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Review

# Microlearning in Health Professions Education: Scoping Review

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## Abstract

**Background:** Microlearning, the acquisition of knowledge or skills in the form of small units, is endorsed by health professions educators as a means of facilitating student learning, training, and continuing education, but it is difficult to define in terms of its features and outcomes.

**Objective:** This review aimed to conduct a systematic search of the literature on microlearning in health professions education to identify key concepts, characterize microlearning as an educational strategy, and evaluate pedagogical outcomes experienced by health professions students.

**Methods:** A scoping review was performed using the bibliographic databases PubMed (MEDLINE), CINAHL, Education Resources Information Center, EMBASE, PsycINFO, Education Full Text (HW Wilson), and ProQuest Dissertations and Theses Global. A combination of keywords and subject headings related to microlearning, electronic learning, or just-in-time learning combined with health professions education was used. No date limits were placed on the search, but inclusion was limited to materials published in English. Pedagogical outcomes were evaluated according to the 4-level Kirkpatrick model.

**Results:** A total of 3096 references were retrieved, of which 17 articles were selected after applying the inclusion and exclusion criteria. Articles that met the criteria were published between 2011 and 2018, and their authors were from a range of countries, including the United States, China, India, Australia, Canada, Iran, Netherlands, Taiwan, and the United Kingdom. The 17 studies reviewed included various health-related disciplines, such as medicine, nursing, pharmacy, dentistry, and allied health. Although microlearning appeared in a variety of subject areas, different technologies, such as podcast, short messaging service, microblogging, and social networking service, were also used. On the basis of Buchem and Hamelmann's 10 microlearning concepts, each study satisfied at least 40% of the characteristics, whereas all studies featured concepts of maximum time spent less than 15 min as well as content aggregation. According to our assessment of each article using the Kirkpatrick model, 94% (16/17) assessed student reactions to the microlearning (level 1), 82% (14/17) evaluated knowledge or skill acquisition (level 2), 29% (5/17) measured the effect of the microlearning on student behavior (level 3), and no studies were found at the highest level.

**Conclusions:** Microlearning as an educational strategy has demonstrated a positive effect on the knowledge and confidence of health professions students in performing procedures, retaining knowledge, studying, and engaging in collaborative learning. However, downsides to microlearning include pedagogical discomfort, technology inequalities, and privacy concerns. Future research should look at higher-level outcomes, including benefits to patients or practice changes. The findings of this scoping review will inform education researchers, faculty, and academic administrators on the application of microlearning, pinpoint gaps in the literature, and help identify opportunities for instructional designers and subject matter experts to improve course content in didactic and clinical settings.

**KEYWORDS**

online learning; health occupations students; mobile applications; active learning; distance learning; Web 2.0

## Introduction

### Background

Technology is changing the way the world communicates—how we learn, remember, and transform information [1]. Many health disciplines, such as allied health, dentistry, medicine, nursing, and pharmacy, are embracing emerging technologies to leverage learning opportunities for their students [2]. One such innovative pedagogy is the practice of microlearning, which refers to small lesson modules and short-term activities intended to teach and reinforce course objectives [3]. One of the advantages of this pedagogy is the asynchronous aspect, allowing the learner to control the place, method, and time of access to information [3]. Although microlearning is characterized in terms of the size of content, learning occurs remarkably quickly within minutes or seconds of time instead of hours, days, or months, a concept known as *just-in-time* learning [4,5]. Although microlearning is an emerging trend especially in continuing education [4,5], no standardized concepts or applications have been established in health professions education.

