

Reliability of Virtual Objective Structured Clinical Examination in Pharmacy Practice Experience Education Using Generalizability Theory

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ABSTRACT

Background and Objectives: The virtual Objective Structured Clinical Examination (OSCE) was established using the MyDispense database in various pharmacy schools worldwide. However, rigorous reliability estimation is lacking, which could affect student preparedness for the real-world pharmacy practice experience. Hence, this study aims to estimate the reliability of virtual OSCE using a robust reliability estimation method that has already been successfully established in medical schools. **Materials and Methods:** The reliability and components of variation were estimated using the generalized theory (G-theory) statistical framework. 4 facets were used to assess the components of variation: students, stations, items and years. The reliability of different stations (from 2-5) in virtual OSCE was estimated, with 182 students registered for pharmacy practice experience in various academic years between 2020 and 2023. The case scenarios were studied for content validity through expert academicians in pharmacy practice from universities other than the study site. **Results:** The G-coefficient with various virtual OSCE stations was close to the benchmark reliability of 0.70; however, it is still a low-stakes assessment. This study's low-stakes assessment might be due to the estimation of component variance in more significant (22.60%) regarding the student's performance varies mainly in different stations across the academic years. The low component variance (1.41%) indicated the negligible difference between the levels of students in various academic years. **Conclusion:** The number of stations in virtual OSCE strongly influences reliability. Pharmacy curriculum academicians can consider G-theory to estimate the reliability of virtual OSCE in preparing students for a better real-world pharmacy practice experience.

Keywords: Generalizability Theory, Pharmacy Practice Experience Education, Reliability, Virtual Objective Structured Clinical Examination.

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INTRODUCTION

Virtual Simulations (VS) have gained global acceptance in pharmacy education, with schools using them worldwide to train pharmacy practice students. VS provides a safe environment for students to practice medication dispensing and labeling and to experience patient communication with virtual patients, preparing them for real-world practice.¹ A notable example is MyDispense, a virtual simulation platform established by the Faculty of Pharmacy and Pharmaceutical Sciences at Monash University. MyDispense immerses students in pharmacy practice, providing immediate feedback that enhances their learning experience and allows them to learn from their mistakes in a

risk-free environment.² MyDispense has successfully integrated with pharmacy practice experience courses in over 200 pharmacy schools worldwide, with the investigators having published numerous articles on its effectiveness.³⁻⁸

Objective-Structured Clinical Examination (OSCE) helps assess pharmacy students' competency in dispensing and patient-related activities.⁹ The OSCE in pharmacy practice comprises patient interviews, dispensing, labeling and counseling domains.¹⁰ MyDispense platform helps to conduct virtual OSCE, which saves time, cost and manpower and the report can be downloaded as an Excel report, which allows the instructor to evaluate the students rapidly.² In this context, the MyDispense platform also helps researchers validate the framework of OSCE. However, the validation of OSCE was reported as increasingly complex and a framework is needed to validate the OSCE used in VS. The validation process was reported as greater evidence of the quality of implementing virtual OSCE.¹¹⁻¹³ Although Cronbach's α was an established indicator for estimating internal consistency;



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it was criticized regarding error measurement in the raw scores of examinees.¹⁴

Generalizability Theory (G-Theory) is a statistical framework vital in validating OSCE. It determines the reliability of different observations or ratings and comprehensively represents the error in the raw score of examinees. In the context of OSCE, G-Theory is used to design Generalizability studies (G-studies) and Decision studies (D-studies). G-studies help to determine the composition of assessment scores, while D-studies help to predict the reliability of the same data under various conditions. G-Theory provides insights that allow us to quantify the variance contributed by several influencing factors of OSCE assessment, including rater bias, the rater's or examinee's attention or mood, the capabilities of standardized patients and the overall environment.¹⁵

G-Theory was a reliable tool for comprehensively assessing OSCE conducted in numerous medical schools.¹⁶⁻¹⁸ Recently, G-theory was implemented to validate the in-person OSCE in the PharmD curriculum and it was found helpful in determining the changes needed in the OSCE.¹⁹ However, the reliability of virtual pharmacy OSCE is yet to be investigated using G-Theory. Therefore, the present study aims to examine the reliability of virtual pharmacy OSCE with the help of G-Theory.

MATERIALS AND METHODS

Study design and ethical considerations

This study is a retrospective analysis of pre-existing data related to the results of the virtual OSCE for Pharmacy Practice Experience course in the Faculty of Pharmacy, University of Tabuk, for the past 5 years, from January 2020 to December 2023. The study was approved by the local research ethics committee of the University of Tabuk (UT-187-42-2022).

