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A Web-Based Global Educational Model for Training in Semen Analysis during the COVID-19 Pandemic

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Purpose: In response to the COVID-19 pandemic, the American Center for Reproductive Medicine (ACRM) transitioned its annual training in assisted reproductive technology (ART) from a hands-on, laboratory-based training course to a fully online training endorsed by the American College of Embryology. Here we describe our experience and assess the quality of an online training format based on participant outcomes for the first three modules of a planned series of online ART training.

Materials and Methods: These modules included manual semen analysis, sperm morphology and ancillary semen tests (testing for leukocytospermia, sperm vitality, and anti-sperm antibody screening). The virtual format consisted of lecture presentations featuring laboratory protocols with corresponding video demonstrations of routine techniques and best practices. Practical scenarios, troubleshooting, and clinical interpretation of laboratory results were also discussed. At the end of each module, an optional multiple choice question test was held as a prerequisite to obtain certification on the topics presented. Course quality was assessed using participant responses collected *via* online surveys.

Results: The digital delivery methods used were found to have largely or completely met the participants' expectations for all questions (>85%). The majority (>87%) of the participants either strongly agreed or agreed that the course content was well-

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structured with appropriate depth, and that their overall expectations of the course had been met.
Conclusions: This training format appears to be a realistic teaching option to freely share highly specialized expertise and technical knowledge with participants from anywhere in the world with varying levels of competency or experience.

Keywords: Andrology; Education, distance; Semen analysis; Surveys and questionnaires

INTRODUCTION

Infertility affects between 2.5% and 12% of couples worldwide, with male factor infertility solely accounting for 20% to 30% and contributing to 50% of the overall infertility cases [1]. In the United States alone, infertility affects 9.5% of men [2]. The clinical evaluation of male infertility is based on the semen analysis where the results can significantly influence the diagnostic interpretation and management. While many clinicians rely on semen parameters as a surrogate marker of a man's ability to father a child, the results of semen analysis should, however, be interpreted with caution considering its inherent limitations [3,4].

A properly performed semen analysis and an adequate clinical examination of the male along with questions regarding current medical conditions and lifestyle circumstances that could affect sample quality, can provide valuable information related to a man's fertility potential. This information facilitates a better understanding of the physiology of the reproductive organs and the underlying causes of dysfunction [5-7]. However, manual semen analysis has its inherent challenges associated with high subjectivity, lack of standardization, inadequate quality control and quality assurance, as well as inadequate assessment of competency, and training of laboratory personnel performing the test [7,8]. Unlike sperm concentration and motility, sperm morphology has even more subjectivity in reporting the results, with increased intra- and inter-variability [8-10]. Therefore, quality control is imminent in preventing such variations and retaining uniformity in all assessments by all operators. This includes pre-analytical (test requisition, correct sample collection, delivery of sample), analytical (mixing and loading of sample, correct preparation of smears or calculation of results), and post-analytical (correct reporting of results to the clinician) indicators. To minimize errors, daily, weekly, or monthly quality control of reagents and equipment is imperative. It is also important to identify and document the sources of error in sperm concentration, motility, and morphology. Several factors are responsible for variation in the results of sperm morphology, including differences in the methods used to prepare and stain specimens, differences in proficiency among technicians, and inherent differences in classification criteria and methods [11]. Thus, it is essential to have step-by-step protocols (Standard Operating Procedures), conduct training, and assess the performance of laboratory personnel using proficiency testing material and test competency assessments at regular intervals [6,12].

Hands-on laboratory training sessions are critical to grasp an understanding of safe laboratory practices, correct use and setup of the microscopes, learn step-by-step methodology to conduct a proper semen analysis, and to troubleshoot possible errors. Furthermore, it should also encourage the trainee to participate in interactive discussion and teaching sessions. The performance of the trainee in semen analysis can be successfully evaluated by both the assessment of competency in adequately performing semen analysis and the assimilation of information delivered by multiple choice question (MCQ). In the past eighteen years that the hands-on assisted reproductive technology (ART) training program has been running at the American Center for Reproductive Medicine (ACRM), over 200 candidates from more than 45 countries have been successfully trained. ACRM's ART training program focuses on teaching candidates the newest practical techniques in both routine and advanced andrology. The Case Western Reserve University has recognized this ART training program with a Scholarship in Teaching Award. Most trainees found the program to be invaluable in terms of theoretical background and hands-on guidance, received by expert instructors at a pace that

was best suited for their individual abilities.

However, during the COVID-19 pandemic with all its accompanying restrictions, the hands-on laboratory training had to be converted to a virtual training model (format) that utilizes PowerPoint presentations along with video demonstrations of the laboratory techniques presented by course speakers. The target participants for these virtual ART training courses included laboratory technologists, embryologists, undergraduate students, andrologists, and medical graduates among others.

The objective of this study is to evaluate the quality of the first three modules 1A, 1B, and 1 of the virtual training course on semen analysis based on the participants' responses to an online survey.

MATERIALS AND METHODS

1. Online assisted reproductive technology training: participant registration

The first 3 sessions of the virtual ART training program focused on manual semen analysis (Module 1A), sperm morphology (Module 1B), and ancillary semen tests (Module 1). Participants registered free of cost for each module by completing a short Google Form, where they were asked to fill in their personal details as well as a certified identification document to verify participant credentials. Besides being a user-friendly method, Google Forms was the most suitable approach as it automatically generates graphs and a comma-separated value (CSV) file containing all the responses collected. The link for registration *via* Google Form was posted on different platforms including LinkedIn, Facebook, Instagram, and WhatsApp. Following registration for each module, participants were included into Whats App groups, formed to serve the respective number of participants. WhatsApp was used as the main communication platform to inform participants about the training and for direct communication with the course coordinators in potential queries or further guidance on the course. Moreover, all documents pertaining to course organization were posted on WhatsApp in English and translated in Spanish, Persian, Portuguese, French, and Arabic by a team of 9 international coordinators to provide information that was easily understood, particularly for candidates who were not native English speakers. However, as the course content was entirely in English, having the English language as a first or second language was a pre-requisite for all participants. Informative videos or audio messages were recorded as short clips to facilitate the receipt of the information.

