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ORIGINAL RESEARCH REPORTS

The Impact of Theoretical Knowledge Acquisition on Practical Clinical Skills: Multi-Disciplinary Retrospective Study

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Abstract

Purpose: Assessment drives learning, and one assessment tool cannot measure all students learning competencies. Thus, multiple methods of assessment were developed to address this matter. This study aimed to measure whether in-classroom theoretical knowledge impacts students' mastery of practical clinical skills and whether a strong association between the two parameters exists.

Methods: A retrospective, correlational study design was conducted to examine the correlation between the theoretical knowledge (assessed by final written MCQs examination) and students' practical clinical skills (assessed by OSCE and/or OSPE). Two batches of male and female students (a total of 478) were included in the study from the nine programs offered at College of Applied Medical Sciences (CAMS) at King Saud bin Abdulaziz University for Health Sciences (KSAU-HS).

Results: Interestingly, moderate to strong correlations were observed between the theoretical and practical skills assessments across the nine programs. However, there were no consistent differences in the correlations when the subjects were stratified by gender nor by third- and fourth-year courses. The study also came across a couple of interesting findings in which both male and female students performed better in practical skills than theoretical knowledge assessment. Moreover, female students' performance exceeded the male counterpart in both assessments across the different programs.

Discussion: All students performed better at the practical skills than theoretical knowledge assessment, and female students surpassed male students in both practical and theoretical assessments in the five programs offered to both genders. There is a need to perform an in-depth analysis about the assessment methods utilized for practical assessments (OSPE and OSCE) among different programs/courses offered at CAMS to verify that the significant correlations obtained between the theoretical knowledge and practical assessments were not due to the similarities of construct/content of the assessment methods.

Keywords: Assessment, Clinical skills, Knowledge, Health professions, Medical education, Practice

1. Introduction

The main goal of medical education is to strengthen the students' competence of clinical skills at all levels of their curriculum, and since it

has been well recognized that "assessment drives learning", great care should be taken in choosing the appropriate assessment methods [1]. Health profession students need to be assessed at a regular interval to ensure the advancement of their competency to an adequate level. The selected

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assessment tool can either enhance students' performance, [2] or lead to deleterious impact on their career and the welfare of the community at large [3–6]. As a single assessment method cannot assess all students' competencies, [5,7–9] multiple assessment tools have been developed to address all aspects of learning, such as knowledge, comprehension, skills, attitude, and communication. When designing an assessment method, several criteria need to be taken into consideration which include reliability, validity, objectivity, and feasibility or practicability of the assessment tool. Furthermore, the utilization of assessment methods designed to evaluate students' theoretical knowledge is as important as the use of skills-based testing tools that assess their practical knowledge. Multiple assessment tools have been developed for assessing theoretical and practical knowledge, such as Multiple-Choice Questions (MCQs), Short Answer Questions (SAQs), Extended Matching Questions (EMQs), Objective Structured Clinical Examination (OSCE), and Objective Structured Practical Examination (OSPE) [10–13]. Each one of those assessment tools has its own strengths and weaknesses [13].

Both students and instructors were unsatisfied with the traditional methods of clinical and practical skills assessment [14,15]. Therefore, there was an urgent need for developing and using alternative methods for assessing such skills. OSCE was developed by Harden and his colleagues to resolve this issue in which OSCE was introduced as the ideal method for assessing clinical skills [12]. OSCE was later modified by Harden and Gleeson (1979) to OSPE in order to assess students' practical knowledge and skills in basic sciences [10]. OSCE and OSPE were developed to overcome the shortcoming of traditional assessment methods used for clinical and practical skills, respectively [16]. Traditional methods of practical skills assessment have several problems, such as subjectivity and examiner bias, [17–19] and these methods can affect the correlation between assessor and students' performance in a negative manner [20]. OSCE and OSPE gained worldwide recognition and became recognized as the golden-standard assessment methods for clinical and practical skills [21–24]. These tools have been employed as skills-based assessment for the preclinical and clinical years and have been well integrated in the health profession curricula [22–25].

