A comparative analysis of the impact of online, blended, and face-to-face learning on medical students' clinical competency in the affective, cognitive, and psychomotor domains

Leanthea C. Enoch (Enochl@ukzn.ac.za)
University of KwaZulu-Natal

Reina M. Abraham
University of KwaZulu-Natal

Veena S. Singaram
University of KwaZulu-Natal

Research Article

Keywords: Online learning, Knowledge Transfer, Theory-practice gap, Clinical skills, OSCE, COVID-19 pandemic, Medical Education, Blended learning

Posted Date: June 16th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1733374/v1

Abstract

Background: The Coronavirus Disease-2019 (COVID-19) pandemic in South Africa compelled medical schools to switch to a purely online curriculum. The innovative changes transformed the standard clinical skills curriculum to increase learning transfer to bridge the theory-practice gap. The efficacy of this intervention remains unknown. This study aims to measure medical students' clinical competency in the affective, cognitive, and psychomotor domains by assessing clinical skills knowledge retention and transfer from the online platform compared to face-to-face and blended learning.

Methods: A cross-sectional study assessed third-year medical students' knowledge retention and learning transfer in three domains of clinical skills competence. Data were obtained using a score sheet during a directly observed formative and summative Objective Structured Clinical Examination. One hundred and one third-year medical students volunteered for the formative onsite OSCE that tested the psychomotor domain. Two hundred and thirty-nine students were evaluated on the affective and cognitive domains in a summative online OSCE. The OSCE scores were analysed using descriptive statistics. The significance of the findings was evaluated by comparing OSCE scores with the pre-pandemic 2019 third-year medical students.

Results: Statistically significant differences were found between the two cohorts of medical students from both years ($p<0.05$). The 2021 blended group's (n=101) medians were 90%, 95%CI [86, 92], 82%, 95%CI [80, 85], and 87%, 95% CI [84, 90] for the psychomotor, affective, and cognitive skills, respectively. The e-learning group's affective and cognitive skills medians were 78%, 95%CI [73, 79] and 76%, 95%CI [71, 78], respectively. The 2019 face-to-face group (n=249) achieved medians of 70%, 95% CI [69, 72] and 84%, 95%CI [82, 86] for the affective and psychomotor skills, respectively.

Conclusion: Online medical students demonstrated near and far transfer bridging the theory-practice gap in three clinical skills domains. The blended group performed significantly better than the e-learning and face-to-face groups. Medical schools and educators play a vital role in overcoming learning challenges and achieving higher transfer levels by adopting multiple student-centered teaching delivery approaches and arranging immediate application opportunities. This study offers medical educators suggestions that encourage the transfer of online learning to face-to-face practice, decentralising medical education with a revised blended learning strategy.

Introduction

In March 2020, medical education transitioned drastically in South Africa due to the SARS-CoV-2 pandemic. With minimal preparation, educators and students had to adapt to the unconventional practice of teaching and learning "hands-on" clinical skills on a "hands-off" online platform [1, 2]. Conventional teaching methods are structured as face-to-face interactions in a clinical skills laboratory [3]. However, this was no longer possible due to the physical distancing measures stipulated during the pandemic. This

sudden change demanded innovative teaching strategies and entirely transitioned to online learning [4] to ensure the continuity of undergraduate clinical skills training [5–7].

The traditional teaching of clinical skills (Pre-pandemic period):

Clinical skills are traditionally taught in a clinical skills laboratory (CSL) using mannequins or simulated patients trained to pose as examination models. Training supports the combination of practical examination, procedural and communication skills, and patient management [8] to develop competence in the psychomotor, affective, and cognitive domains of clinical skills [9], respectively. Bloom's classification considered that demonstrative, behavioral, and intellectual knowledge could be stratified within the three domains [10]. Teaching these skills has evolved from Halsted's apprenticeship model [11] of "see one, do one" to a constructivist model where students actively build their knowledge on an existing foundation [12]. The CSL is a safe space for students to learn the fundamental practices in a standardised and controlled environment compared to a hospital setting, where actual patients may impact the students' ability to learn a skill for the first time [13]. However, the traditional learning environment does not entirely satisfy students' needs. Skills have varying levels of difficulty, time is restricted, and student cohorts are large, impacting the effective transfer of learning and knowledge retention needed for students to become competent [14, 15].

Transfer of Learning

Education aims to apply what we learn to different contexts and extend this learning to new situations, thereby bridging the theory-practice gap through transfer [16, 17]. Transfer of learning occurs when existing knowledge, skills, and abilities affect the learning and performance of new tasks [18]. A notable difference between "learning" and "transfer" is that "learning" implies that the same task is repeated, whereas "transfer" implies that the task may differ in varying degrees from the original context [19].

Thorndike's "Identical Elements" theory states that two tasks may differ yet share common components [19]. Therefore, transfer theories can be described as near or far. Near transfer is when the context of the assessed task resembles the initial learning situation. Far transfer is when the original learning context differs from the application environment [16]. The online teaching and learning environment is vastly different from the eventual application context at the bedside[20]. Therefore, to optimise the transfer and retention of knowledge and skills from the online platform, the salient details of the skill must be identified and taught [18].

Retention

Knowledge retention recalls material 25.5 days after learning [21] by transferring new information from short-term to long-term memory. This ability is essential for diagnostic decision-making in medical practice. Doctors execute this skill primarily due to clinical reasoning, as described by the Dual Process theory. The theory comprises System 1, which is fast, autonomous, and expertise-driven, and System 2,

which is slow, analytical, and uses higher-order processes [22]. Students employ the latter due to their lack of experience in medical practice. In place of experience, clinical reasoning and enhanced decision-making rely on knowledge recollection. Retention, however, is a struggle for many students, as shown by the Ebbinghaus Forgetting Curve [23]. A typical "forgetting curve" suggests that fifty percent of new knowledge is forgotten by learners just twenty minutes after the lesson has ended. However, as learners absorb new and profound concepts more meaningfully, it is expected to be forgotten more slowly [24], augmenting a cognitivist model. "Hands-on" training in a CSL promotes deliberate practice, further developing expertise and competence [25]. The complete transition to the online platform may deprive students of the experiential learning opportunities associated with the face-to-face curriculum [26, 27].

The transition to online learning (Pandemic period):

In the United States of America, the Instructional Technology Council has defined E-learning as delivering instructional materials to remote sites using technologies such as the internet and smart devices [28]. The online transition of medical education saw institutions of higher learning using videoconferencing platforms like Zoom and Microsoft Teams to deliver lectures [27, 29–31]. Besides the challenge of losing in-contact training, novel challenges also arose. Globally, students and tutors faced early issues in transitioning to this platform due to technical naivety, poor connectivity, and device issues [32, 33]. In developing countries, the situation was compounded by other socio-economic challenges, such as the lack of infrastructure and financial support [34]. Additionally, South Africa experienced an unstable electrical grid resulting in rolling electricity outages called "load shedding," causing further difficulties.