2. Reading material

Scientific literature, including reviews, original studies, guidelines, and protocols, were made available in advance to all registered participants in a Dropbox folder. Participants were highly encouraged to read the shared documents before attending the corresponding training session. The access link to the relevant folder was shared in the description box of each WhatsApp group. For Module 1A, the reading material covered topics such as spermatogenesis, the importance of basic semen analysis in the diagnostics of male infertility, the impact of COVID-19 on performing laboratory procedures, and the importance of quality control in an andrology laboratory. For Module 1B, topics included the importance of sperm morphology evaluation in clinical practice, the technical challenges associated with sperm morphology evaluation, the staining techniques used, the importance of a quality control program in morphology evaluation, and the role of sperm morphology evaluation in ART setting. Finally, the reading material provided for Module 1 included testing for leukocytospermia, sperm vitality, antisperm antibody screening, azoospermia, post-vasectomy screening, retrograde ejaculation, and sperm count.

3. Training sessions

Online training sessions were conducted using the Cisco WebEx platform. Detailed and step-by-step instructions about how to connect through this platform were shared with all registered participants *via* Whats App. Before each training session, 2 "practice sessions" were organized to allow participants to familiarize themselves with using the WebEx platform and to solve any possible technical issue that arose. During these practice sessions, coordinators were available to answer any of the participants' questions about the use of this platform and to provide technical support. The link to the training session was shared in the Whats App group one day before the official commencement of the course. The training sessions for Modules 1A, 1B, and 1 were conducted on November 10, 2020, December 8, 2020, and January 12, 2021, respectively. These live sessions were hosted on the WebEx platform with a

maximum capacity of 1,000 participants. An additional streaming link was provided to the participants who were not able to join directly *via* WebEx.

4. Objectives of training modules

The objectives of Module 1A were first to recognize essential steps for the reproductive labs and IVF (*in vitro* fertilization) clinics engaged in fertility testing as well as gamete cryopreservation to protect their patients and employees from COVID-19. Second, to provide knowledge and understanding of the importance pertaining to regular quality control and quality assurance in the Andrology laboratory. In addition, trainees would acquire knowledge and understanding of conducting a manual and automated semen analysis. The trainees were provided with information regarding the steps involved in laboratory procedures including the microscopic and macroscopic examination. The trainees were also given lectures by a specialized clinician to help them understand the reference ranges for normal semen parameters and definitions of various categories of abnormal semen parameters.

The focus of Module 1B was the accurate assessment of sperm morphology parameters. The speakers explained sperm morphology with its specific morphological features and a brief overview of the historical development and definition as 'strict criteria'. The lectures highlighted normal and most frequent abnormal morphological presentations of human spermatozoa, and their association with male fertilization potential as well as to certain andrological conditions.

The objectives of Module 1 were to summarize the significance of ancillary tests such as leukocytospermia, sperm vitality test and antisperm antibody test and highlight the use of specialized test such as nuclear fast red and picroindigocarmine (NF-PIC) staining in azoospermia samples for assessment of cryptozoospermia (condition where sperm are not observed in fresh preparation, but only after centrifugation of the ejaculate) [6]. Another important objective was to develop an understanding of the applicability of these tests in a clinical setting. The lectures explained the relevance of each test by giving different laboratory and clinical scenarios. Futhermore, the importance of quality control, quality assurance, and competency assessment were covered for all the ancillary tests. Finally, topics also covered the importance of screening and reporting of results in post-vasectomy patients as per the American Urological Association (AUA) guidelines [13].

5. Development of the lecture material

The lectures were prepared by each speaker with the support of the ACRM management team through extensive rounds of revision based on the feedback of international collaborators and experts in male infertility and ART. Each lecture was prepared based on the most updated evidence published in the literature and citing currently available guidelines and regulatory standards, such as Code of Federal Regulations (CFR) and Clinical Laboratory Improvement Amendments (CLIA). Lectures were delivered in real-time with the exceptions of few speakers who were in a different time zone or having connectivity issue. In these cases, pre-recorded video of their lectures were projected during the training sessions.

Protocols were illustrated and discussed in depth by showing images and videos recorded personally by the speakers to better present the routine laboratory practice and make the course participants feel as if they were live in the laboratory. Finally, practical laboratory and clinical scenarios were discussed along with troubleshooting and the clinical interpretation of laboratory results.

6. Multiple choice question test

At the end of the two-hour training session, a link for an MCQ test was shared on each of the WhatsApp groups. The questions in the MCQ test were formulated by the relevant expert speaker in each section, collated and populated on the Google Forms platform. These questions were then moderated and revised independently by two or more international expert collaborators who were not involved in the management of the course. The aim of having the questions reviewed by independent experts was to help 1) maintain the standard of the questions and 2) ensure that the questions were clear, and easily understandable to a large international audience. The test included 40 to 60 questions based on the contents of each online module. The time allotted for each test ranged between 30 and 40 minutes, depending on the total number of questions in the test. The duration of the test was calculated considering 30 seconds per question, with additional time given for participants to provide their personal information (full name, email, country). Each question had only one correct answer, and no negative

Table 1. Demographics of participants who answered the surveys for Modules 1A, 1B, and 1

Category	Number of participants			
	Module 1A (n=888)	Module 1B (n=796)	Module 1 (n=760)	Total across all 3 Modules (n=2,444)
Age (y)				
18–25	197	180	166	543
26–35	407	357	336	1,100
36–45	211	189	187	587
46–55	60	57	58	175
56–65	13	12	12	37
>65	0	1	1	2
Qualification				
Undergraduate	15	17	12	44
BSc	189	184	185	558
MSc	281	258	249	788
MS	19	12	11	42
MD or MBBS	184	174	171	529
MVSc	8	7	7	22
PhD	101	87	86	274
DVM	9	6	1	16
Others	82	51	38	171
Vocation				
Academic	31	70	60	161
Undergraduate student	38	35	30	103
Postgraduate student	83	77	73	233
Andrologist in training	33	20	25	78
Embryologist in training	109	98	94	301
Practicing andrologist	66	77	78	221
Practicing embryologist	237	205	209	651
Clinician	149	155	133	437
Others	142	59	58	259
Years of experience				
<2	342	317	296	955
2–5	250	228	209	687
5–10	151	131	130	412
>10	145	120	125	390
Location	878	784	751	2,413
Africa	124	137	143	404
Asia	445	390	392	1,227
Australia	3	2	1	6
Europe	89	75	66	230
North America	37	32	25	94
South America	180	148	124	452
Total number of registered participants	1,337	1,173	1,136	3,646
Number of participants who attended the virtual training	1,002	901	826	2,729
Number of participants who took the online survey	888	796	760	2,444
Total number of participants who took the MCQ test	633	826	735	2,194
Total number of participants who passed the MCQ test	515	570	379	1,464

BSc: bachelor of science, MSc: master of science in medicine or surgery, MS: master of surgery, MD: doctor of medicine, MBBS: bachelor of medicine and bachelor of surgery, MVSc: master of veterinary science, PhD: doctor of philosophy, DVM: doctor of veterinary medicine, MCQ: multiple choice question.

marking was applied. In Module 1A, candidates passed the test if they scored more than 60%, while the passing score for Module 1B and Module 1 was increased to 65% in view of the overall difficulty of the questions. Participants who achieved a passing score in the MCQ test for a particular module received a special certificate of participation from the course organizers.