Subjects and setting

From 2020 to 2023, virtual OSCE was administered among fourth-year students of Pharm. D., who enrolled in Pharmacy Practice Experience. During the study period, all the students were given formative virtual OSCE assessments, and their scores were documented. The virtual OSCE included 5 workstations: patient interviews, dispensing, labeling, counseling and answering patient questions. After the exam, the OSCE results were downloaded as an Excel report from the MyDispense database and handed over to the raters. The evaluator has a Ph.D. in Pharmacy Practice and at least 5 years of teaching experience and was assigned to evaluate all the stations in each virtual OSCE. All the raters were given sufficient workshops related to the MyDispense program to prepare them regarding the OSCE in terms of case scenarios, evaluation checklist and download of the results. The evaluators were given clinical case scenarios, rubrics for evaluation and a guide for using the MyDispense program before one week of virtual OSCE.

Details of Case scenarios and exercise in OSCE

Each scenario briefly describes the chief complaint or the diagnosis of the patient waiting in the pharmacy with the prescription to receive the medications. In the 1st station, a 3-D virtual patient appears on the computer screen and the student needs to ask at least 5 questions relevant to the cases, e.g., "What is your chief complaint?", "Did you take any OTC medications for the chief complaint?", "Are you suffering from any chronic illness?", "Are you taking any medications for your chronic illness?", "Have you experienced allergies to any medication?", "Do you smoke?", "Did you take alcohol?", "Are you pregnant or breastfeeding?". The student must ask the 5 mandatory questions relevant to the case.²⁰ Each question is considered an item; therefore, this station has 5 items.

In the 2nd station, the student must follow all 5 rights regarding dispensing, including the right patient, drug, time, dose and route.²¹ Each right was considered one item and this station had 5 items. The 3rd station, labeling, also had 5 items: medicine name, dose, dosing interval, duration of treatment and direction for use.²² The 4th station was patient counseling and once again, the same 3-D virtual patient already seen in the patient interview station appeared. This station included 5 items: counseling briefs about the purpose of the drug, instruction for administration, possible side effects, the importance of compliance and storage conditions.²³ The fifth station was answering patient questions, e.g., "What happens if I miss the doses?", "What is the use of this drug?", "What to do if I experience any side effects?" "Are there any other side effects of this drug?" and "How do I store this drug?"²⁴ Students received a mark "1" for each item upon successful completion and "0" for items unsuccessfully completed or not done. The number of stations in the exercises depends on the OSCE, ranging from 2-5 stations and the completion time is also about 10-25 min. Each station had no stipulated period since the OSCE took place through a virtual platform. The student marks depended on the number of items included, as each item carried one mark. A pilot virtual OSCE was conducted to assess the feasibility with ten students before introducing them to the students.

Content validity

The items included in various stations represent the assessment subject, which the content validity ensures. Four expert academicians from the Department of Pharmacy Practice from various institutions other than the study site evaluated the adequacy of the stations and items relevant to the case scenario. Gupta *et al.* (2017) established a 5-point Likert scale questionnaire for the content validity.²⁵ The scenario and items were corrected based on the agreement scores of expert academicians.

Implementation of G-Theory in Virtual OSCE

A student mark reflects a student's ability and measurement error denoted by the measurement theory. G-Theory is vital in investigating measurement error by understanding the contributing factors to student mark variance and estimating reliability using variance components with different facets.²⁶ G-Theory appropriately assesses the reliability of the OSCE since it estimates the influence of facets, such as students, stations, items and years. Hence, the virtual OSCE was implemented with various stations and items from the academic year 2020 to 2023.

According to G-Theory, multiple facets have been included, mentioned below

- Students (p): The inconsistency in marks due to typical differences between students.
- Stations (s): The inconsistency in difficulty regarding the various stations.
- Items (i): The inconsistency of difficulty regarding the items in each station associated with the case scenario.
- Year (y): The inconsistency of student marks associated with the different years.

The following was the helpful information identified through the degree of variance contributed by each facet.

Does the virtual OSCE assessment adequately discriminate between low and high achievers?

Do the stations or items adequately differ in the level of difficulty?

Is the basis of errors triggered by courses threatening the reliability of assessment?