During OSCE or OSPE, students rotate between a number of stations in which they get subjected to different clinical or practical scenarios, respectively, and the students' exhibited behaviors get assessed

by evaluators with well-established checklists [12]. With proper planning of number of stations, timing of each station, coverage of the learning outcomes, training of the evaluators, and use of rubrics, OSCE and OSPE can become very reliable, valid, objective, and suitable as practical assessment tools for clinical and practical skills at any health profession institute [9–12],[26–34]. Furthermore, both methods can distinguish between the level of competence of students, can be used as formative and summative assessments, [32–35] and can cover a broad range of learning objectives while eliminating evaluator bias and subjectivity [21–31],[36–39]. Students found OSPE to be a fair, unbiased and more satisfying experience over traditional assessment methods of practical skills [40]. The advantages of OSCE and OSPE as assessment methods for clinical and practical skills outcompete their few limitations [21],[36–38],[41]. These methods assess students' knowledge as well as their skills and attitude. Thus, they are not only assessment tools for the cognitive domain but for the psychomotor and affective domains as well.

Knowledge is the base of practical skills. According to Miller's pyramid, knows and knows how comes before shows how and does (Fig. 1) [42]. Furthermore, knowledge is also the base of practical skills in Bloom's taxonomy in which the cognitive domain precede the psychomotor domain [43]. For any person to perform an action, he or she needs to reach to an understanding about the purpose, the benefit, and the mechanism of that action. In medical education, students have to turn the knowledge they acquire into practical and clinical skills and into health care services as health care practitioners. In the current study, we hypothesized that there is a relationship between in-class theoretical knowledge and students' practical skills performance. Students who perform well in knowledge-based assessments are expected to also perform well in practical-based assessments and vice versa. Coming up with a such conclusion will verify the appropriate design of the curriculum, and the proper selection and conduction of educational and assessment

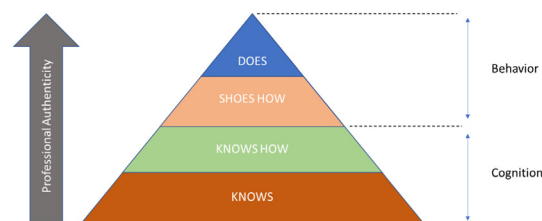


Fig. 1. Miller's pyramid for assessing clinical competence.

Table 1. Number of student participants and their academic programs.

Program	Male (%)	Female (%)	Total (%)
CLAB	13 (45)	16 (55)	29 (6)
REST	61 (58)	45 (42)	106 (22)
EMMS	55 (72)	21 (28)	76 (16)
OCTH	40 (45)	48 (55)	88 (18)
RADS	24 (59)	17 (41)	41 (9)
ANTC	30 (55)	25 (45)	55 (12)
ICVT	30 (100)	—	30 (6)
ECVT	—	24 (100)	24 (5)
CLNS	—	29 (100)	29 (6)
Total	253 (53)	225 (47)	478 (100)

*Note. ICVT program is not offered for female students. ECVT and CLNS programs are not offered for male students. RADS program has two tracks during the fourth year (CT/MRI and Ultrasound) which are available to different genders.

methods. The major aim of the study is to (a) identify the impact of theoretical knowledge acquired in the classroom on students' practical skills, and (b) identify the theoretical-to-practical knowledge correlations stratified by programs, by cohort course levels (i.e., third- and fourth-year courses), and by gender.

2. Methods

This is a retrospective, correlational study design. Institutional Review Board (IRB) approval was obtained from King Abdullah International Medical Research Center under protocol #SP19/504/R prior to initiating the study. The procedure used in the study adhered to the ethical guidelines of the Declaration of Helsinki.