Although the global pandemic catapulted medical education into the online realm, the medical educator's goal remains to develop learners into critical thinkers capable of clinical reasoning skills which is the hallmark of the competent physician [22]. There are concerns about the retention and transfer of learning from online training settings to the clinical skills laboratory in this unprecedented situation, making it necessary to identify students' knowledge gaps to correct incompetence. While tutors' and students' perceptions of online and blended learning have been vastly researched [35, 36], the effectiveness of this intervention as a sole pedagogy in medical education has not been well established [1, 37]. Brabrand [36 (p1)] asked, "How can we make sure our students learn what we want them to?". Similarly, the authors of this study ask: "How can we be sure that the students learned the clinical skills we taught them in the new online teaching platforms?" This understanding will inform post-pandemic pedagogical changes and practices regarding online versus face-to-face or a combination thereof. Hence this study aims to evaluate medical students' capacity to bridge the theory-practice gap by assessing their retention and transfer of clinical knowledge and skills following an online training programme in comparison to a previous face-to-face programme.

Methods

Setting and Context

This study was conducted at the Nelson R Mandela School of Medicine, University of Kwa-Zulu Natal, during the second semester between August and November 2021. Medical students at this institution complete their pre-clinical training in their third year in the CSL using simulated patients before beginning clinical practice at the hospital with actual patients. During the pandemic, all teaching at the University of KwaZulu-Natal medical school was conducted off-site for more than one year using the online Zoom videoconferencing platform. Tutors delivered live interactive clinical skills lectures and "practical" sessions synchronously, while pre-recorded lectures were uploaded onto the Learning Management System – Learn2021® asynchronously. Teaching was adapted for the online platform, and all lessons were conducted remotely. Students had access to tutors via email, discussion forums, and interactive Zoom sessions.
Adaptations to the clinical skills online teaching

a. Psychomotor/Examination and Procedural Skills:

The online Zoom training for examination and procedural skills was conducted by adapting and modifying George's [39] five-step framework for teaching clinical skills (Table 1)[6].

Step 1 is the overview, addressing the need for the skill. Traditionally this was taught in a lecture hall. For online learning adaptation, voice-recorded lectures were uploaded onto Learn2021® as pre-reading material or delivered synchronously as an online live lecture over Zoom.
In Step 2, the preceptor demonstrates the skill precisely without explanation. Traditionally this was done by playing a video of the skill being performed. There was no need to adapt this step as the same videos were shared with the students for online self-directed learning.

In Step 3, the preceptor demonstrates the skill again but takes time to explain each process. In the traditional setting, the tutor demonstrates the skill on a simulated patient with a detailed explanation. The adapted step 3 replaced demonstration and explanation by the tutor with "discussion." This involved demonstration by video and stepwise explanation by the tutor. Additional teaching media was used to integrate the students' existing knowledge into the new knowledge, emphasizing "why" the technique was performed specifically, not merely on "how" a procedure was done.

The traditional Step 4 comprises a demonstration by the tutor and a step-by-step explanation by students. This was modified to "comprehension," with the demonstration by video while students explained the systematic approach and techniques.

Step 5 is where the students are allowed to practice the skill on the simulated patient while receiving feedback from their peers and tutor. This step was modified to "consolidation," allowing for demonstration by students on themselves, where possible, or simulated models created by students at home using household items. Self-demonstration skills were restricted to body parts easily seen across the video platform. Where demonstration was not possible, students analyzed pictures and videos to consolidate their learning and create a clinical context.

Table 1
George's Simple Five-step Method for Teaching Clinical Skill and our adaptations in clinical skills online teaching [6]

	Traditional	Adapted Online
1	LGRS in Lecture Hall	Voice over recording
2	AV DEMO	AV DEMO
3	Demonstration with explanation by tutor	Discussion with stepwise explanation by tutor
4	Tutor demonstrates; students explain	Comprehension – explanation by students
5	Student demonstrates with feedback	Consolidation – linking to clinical context

b. Affective/Communication Skills:

Communication skills adaptation was achieved by virtual simulation-based training using Zoom as the online platform (Fig. 1). The Calgary-Cambridge Guide to the medical interview (CCG) [40] was screen shared and discussed. All participants had their video and audio turned on. A tutor acted as the simulated patient, a student acted as a simulated doctor, and the remaining participants observed the virtual consultation and gave feedback. The simulated doctor took a part of the history from the simulated patient as per the CCG. Throughout the case, all students provided verbal or written feedback and medical summaries on the Zoom chat facility.

c. Cognitive Skills:

Spaced learning was implemented to aid knowledge retention by ensuring that students had multiple opportunities to interact with the same topic with repeated exposure to the material at each of the five steps (Table 1). For step one, a live zoom lecture introduced the topic, followed by videos and self-directed learning through mandatory weekly quizzes on Learn2021®, where passive feedback was given as preparation for the scheduled online practical sessions. Each topic was covered as an online practical session in smaller groups with a tutor for steps three to five. These sessions included active learning where students participated in polls, answered questions via Zoom chats, and received immediate feedback from tutors. Students then had to prepare for summative tests after each theme and an OSCE at the end of each semester. This method motivated students to revisit topics hours, days, weeks, and months after their first contact with new information, an approach that is well recognized as effective in retaining knowledge [41, 42].

Study Design

Study population, sample size, and sampling method

A cross-sectional mixed-methods study was conducted to assess medical students' knowledge retention and both near and far transfer of clinical skills following online training. This paper focuses on the comparative component, which includes a prospective Cohort A (2021) and a retrospective Cohort B (2019) of medical students.

Cohort A:

Third-year medical students from 2021 were selected for the study as they had experienced almost two years of exclusive online learning. Students that participated in the end-of-semester online OSCE were included in the study (n = 239) and referred to as Cohort A. Cohort A was invited to participate in an onsite formative assessment initiative called the "Readiness Programme" (RP) a week before the online summative OSCE. The RP participating students were a subgroup of Cohort A and labeled Group A1 (n = 101) or the blended group.

Students who participated in the online summative OSCE but did not attend the RP were labeled Group A2 (n = 138) or the e-learning group. The blended Group A1 and e-learning Group A2 comprised the 2021 3rd year MBChB Class.
Cohort B:

The third-year class in 2019 were students trained and assessed in the traditional onsite clinical skills programme before the pandemic, and they are the face-to-face learners known as Cohort B (n = 249).

Data collection

Onsite Formative OSCE:

The RP was hosted as an onsite formative OSCE to evaluate the students' competence in specified psychomotor skills following online learning. The obstetric examination and the pap smear skills were selected as they assessed far transfer, with varying degrees of difficulty. The students were advised to prepare for the session as expected for a summative examination.