Referred to as *micro-* or *bite-sized content*, *microcourses*, or *just-enough information*, microlearning teaches a small learning unit in a step-by-step approach [3,5]. The emergence of user-generated content such as Web 2.0 has enabled participants to generate large amounts of information that can be circulated immediately worldwide [6]. Microlearning harnesses Web 2.0 technologies to engage students and to promote self-determined learning, also known as heutagogy [7,8]. This learning theory emphasizes the creativity, flexibility, and ability of learners [9]. It empowers students to be self-directed and self-determined in their own learning [7,10]. The ubiquitousness of Web 2.0 has contributed to the renewed attention to heutagogy [7], a learner-centric approach that enables students to access smaller, targeted, and manageable chunks of information available on the Web at their convenience [4,11]. In contrast to reading chapters in a textbook and memorizing content as in older education designs, microlearning is more favorable than macrolearning to students in that the former encourages students to attain information that is as up to date as possible in the moment they are ready or need to learn the material, whereas the latter is usually organized in a hierarchical and static manner [3,11].

As the amount of information that learners are faced with has increased, microlearning can help break down the material into smaller units that can be processed more easily [2,8,11]. Learning is then focused on making connections between and among the small units, which is a foundation of critical thinking and clinical reasoning [3,11]. This is particularly important in health professions education, which changes constantly with advancements in medicine and health care delivery systems [12]. The effectiveness of microlearning for health care professionals has been reported in clinical studies, such as a mobile app for recording learning experiences in nursing

practice [13]; an interactive case-based teaching session in medical training programs [14]; a mobile gaming device that promotes nursing research knowledge, attitudes, and practice [15]; and a streaming video system with point-of-view camera transmission of surgeries to students' smartphones and tablets [16]. As such, microlearning has been endorsed by many health professions educators, programs, and organizations as a means of facilitating student learning, training, and continuing education [17,18].

### Objectives

Despite its popularity and applicability to a wide range of health disciplines, microlearning is difficult to define in terms of its features and processes [5,19]. Moreover, a systematic review has not previously been used to analyze studies on health professions students' microlearning and the outcomes associated with this pedagogy. Thus, the purpose of this review was to (1) conduct a systematic search of the literature on microlearning utilized for health professions students to identify key concepts and gaps in the research, (2) describe the nature of educational outcomes associated with microlearning experienced by health professions students, and (3) examine how microlearning was characterized as an educational strategy for health professions students.

## Methods

### Framework

This scoping review follows the Joanna Briggs Institute (JBI) methodology to map the key concepts of microlearning within health professions education. In contrast to systematic reviews that strive to answer a precise question, scoping reviews are designed to determine the extent and nature of the evidence available on a topic [20]. To facilitate this broader scope, the objectives of this review were developed using the Population-Concept-Context model, where the population is health professions students, the concept is microlearning, and the context is any learning environment where microlearning was introduced and evaluated. This review was conducted following the 5-step framework by Arksey and O'Malley: (1) identify the research questions; (2) identify the relevant studies; (3) select studies; (4) chart or map the data; and (5) collate, summarize, and report the data [21]. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews checklist guided the reporting of this review [22]. A protocol for the review was published in the *JBI Database of Systematic Reviews and Implementation Reports* [23].

### Search Strategy

The search strategy was developed to comprehensively identify published and unpublished literature following the 3-step approach developed by JBI [20]. First, a preliminary search was conducted in PubMed (MEDLINE) and CINAHL. The authors

analyzed the titles, abstracts, and index terms used to describe the articles captured in the initial search. This informed the second phase of the search process where the strategy was finalized and then tailored to each information source. The search was conducted in PubMed (MEDLINE), CINAHL, Education Resources Information Center, EMBASE, PsycINFO, Education Full Text (HW Wilson), and ProQuest Dissertations and Theses Global using a combination of keywords and subject headings related to microlearning, electronic learning (e-learning), or just-in-time learning combined with health professions education. No date limits were placed on the search, but the results were limited to English-language materials. A full search strategy for each database is detailed in [Multimedia Appendix 1](#). The search was conducted from January to May 2018. After full-text screening of the search results, the third phase of the search process involved reviewing reference lists for articles.