2.1. Setting

The study was conducted at the Assessment Unit, College of Applied Medical Sciences (CAMS), King Saud bin Abdulaziz University for Health Sciences (KSAU-HS), Riyadh, Saudi Arabia. KSAU-HS is one of the unique teaching facilities among the other institutes in Saudi Arabia in which it focuses on graduating health care practitioners. CAMS offers nine programs including Clinical Laboratory Sciences (CLAB), Clinical Nutritional Sciences (CLNS), Anesthesia Technology (ANTC), Emergency

Medical Services (EMMS), Radiological Sciences (RADS), Occupational Therapy (OCTH), Respiratory Therapy (REST), Invasive Cardiovascular Technology (ICVT), and Echo Cardiovascular Technology (ECVT).

2.2. Participants

CAMS programs offer a total of 247 courses in which 69 of them are mixed courses (i.e., courses include both theoretical and practical parts), and those courses were the focus of the study. The study included two batches of CAMS third- and fourth year, male and female students from KSAU-HS, Riyadh (Table 1).

2.3. Sample size

The sample size required to test whether a correlation coefficient differs from zero (No correlation) at 5% level of significance, power of 80%, and with an expected correlation coefficient of a minimum of 0.4 was estimated to be $n = 50$. Calculation was done using the statistical tool provided by University of California San Francisco (<http://www.samplesize.net/correlation-sample-size/>). Nonprobability consecutive sampling method was utilized in the study in which all students from all nine programs were included in the study.

2.4. Procedure

Assessment data was acquired from CAMS Assessment Unit, Riyadh campus without exposing the participants identity (Appendix A). Students' theoretical knowledge was assessed using the final written MCQs examination while students' performance in the practical knowledge was determined using End-of-block OSPE, and/or OSCE. The actual scores of both assessments were converted into percentages prior to conducting the correlational studies. The assessment configuration at CAMS is unified between all the programs in which the final written (mainly MCQs) exam comprises 30% of total mark and the same weight is

Table 2. The assessment configuration of CAMS programs.

Course requirement	Instrument	Weight/Equivalent Mark
Midsemester Assessment (20%)	Midterm written examination	20%
Continuous Assessment (20%)	Assignments, quizzes, supervisor and preceptors' feedback, problem-based learning (PBL) evaluation, etc.	20%
End-of-block Assessment (60%)	Final written exam	30%
	Final OSPE/OSCE	30%
Total		100%

Table 3. The correlation between MCQs examination and End-of-block OSPE/OSCE.

Program	N	Pearson Correlation Coefficient (R)	P (two-tailed)	95% confidence interval
CLAB	29	0.9136	<0.0001	0.8224 to 0.9590
ECVT	24	0.8842	<0.0001	0.7473 to 0.9491
ANTC	55	0.8213	<0.0001	0.7109 to 0.8922
EMMS	76	0.7717	<0.0001	0.6613 to 0.8494
OCTH	88	0.7563	<0.0001	0.6497 to 0.8337
ICVT	30	0.7142	<0.0001	0.4765 to 0.8546
REST	106	0.5235	<0.0001	0.3697 to 0.6494
CLNS	29	0.5585	0.0016	0.2414 to 0.7678
RADS	41	0.5577	0.0002	0.3019 to 0.7386
Overall	478	0.6383	<0.0001	0.5820 to 0.6886

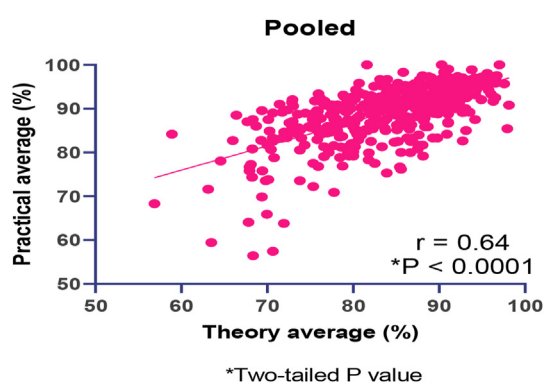


Fig. 2. The average correlation between theoretical and practical courses for all CAMS programs.

allocated for the final practical exams (OPSE and/or OSCE) (Table 2).