Conduct

At the RP, the blended group students were allowed 15 minutes of self-directed practice to familiarize themselves with the equipment and models for the obstetric exam and Pap smear skills. They were then directed to an examiner who assessed both skills using the OSCE score sheet. Each student was allowed 10 minutes to complete both skills and was scored. The examiner offered feedback and correction on the performance. Without additional marks awarded, a second attempt at the skills was provided to clarify misconceptions.

Students continued with self-directed practice at other skills stations post-assessment. Figure 2 illustrates the process.
Online Summative OSCE:

A low-stakes end-of-semester summative OSCE was piloted online with Cohort A to assess affective and cognitive clinical competence using three clinical skills stations. All examiners and students were remote and used the Zoom videoconferencing platform. Students entered the "meeting room", were verified, and then assigned a breakout room to be assessed by an examiner. Each student was examined at the three exam stations by one examiner.

Station one assessed communication skills using a reproductive history-taking scenario based on the CCG [40]. The student had eight minutes to gather the history from the simulated patient role-played by the examiner, identifying the presenting problem, background history, and patient's perspective of the illness using various process skills. They also proposed a differential diagnosis and answered clinical questions. This affective domain station assessed behavioral knowledge and clinical skills competence [10]. History-taking was taught online repetitively, and the examination format closely resembled the teaching environment needed for near transfer.

The second station was a five-minute examination skills station where the student was randomly assessed on either one of the examination skills, as illustrated in Fig. 3.

The third station was a five-minute procedural skill assessment. The student was questioned on either one of the procedural skills, as illustrated in Fig. 3. Stations two and three assessed near transfer using a clinical scenario where students were required to explain the indication, procedure, and the principles underpinning the skill in a viva voce. These scores were combined to assess intellectual knowledge and clinical reasoning as part of the cognitive domain of skills competence [10].

The data for Cohort A was collected for all three domains of clinical skills during the formative onsite (Group A1 only) and summative online OSCEs (Groups A1 and A2) held in 2021, as summarised in Fig. 3.

The impact of online learning was determined by comparing the OSCE scores of online learners (Cohort A) to pre-pandemic learners (Cohort B). Cohort A's affective/history taking scores were compared with Cohort B's scores, and Group A1's psychomotor/pap smear scores were compared with Cohort B's scores for the same skill. A summary of the data points is seen in Fig. 4 below.

Figure 4: Timeline of data collection from Cohort A [blended group A1 & e-learning group A2] and Cohort B [face-to-face group]

Instrument

The data collection instrument was the standardised, pre-pandemic OSCE rubric for assessing the affective and psychomotor skills. The history-taking skill was scored out of 50 marks (Annexure 1a). It assessed the extraction of the biomedical history, the process skills used for gathering this information from the simulated patient, and the ability to derive a differential diagnosis. The obstetric examination and the pap smear skill were scored out of 25 marks each (Annexures 1b and 1c) and assessed the professional approach and techniques required to perform these skills. The cognitive data collection tool was a newly developed OSCE score sheet (Annexure 1d) adapted for the online examination. It was scored out of 25 marks and assessed the application of knowledge and clinical reasoning.

Data Analysis

The quantitative data were analyzed statistically using the Statistical Package for the Social Sciences version 27 (IBM, USA). The results were interpreted using descriptive statistics to assess the medians and illustrated using graphs and tables. Confidence intervals [CIs] were set at 95% and statistical significance at $p < 0.05$. The normality of the distribution was assessed using the Shapiro-Wilk test. Non-parametric tests (The Mann-Whitney U test and Spearman Rho test) were used to determine the differences between the median scores and correlations between the psychomotor skills examined, respectively.
Ethical approval for this study was granted [HSSREC/00003459/2021] by the University of KwaZulu-Natal's ethics committee.

Results

One hundred forty-two students volunteered to participate in the formative onsite OSCE (59%). However, only one hundred one students, Group A1 (n = 101), were selected due to COVID-19 pre-screening requirements and related challenges (response rate = 42.3%). Group A2 (n = 138) made up 67.3% and included the remainder of the class. Groups A1 and A2 comprised Cohort A (n = 239) (Fig. 4).

Group A1 represented the diversity in the third-year class's age, gender, ethnicity, and first language (Table 2).

Table 2: Demographics of 3rd year medical students in Group A1 (RP)

Demographic		Frequency (n=101)	Percentage (%)
Age	18-25	92	91.1
	>25	9	8.9
Race	African	59	58.4
	Indian	37	36.6
	White	2	2.0
	Coloured	3	3.0
Sex	Male	44	43.6
	Female	57	56.4
First Language	English	42	41.6
	Other	59	58.4

Formative Onsite OSCE

a) Psychomotor Domain

The median OSCE score achieved by the 2021 blended group (Group A1) for the pap smear procedural skill and the obstetric examination was 90% 95%CI [86, 92] and 84% 95%CI [80, 86], respectively. There was a correlation coefficient of 0.539 ($p < 0.001$) between both scores, indicating a positive correlation between the performance of both skills that required far transfer.

The significance of this result was established by comparing the blended group of learners to their pre-pandemic, face-to-face counterparts, who performed the pap smear skill in 2019 in a summative OSCE. The blended group achieved a median of 90% compared to the face-to-face students, who achieved a median of 84% (Table 3). Figure 5 describes two methods used to analyze the learning and assessments conducted in both years. In method 1, Group A1 students performed significantly better in transferring skills from the online platform to the onsite platform than Cohort B students who were taught and assessed onsite ($p < 0.05$) (Fig. 5a). Method 2 is discussed below.

Summative Online OSCE

The 2021 online summative OSCE assessed the affective and cognitive domains of clinical skills.

b) Affective Domain

Cohort A's online history taking OSCE median score was 80%, 95%CI [78, 81], indicating near transfer of affective skills as the learning and assessment were on the same platform. Groups A1 and A2 had median scores of 82%, 95%CI [80, 85] and 78%, 95%CI [73, 79], respectively ($p < 0.05$). The blended group performed better than the e-learning group ($p < 0.05$), as illustrated in Table 3.

The median difference of the results for this domain was established by comparing Cohort A to Cohort B, who performed the same skill in 2019 (Fig. 5b). Method 2 describes learning and assessment being online for Cohort A and onsite for Cohort B. Cohort A's median was 80% 95%CI[78, 81] and significantly better than Cohort B, whose median was 70% 95%CI[69.00, 72] ($p < 0.05$) (Table 3).