7. Assessment of the module delivery surveys

At the end of the MCQ test, participants were asked to complete an online survey created on Google Forms. Completing this survey was a requirement for participants in order to obtain the certificate, provided that they scored a passing mark in the post-course MCQ test. The link for the survey was also shared on each of the WhatsApp groups. The survey was constructed for collecting demographic data of the participants and to evaluate 5 components of the online ART training modules: 1) participants' evaluation of the application process and organization/handling of the course; 2) participants' evaluation of the technological tools (Dropbox, WhatsApp, WebEx) used during the course; 3) participants' evaluation of the faculty and speakers; 4) self-rating of knowledge pre- and post-online courses; and 5) self-reported benefits of attending the lectures. Survey results were used to improve the organization of the subsequent online module.

The survey questions were created and extensively revised by a team of international collaborators with expertise in teaching and learning, who were independent of the course management. The same survey questions were submitted at the end of each session for all 3 ART modules, except those related to the self-rating of knowledge pre- and post-online courses, as these questions were specific for the topics covered in a particular module.

8. Statistical analysis

Statistical analysis was performed using MedCalc statistical software version 19.7.4 (MedCalc Software bv, Ostend, Belgium). The answers were analyzed all together when the questions were common across all three modules, while answers for the self-rating of knowledge pre- and post-online courses were analyzed individually for each module. Some questions were optional, hence numbers of participants in the modules might vary slightly. Descriptive statistics of the participant cohort were represented as mean±standard deviation and median (interquartile range). Kolmogorov–Smirnov test for normal distribution was used to understand the distribution of data variables. Wilcoxon test for comparison was used to compare pre and post self-reporting of the participants' own performance based on the non-parametric distribution of data. A p-value less than 0.05 was considered statistically significant.

RESULTS

The online surveys were completed by a total of 2,444

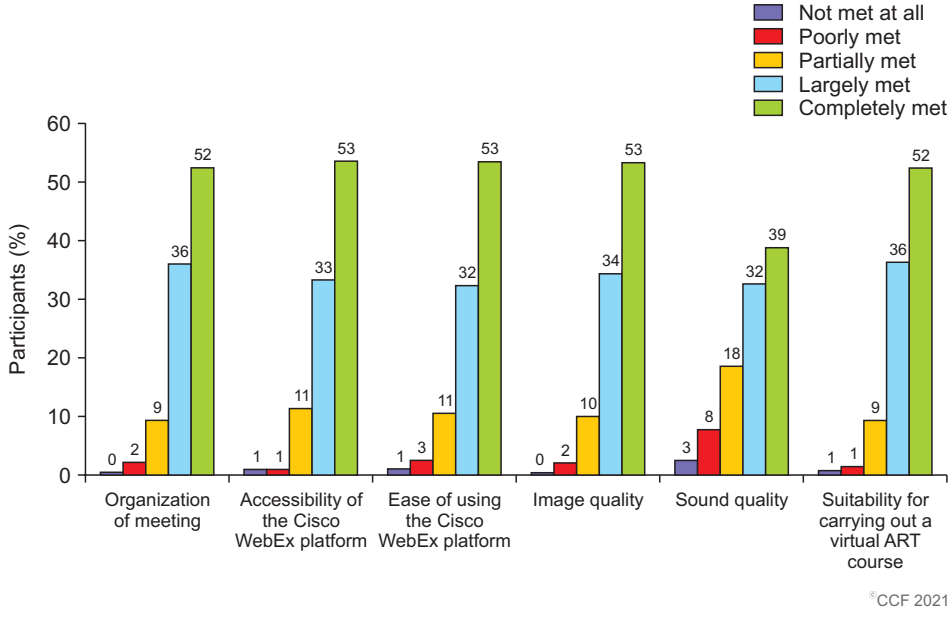


Fig. 1. Digital delivery methods rated by the participants according to their expectations. ART: assisted reproductive technology.

participants from 60 to 64 countries. The demographics of the participants who answered the surveys for Modules 1A, 1B, and 1 are depicted in Table 1.

The primary reason for the participants having attended the ART lectures was the same across all three modules, namely 'to improve knowledge, skills, and expertise in the field of andrology, male reproduction, ART, and infertility' (Modules 1A: 48.8%, 1B: 72.2%, 1: 68.0%). Other reasons for wanting to attend the courses included: learning contemporary techniques (Modules 1A: 8.1%, 1B: 10.5%, 1: 7.6%), the opportunity of obtaining a certificate (Modules 1A: 2.4%, 1B: 6.4%, 1: 8.1%) as well as for the chance to build a global network and career (Modules 1A: 0.4%, 1B: 1.7%, 1: 2.1%). Also, the main expectation from the online ART courses resonated well across all the three modules as 'to gain a better understanding of basics as well as recent advances in the field of andrology and human reproduction' (Module 1A: 59.0%, 1B: 52.7%, 1: 69.3%).

The evaluation of the technological tools/digital delivery methods used during the online ART course in all three modules is illustrated in Fig. 1. More than 85% of the participants responded positively that the digital delivery methods used had largely/completely met their expectations for all questions, except for the sound quality, where the percentage was equal to 71%.