Statistical analysis of the acquired data from the study was performed using GraphPad Prism 8.3.0. Pearson correlation coefficient (PCC) analysis was utilized to identify the strength of the correlations between theoretical and practical knowledge assessments. The correlations were considered significant if the P value is < 0.05. Secondary data obtained from the college Assessment Unit were accessed only by the researchers involved in the study. All acquired assessment data were kept in a secure place within KSAU-HS premises both hard and soft copies.

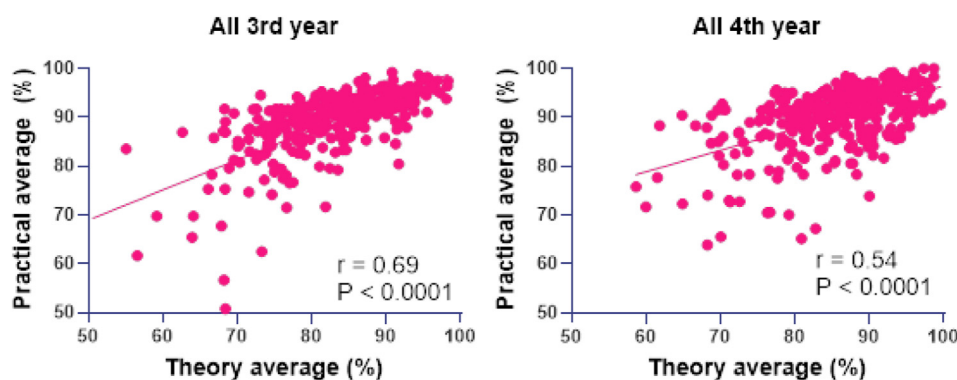


Fig. 3. The correlations of the theoretical-to-practical knowledge stratified by third and fourth year courses for seven academic programs in CAMS.

Table 4. The correlations of the theoretical-to-practical knowledge stratified by third and fourth year courses for seven academic programs in CAMS.

Programs	N	PCC for 3rd year courses (P)	PCC for 4th year courses (P)
ICVT	30	0.6002 (0.0005)	0.4178 (0.0216)
ECVT	24	0.7225 (<0.0001)	0.5777 (0.0031)
CLNS	29	0.4611 (0.0118)	0.7992 (<0.0001)
EMMS	76	0.7027 (<0.0001)	0.6488 (<0.0001)
ANTC	55	0.7267 (<0.0001)	0.7623 (<0.0001)
CLAB	29	0.8977 (<0.0001)	0.8057 (<0.0001)
OCTH	88	0.6524 (<0.0001)	0.7389 (<0.0001)
All 7 programs	331	0.7389 (<0.0001)	0.5412 (<0.0001)

*Note. REST program was excluded from this analysis because it does not have any courses with combined theory and practical parts (mixed) in the fourth year. RADS program was excluded because it includes different tracks during the fourth year offered to different students.

Table 5. The correlations of the theoretical-to-practical knowledge stratified by gender for five academic programs in CAMS.

Programs	PCC Females (P)	PCC Males (P)	(N) Females	(N) Males
CLAB	0.89 (<0.0001)	0.90 (<0.0001)	16	13
OCTH	0.75 (<0.0001)	0.62 (<0.0001)	48	40
EMMS	0.59 (<0.0001)	0.70 (<0.0001)	62	55
ANTC	0.62 (0.0009)	0.75 (<0.0001)	25	30
REST	0.45 (0.002)	0.53 (<0.0001)	45	61
All 5 programs	0.62 (<0.0001)	0.60 (<0.0001)	134	199

*Note. CLNS, ICVT, ECVT, and RADS programs were excluded from this analysis since those programs are offered to either male or female students but not both.

