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Reliability of Online Simulation-Based Assessment to Measure Cognitive Performance and Its Acceptance Among Pharmacy Students

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ABSTRACT

The majority of conventional evaluations of cognitive skills (CSs) utilise paper-based or online multiple-choice questions or single best-answer questions. However, examination that uses online simulation of real scenarios has the potential to complement medium-to-high level CSs that make use of the intellectual capabilities of applying, analysing and evaluating complex information. Nevertheless, the reliability of online simulation as an alternative learning and assessment tool for Malaysian pharmacy courses has never been investigated. This paper illustrates online remote simulation-based assessment, its psychometric properties and students' feedback towards this new learning and assessment tool opportunity. A virtual web-based simulation examination consisting of three infectious disease scenarios was administered in an undergraduate pharmacy course to assess physically distanced students for medium-level clinical pharmacy CSs. Students responded through written typed communication to online enquiries from health professionals, patients or caretakers' avatars. Rasch analysis and a feedback survey were employed to measure the reliability of online simulation and to understand students' experiences with the new web-based tool. This study found that the remote simulation examination had good reliability (ir = 0.95, pr = 0.73) for measuring medium-level clinical pharmacy CSs. The students' survey indicates that the web-based simulation activities improved knowledge, engagement and cognitive reasoning. This article contributes to the pharmacy education literature by illustrating how a different type of assessment is feasible and reliable for evaluating students' CSs for final examinations and potentially has equitable opportunities for distance-learning students to enhance their learning capabilities and show their performances. Future research to investigate the potential of remote online simulation examinations for inter-professional learning and assessment is highly recommended.

Keywords: *Clinical pharmacy, Cognitive skills, Competence, Web-based simulation*

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INTRODUCTION

Multiple-choice question (MCQ) and single best-answer question (SBAQ) formats are commonly used in higher education for the assessment of cognitive skills (CSs) in the medical and health sciences (1–2). CSs refer to brain-based functions, such as learning, thinking, reasoning and other intellectual capabilities, that allow the processing of knowledge and information. The taxonomy of cognitive learning involves six cognitive process dimensions: remembering, understanding, applying, analysing, evaluating and ultimately, creating (3). These cognitive process dimensions are achievable through a combination of teaching strategies and students' face-to-face participation during teaching and learning activities and are reflected in their performances in the final examination. However, with physical restrictions in place during the COVID-19 pandemic, concerns arose regarding the levels of student engagement and participation when relegated to online learning. Additionally, assessment of moderate-to-higher order cognitive processes (apply, analyse, evaluate and create) only through MCQ or SBAQ formats may be insufficient. For example, an assessment with a high proportion of MCQs could potentially hinder learners' critical thinking (4) and could be of questionable quality if there are no active quality assurance processes at the course and department levels (5).

Changes in the learning environment and the demand for online learning require adjustments to learning strategies and assessments. As such, rapid progress in online teaching and learning has been seen over the past two years, prompted by the rising necessity of social distancing. An appropriate online learning and assessment format is one of the two key components for excellent students' engagement during online learning (6). Computer-based simulation (7), game-based activities (8) and digital stories (9) were some of the customised pedagogical learning strategies successfully implemented to drive active engagement during the pandemic lock-down period. Additionally, newer types of online assessments using digital learning platforms, which diversify from traditional written exams, have also been seen to improve student engagement (10). While creative online teaching and assessment activities have materialised rapidly in recent years, aligning these activities with the intended learning outcomes is also crucial, especially for professional medical and health science degrees.

In these professional degrees, the outcome-based education (OBE) framework is widely implemented and is a central feature of programme accreditation. In OBE, the teaching–learning processes and assessments have to be aligned with the learning outcomes (11). The OBE framework strongly emphasises having relevant assessment types to allow learners to demonstrate competency in the intended learning outcomes. Therefore, while fulfilling the necessity of developing online objective assessments is readily possible, suitably assessing the expected competencies in learning outcomes is a challenge. In addition, using a single summative assessment type to assess all levels of cognitive learning may be unfair to students who have different capacities to access online materials due to challenges in their environment or personal backgrounds brought about by the pandemic (12). In this period, pre-recorded lectures were viewed significantly less by the disadvantaged students when compared to the pre-

pandemic time and compared to students from non-disadvantaged backgrounds.