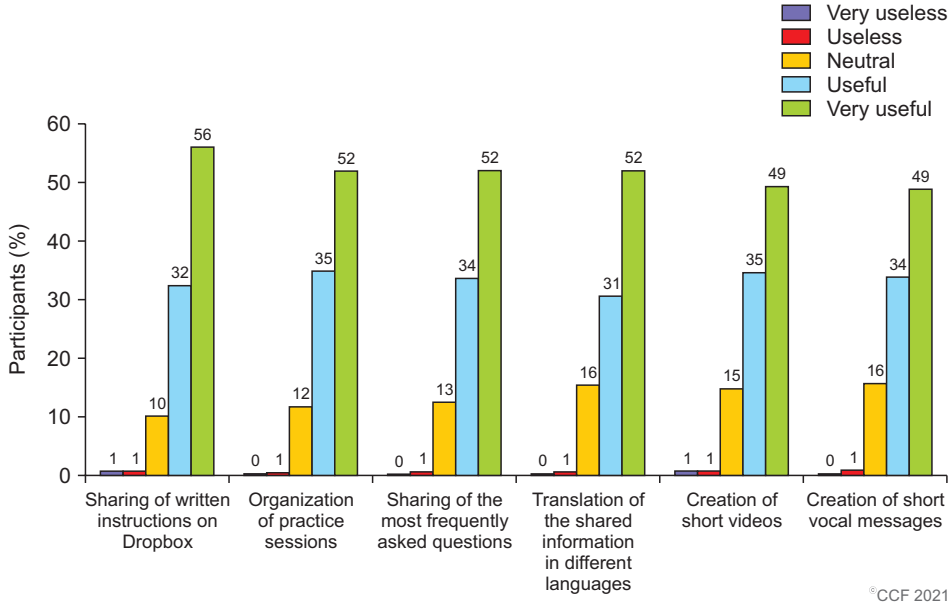


Fig. 2. Utility of the measures to facilitate the use of WebEx.

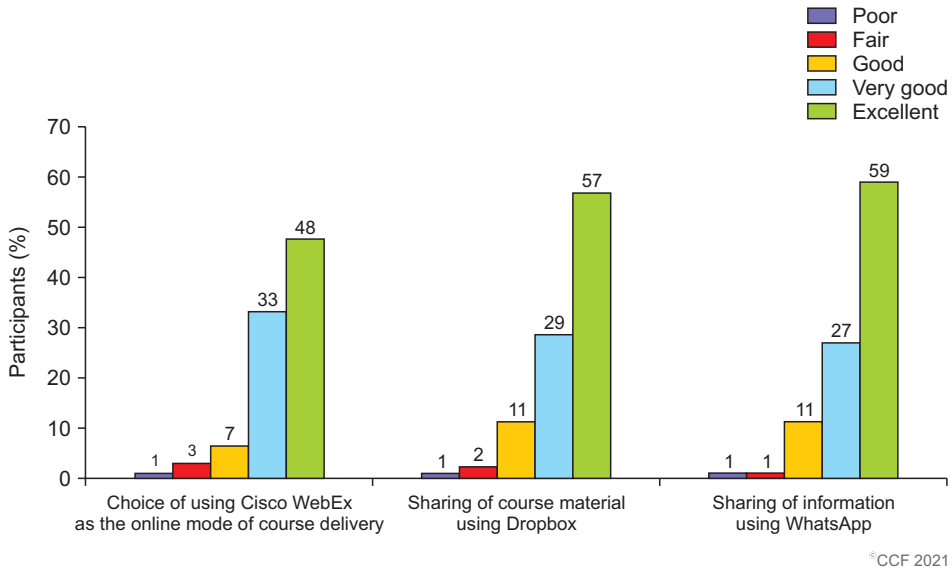


Fig. 3. Rating of the delivery mode of the course by the participants.

Similarly, the use of Dropbox for sharing written instructions, organization of practice sessions, sharing of the most frequently asked questions (FAQs), translation of the shared information into different languages, creation of short informative video clips, and voice messages were rated as either useful or very useful by more than 80% of the participants (Fig. 2). Although sharing of information using various electronic platforms was generally rated as very good or excellent by more than 80% of the participants, the preferred platforms appeared to be WhatsApp with a rating of 86%, Dropbox (85%), and WebEx (81%) (Fig. 3). Overall, analysis of the responses related to the technological tools used in the online ART course showed that 51.7% of participants found this program to be very useful and the digital delivery methods had completely met their purpose. Moreover, 33.0% had found these tools to be helpful and very good, although 11.9% found them neutral and good.

More than 70% of the participants regarded the fol-

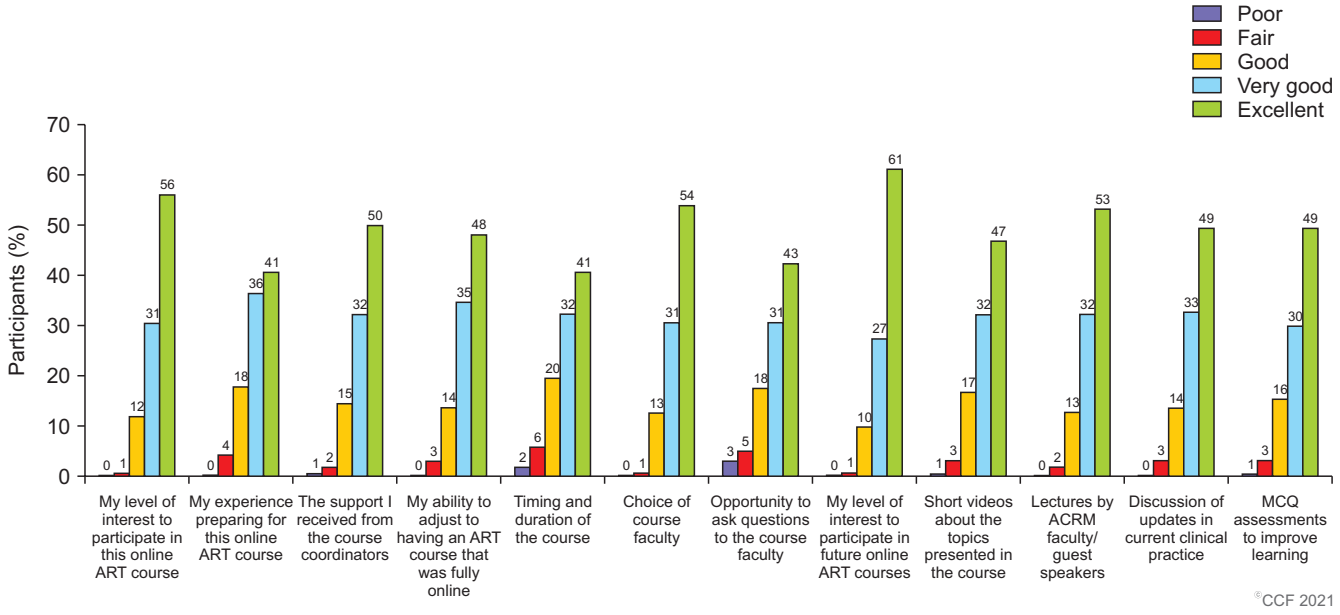


Fig. 4. Rating of aspects that were important for the participants. ART: assisted reproductive technology, ACRM: American Center for Reproductive Medicine, MCQ: multiple choice question.