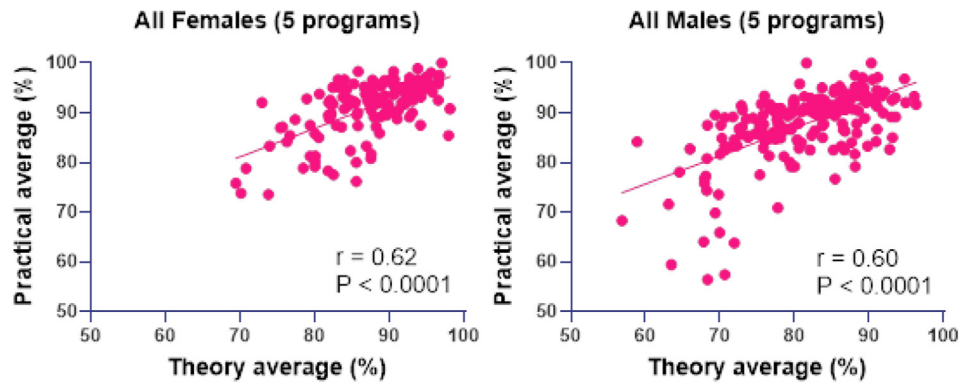


Fig. 4. The correlations of the theoretical-to-practical knowledge stratified by gender for five academic programs in CAMS.

3. Results

Upon analyzing the assessment data, significant positive correlations between the theoretical knowledge and practical skills were identified. The correlation between the two assessments (i.e., MCQs examination and End-of-block OSPE and/or OSCE) varied from moderate to strong for each program (Table 3). The correlation for all programs pooled together was significant as well (Fig. 2).

The correlations of the theoretical-to-practical knowledge stratified by third- and fourth-year courses were also significant for all seven programs included in the analysis (Fig. 3), but no consistent pattern was observed. For example, third year courses for some programs had higher correlations, while for other programs the correlations were higher among fourth year courses (Table 4).

The same outcomes were true for the correlations of the theoretical-to-practical knowledge stratified by gender in which all correlations were significant for each of the five programs included in this analysis (Table 5) as well as for all five programs pooled together (Fig. 4).

Finally, this study identified an interesting finding in which students across nine programs performed better in the practical skills assessment than theoretical knowledge, statistically analyzed using paired T-test (Fig. 5). Moreover, female students' performance was better than males in

both theoretical knowledge as well as in the practical skills which was identified using non-paired T-test statistical analysis in GraphPad Prism 8.3.0. (Fig. 6). These observations deserve further investigations.

4. Discussion

The study identified significant correlations between theoretical knowledge and practical skills among all nine programs offered at CAMS which is consistent with previously published work [44,45]. The study published by Schoeman and Chandratilake identified significant correlations between the three assessment methods (written examination, OSPE, and OSCE) in the anatomy subject utilizing three cohorts of medical students ($n = 538$) [44]. The weakest correlations were found between the written and OSCE assessments which was interpreted by the authors that OSCE assess a learning domain that is unique from written examinations. Furthermore, a cross-sectional study for last year medical students in pediatric ($n = 219$) conducted by Idris and his group demonstrated high and significant correlations between MCQ, OSPE, and OSCE ($r = 0.79$ and above) in the dermatology subject [45].

On the other hand, Dennehy et al. showed a contradicting findings in which the outcomes of the OSCE assessments did not correlate well with the written examination of dental students [46]. The justification of the authors of such findings was that