As a strategy to diversify and provide equal opportunities in teaching and assessment, this article demonstrates a virtual assessment construct in the form of a remote objective structured clinical examination (OSCE). This remote OSCE was developed using the MyDispense platform in a collaborative effort between pharmacy academics from five universities. MyDispense is a free web-based pharmacy simulation programme developed by Monash University and is now used by more than 130 institutions around the world (13). This platform preserves its low bandwidth by omitting any video camera requirements, thus making it suitable for learners with various internet speeds and coverage.

OSCE is widely used in medical and health science fields, including nursing, pharmacy and occupational therapy. The primary aim of the OSCE is to assess clinical competence. OSCE tasks are designed by constructing several simulated scenarios in which students must complete the required tasks within a specified time. In this article, we illustrate the development of virtual web-based simulation assessment and OSCE, its psychometric properties and students' feedback towards this new learning and assessment tool opportunity.

MATERIALS AND METHODS

Virtual Assessment Construct (Remote OSCE)

After thorough consideration of internet stability, adequacy of assessment coverage and learning level, a remote web-based OSCE was planned for second-year pharmacy students registered for the 2020/2021 session of the Pharmacotherapy for Infectious Diseases course. This course covers the pathophysiology and management of infectious diseases caused by viruses, fungi and bacteria. The learning outcomes assigned for this assessment are interpreting laboratory test results based on the principles of patient management, and solving pharmaceutical care issues that arise in the management of infectious diseases. These learning outcomes reflect the medium-level cognitive process dimension (apply and analyse), in which students need to execute instructional tasks by using the information provided in the web-based simulation platform. The remote OSCE is part of the course's summative assessments and constitutes 20% of the total marks.

Three OSCE scenarios were decided by the course coordinators after a thorough discussion with the course lecturers. Each simulated case scenario was designed to include tasks on the following topics: retroviral disease, tuberculosis and COVID-19. Students were required to respond, through written typed communication, to online enquiries from avatars of the health professional, patients or caretakers. Each case scenario was allocated a time limit of 20 minutes, which totalled one hour for the whole assessment. The tasks and answer rubric were developed by respective faculty academicians who were experts in the field and subjected to moderation and vetting processes by the Department of Clinical Pharmacy and the Quality Unit, Faculty of Pharmacy. An external examiner, who is an expert in pharmacotherapy, was requested to review the scenario tasks, questions and the answer rubric. Changes to the scenario task, questions and answer rubric were made accordingly through consensus with the scenario's question developers after obtaining comments from both internal and external reviewers.

The vetted OSCE scenarios and their tasks were then inputted into the MyDispense web-based simulation platform with technical support provided by a MyDispense expert (MA). A trial run was conducted and iterations were made to ensure smooth flow of the remote OSCE. All online responses submitted by the students were

automatically captured and stored on the same platform for marking purposes. Remote simulation-based activity can be marked directly through this platform by the assigned markers manually or automatically by inputting the marks into this online simulation platform.

Implementation of Remote OSCE

Forty-seven Year 2 students enrolled in the Pharmacotherapy for Infectious Diseases course. As part of the course, students were provided with nine remote web-based simulation exercises on various infectious disease topics across 14 weeks of the Semester 1 2021/2022 academic session using the MyDispense digital platform. In this simulated exercise environment, students may make mistakes without experiencing serious consequences in practice compared to a real-world hospital pharmacy setting. Students were allowed to attempt exercises as many times according to their learning pace and received automated feedback per attempt. Additionally, the online remote simulation activities were unique because written communication through typing on the keyboard was used as a medium instead of the verbal communication used in traditional face-to-face OSCE.