### Study Selection

All identified citations were managed using EndNote V8.2 (Clarivate Analytics), and duplicates were removed. The citations were imported into the Covidence systematic review software (Veritas Health Innovation) for title and abstract screening by 2 independent reviewers. Studies were included if the following criteria were met: (1) they reported on concepts of microlearning in the form of micro- or bite-sized content, microcourses, *just-in-time* learning, or just-enough information; (2) they involved health professions students, defined as undergraduate medical students, prelicensure medical students, undergraduate or graduate nursing students, dentistry students, pharmacy students, and allied health professions students; and (3) they took place in an academic setting, hospital training setting, community learning setting, clinical skills laboratory, virtual class, or any other setting where microlearning in health professions was introduced and evaluated. The full texts of selected studies were retrieved and assessed in detail against the inclusion criteria. Full-text studies that did not meet the inclusion criteria were excluded, and the reasons for exclusion were noted. Disagreements between the reviewers were resolved through discussion or with a third reviewer.

### Data Extraction and Synthesis

Data were extracted from eligible publications included in the review using the standardized data extraction tool in Covidence. NVivo 12 (QSR International Pty Ltd) was also used to assist in organizing, synthesizing, and identifying emerging themes from the literature review. In this method, each document stored in EndNote was imported into NVivo as a case, and the case was then assigned attributes (ie, study year, author(s), country, study purposes, study design, target audience, sample size, theoretical framework, definition of microlearning, course or instructional design, topic, technology platform, measurement tool, key findings, and learning outcomes). Pedagogical outcomes were assessed according to Kirkpatrick 4 levels of evaluation (reaction, learning, behavior, and results)—the most widely used program evaluation strategy in both traditional classrooms and mobile learning in health professions education [24,25]. A formal assessment of methodological quality was

not performed as this scoping review aimed to provide an overview of the existing evidence regardless of quality [20].

## Results

### Overview

Our search yielded 3096 potentially relevant studies. Of the 246 articles that underwent full-text review, 229 (93.1%) were excluded for the following reasons: absence of the concept of microlearning (103/229, 45.0%), conference abstracts (65/229, 28.4%), nonempirical literature such as review or editorials (22/229, 10.0%), focused on the evaluation of technology rather than learning (19/229, 8.3%), only available in abstract form (7/229, 3.1%), did not target health professions education (6/229, 3.0%), duplicate article (4/229, 1.7%), or non-English literature (3/229, 1.3%). Ultimately, 17 articles met the inclusion criteria ([Multimedia Appendix 2](#)).

### Study Characteristics

The 17 studies reviewed included 2228 participants in various health-related disciplines such as medicine (n=8), nursing (n=3), pharmacy (n=2), dentistry (n=2), and allied health (n=2). The course topics that were taught via microlearning included violence response, graduate psychology, splinting techniques, pharmacology, public health, embryology, dentistry, physiomics, internal medicine clerkship, biochemistry, cellular biology, anatomy and physiology, urology, mental health, and pharmacotherapy. Articles that met the inclusion criteria were published in 2011 through the first half of 2018, which reflects the contemporary practice of microlearning and research interest in the subject.

The researchers came from a wide range of countries, including the United States (n=5), China (n=3), India (n=3), Australia (n=1), Canada (n=1), Iran (n=1), the Netherlands (n=1), Taiwan (n=1), and the United Kingdom (n=1). Research methods included quasi-experimental (n=6), mixed methods (n=5), descriptive (n=4), randomized control trial (n=1), and correlation (n=1). Many different technology platforms and apps were also utilized, including podcast (n=7), short messaging service (SMS; n=4), microblogging (n=3), social networking service (n=2), and internet-based apps (n=1). Interestingly, none of the 17 studies provided a definition of microlearning.