Figure 5: Methods 1 and 2 comparing Cohort A (2021) and Cohort B (2019) 3rd year OSCE scores in psychomotor and affective skills

c) Cognitive Domain

Cognitive skills were demonstrated by applying clinical reasoning to patient scenarios based on examination and procedural skills. Cohort A's median score for the online summative OSCE was 80%, 95%CI [78, 85]. Groups A1 and A2 achieved medians of 87%, 95% CI [84, 90] and 76%, 95%CI [71, 78], respectively, indicating near transfer as the learning and assessment were on the same platform. Group A1 performed better than Group A2 ($p < 0.05$) (Table 3).

Table 3
Results of Cohort A [2021 3rd Year Summative Online OSCE (Group A1 and A2), & Formative Onsite OSCE (Group A1)], and Cohort B [2019 Summative Onsite OSCE]

	COHORT A		COHORT B	
Domain	**Group A1** Blended Group Median (IQR)	**Group A2** E-learning Group Median (IQR)	Face-to-face group Median (IQR)	p-value
Affective	82% (15)	78% (20)	70% (17)	$p < 0.05$
Cognitive	87% (17)	76% (23)	-	$p < 0.05$
Psychomotor	90% (12)	-	84% (14)	$p < 0.05$

Discussion

The unprecedented shift to online medical education expanded the scope of computer-mediated instruction, forcing medical educators to re-examine existing training methods for practical skills traditionally reserved for the CSL and bedside [20]. This study allowed the platform to be rigorously vetted and found that our 2021 students were competent in the affective, cognitive, and psychomotor domains of clinical skills, which required different degrees of transfer for learning to occur. Furthermore, the integrated online platform produced superior results to the traditional teaching approaches in some respects.

Psychomotor Domain

There are inconsistent claims made regarding the role of the online platform in clinical skills [43]. Though, blended learning has received positive responses as an effective active learning strategy for theoretical knowledge it has had a minimal role in clinical skills [2, 32, 37, 44]. Students in our study competently demonstrated psychomotor skills they had never previously attempted. The remote online teaching programme provided knowledge through online lectures, interactive practical zoom sessions, video demonstrations, and quizzes. Learning hands-on skills like the obstetric examination and pap smear procedure on an online platform required degrees of far transfer for students to perform the skills competently. Competent execution of these skills in the CSL was interesting since skills requiring far transfer are more difficult to perform [19, 22]. To further appreciate its impact, the blended students' performance was significantly better compared to the 2019 face-to-face students, similar to the findings by George et al. [6]. The latter performed the same skill in a traditional summative onsite OSCE. Summative assessments may impede performance due to students' nervousness and anxiety, but OSCEs are considered less stressful than other examinations [45]. Further, the procedure assessed was technically more challenging for students taught online due to the lack of opportunity and equipment required for self-directed practice. The instructional teaching design, which was deliberately tailored to the

online platform by employing novel home simulations, might be an element leading to the better result in the blended group. Both Offiah et al. [46] and Anderson & Warren [25] found that simulation-based training is a successful online and onsite instructional technique that enhances learning. The psychomotor results achieved by Group A1 support Lala et al. [20], who described the blended learning teaching model as improving bedside training and essential clinical skills training. Aspects of online learning are possibly superior to traditional learning and bridge the gap between the textbook and the "hands-on" application of learned skills [20, 47].

Our study showed that using an online platform, with quality adaptations to teaching on par with traditional methods and learning process integration, could effectively train students for performance-based clinical skills requiring far transfer.

Affective Domain

The 2021 learners demonstrated competence in the affective domain. Although the OSCE's clinical case was changed, the elements in the initial teaching context were nearly identical to the exam setting, facilitating the evaluation of near transfer. This increased the likelihood that learners would perceive the two scenarios as comparable, resulting in improved transfer [18].

While online proctoring can be challenging [48], our study found that the directly assessed history-taking scenario was dynamic, requiring students to interact and actively demonstrate process skills and develop interpersonal relationships. This included showing empathy, emotions, and an existing knowledge base while gathering information from the simulated patient and clinically reasoning through the process.

Shahrvini et al. [49] reported that students could perceive online learning as isolated due to a lack of connection to their colleagues and the institution, resulting in increased anxiety. One possible explanation for the higher performance of the blended group in our study might be they benefited from the in-person interaction with instructors at the formative OSCE, which may have reduced their anxiety. Comparatively, Cohort A outperformed Cohort B, who were trained and assessed face-to-face. Virtual simulation-based training using the Zoom online platform enables interactive small group teaching that facilitates the effective transfer of communication skills [6, 50]. Our study thereby confirmed suggestions by Prober & Khan [15] that interactive and collaborative activities that reinforce the constructivist model could exceed the expectations of the learner using the online platform [51].

Cognitive Skills

Intellectual skills such as establishing a knowledge base, problem-solving, and critical thinking were examined. Despite this component being novel, students displayed adequate clinical knowledge retention when reasoning through the procedural and examination-related cases. Students explained, defined, and rationalised the purpose of these skills, demonstrating near transfer of abilities since the assessment setting was similar to the learning environment [22]. Further analysis of the assessment scores revealed

that the blended group outperformed the e-learning group. This finding supports Turk et al. [52], who reported that combining online teaching and onsite practice may be preferable to online teaching alone.

Student characteristics, learning design, and onsite environmental conditions are also aspects to consider for the performance gap between the two groups [17]. Since the blended student group had volunteered for the onsite session, they may be more self-motivated. The formative OSCE was also preparation for the summative examination implying spaced learning [22]. The structure of the formative assessment allowed students to have one-on-one tutor interaction, where techniques were corrected, and questions answered. Furthermore, the onsite practice allowed students to construct the applied skills on their existing knowledge, which is crucial in developing competence [17, 53, 54]. Using a variety of teaching delivery approaches and arranging immediate application opportunities, with support from clinical educators, could explain the higher-level transfer of assessed skills [6].

Despite the differences between the subgroups, Cohort A's overall performance meant that most students could have a meaningful discussion with the examiner, demonstrating clinical reasoning and knowledge transfer [55]. Compared to the pre-pandemic onsite OSCE, the online model examined a more significant proportion of the cognitive domain, allowing for early exposure to diagnostic reasoning, a deeper understanding of concepts, and better information retention, preparing students for hospital rotations [15, 56]. Since online cognitive skills training went beyond the face-to-face scope, combining an e-learning platform with traditional teaching and assessment methods can potentially produce better outcomes [47].

Our study showed that medical students taught clinical skills on an online platform can effectively retain knowledge and transfer affective, cognitive, and psychomotor skills competently, bridging the theory-practice gap in three domains of clinical skills. The improved transfer to "hands-on" practice petitions a revised blended-teaching strategy designed at the planning stage of the academic curriculum. Apart from the academic advantages, online learning also allows students to build up their skills and confidence before interacting with actual patients and other medical professionals [57]. Finally, in resource-constrained training contexts, the documented benefits of the online platform regarding time management, flexibility, and cost-effectiveness [37, 49, 52] could mean that more students can be included and trained.