These exercises had a time limit but permitted multiple attempts. The exercise attempts were self-regulated by the students. The students obtained autofeedback directly after the completion of each simulation exercise. Scheduled tutorial sessions were conducted for further discussion with students after attempting the exercises. These exercises are important for students to become familiar with the remote web-based simulation setting for the final remote OSCE assessment.

Before the actual remote OSCE, the students were briefed and underwent two mock trials of an online remote simulation-based assessment. In addition, a guidebook for remote OSCE was also provided to the students. Feedback was obtained from students after the trials to improve the future conduct of the remote OSCE. On the actual OSCE day, students were instructed to sign and submit a student exam declaration within 20 minutes prior to the start of the OSCE. A second feedback survey was distributed to the students after completion of the remote OSCE. All participating students provided consent for this study and its publication in line with the ethical approval obtained. However, due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data are not available.

Psychometric Testing of OSCE Data

Rasch analysis provides information on the behaviour of individual test items and the constructs analysed, and it can perform as a quality assurance framework for measurements, such as tests and questionnaires (14). Rasch modelling utilises students' response patterns to establish measurements (measures) through the scaling method. In Rasch analysis, the ideal standards of construct validity (invariance comparison, unidimensional and sufficiency) that are embedded in a mathematical formula can be investigated. In this study, the construct is clinical pharmacy competency. For an OSCE scenario to be regarded as an "objective measurement" for a construct, students' response patterns to the test items in each of the OSCE stations should be similar to the pattern estimated by the Rasch model.

In Rasch analysis, anomalies in the response pattern or misfit of data to the model can be observed through multiple graphical and statistical indicators. In the context of OSCE, Rasch analysis can inform the assessment provider of whether students' response patterns deviate from the pattern expected by the Rasch model. The analysis can further help in the decision to exclude or retain any particular OSCE station in the next cycle.

Data Analysis

Rasch analysis was conducted using Ministep, a reduced version of Winsteps® but with full functionality of the latter (15). The software allowed for the analysis of 25 items and 75 individuals. Since the number of items and students in this study did exceed the minimum number of items and persons able to be analysed in Ministep, the software is deemed suitable for the present study.

Data Design and Structure of the OSCE

The OSCE data for the Year 2 pharmacy students registered for the Pharmacotherapy for Infectious Diseases course consisted of data from three OSCE stations that had structured clinical scenarios. Each station scenario assessed a predetermined set of clinical skills. Table 1 describes each OSCE scenario and the components of clinical competence to be evaluated.

The three station scenarios were assumed to measure a common underlying construct: clinical competence. A Rasch analysis was conducted to assess whether the tasks assessed in the three OSCE stations exhibited unidimensionality by being represented by a common continuum of clinical competence. The maximum marks for stations 1, 2 and 3 were 10, 12 and 11, respectively. The raw scores for each station were categorised into 10 categories consisting of zero to nine and were entered into Ministep. In this study, each station was analysed as one item. Additionally, the reliabilities and the person and item separation of the assessment were also evaluated.

RESULTS

A total of 47 Year 2 students completed the remote OSCE over one hour. The majority of the students undertook the remote OSCE at home (72%, N = 34/47) and had none to minimal disruption in their internet coverage (97%, N = 46/47). An extra five to ten minutes was permitted for students who had experienced interruptions to complete their submissions.

Validity and Reliability of Remote OSCE Stations

Unidimensionality

In Rasch analysis, unidimensionality indicates that a set of investigated items measures a single construct. Inspection of the raw variance explained by the measures showed that the value was 69% (Figure 1). In Rasch analysis, measures with good unidimensionality should have the raw variance explained by a measures value of more than 40% (16) and an eigenvalue of 1st contrast of less than 2 (14, 17). Thus, the designed remote OSCE measures a single construct, as shown by unidimensionality.