### Kirkpatrick Outcome Evaluation

Pedagogical outcomes were assessed according to Kirkpatrick 4 levels of evaluation [25]. Level 1 is *reaction*, where learners react to the learning event with a positive attitude such as satisfaction or engagement. Level 2 is *learning*, where learners obtain knowledge, skills, confidence, and commitment by engaging in the learning event. Level 3 is *behavior*, where learners apply their acquired knowledge, skills, confidence, and commitment to real tasks such as practical examinations or final course grades. Level 4 is *results* where learners provide benefit to the patients or practice, such as patient safety or quality of care, utilizing those acquired knowledge, skills, confidence, or commitment [25].

Reaction, one of the easiest outcomes to measure, can be determined by evaluating the user's engagement, relevance, and

satisfaction [25]. Overall, 16 out of 17 studies (94%) in our review measured student responses to the microlearning interventions with qualitative assessments. For example, Ball et al gathered student feedback on the helpfulness, relevance, and appropriateness of video podcasts [26], whereas Bledsoe et al gathered student opinions on access to information, communication, classroom engagement, and overall experience with the Twitter learning intervention [27]. Learning, level 2 in Kirkpatrick model can be evaluated based on the knowledge, skills, attitudes, confidence, and commitment that participants gain [25]. In total, 14 of the 17 studies (82%) evaluated student learning this way. For example, Evans evaluated student achievement in an end-of-module written examination that demonstrated high average levels of knowledge and understanding [28]. Similarly, Cheng et al measured students' success of splint application against a 6-point skills checklist and then compared the completion times among the groups [29].

Behavior, level 3, is considered the most important outcome to assess because it is the degree to which learners will apply what they have learned when they are practicing on their own [25]. Overall, 5 of the 17 studies (29%) measured student behavior. Among them, Diug et al examined the long-term effects of Twitter learning interventions by comparing students' end-of-semester grades [30]. Lameris et al evaluated the effect of their smartphone app on student behavior by comparing the number of hours students spent studying before and after the intervention [31]. Level 4, results, is the degree that targeted outcomes and changes in practice occur due to the learning intervention [25]. None of the studies evaluated this highest level of learning outcomes.

### Theoretical Frameworks of Microlearning

Although they were not found in every study, some theoretical frameworks were identified as foundational for microlearning. Banning's theoretical framework used in Chuang and Tsao's study of the effect of microlearning on nursing pharmacology students examined how students acquire, store, and retrieve knowledge and how it differentiated between reasoning styles [32]. Chuang and Tsao and Sichani et al also used the information processing theory (IPT) to guide their curriculum design [32,33]. Similar to Banning's framework, the IPT examined how individuals acquire, store, and then retrieve knowledge (stimulus and response). According to the IPT framework, an external stimulus is held in the sensory register for a short time and transferred to the short-term memory and eventually to the long-term memory by a process of organizing, repeating, elaborating, and distributing practice [32]. As such, Chuang and Tsao's design included organized pharmacology information delivered to nursing students 2 times per day via text [32]. This repetition significantly increased students' memory of cardiovascular medications and supplied the study material for later referral. Using the IPT, Sichani et al sent questions via text that were relevant to the material covered in lectures during class; these students showed significant improvements in pre- and posttest scores compared with students who did not receive the texts [33].

Swartzwelder used the social learning theory to examine students' perceptions of the use of texting and its effects on

learning comprehension compared with email [34]. In her study, the students who received weekly questions via text reported increased interactivity, convenience, and critical thinking [34]. Wang et al also examined interactivity using Henri's analytical model as a pedagogical guide [35,36]. Henri's model contains 5 dimensions: participative, social, interactive, cognitive, and metacognitive, and this model has been used extensively by educators to assess the learning process of discussion forums [36]. Interactivity consists of communication of information, an initial response to the information, followed by an answer to the initial response [36]. The researchers utilized participation, social attendance, level of interaction, and cognitive skills to evaluate participant responses to cases posted on the social media site Weibo, a site similar to Twitter [35].