Limitations

The "Readiness Program" coincided with the fourth wave of the COVID-19 pandemic in South Africa, resulting in lower student participation. Students that volunteered were possibly more motivated learners and academically more proficient. The online OSCE had three clinical skill stations, with students being assessed by one examiner for all skills. As the online OSCE was in a pilot phase, examiners were limited as training was required to facilitate this exam, and with fewer examiners, time constraints were a concern. Although the findings demonstrated that students did transfer knowledge and skills from the online platform, a comprehensive summative onsite OSCE assessment of the entire class would better

reflect the scale of far transfer. The ultimate test of competency would be to evaluate students at the bedside of patients.

Conclusion And Recommendations

The COVID-19 pandemic created an unprecedented opportunity to pilot an online approach to medical education and compare its impact on blended and face-to-face learning. The blended learning group performed significantly better in all clinical skill domains. Furthermore, our 2021 online learners bridged the theory-practice gap effectively and demonstrated higher-level transfer and knowledge retention than the 2019 face-to-face learners. Medical education needs to advocate a structural shift [58] to decentralize the classroom and provide an efficient and economical learning environment [44] that accommodates large cohorts [59]. Technology offers flexibility, small group work, and resource access that reinforces a constructivist model. Incorporating a digital curriculum that uses these varied instructional designs and assessments may support traditional teaching methods. Our study corroborates the findings of the blended learning literature and extends the current knowledge to clinical skills training. The contributing factors need to be critically analysed to implement a hybrid-teaching delivery model that formalises the gains made during this unique experience. A conceptual framework that optimises learning by amalgamating the best of the online and face-to-face platforms may evolve medical education while simultaneously minimising the impact of occurrences that can threaten the normal functioning of the physical institution.

Abbreviations

COVID-19
Coronavirus Disease 2019
CSL
Clinical skills laboratory
CCG
Calgary-Cambridge Guide
RP
Readiness Programme

Declarations

Acknowledgements: University of KwaZulu-Natal – Clinical Skills Department. To the staff and students who participated in this study

Ethics approval and consent to participate

Research involving human participants, human material, or human data, must have been performed in accordance with the Declaration of Helsenki. Ethical approval for this study was granted by the University of KwaZulu-Natal's ethics committee (approval number HSSREC/00003459/2021). Informed consent

was obtained. The authors confirm that all methods were carried out in accordance with UKZN's guidelines and regulations.

Consent for publication:

Not applicable

Availability of data and materials:

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests:

The authors declare that they have no competing interests

Funding:

Not Applicable

Authors' contributions:

LCE had the concept of the article, performed the literature search, data collection, data analysis & interpretation, and drafted the first version of the manuscript. Both RMA and VSS have contributed substantially to the conception, design, and data collection, analysis, and interpretation. They have been involved in drafting the manuscript and critically revising it. All authors read and approved the final manuscript.

Authors' information (optional)

LCE is an anaesthetist practicing in the public sector. The author is also involved in undergraduate clinical skills training at the Nelson R Mandela School of Medicine, School of Clinical Medicine, University of KwaZulu-Natal

References

1. Eglseder K, Littleton A. Teaching Clinical Skills Online: Techniques, Student Feedback, and Lesson Learned. J Occup Ther Educ 2021;5:(2):11. https://doi.org/10.26681/jote.2021.050211.
2. Bock A, Kniha K, Goloborodko E, Lemos M, Rittich AB, Möhlhenrich SC, et al. Effectiveness of face-to-face, blended and e-learning in teaching the application of local anaesthesia: a randomised study. BMC Med Educ 2021;21:1–8. https://doi.org/10.1186/s12909-021-02569-z.
3. Al-Elq AH. Medicine and clinical skills laboratories. J Family Community Med 2007;14:59–63.
4. Gill D, Whitehead C, Wondimagegn D. Challenges to medical education at a time of physical distancing. Lancet 2020;396:77–9. https://doi.org/10.1016/S0140-6736(20)31368-4.

5. Khalil R, Mansour AE, Fadda WA, Almisnid K, Aldamegh M, Al-Nafeesah A, et al. The sudden transition to synchronized online learning during the COVID-19 pandemic in Saudi Arabia: a qualitative study exploring medical students' perspectives. BMC Med Educ 2020;20:285. https://doi.org/10.1186/s12909-020-02208-z.
6. Abraham R. The need of the hour: Adapting the delivery of clinical skills teaching remotely. Perspect Educ 2021;39:82–94. https://doi.org/10.18820/2519593x/pie.v39.i2.7.
7. Moercke AM, Eika B, Haskell RE, Creswell J, Rao N, Pintrich RR, et al. Teaching medical students how to interpret chest x-rays: The design and development of an e-learning resource. Med Educ 2021;8. https://doi.org/10.1007/s40670-021-01231-z.
8. Michels MEJ, Evans DE, Blok GA. What is a clinical skill? Searching for order in chaos through a modified Delphi process. Med Teach 2012;34:(8): e573-81. https://doi.org/10.3109/0142159X.2012.669218.
9. Nascimento J da SG, Siqueira TV, Oliveira JLG de, Alves MG, Regino D da SG, Dalri MCB. Development of clinical competence in nursing in simulation: the perspective of Bloom's taxonomy. Rev Bras Enferm 2021;74:(1):e20200135. https://doi.org/10.1590/0034-7167-2020-0135.
10. Adams NE. Bloom's taxonomy of cognitive learning objectives. J Med Libr Assoc 2015;103:152–3. https://doi.org/10.3163/1536-5050.103.3.010.
11. Stambough JB, Curtin BM, Gililland JM, Guild GN, Kain MS, Karas V, et al. The Past, Present, and Future of Orthopedic Education: Lessons Learned From the COVID-19 Pandemic. J Arthroplasty 2020;35:S60–4. https://doi.org/10.1016/j.arth.2020.04.032.
12. Taylor DCM, Hamdy H. Adult learning theories: Implications for learning and teaching in medical education: AMEE Guide No. 83. Med Teach 2013;35:1561–72. https://doi.org/10.3109/0142159X.2013.828153.
13. Tolsgaard MG, Cleland J, Wilkinson T, Ellaway RH. How we make choices and sacrifices in medical education during the COVID-19 pandemic. Med Teach 2020;42:741–3. https://doi.org/10.1080/0142159X.2020.1767769.
14. Giacomino K, Caliesch R, Sattelmayer KM. The effectiveness of the Peyton's 4-step teaching approach on skill acquisition of procedures in health professions education: A systematic review and metaanalysis with integrated meta-regression. PeerJ 2020;8:e10129. https://doi.org/10.7717/peerj.10129.
15. Prober CG, Khan S. Medical education reimagined: A call to action. Acad Med 2013;88:1407–10. https://doi.org/10.1097/ACM.0b013e3182a368bd.
16. Bossard C, Kermarrec G, Buche C, Tisseau J. Transfer of learning in virtual environments: a new challenge? Virtual Real 2008;12:151–61. https://doi.org/10.1007/s10055-008-0093-y.
17. Botma Y, Van Rensburg GH, Coetzee IM, Heyns T. A conceptual framework for educational design at modular level to promote transfer of learning. Innov Educ Teach Int 2015;52:499–509. https://doi.org/10.1080/14703297.2013.866051.