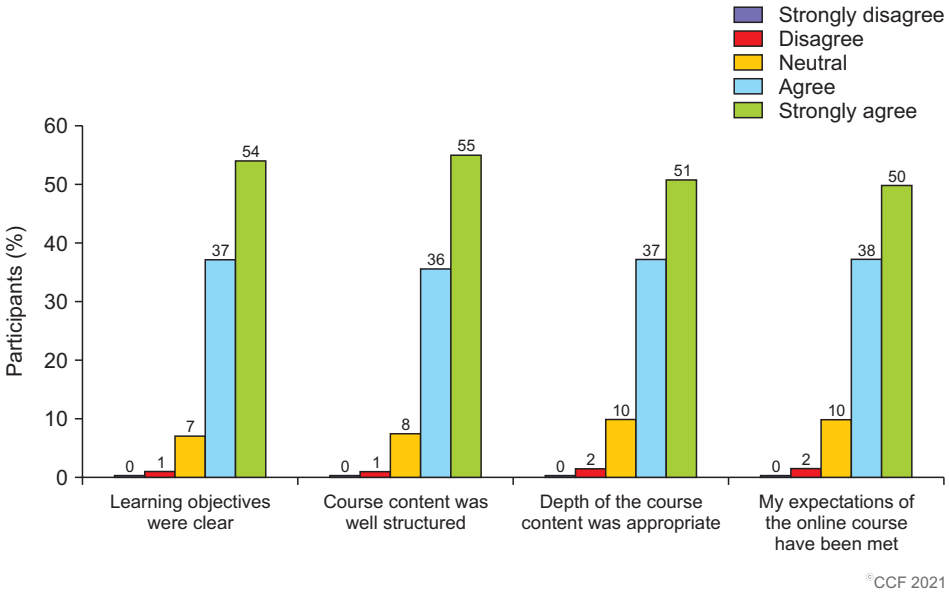
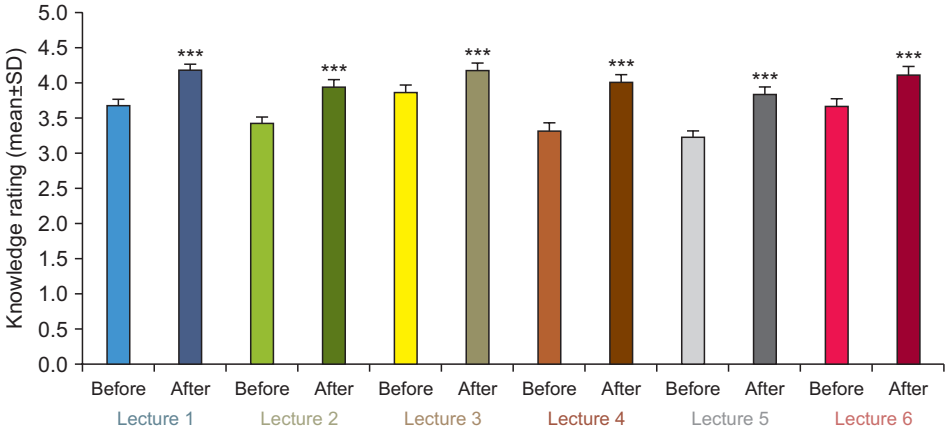


Fig. 5. Rating of the learning objectives and delivery of the course contents.

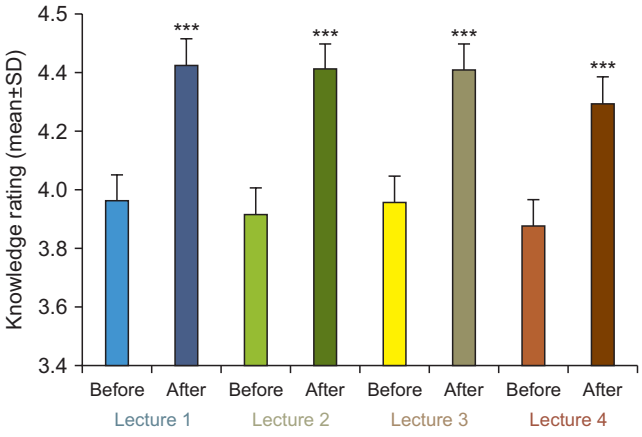


Lecture 1: Implementing COVID-19 safety procedures in an Andrology lab
Lecture 2: Daily quality control in an Andrology lab
Lecture 3: Manual semen analysis and WHO 2010 reference values
Lecture 4: Automated semen analysis
Lecture 5: Quality assurance and proficiency testing in an Andrology lab
Lecture 6: Interpretation of lab results in clinical management

Fig. 6. Knowledge rating before and after taking Module 1A. SD: standard deviation. ***p<0.0001.

lowing aspects of program as either very good or excellent: 1) participants' level of interest in participating in the modules, 2) experience preparing for the courses, 3) course coordinators support, 4) ability to adjust to a completely online course, 5) timing and duration of the course, 6) choice of course faculty, 7) opportunity to ask questions, 8) level of interest to participate in future courses, 9) short videos about the lecture topics, 10) lectures given by the ACRM faculty/guest speakers, 11) discussion of updates in current clinical practice, and 12) MCQ assessments to improve learning (Fig. 4). The majority (>87%) of the participants gave ratings of either strongly agree or agree that the learning objectives were clear, the course content was well-structured and had appropriate depth and that, as an overall, their expectations of the course had been met (Fig. 5).