The just-in-time training (JITT) model is a teaching methodology that provides tailor-made, immediate, and focused training; it is well suited for application to microlearning [4,5]. This method, originally rooted in the automotive industry, has migrated to education [29] and can be used to provide immediate information when it is needed the most, specifically for health care students and providers at the point of care with a patient. This modality can also be applied in remote regions of the world where education resources and trained health care professionals are uncommon. In our review, this model was used to teach the application of wrist splints to medical students [29]. Providing the JITT video to learners immediately before they were required to perform the procedure decreased learning time and improved overall performance. This type of pedagogical concept may increase performance and safety at the patient bedside and in remote parts of the world [29]. A summary of the characteristics of the 17 articles reviewed is provided in [Multimedia Appendix 3](#) [26-35,37-43].

### Characteristics of Microlearning

To understand the characteristics of microlearning in the 17 studies, we utilized Buchem and Hamelmann's review of microlearning that posits the following 10 concepts: (1) learning context, (2) time spent, (3) content type, (4) content creation, (5) content aggregation, (6) content retrieval, (7) structure of the learning cycle, (8) target group, (9) learner's role, and (10) learner participation [19]. [Multimedia Appendix 4](#) illustrates the presence of these characteristics in each study reviewed. As seen, each of the studies addressed some of the 10 microlearning characteristics, whereas only 2 of the studies, those by Bledsoe et al and Diug et al, presented all 10 characteristics [27,30]. The last column shows that each article satisfies at least 40% of the 10 concepts identified in Buchem and Hamelmann's review [19].

### Learning Context and Time Spent

Buchem and Hamelmann differentiated microlearning from macrolearning, explaining that the former offered informal learning opportunities that take place outside of the traditional classroom [19]. Looking closely at the context of the microlearning interventions, we found that many of the microlearning activities were used as supplemental tools to didactic and established courses (14/17, 82%). For example, Kalludi et al gave 1 group of Indian dental students access to 12-min audiovisual podcasts after they attended regular lectures;

the control group did not see the podcasts [38]. Students who saw the podcasts performed significantly better on a follow-up multiple-choice questionnaire than those in the control group ( $P=.021$ ) [38].

Unlike formal learning, the time spent on microlearning ranges from a few seconds to 15 min, which offers flexible, personalized on-demand learning [19]. Cheng et al utilized a 3-min instructional video on short-arm volar splinting to provide JITT to medical students at a US children's medical center [29]. Both Sichani et al and Swartzwelder sent out single multiple-choice questions daily to students via SMS texts [33,34], whereas Lameris et al utilized an app to provide students with practice questions that needed to be answered within 60 seconds [31]. All of our 17 studies featured the concept of shortened time spent—less than 15 min.

### **Content Type and Creation**

Another important key to microlearning is narrowing the topic to a single definable idea, published in short form and accessible through the Web 2.0 via blog posts, wiki pages, permalinks, and hashtags [19]. For example, to improve patient safety and outcomes by enhancing nursing students' knowledge of pharmacology, Chuang and Tsao utilized mobile phone SMS texts limited to 70 Chinese words (including the names, actions, clinical uses, side effects, and contraindications of cardiovascular drugs) [32]. A study by Evans addressed the challenging topic of embryology with 5- to 10-min audiovisual screencasts on the fertilization and development of embryos for medical students in the United Kingdom [28].

Microlearning is regarded as a deviation from traditional transfers of knowledge between a subject matter expert and learner; most microcontent is cocreated by end users utilizing Web 2.0 and other e-learning tools [19]. Although all of the studies used microcontent for their course development and delivery process, of our 17 studies, only 5 (29%) cocreated learning content with students. For example, Bledsoe et al used the social media platform Twitter as a collaborative educational environment where American graduate psychology students created unique hashtags based on common topics among their members and then used these hashtags to communicate and share information regarding the course's research questions [27]. Diug et al also utilized Twitter as a pedagogical tool [30]. They required first-year biomedical students to identify a public health issue in their daily lives by posting a photo, image, or link to a journal article of interest via Twitter, which was then linked through a hashtag to the course. Similarly, different Chinese microblogging platforms have been used to facilitate learning for pharmacy students by sending informative push notifications and actively responding to these, while allowing students to work together with their group to address patient scenarios via group chats [35,42,43].