18. Cormier SM, Hagman JD. Transfer of learning: Contemporary research and applications. Academic press. 2014.
19. Hajian S. Transfer of Learning and Teaching: A Review of Transfer Theories and Effective Instructional Practices. IAFOR J Educ 2019;7:93–111. https://doi.org/10.22492/ije.7.1.06.
20. Lala SG, George AZ, Wooldridge D, Wissing G, Naidoo S, Giovanelli A, et al. A blended learning and teaching model to improve bedside undergraduate paediatric clinical training during and beyond the COVID-19 pandemic. African J Heal Prof Educ 2021;13:18–22.
21. Andrusyszyn MA. The effect of the lecture discussion teaching method with and without audio-visual augmentation on immediate and retention learning. Nurse Educ Today 1990;10:172–80. https://doi.org/10.1016/0260-6917(90)90022-I.
22. Rosby L V., Schmidt HG, Tan GJS, Low-Beer N, Mamede S, Zwaan L, et al. Promotion of knowledge transfer and retention in year 2 medical students using an online training exercise. Adv Heal Sci Educ 2021;26:1059–74. https://doi.org/10.1007/s10459-021-10037-y.
23. Murre JMJ, Dros J. Replication and analysis of Ebbinghaus' forgetting curve. PLoS One 2015;10:(7): e0120644. https://doi.org/10.1371/journal.pone.0120644.
24. Badiei M, Gharib M, Zolfaghari M, Mojtahedzadeh R. Master's Student in School of Nursing. Med J Islam Repub Iran 2016;30:364.
25. Anderson JDM, Warren JB. Using Simulation to Enhance the Acquisition and Retention of Clinical Skills in Neonatology. Semin Perinatol 2011;35:59–67. https://doi.org/10.1053/j.semperi.2011.01.004.
26. Sahu P, Chattu V, Rewatkar A, Sakhamuri S. Best practices to impart clinical skills during preclinical years of medical curriculum. J Educ Health Promot 2019;8:57. https://doi.org/10.4103/jehp.jehp_354_18.
27. Ibrahim NK, Al Raddadi R, AlDarmasi M, Al Ghamdi A, Gaddoury M, AlBar HM, et al. Medical students' acceptance and perceptions of e-learning during the Covid-19 closure time in King Abdulaziz University, Jeddah. J Infect Public Health 2021;14:17–23. https://doi.org/10.1016/j.jiph.2020.11.007.
28. Holsapple CW, Lee-Post A. Defining, Assessing, and Promoting E-Learning Success: An Information Systems Perspective*. Decis Sci J Innov Educ 2006;4:67–85. https://doi.org/10.1111/j.1540-4609.2006.00102.x.
29. Gordon L, Cleland JA. Change is never easy: How management theories can help operationalise change in medical education. Med Educ 2021;55:55–64. https://doi.org/10.1111/medu.14297.
30. Abraham R. Turning constraints into opportunities: Online delivery of communication skills simulation sessions to undergraduate medical students during the COVID-19 pandemic. Perspect Educ 2021;39:57–71. https://doi.org/10.18820/2519593X/PIE.V39.I4.5.
31. Forbes R, Hoyle M, Penman A, Smith S. Exploring allied health professional student and academic teacher experiences of teaching and learning clinical skills online in response to COVID-19. Aust J Clin Educ 2021;9:0–15.

32. Gaur U, Majumder MAA, Sa B, Sarkar S, Williams A, Singh K. Challenges and Opportunities of Preclinical Medical Education: COVID-19 Crisis and Beyond. SN Compr Clin Med 2020;2:1992–7. https://doi.org/10.1007/s42399-020-00528-1.
33. Bączek M, Zagańczyk-Bączek M, Szpringer M, Jaroszyński A, Wożakowska-Kapłon B. Student's Perception of Online Learning during COVID Pandemic. Medicine (Baltimore) 2021;100:(7). https://doi.org/doi: 10.1097/MD.0000000000024821.
34. Bordoloi R, Das P, Das K. Perception towards online/blended learning at the time of Covid-19 pandemic: an academic analytics in the Indian context. Asian Assoc Open Univ J 2021;16:41–60. https://doi.org/10.1108/aaouj-09-2020-0079.
35. Sebbani M, Adarmouch L, Mansouri A, Mansoury O, Michaud S, Eladib AR, et al. Implementation of Online Teaching in Medical Education: Lessons Learned from Students' Perspectives during the Health Crisis in Marrakesh, Morocco. Educ Res Int 2021;2021:e5547821. https://doi.org/10.1155/2021/5547821.
36. Schlenz MA, Schmidt A, Wöstmann B, Krämer N, Schulz-Weidner N. Students' and lecturers' perspective on the implementation of online learning in dental education due to SARS-CoV-2 (COVID-19): A cross-sectional study. BMC Med Educ 2020;20:354. https://doi.org/10.1186/s12909-020-02266-3.
37. Dost S, Hossain A, Shehab M, Abdelwahed A, Al-Nusair L. Perceptions of medical students towards online teaching during the COVID-19 pandemic: A national cross-sectional survey of 2721 UK medical students. BMJ Open 2020;10:e042378. https://doi.org/10.1136/bmjopen-2020-042378.
38. Brabrand C. Constructive alignment for teaching model-b based design for concurrency. Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 5100 LNCS, Springer Verlag; 2008, p. 1–18. https://doi.org/10.1007/978-3-540-89287-8_1.
39. George JH, Doto FX. A simple five-step method for teaching clinical skills. Fam Med 2001;33:577–8.
40. Kurtz S, Silverman J, Benson J, Draper J. Marrying content and process in clinical method teaching: Enhancing the Calgary-Cambridge guides. Acad Med 2003;78:802–9. https://doi.org/10.1097/00001888-200308000-00011.
41. Shail MS. Using Micro-learning on Mobile Applications to Increase Knowledge Retention and Work Performance: A Review of Literature. Cureus 2019;11:(8). https://doi.org/10.7759/cureus.5307.
42. Kang SHK. Spaced Repetition Promotes Efficient and Effective Learning: Policy Implications for Instruction. Policy Insights from Behav Brain Sci 2016;3:12–9. https://doi.org/10.1177/2372732215624708.
43. Chen F, Lui AM, Martinelli SM. A systematic review of the effectiveness of flipped classrooms in medical education. Med Educ 2017;51:585–97. https://doi.org/10.1111/medu.13272.
44. Gormley G, Collins K, Boohan M, Bickle I, Stevenson M. Is there a place for e-learning in clinical skills? A survey of undergraduate medical students' experiences and attitudes. Med Teach 2009;31:(1):e6-12. https://doi.org/10.1080/01421590802334317.