Table 1: Structure and components of OSCE scenarios

Scenario	Topic	Clinical competency to be evaluated
Scenario 1	Retroviral disease	Interpretating laboratory results Recommending management of disease Intervening for pharmaceutical care issues
Scenario 2	Tuberculosis	Interpretating laboratory results Recommending management of disease Patient counselling
Scenario 3	COVID-19	Patient counselling

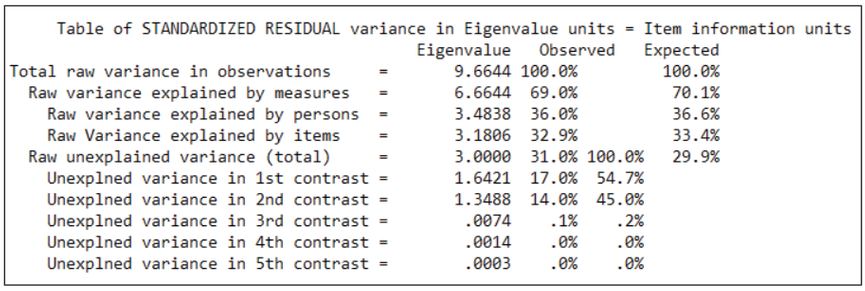

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    Table of STANDARDIZED RESIDUAL variance in Eigenvalue units = Item information units
                                    Eigenvalue   Observed   Expected
Total raw variance in observations     =       9.6644 100.0%          100.0%
  Raw variance explained by measures   =       6.6644  69.0%           70.1%
    Raw variance explained by persons  =       3.4838  36.0%           36.6%
    Raw Variance explained by items    =       3.1806  32.9%           33.4%
  Raw unexplained variance (total)     =       3.0000  31.0% 100.0%    29.9%
    Unexplned variance in 1st contrast =       1.6421  17.0%  54.7%
    Unexplned variance in 2nd contrast =       1.3488  14.0%  45.0%
    Unexplned variance in 3rd contrast =        .0074    .1%    .2%
    Unexplned variance in 4th contrast =        .0014    .0%    .0%
    Unexplned variance in 5th contrast =        .0003    .0%    .0%
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Figure 1: Analysis of raw variance using Rasch analysis.

Model data fit

The investigated item–trait interaction statistics evaluate the suitability of the data to establish construct and its measures. The two types of items in Rasch fit analysis are infit and outfit statistics. The infit and outfit mean square (MNSQ) should be more than 0.7 but less than 1.3 to demonstrate a good fit (18). Table 2 presents a summary of the item and person measurements from the Rasch analysis. Inspection of the item measurement summary showed that the values for the item infit and outfit MNSQ of the OSCE stations were 1.05 and 0.95, respectively. Additionally, the values for the person infit and outfit MNSQ of the OSCE stations were 0.96 and 0.95, respectively. The results showed that the data fit the Rasch model at both item and person levels, suggesting that the OSCE is an "objective measurement". Additionally, fit analyses also include standardised fit statistic (ZSTD), and was observed to be more than –2.0 but less than 2.0, suggesting that the data had reasonable predictability (19).

Data separation

Rasch analysis enables reporting of separation or discrimination for its parameters' estimates, meaning whether or not the difficulty of the assessment is independent of the combination of students' abilities and performance in the assessment. The items' separation level is high (> 3); therefore, the assessment is considered good, as it includes stations with different difficulties. A value of 1.5 for a person separation index has been suggested as an acceptable level and is considered the minimum value to divide the sample into two distinct strata (i.e., low and high ability) (20). In this study, a person separation of 1.63 was observed, indicating that the assessment was sufficiently precise to discriminate between the performances of various individuals. However, the OSCE may be improved by including more stations to distinguish between high and low performers.

Table 2: Summary of item and person measurement from Rasch analysis

	Summary of item measurement				
		Infit		**Outfit**	
	Measure	**MNSQ**	**ZSTD**	**MNSQ**	**ZSTD**
Mean	0.00	1.05	0.20	0.95	–0.25
Separation	4.43				
Item reliability	0.95				
Summary of Person measurement					
Mean	1.35	0.96	–0.27	0.95	–0.25
Separation	1.63				
Item reliability	0.73				

Reliabilities

As shown in Table 2, the item reliability (*ir*) was 0.95. Since the value is more than 0.8, the reliability of the OSCE is considered to be high (18). Person reliability (*pr*) was observed to be moderate but acceptable, with a value of 0.73. The students' performance was consistent when tested with different stations but measured the same constructs.