Out of 2,444 participants, 28.0% found the application process for the online ART Course to be straightforward, while it was perceived as complicated by 29.7% of the participants. On evaluating the role of the Course Coordinators in organizing the current online ART course, 47.1% of candidates were in strong agreement that the Course Coordinators helped stimulate their interest in the course content. While 58.1% of the participants strongly agreed that the Coordinators effectively used WhatsApp to share detailed information about the course, 51.0% found the Coordinators helpful in clarifying their doubts, 49.0% strongly agreed that the Coordinators were prompt in their feedback, and 53.3% of candidates found them always approachable



Lecture 1: Importance of strict criteria in assisted reproduction
Lecture 2: Sperm morphology: step by step protocol and quality control
Lecture 3: Sperm morphology evaluation by strict criteria
Lecture 4: Sperm morphology and clinical management

Fig. 7. Knowledge rating before and after taking Module 1B. SD: standard deviation. ***p<0.0001.

and courteous. Only about 3% of the candidates appeared not to have been satisfied with the Coordinators' performance.

The self-reported increase in the participants' knowledge following participation in these online lectures, as per the ratings provided by the participants before and after the lectures, was highly significant (p<0.0001) for all modules (Fig. 6-8). The self-reported benefits of participating in all three online ART modules and the ways how the information gathered was self-reported to help the participants in their line of work/area of

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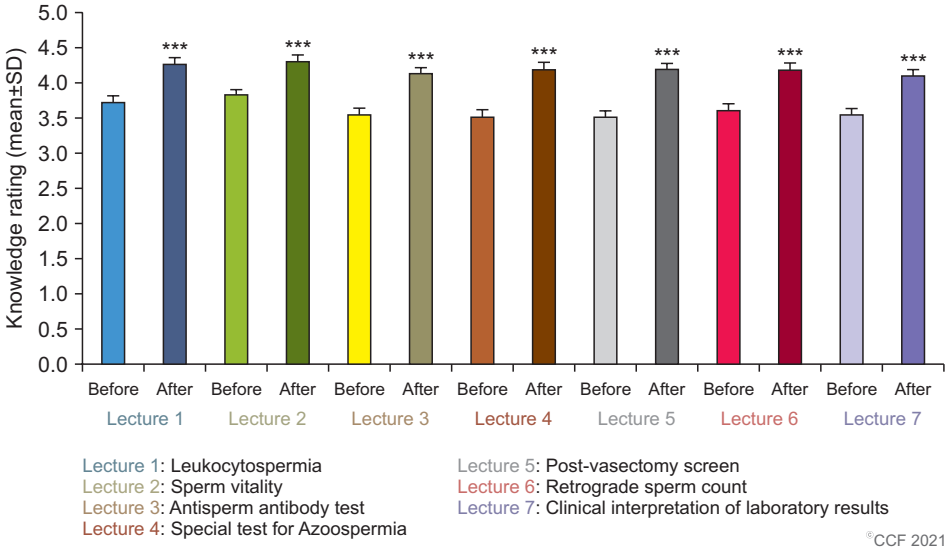

Fig. 8. Knowledge rating before and after taking Module 1. SD: standard deviation. ***p<0.0001.

Table 2. Top self-perceived benefits of taking the course and the ways how the information gathered by the participants was self-perceived to help them in their line of work/field of study for all three online ART training modules

Top self-perceived benefits of taking the course	No. of participants
Deeper knowledge of Andrology, male reproduction, ART, and infertility	1,987
Learn more about good clinical practices in an accredited clinical Andrology lab	1,417
Learn more about contemporary techniques in Andrology/Embryology	1,283
Opportunity to listen to talks from world-renowned scientists and/or clinicians	1,163
Opportunity to obtain a certificate endorsed by the American College of Embryology	986
Opportunity to aim for a year's worth of free membership with the American College of Embryology	521
Opportunity to build a global network	413
All of the above	2
Others: "Get help for my field of study in animal reproduction"	1
Common responses of the ways how the information gathered was self-perceived to help the participants in their line of work/field of study	**No. of participants**
Implement strategies and protocols in my workplace	1,036
Updating knowledge	888
Increase my knowledge of clinical guidelines to be followed	754
Improve my understanding of the protocols and the correct interpretation of results	665
Implement the quality control of instruments and procedures in my workplace	572
Help in conducting my current research	181
Learn about automated semen analysis	58
Increase the level of biosafety in my workplace	16
To do semen analysis in a standardized way	10
Implement the SOPs, follow the quality checks	2

ART: assisted reproductive technology, SOP: Standard Operating Procedure.

study are listed in Table 2. The top 3 benefits were recognized as a deeper knowledge of 1) Andrology, male reproduction, ART, and infertility; 2) good clinical practices in an accredited clinical Andrology laboratory, and 3) contemporary techniques in Andrology/Embryology. The participants stated that the information gathered from the modules would help them implement strategies and protocols in their own workplace and update their knowledge, amongst the other selected options. Additionally, the participants became more familiar with clinical guidelines, laboratory protocols and correct interpretation of the results, implementing

the quality control of instruments and procedures in their workplace, analyzing semen samples in a more standardized way, and increasing the biosafety level in their workplace.

DISCUSSION

The traditional ART training program organized by ACRM since 2004 has offered a unique opportunity for the participants to learn the latest techniques in routine and advanced Andrology along with the full spectrum of embryology-focused technology. In the last 18 years, the ACRM team has successfully trained over 200 candidates from more than 45 countries. The sudden disruption in face-to-face learning brought by the COVID-19 pandemic became an unexpected catalyst to convert the yearly ART training from the well-established traditional model to a fully online format for the first time.

The present study reports the quality of the first three ART training modules offered by the ACRM during the COVID-19 pandemic, which included modules on manual semen analysis, sperm morphology, and ancillary semen tests (evaluation of leukocytes concentration, sperm vitality and anti-sperm antibody). In recognition of the need for ART training to continue during the COVID-19 pandemic, the American College of Embryology (EMBCOL) supported ACRM's efforts of creating a unique opportunity and providing an accessible platform for both local and global candidates who needed ART training. Participants who achieved the pre-set passing score in the online MCQ test at the end of each ART training module were issued a certificate of participation endorsed by both the ACRM and the EMBCOL.

The majority (>87%) of the survey participants gave ratings of either strongly agree or agree that the learning objectives were clear, the course content was well-structured and had appropriate depth, and that as an overall, their expectations of the course had been met. When designing teaching and learning, good quality design is associated with the following: "clear learning objectives, carefully structured content, controlled workloads for faculty and students, integrated media, relevant student activities, and assessment strongly tied to desired learning outcomes" [14]. In the ART course herein presented, the first step in the creation of an outline for the components in each training module was to define clear objectives for the module as well as for each individual lecture within the respective modules. These specific objectives provided the broad structure for each module and the detailed topic covered. The learning objectives were designed to be clear cut and succinct. The course content and curriculum were created in a well-structured and comprehensive manner and helped define the objectives for each module.