45. Vincent SC, Arulappan J, Amirtharaj A, Matua GA, Al Hashmi I. Objective structured clinical examination vs traditional clinical examination to evaluate students' clinical competence: A systematic review of nursing faculty and students' perceptions and experiences. Nurse Educ Today 2022;108:105170. https://doi.org/10.1016/j.nedt.2021.105170.
46. Offiah G, Ekpotu LP, Murphy S, Kane D, Gordon A, O'Sullivan M, et al. Evaluation of medical student retention of clinical skills following simulation training. BMC Med Educ 2019;19:263. https://doi.org/10.1186/s12909-019-1663-2.
47. George PP, Papachristou N, Belisario JM, Wang W, Wark PA, Cotic Z, et al. Online eLearning for undergraduates in health professions: A systematic review of the impact on knowledge, skills, attitudes and satisfaction. J Glob Health 2014;4:(1):010406. https://doi.org/10.7189/jogh.04.010406.
48. Reisenwitz TH. Examining the necessity of proctoring online exams. J High Educ Theory Pract 2020;20:118–24. https://doi.org/10.33423/jhetp.v20i1.2782.
49. Shahrvini B, Baxter SL, Coffey CS, MacDonald B V., Lander L. Pre-clinical remote undergraduate medical education during the COVID-19 pandemic: a survey study. BMC Med Educ 2021;21:1–13. https://doi.org/10.1186/s12909-020-02445-2.
50. Rauch C, Utz J, Rauch M, Kornhuber J, Spitzer P. E-Learning Is Not Inferior to On-Site Teaching in a Psychiatric Examination Course. Front Psychiatry 2021;12:371. https://doi.org/10.3389/FPSYT.2021.624005.
51. Suwannaphisit S, Anusitviwat C, Hongnaparak T, Bvonpanttarananon J. Expectations on online orthopedic course using constructivism theory: A cross-sectional study among medical students. Ann Med Surg 2021;67:102493. https://doi.org/10.1016/j.amsu.2021.102493.
52. Turk B, Ertl S, Wong G, Wadowski PP, Löffler-Stastka H. Does case-based blended-learning expedite the transfer of declarative knowledge to procedural knowledge in practice? BMC Med Educ 2019;19. https://doi.org/10.1186/s12909-019-1884-4.
53. Herring JE. Year 12 students' use of information literacy skills: A constructivist grounded analysis. Pract. Inf. Lit. Bringing Theor. Learn. Pract. Inf. Lit. Together, 2010, p. 143–65. https://doi.org/10.1016/B978-1-876938-79-6.50007-8.
54. Gitonga J. Transfer of Learning in Continuing Medical Education (CME): A Conceptual Model. Online Submiss 2007.
55. Botelho MG, Agrawal KR, Bornstein MM. An systematic review of e-learning outcomes in undergraduate dental radiology curricula—levels of learning and implications for researchers and curriculum planners. Dentomaxillofacial Radiol 2019;48. https://doi.org/10.1259/dmfr.20180027.
56. Remmen R, Scherpbier A, van der Vleuten C, Denekens J, Derese A, van Rossum H, et al. Effectiveness of basic clinical skills training programmes: a cross-sectional comparison of four medical schools. Med Educ 2001;35:121–128.
57. Ellman MS, Schwartz ML. Online Learning Tools as Supplements for Basic and Clinical Science Education. J Med Educ Curric Dev 2016;3:109–14. https://doi.org/10.4137/JMecd.S18933.

58. Regmi K, Jones L. A systematic review of the factors - Enablers and barriers - Affecting e-learning in health sciences education. BMC Med Educ 2020;20:1–8. https://doi.org/10.1186/s12909-020-02007-6.
59. McDonald EW, Boulton JL, Davis JL. E-learning and nursing assessment skills and knowledge – An integrative review. Nurse Educ Today 2018;66:166–74. https://doi.org/10.1016/j.nedt.2018.03.011.

Figures

Figure 1

Communication skills virtual simulation process [30]

Figure 2

Formative OSCE process assessing psychomotor skills and data collection – Blended Group A1