### **Content Aggregation and Retrieval**

Multiple learning objectives, which divide up and rearrange content, are usually developed to establish the scope of formal learning. However, these pieces of information collectively represent an idea or topic and rely on each other for clarity and completeness [19]. Microlearning consists of self-contained

ideas that can stand alone without necessary supplementation because of the narrowed and concentrated focus of a topic [19]. All of our 17 studies featured these self-contained concepts. For example, Lameris et al utilized an open-source HTML-based app to focus specifically on circulation and respiration concepts for Dutch biomedical students in a physiomics course [31]. Over a 4-week period, the students used the app to study short modules and complete practice questions, after which they took their final exam [31].

Most traditional topics, including those used in e-learning, can be retrieved via unique URLs that direct a user to a broad concept and a collection of objectives. However, the unique URL of microcontent allows for the smallest bits of information to be retrieved and linked together while still being able to stand on their own [19]. Buchem and Hamelmann contended that large bundles of information on the internet are often ignored, whereas small pieces of the whole are tagged and linked in ways that create new patterns, ideas, and meaning [19]. Of our 17 studies, only 6 (35%) reported the use of unique URLs for content retrieval. Examples include the use of the computer program TweetDeck [44], which allows students to organize tweets from the accounts they follow [27] and the development of links called *5 Minute Medicine* to address common patient disorders that internal medicine residents would face during their patient assessments [39]. These learning materials were uploaded to the website, which is now available through a YouTube channel [45].

### **Structure of the Learning Cycle and Target Group**

The framework of traditional macrolearning, based on learning objectives, is usually organized in a hierarchical and sequential fashion, whereas the structure of microlearning is dynamic and fluid, based on the user's self-directed learning through aggregation and modification [19]. One example is the use of microblogging, which allows learners to write and edit structured and strategic responses, thus generating perceptions of credibility and trust [46]. In our review, only 5 studies (29%, 5/17) espoused the concept of nonsequential learning using microblogging. As an example, Diug et al used Twitter to encourage students to reflect on their learning regarding public health issues by tweeting about their use of the game app *Dumb Ways to Die*, a public service campaign developed by the metro stations in Melbourne, Australia, to promote railway safety [30]. In Wang's study, students were required to complete case studies in their groups and work together to address disease states, therapeutic goals, drug information, adverse drug events, drug interactions, monitoring plan, and patient education utilizing the Chinese microblogging platform Sina Weibo, which is similar to Twitter [35].

As Buchem and Hamelmann posited, the goals of microlearning are broader than the learning outcomes defined by content experts in traditional macrolearning; they focus more on the exploration of concepts and practical problem solving. Microlearning is appealing to self-directed learners who are drawn to the informal, flexible, and shortened learning activities that can be easily integrated into their lives [19]. All of the studies in our review targeted learners who are practical and in

search of information and knowledge that can be applied immediately to boost their careers and confidence.

### ***Learner's Role and Learner Participation***

The student's role within microlearning is not one of consuming content in an effort to mirror an expert but to produce the learning content through social interaction and concept exploration [19]. By shifting to the role of a *prosumer* transforming from a consumer to a producer, learners are more motivated and feel a greater responsibility for the achievement of their own learning goals [19]. Sichani et al argued that self-directed learning was encouraged by the delivery of single answer or multiple-choice questions to Iranian medical students via SMS [33]. Wang et al found a significant difference in the scores of the students who actively responded to the WeChat push notifications from faculty compared with those who did not reply ( $P < .01$ ) [42]. Interestingly, this prosumer concept was not a common guiding principle in any of our 17 studies, as evidenced by the small number of cases ( $n=6$ , 35%).

