was D3b (-0.56 logit), which highlights the student's ability to determine the correct methods and procedure, including the design of the experiment. By incorporating the theoretical, fundamental and specialised knowledge the students have learned in lectures, they can design experiments by selecting appropriate methods and procedures to solve the given problems. The practical application of theoretical concepts to create a structured and effective experimental design can develop the student's psychomotor at manipulation and operational levels. Although the students may not have direct access to physical laboratories in an ODL environment, they can still engage in virtual experiments or simulations. Thus, their ability to navigate digital tools and platforms to design experiments effectively demonstrates their psychomotor skills in a digital context.

The second-ranked statement was D3f (-0.52 logit), which reflects the student's ability to synthesise information towards providing relevant solutions to overcome problematic conditions, which requires the ability to analyse and synthesise information, combining theoretical understanding with practical considerations to address real-world problems. It involves problem-solving skills, where students apply their knowledge to develop effective solutions, aligning with the psychomotor domain's emphasis on practical application. However, in ODL, the learners effectively analyse and process information from various sources, using online resources, digital libraries, and collaborative tools to synthesise data. Thus, they apply psychomotor skills in navigating digital information environments to develop practical solutions.

The third-ranked D3g (-0.51 logit) demonstrated the students' ability to propose valid solutions and conclusions for the given problem, interpret experimental results, apply analytical skills to draw meaningful insights and use theoretical knowledge to derive accurate conclusions. It aligns with the psychomotor domain as students engage in hands-on analysis and application of knowledge to reach valid conclusions. Students might engage in virtual experiments or remote data analysis in a remote learning setting. Thus, they apply psychomotor skills in critically analysing data, interpreting trends, and drawing conclusions based on digital data sets, reflecting the practical aspect of this skill. In all these three top-ranked programme outcomes, acquiring the psychomotor domain involves integrating theoretical knowledge with practical experiences. ODL presents unique challenges in providing hands-on experiences, but it also offers opportunities for students to apply psychomotor skills in digital contexts through virtual labs, simulations, and data analysis software applications. The emphasis on problem-solving, practical application, and hands-on engagement remains at the core of these P.O. developments, even in a remote learning environment.

Accurate data collection is a fundamental psychomotor skill involving hands-on activities to gather precise measurements and observations during experiments. However, the respondents ranked last in the ability to collect data from experiments accurately, as reflected in the last statement, D3d (-0.12 logit). It shows that the lack of ability to collect data from experiments accurately using tool usage might be influenced by several factors related to ODL and the challenges it presents.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

This paper focuses on the programme outcomes or graduate attributes related to the psychomotor learning domain acquired through laboratory courses during open distance learning or ODL from the perspective of engineering students. The findings from the survey, which was responded to by 272 students, found that the top-ranked programme outcome attainment related to psychomotor skill development during ODL is the ability to determine the correct methods, procedures, and designs of experiments. In contrast, the ability to collect data from experiments accurately had a minor agreement and ranked last in the seven (7) possible programme learning outcomes attained. While accurately collecting data from experiments remains a fundamental psychomotor skill, it is ranked as the last P.O. attainment in ODL, highlighting the unique challenges and considerations inherent in teaching and assessing practical skills in a remote environment. This again addresses the issue of the suitability of alternative virtual experiments conducted and the question of whether the data collected and analysis conducted from the virtual experiments are reflective and achieve the objectives and learning outcomes of the respective laboratory courses. Therefore, reviewing and improving the alternative virtual experiments is vital to ensure that they reflect the experimental setup and accurate data collection. In this study, the number of respondents is considered negligible due to the limited number of respondents involved in the survey. All respondents are students from Malaysia, with most of the respondents from Universiti Teknologi MARA. Therefore, this limitation constrained the study's findings from being generalised to all the universities in Malaysia or universities all over the world. Future research on a more significant number of respondents and to include a broader range of respondents from different countries is recommended.

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Conflict of Interest

The authors affirmed that there is no conflict of interest in this article.

Authors' Contributions

Che Maznah Mat Isa is the first and corresponding author to conduct the fieldwork and run the statistical analysis using the Rasch Model, preparing the abstract and interpreting results and findings. Mohd Azuan Tukiar and Narita Noh prepared the background of the study and literature review. Nur Asmaliza Mohd Noor wrote the research methodology, while Oh Chai Lian contributed to the analysis and discussion of results. Wardah Tahir and Moses wrote the conclusions and overall paper structure and continuity. At the same time, Chiew Fei Ha contributed to parts of the conclusion, limitations, and recommendations for future research and prepared the co-author contribution, acknowledgements, and checking of references.

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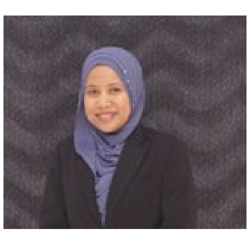	Narita Noh is a senior lecturer at the Civil Engineering Studies, College of Engineering, Universiti Teknologi MARA Johor. Her research interests include engineering education, sustainable materials for construction, and building stability. She joined UiTM in 2011, and her research area is structural and sustainable material for construction. Also actively published articles and journals in engineering education related to Open Ended Laboratory (OEL) and Conceive-Design-Implement-Operate

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