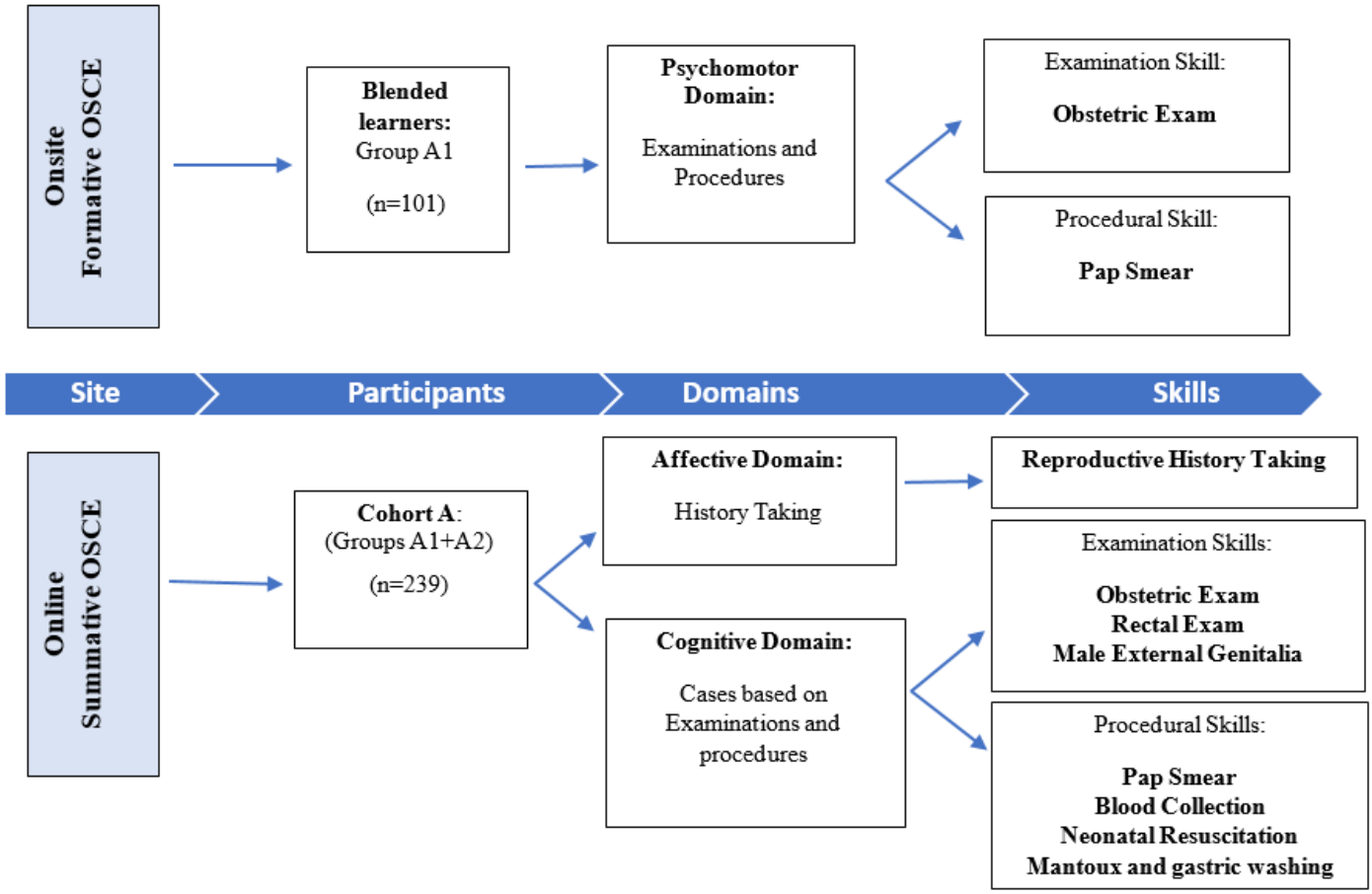

Figure 3

Method of assessment and data collection of 3rd year students in 2021

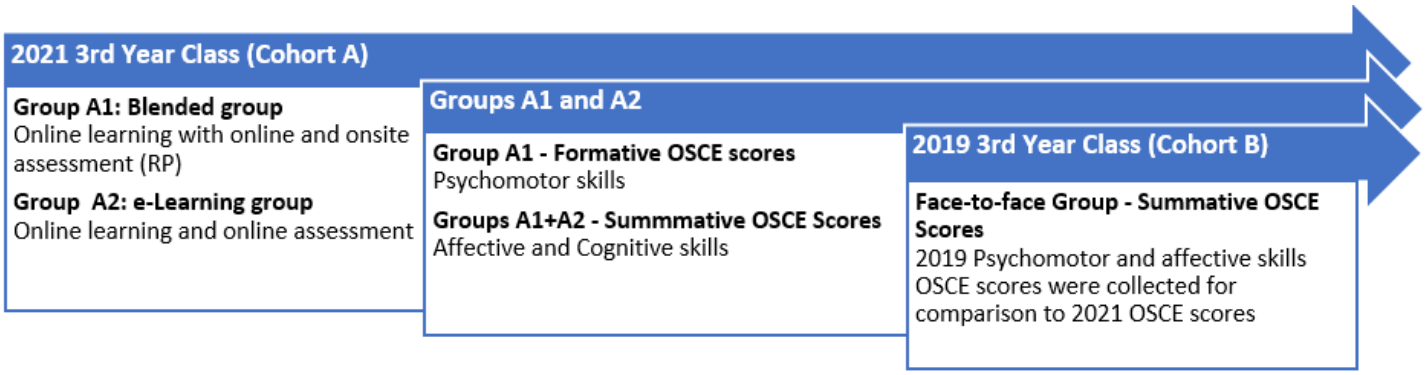

Figure 4

Timeline of data collection from Cohort A [blended group A1 & e-learning group A2] and Cohort B [face-to-face group]

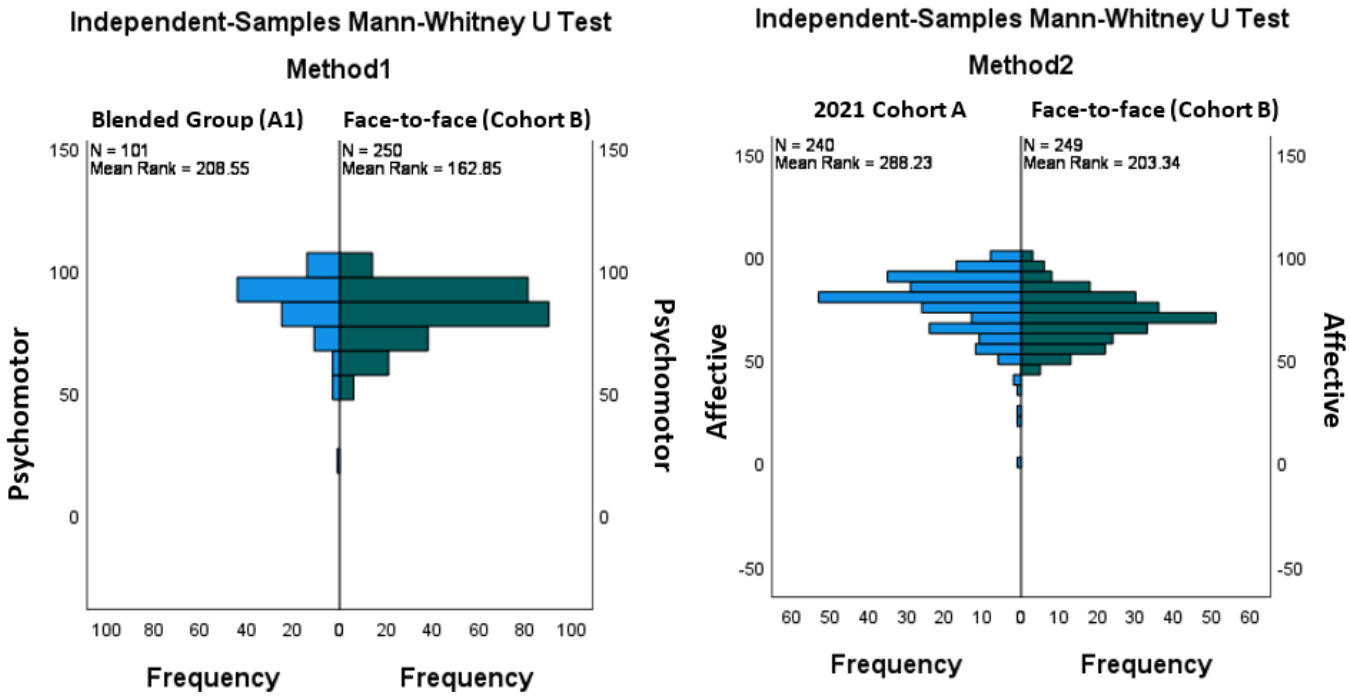

Figure 5

a Psychomotor domain - Comparison between 3rd year medical students' onsite OSCE marks (2019 and 2021) for Pap smear skills

b Affective domain - Comparison between 3rd year medical students' onsite OSCE marks (2019) and online OSCE marks (2021) in communication skills