Post-OSCE Feedback

All students responded to the feedback survey after completion of the remote OSCE (response rate = 100%). The majority of students agreed that MyDispense simulation-based activity improved their clinical pharmacy knowledge (91%, N = 43/47), clinical reasoning skills (87%, N = 41/47) and response to clinical enquiries (92%, N = 43/47) (Table 3). The students also agreed that the simulation-based activity facilitated self-learning (90%, N = 42/47) in a structured manner (90%, N = 42/47). Importantly, the students agreed that this online simulation-based activity could complement experiential teaching and learning (96%, N = 45/47).

Table 3: Feedback survey after remote OSCE conduction

Student perceptions on MyDispense activity	Percentage				
	SA	A	N	D	SD
Participating in the MyDispense activity has improved my clinical pharmacy knowledge	55	36	9		
Participating in the MyDispense activity has given me experience in preparing for the online OSCE	66	30	4		
Participating in the MyDispense activity has improved my clinical reasoning skills	40	47	13		
Participating in the MyDispense activity has trained me in self-learning skills	47	43	10		
Participating in the MyDispense activity has improved my written communication skills	47	36	15	2	
Participating in the MyDispense activity increased the knowledge level of the topics concerned	56	38	6		
Participating in the MyDispense activity has improved my ability of facing questions	47	45	8		
MyDispense is a more structured type of teaching and learning activity	45	45	10		
The idea of MyDispense as an alternative to complement experiential teaching and learning tool is exciting	58	38	2	2	
MyDispense can be included as an effective teaching and learning method	49	38	13		
MyDispense requires too much time and is not worth the effort	9	4	15	38	34

Notes: SA = Strongly agree; A = Agree; N = Neutral; D = Disagree; SD = Strongly disagree

DISCUSSION

The present study attempts to develop an online assessment of medium-level clinical pharmacy CSs using a web-based platform, investigate its psychometric properties and evaluate students' responses and acceptance of the platform and activities. The tasks developed using the web-based simulation platform were reliable in measuring medium-level clinical pharmacy CSs in the study population and allowed discrimination between the performance achievements of various students. From the students' perspectives, the simulated tasks aided in the understanding of clinical knowledge and reasoning skills. Overall, there was a general acceptance of simulation-based teaching, learning and assessment activities among the pharmacy students.

This remote OSCE is innovative because it uses a different format from any other OSCE by imposing the use of written (typed) communication to respond to inquiries from the simulated avatar of health practitioners, patients or caretakers. This study adds to the breadth of knowledge by highlighting the urgent need for online and remote web-based simulations for learning and assessment to nurture the development of complex CSs by improving students' engagement. Findings from pre-pandemic empirical studies from schools and higher education underscore the importance of simulation-based learning for knowledge and skills, but the majority of studies referred to on-site simulation (21). Funding and resources for online remote simulation-based learning and assessment are therefore a necessity for all educational institutions to ensure equal opportunities of learning, fair assessments to all students from various backgrounds and in keeping with the digital revolution where humans and machines work synchronously.

Other advantages of the online remote web-based simulation assessment were less error in marking and grading students and ease in data archiving and analysis. Systematic data management and archiving are desirous and advantageous during audit and accreditation processes. Additionally, the usual manpower required to run a face-to-face simulation-based activity was able to be reduced and the cognitive workload to assess students can be minimised by having a specific assessment rubric for a focused task that measured a specific cognitive competency. This remote OSCE had expedited the creation of specific measures to fulfil course learning outcomes that covered medium-level CSs; thus, unintentional complex task scenarios, inconsistencies from on-site human errors and poor instructional design to assessors can be avoided (22).