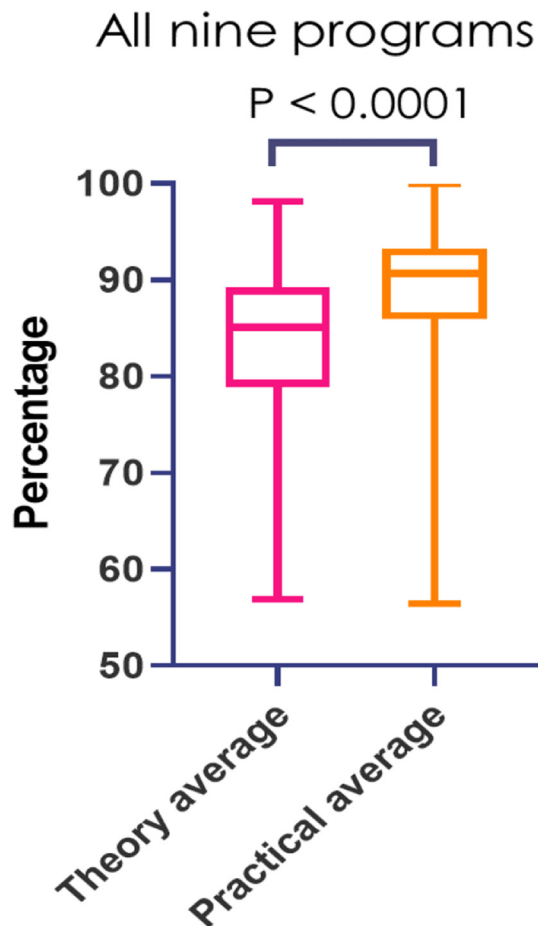


Fig. 5. Comparison of students performance in theoretical knowledge to practical skill.

OSCE assess competencies, such as problem-solving ability, critical thinking, and communication skills which are different from written examinations that assess knowledge and cognitive domains. Moreover, our study demonstrated that there is a significant correlation between third- and fourth-year courses and between male and female students, but no consistent patterns were identified.

The main strength of the current study is the fact that it is a multidisciplinary and multisubject which makes it the first study of its kind in Saudi Arabia (and probability elsewhere since previous published work were conducted on a specific course/discipline). The same point that gave this study its strength is also the source of its limitation. Conducting a multidisciplinary and multi-subject study introduced multiple confounders (different programs, courses, instructors, teaching methods, and assessment methods).

5. Conclusion

The study identified significant correlations between theoretical knowledge and practical skills among all nine programs offered at CAMS. The correlations of the third and fourth year courses and between male and female students did not show consistent patterns. This study demonstrated that all students performed better at the practical skills than theoretical knowledge assessment and that females surpassed male students in the five programs (i.e.,

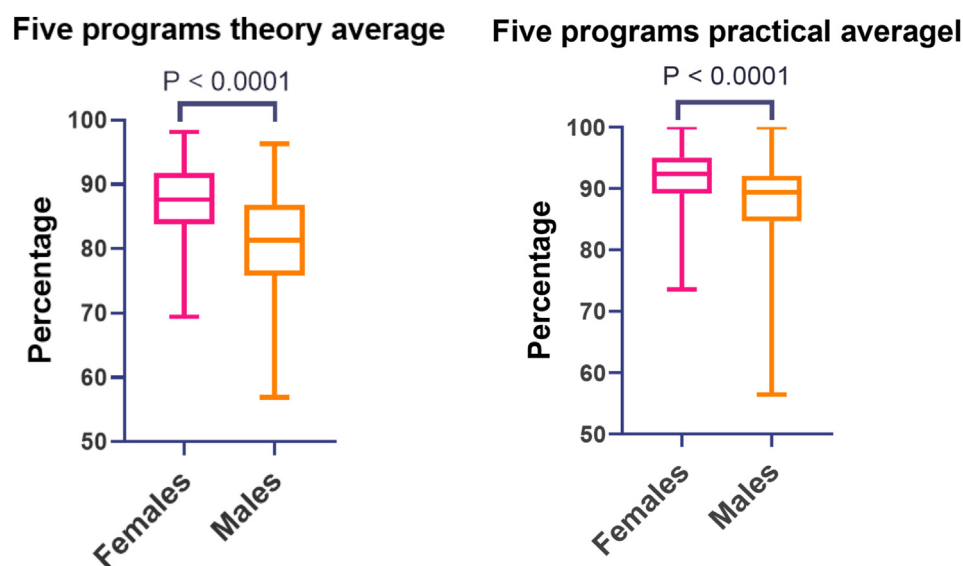


Fig. 6. Comparison of female-to-male students performance in theoretical knowledge and practical skill.

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