Based on this, it appears that the ACRM was able to adequately modify the content of its annual ART course to suit the current needs of students amidst the COVID-19 pandemic, by switching to an e-learning approach. This has been previously shown to be useful in medical education [15,16]. Overall, the structured online delivery model with clear cut objectives in the COVID-19 era seems to have helped the trainees acquire the knowledge and skills of the subject matter related to Andrology despite the physical distancing.

The contents of the training modules comprised a collaborative effort between andrologists, reproductive biologists, and clinical male infertility experts to cover all the objectives of the course. The faculty involved in this online course was all established international experts in the fields of Andrology and human ART, as well as experienced technical supervisors at the ACRM.

Prior to each module, relevant course resources were shared with all registered participants. These pre-module reading materials were carefully curated by the ACRM for each specific module based on the importance and applicability of the resource material. There were several reasons for sharing the resources ahead of the course session. First, it allowed registered participants from mixed levels of competence to familiarize themselves with the key concepts that were going to be discussed during a particular ART training module. This approach prescribes to the cognitive load theory which describes how new learners possess a working memory with a limited capacity to process new information, while those who already have some prior knowledge on a topic advance by linking new information to pre-existing knowledge [17]. Thus, learners who are novices in a subject matter are quickly overwhelmed when exposed to vast amounts of new terminology and concepts in lectures. These learners usually end up relying on mere surface learning [18]. Moreover, having early access to the pre-module learning resources presented the participants with a sufficient window whereby to read and better understand the subject

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matter at their own time and convenience. This could facilitate a deeper understanding, activate the appropriate knowledge connections that the participants may have initially lacked and steer their attention towards capturing information more comprehensively during the actual online session. As such, participants who engaged with the pre-module reading material could potentially have found it 1) beneficial in making the course topics easier to understand and follow, and 2) helpful in connecting with the new concepts in a more meaningful manner [17].

Although guidelines for the semen analysis are provided by the World Health Organization manual [6], the semen analysis process is reported to be prone to error and inconsistencies, including collection of semen samples, laboratory evaluation, and reporting of the results [9]. Here, the adherence to these guidelines does not necessarily provide good reliability of results due to lack of standardized records, technician subjectivity, and poor technician competence [9]. A large variation in the results is also reported between different laboratories [19]. Professional training is essential to improve the reliability of relevant semen analysis tests, where online training tools have been proposed to meet the needs of shrinking ART training courses globally [20].

Participants were required to complete and pass the MCQ component to qualify for conferment of the certificate in each online training module. However, a small percentage of trainees stated that they did not participate in the online assessment as they were either not well prepared or were not interested in taking the MCQ test. The goal of the MCQ test was to assess the understanding of the knowledge component of the candidates after the online training was provided.

The majority of the registered participants across all the three modules had taken the online MCQ test with very few opting not to do so. Based on participant feedback, one of the most common reasons given for not taking the optional MCQ test at the end of each module was the lack of stable internet access and/or intermittent connectivity. This is certainly a potential drawback of having an online assessment and this is discussed further below. Other reasons given by the participants for not having taken the MCQ tests were time constraints from concurrent work/study responsibilities, and having found out about the course and/or joining the training sessions very close to the actual training dates.

The collaboration between EMBCOL and ACRM in developing this new teaching format has also made it possible for the ACRM to share extremely specialized expertise and technical know-how freely with a wider global audience, thereby promoting the inclusion of participants regardless of their competencies or prior experience. Besides making the information accessible to a large audience, the online format of free training organized by the ACRM also merits the importance of having a common ground in male fertility evaluation worldwide, despite the financial ability to participate in specialized programs, which are usually very expensive. This has been further confirmed by senior exponents of the Andrology and Embryology fields, who have provided their endorsement of this innovative program through private communications with the course management.

Despite having several clear advantages, online teaching also presents with certain limitations. While theoretical knowledge could easily be delivered online through concise lectures, certain skills still require a hands-on approach to be developed. This is particularly true for semen analysis and any laboratory protocols, which can be learnt well only through repeated practical training and experience. Moreover, although each lecture in itself was relatively short, the total length of time taken for the entire series of lectures within each module was adequate enough to require the participants to remain online for an extended amount of time. This presented a higher probability for the participants to become disengaged and get distracted than they would during a conventional in-person meeting [21].

The ability to attend the online sessions may have also been challenging for some participants due to either poor or unstable internet connectivity, or other reasons beyond the course management's control. For example, access to the platform used to host the online training platform (WebEx) is restricted in some countries (such as Iran, Algeria, and Nigeria amongst others) and therefore the participants from those regions had to rely on virtual private network (VPN) to ensure connectivity. During the first training session, this restriction resulted in a large number of candidates being unable to either complete the online MCQ test or they inadvertently obtained a lower score as they were in a rush to complete the test, fearing they would lose the internet access.

Taking these challenges into consideration, from the second session onwards, several measures were implemented to address the aforementioned issues when plausible. To navigate the connectivity issues due to restriction in certain regions, the team of coordinators was pro-active in providing VPN access to those participants who faced difficulties in joining the training sessions *via* WebEx. Additionally, the time allotted for completing the MCQ test was also lengthened. The minimum score needed to pass the module was set at 65%, although this score is considered akin to a grade D or grade point average (GPA) of 1.0 based on conventional American standards [22].

Each module was run as a 2 hours training session followed by an hour of the MCQ test. In Modules 1A and 1, there were six 15-minute lectures followed by one 15 minute Q&A session, while Module 1B had four lectures of 15 to 30 minutes, with one 10 minute Q&A session. The tight schedules in these half-day training sessions were just right for the delivery of lectures. As a result, not much time was available for interaction between speakers and attendees, which limited the opportunity for the speakers to immediately address any questions or doubts that the participants may have had [23,24]. Hence, the management relied on the survey results to gather participant feedback and identify any weaknesses in the general organization of the training.