Statistical Analysis

The ultimate design was (p:i) x (y:s), where students were nested with the items crossed with years nested with stations. The G-theory was used to estimate the components of variance related to various facets, which were distributed to evaluate multiple influences contributing to measurement error.²⁶ The impact of the facets estimated for the reliability of virtual OSCE through students, stations, items and years. Currently, the G-theory is established for the reliability analyses of OSCE and used to assess the core construction and reliability of virtual OSCE. In reliability analysis, the bootstrap method was used to estimate a 95% confidence interval and components of variance.

A D-study is a post hoc analysis of the G-study using their estimates of variance components, followed by an examination of the projected reliability among students from different academic years.²⁷ The G coefficient was estimated using the urGenoca (University of IOWA, IOWA, IA) software. The G coefficients were used for normative assessments, a performance relative from one student to another student.

RESULTS

This retrospective analysis included all the OSCE data of 182 students registered in the various academic years: 2020 ($n=42$), 2021 ($n=47$), 2022 ($n=44$) and 2023 ($n=49$) (Table 1). Overall student performance and each station in virtual OSCE in different academic years were documented. The mean \pm SD values of the virtual OSCE score had no significant difference among the overall and all stations between 2020 and 2023. Additionally, the interstation's mean \pm SD values of the virtual OSCE score also have no significant difference (Table 2). The *posthoc* analysis was also performed to investigate the student performance between each other year and the mean difference between them has no statistically significant difference ($p>0.05$). Therefore, the virtual OSCE score was not affected by the students from the different academic years, with differences in the number of stations and items.

The estimation of variance components for virtual OSCE and relative contribution to mark variance is shown in Table 3. Overall, the high percentage of variance (22.60%) was among students across stations in various years, which suggests high variability in actual differences between the learners. This shows evidence that specific students did well on some stations and did poorly on other stations. Followed by 22.32% of the variance was noted to the years across the stations and items. This indicates high variability in student performances in various academic years since the increased number of stations. Also, a 7.9% variance in item-station interaction shows the success of any item moderately predicting the success of other items. The percentage variance of the years that interacted with stations (3.6%) and stations (3.39%) was low, implying negligible interactions with various stations over the OSCE years and a negligible difference between the most and least complicated OSCE years, respectively. The percentage variance of students: years (1.41) interaction and students (0.28) were very low, meaning that students' abilities did not interfere with the OSCE.

Table 1: Details of facets used in the study.

Years (y)	2020	2021	2022	2023
Student (p)	42	47	44	49
Stations (s)	2	3	4	5
Items (i)	10	15	20	25

Table 2: Mean±SD of the percentage of student scores in each station for different years of OSCE.

	Overall	Station 1	Station 2	Station 3	Station 4	Station 5	p
2020	95.71±5.00	96.19±7.94	95.23±8.62	-	-	-	0.600*
2021	95.03±4.49	95.31±8.55	95.74±8.27	94.04±10.14	-	-	0.637**
2022	95.22±3.88	97.27±6.94	96.36±7.80	94.54±9.98	92.72±10.64	-	0.678**
2023	94.04±4.90	96.73±7.46	97.14±7.07	92.24±10.65	91.83±11.48	92.24±11.41	0.088**
p	0.358**	0.662**	0.688**	0.521**	0.700***	-	

*Paired *t*-test; **One-way ANOVA; ***Independent student *t*-test.

Table 3: Variance components estimate for virtual OSCE and relative contribution to mark variance.

Effect of component	Variance component			Description
	Estimated Variance	95% CI	percentage	
Students	0.001	0.000-0.002	0.28	To what degree do student marks differ according to their ability?
Students: Years	0.005	0.000-0.010	1.41	To what degree do student marks within the years offer?
Stations	0.012	0.000-0.024	3.39	Is any station more difficult than other stations?
Items: Stations	0.028	0.014-0.056	7.91	To what degree do student marks differ across the items?
Years x Stations	0.013	0.001-0.026	3.67	To what degree do the years differ across the stations?
Students x Stations: Years	0.080	0.041-0.016	22.60	To what degree do student marks differ across the stations within the years?
Years x Items: Stations	0.079	0.040-0.158	22.32	At what level do the years varied across station and items?
Students x items:Years x stations	0.136	0.102-0.173	38.42	Residual error

Table 4 analyzes and reports the G coefficients from the D-study, which increase with the number of stations and items.¹⁸ This evidences that the reproducibility of OSCE among the students was reasonable regarding normative assessment, which aims to compare a student's performance to that of other students.