This study also highlighted the importance of written communication through various means (text messages and emails) because it remains the most common communication in various professions (23), despite not being well highlighted, structured and taught in professional education. The instant information and understanding from face-to-face verbal communication are optimised with a clear body and facial language, as opposed to written communication, which can be difficult to translate if poorly constructed. In a recent study on pharmacy students, worked examples followed by problem-solving on clinical note-writing were presented as an effective alternative way to expose and optimise pharmacy students' learning of written communication (24). These strategies were similarly implemented prior to the execution of the remote OSCE. Our students undertook MyDispense exercises prior to remote OSCE, which involved a combination of work-example and problem-solving activities through various clinical case scenario exercises.

As the pandemic gradually became under control in many parts of the world, there is a realisation to incorporate assessments of written-typed communication into learning activities. Face-to-face OSCE using a conventional setting can be complemented with an online remote simulation setting to assess written communication. A better teaching and learning format to learn

written communication should not only focus on responding to peers and colleagues but also to the general public. Digital communication is now crucial for day-to-day routine work; therefore, professionally written emails, recommendations and monitoring should be invested in and systematically incorporated into the professional curriculum.

LIMITATIONS AND SUGGESTION FOR FUTURE RESEARCH

One limitation of an online remote simulation-based assessment is the time taken to develop its exercises and configure assessments in the digital platform. This was overcome by connecting with MyDispense experts, whose details were easily found through its website, but the MyDispense digital platform was not customised to the Malaysian health system setting; some pharmacy practice processes and formats are different. However, MyDispense's faculty administrators can creatively develop cases and assessments suited to its locality. Further research and work can be done in the future to accommodate the local setting.

The use of written communication to complete the simulation-based tasks was well received by the students and was seen as an alternative strategy in teaching and learning. However, none of the participating students had any formal or structured training for written communication. One student disagreed that the simulation-based activity improved written communication. Future studies should explore written communication requirements for professional students and the best approach to include in teaching and learning activities. There is also a scarcity of data on activities that combine face-to-face simulation and online remote simulation activities in a continuous series of assessments to simulate real-world situations of both verbal and written communication in solving working problems; this may be worth exploring in the future.

PRACTICAL IMPLICATIONS

This study aspires to contribute novelty to health science courses dealing with an array of health care situations through a pharmacy course as an example by developing an online web-based simulation activity using a unique, pharmacy-specific digital platform. This initiative was driven by a small local community within the profession that was concerned about students' access to online materials and the dropping level of learning engagement, which was also felt elsewhere (12). The advantages of using the simulation platform are numerous. MyDispense is free for academicians and students to access, does not require high internet bandwidth for its access and can be set to permit multiple access for learners to attempt the task at their own pace. The availability of such a platform should be extended to other professions to enhance students' learning engagement and to incorporate an alternative assessment. Therefore, the exploration of interprofessional education using this similar platform is highly recommended. The online remote simulation-based activity and OSCE were reliable for nurturing students' medium-level CSs, as evidenced by the results of the psychometric analysis, and they may be extended to the assessment of high-level CSs. Students with disadvantaged backgrounds can have equal opportunities to enhance their CS competency and be assessed fairly. Finally, to improve simulation-based activities, communication training for students could be added to the course to enrich their professional communication responses to their peers and the public.

CONCLUSION

There is potential for online remote web-based simulation assessment as a method for final examination in the higher education industry, especially in medical and health science courses. Medium-level CS competencies through online

remote simulation-based assessments were feasibly aligned with learning outcomes in education programmes that use the OBE framework. This study demonstrates that CS competencies are carefully planned and nurtured through the use of a web-based simulation programme and can be reliably assessed remotely whenever physical distancing is necessary. This study further underscores the need for more free online simulation-based activities and assessments for equitable opportunities for students.

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ETHICAL APPROVAL

This study received ethical clearance from the institutional University of Malaya Research Ethics Committee (UM.TNC2/UMREC_1372).

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