It must be kept in mind that the nature of surveys as a strategy for identifying areas of improvement may inherently be biased. Although the survey responses were anonymized before being analyzed, desirability bias cannot be excluded [25]. This is linked to the human tendency of providing feedback which may be considered favorable by others. Another potential source of bias is the tendency of some participants to provide only extreme or neutral answers, which cannot be realistically addressed [26]. Furthermore, only a moderate percentage of participants were from English-speaking countries. To limit this bias, the survey was extensively revised by a pool of international coordinators as well as collaborators with large experience in teaching, to make each question understandable and unambiguous to an international audience. In future, the survey questions may also be translated into the first language of the participants in order to avoid comprehension bias.

CONCLUSIONS

In conclusion, we report our experience in utilizing a web-based delivery model as an alternative to the conventional in-person training which had enabled the ACRM to provide continuous education on a global platform. We have shown that the online training for certain ART-related modules can be conducted by means of providing expert-led video demonstrations, power point presentations, clinical lectures, and online interactive e-learning activities. Moreover, complex issues in reproductive biology could be covered by interplay of both laboratory and clinical professionals. The application of several online-based communication tools such as WhatsApp, Dropbox and Cisco WebEx were instrumental in implementing the web-based delivery model.

Leading into the future, the success of this online training creates an emerging avenue for a blended form of learning with both in-person and online education platforms for the Andrology and embryology specialties involved in ART training. The impact of having a virtual modality in place of hands-on learning for ART laboratory professionals during the COVID-19 requires further investigation to determine its effectiveness by comparing to the traditional approach. This comparison will help improve the current strategies for teaching and learning in specialized fields like Andrology. In fact, the inclusion of the best features from both hands-on and e-learning approaches will enhance the design and the implementation of future teaching strategies.

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Conflict of Interest

The authors have nothing to disclose.

Author Contribution

Conceptualization: AA, RSharma, SG, RF. Writing–original

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REFERENCES

1. Agarwal A, Mulgund A, Hamada A, Chyatte MR. A unique view on male infertility around the globe. Reprod Biol Endocrinol 2015;13:37.
2. Martinez GM, Daniels K, Febo-Vazquez I. Fertility of men and women aged 15-44 in the United States: National Survey of Family Growth, 2011-2015. Natl Health Stat Report 2018;113:1-17.
3. Esteves SC. Clinical relevance of routine semen analysis and controversies surrounding the 2010 World Health Organization criteria for semen examination. Int Braz J Urol 2014;40:443-53.
4. Cooper TG, Noonan E, von Eckardstein S, Auger J, Baker HW, Behre HM, et al. World Health Organization reference values for human semen characteristics. Hum Reprod Update 2010;16:231-45.
5. Practice Committee of the American Society for Reproductive Medicine. Diagnostic evaluation of the infertile male: a committee opinion. Fertil Steril 2015;103:e18-25.
6. World Health Organization (WHO). WHO laboratory manual for the examination and processing of human semen. 5th ed. Geneva: WHO; 2010.
7. Baskaran S, Finelli R, Agarwal A, Henkel R. Diagnostic value of routine semen analysis in clinical andrology. Andrologia 2021;53:e13614.
8. Franken DR, Oehninger S. Semen analysis and sperm function testing. Asian J Androl 2012;14:6-13.
9. Tomlinson MJ. Uncertainty of measurement and clinical value of semen analysis: has standardisation through professional guidelines helped or hindered progress? Andrology 2016;4:763-70.
10. Comhaire F, Schoonjans F, Vermeulen L, De Clercq N. Methodological aspects of sperm morphology evaluation: comparison between strict and liberal criteria. Fertil Steril 1994;62:857-61.
11. Franken DR, Barendsen R, Kruger TF. A continuous quality control program for strict sperm morphology. Fertil Steril 2000;74:721-4.
12. Sikka SC, Hellstrom WJ. Current updates on laboratory techniques for the diagnosis of male reproductive failure. Asian J Androl 2016;18:392-401.
13. Sharlip ID, Belker AM, Honig S, Labrecque M, Marmar JL, Ross LS, et al.; American Urological Association. Vasectomy: AUA guideline. J Urol 2012;188(6 Suppl):2482-91.
14. Bates AW. Teaching in a digital age: guidelines for designing teaching and learning. 2nd ed. Vancouver: Tony Bates Associates Ltd.; 2019.
15. Donkin R, Askew E, Stevenson H. Video feedback and e-Learning enhances laboratory skills and engagement in medical laboratory science students. BMC Med Educ 2019;19:310.
16. Wang C, Xie A, Wang W, Wu H. Association between medical students' prior experiences and perceptions of formal online education developed in response to COVID-19: a cross-sectional study in China. BMJ Open 2020;10:e041886.
17. Seery MK, Donnelly R. The implementation of pre-lecture resources to reduce in-class cognitive load: a case study for higher education chemistry. Br J Educ Technol 2012;43:667-77.
18. Young JQ, Van Merrienboer J, Durning S, Ten Cate O. Cognitive load theory: implications for medical education: AMEE guide no. 86. Med Teach 2014;36:371-84.
19. Keel BA. How reliable are results from the semen analysis? Fertil Steril 2004;82:41-4.
20. de Ziegler D, de Ziegler N, Sean S, Bajouh O, Meldrum DR. Training in reproductive endocrinology and infertility and assisted reproductive technologies: options and worldwide needs. Fertil Steril 2015;104:16-23.
21. Latif MZ, Hussain I, Saeed R, Qureshi MA, Maqsood U. Use of smart phones and social media in medical education: trends, advantages, challenges and barriers. Acta Inform Med 2019;27:133-8.
22. National Center for Education Statistics. How is grade point average calculated? [Internet]. Washington, D.C.: Institute of Education Sciences; c2011 [cited 2021 May 3]. Available from: https://nces.ed.gov/nationsreportcard/hsts/howgpa.asp.
23. Olson TM, Wisher RA. The effectiveness of web-based instruction: an initial inquiry. Int Rev Res Open Distance Learn 2002;3:1-17.
24. Sun L, Williams S, Liu K. Knowledge construction in e-learning: designing an e-learning environment. Paper presented at: 5th International Conference on Enterprise Information Systems (ICEIS); 2003 Apr 22-26; Angers, France. pp.111-8.
25. Meisters J, Hoffmann A, Musch J. Controlling social desirability bias: an experimental investigation of the extended crosswise model. PLoS One 2020;15:e0243384.
26. Kember D, Leung DYP. Establishing the validity and reliability of course evaluation questionnaires. Assess Eval High Educ 2008;33:341-53.