DISCUSSION

To my knowledge, this is the 1st study to report the reliability of virtual OSCE in pharmacy practice experience using G-theory. This study examined the virtual OSCE across different stations and students in various academic years, using scenarios about the objectives, including patient interviews, dispensing, labeling, patients counseling and answering patient questions. G-theory was used to estimate the refined reliability measure and identify factors influencing variance components in OSCE.²⁸ The

calculated G-coefficient in the present study at various stations ranged from 0.613 (2 stations) to 0.683 (5 stations) and this report is consistent with previous findings that increasing OSCE stations enhances reliability.²⁹⁻³¹ Also, the G-coefficient range (0.62-0.72) is almost similar to the earlier finding in the medical school.³² Other reports variedly reported the G-coefficient that includes OSCE administered among the internal medicine trainees (0.68), three stations OSCE administered in medical school applicants (0.70), OSCE used to select candidates for clinical rotation (0.73-0.84).³³⁻³⁶ In this study, the G-coefficient with 5 virtual OSCE stations was close to the benchmark reliability of 0.70; however, it is still a low-stakes assessment.³⁷ This study's low-stakes assessment might be due to the estimation of component variance in larger (22.60%) regarding the student's performance varies mainly in different stations across the academic years, followed by high

Table 4: Estimation of reliability using D-study after adjusting the Facets.

Years	Number of stations	Number of items	G coefficient
2020	2	10	0.613
2021	3	15	0.632
2022	4	20	0.654
2023	5	25	0.683

component variance (22.32%) regarding the increased number of items across the stations in various academic years. The stations with other domains, including the interactive approach (patient interview, patient counseling and answering patient questions) and the non-interactive approach (dispensing and labeling). This finding substantiates the previous report regarding the influence of the multi-domain approach in reliability testing using G-theory.¹⁷ Our study authenticates the proposal of prior studies that this normative assessment through OSCE helps validate the practice readiness for a pharmacy practice experience.^{19,38} The low component variance (1.41%) indicated the negligible difference between the level of students in different academic years.

Virtual OSCE using G-theory has already been reported in medical schools and their reports indicated that Cronbach's alphas of virtual OSCE was comparatively higher than in-person OSCE. According to these reports, Cronbach's alpha is inadequate for estimating reliability since it reflects only internal consistency.^{39,40} In this context, G-theory could replace Cronbach's alpha to strengthen the evidence for addressing the reliability of virtual OSCE.¹⁷ The estimation of the reliability of virtual OSCE will be helpful in the following aspects: 1. To continue the pharmacy practice experience education even in the pandemic outbreak in the future without any hindrances and 2. The virtual OSCE is cost-effective and needs a minimal number of human resources as compared to in-person OSCE, 3. G-theory estimates the reliability of virtual OSCE, which helps to determine the student's preparedness for the real-world pharmacy practice experience.

This study was conducted in a single pharmacy school and may not be generalized to other schools. However, it was conducted rigorously and represented the findings from four academic years with different stations. Currently, there is no established method for estimating the reliability of virtual OSCE for pharmacy practice experience education. This study demonstrated the feasibility of conducting reliability testing for virtual OSCE using G-theory. MyDispense allows the instructor to download the student's score in a single .csv file, minimizes the burden of data collection manually. According to the previous report, the virtual OSCE score did not correlate with the in-person OSCE of pharmacy practice experience and this gap can be ruled out by reliability testing of virtual OSCE using G-theory.⁴¹ The validation of clinical cases significantly impacts student performance in virtual OSCE, as addressed by the previous investigator.⁴² This study can be extended by including more stations in virtual OSCE to test the reliability of high-stakes assessments.

CONCLUSION

G-theory makes the reliability of virtual OSCE feasible; however, the number of stations influences the reliability. Student performances in different stations have led to higher variability, which should be optimized in virtual OSCE. OSCE's influence on student preparedness for the real-world pharmacy practice experience necessitates rigorous reliability estimation using G-theory.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

G-theory: Generalized Theory; **OSCE:** Objective Structured Clinical Examination; **OTC:** Over the Counter; **VS:** Virtual Simulation.

INSTITUTIONAL REVIEW BOARD STATEMENT

The study was approved by the local research ethics committee from the University of Tabuk, Saudi Arabia (Reference number: UT-187-42-2022).

SUMMARY

G-Theory is widely established to validate the OSCE world-wide in various curriculum. However, this study pioneered to validate the virtual simulation exercises of pharmacy practice experience using G-theory. Increase in number of stations enhances the reliability of clinical case scenarios in virtual simulation.

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