Finally, Buchem and Hamelmann postulated that macrolearning relies on the learner's interaction with predetermined content, whereas microlearning focuses on the social interactions of the users to drive the creation and transfer of ideas [19]. This concept was well presented in a study by Bledsoe et al who created a collaborative learning environment by utilizing Twitter to address questions from graduate students in a research methodology online course [27]. In this study, 83% of the students agreed that being part of a group aided in their learning of research concepts and 86% agreed that they were learning important research components. Wang et al also reported that more than 60% of the students who used mobile messaging-based case studies (MMBC) agreed that MMBC helped develop their skills and knowledge, understand others' viewpoints, and share their experiences [43]. Social interactions between learners, compared with learner-content interactions, were present in 5 (29%) of the 17 studies reviewed.

## ***Discussion***

### **Principal Findings**

This scoping review identified the literature surrounding the use of microlearning as a pedagogical tool in health professions education, which led to the discussion of what is known about microlearning. The studies demonstrated that microlearning can improve performance and potentially increase safety in the clinical environment [29,30]. This potential is consistent with a wide range of previous research on microlearning and medical training [14,16] and continuing education in nursing [13,15]. Results from previous studies along with our findings highlighted how microlearning could be used as a refresher before performing skills that are infrequently used or when performing new skills without previous experience. This could also improve safety as skills that are very complicated could be rehearsed and not performed from memory. Students can review difficult content as many times as needed to reinforce their understanding or immediately before performing new or difficult procedures in clinical education. In addition, according to the cognitive load theory, the characteristics of microlearning, particularly microcontent and content retrieval, enable learners

to have long-term memory of learning materials by constructing small structures repeatedly [47,48].

Microlearning methods take advantage of the fact that mobile device usage is virtually universal [5]. This environment is conducive to communication and collaboration according to many of the studies in this review [30,32,35,43]. By using social media, podcasts, texting, and SMS, teachers are moving the classroom to the students and changing how they communicate and study [5]. Podcasts have transported the classroom to the virtual world and provide new methods to disseminate learning materials to students. This flexibility and accessibility of information is harnessed by self-directed learning. In a similar vein, students reported that viewing a supplemental video after a live lecture helped them to better understand the material [38]. Podcasts can also help connect the content between lectures and textbooks [39,49]. Students have credited podcasts with increased satisfaction in knowledge acquisition, and they have cited convenience as a major advantage [32,38,39,41]. The potential uses for apps designed specifically to deliver microlearning material are growing [5].

Despite its known benefits, there are some downsides to microlearning. First, traditionalists may have a hard time learning emerging technologies while experiencing increased stress related to change [50]. As instructors must be comfortable with Web 2.0, they may be required to train on the devices or software used. Microlearning may require time-consuming development and labor-intensive lesson planning [27,40]. Freed et al also found that faculty are concerned with lecture recording, which may encourage students to take a passive role in the classroom [50]. If podcasting is for review and not associated with active learning activities in class, the student may just listen to the lecture when studying for an exam and fail to read and utilize other forms of independent study [51]. Another concern from faculty is about who owns materials such as podcasts or audiovisual lectures [52]. Faculty may not be aware that institutional policies consider teaching materials they develop as the property of the employer [52]. Podcasts are stored digitally and often recycled [39]. Thus, if recycled over an extended period, the information will be outdated, which could reflect poorly on instructors. Thus, it is necessary for universities and faculties to develop clearly defined guidelines about educational podcasts [52].

Microlearning relies on having network connectivity and interactivity. Himmelsbach suggested that technology in education may create a disconnect from social interactions [53]. As discussed in Wang et al's study, some students believed that the collaborative learning was not effective, the quality of interaction was low, and it was hard to follow the stream of comments because of the large volume of interactions [35]. Students do not necessarily have equal access to technology [38]; therefore, faculty must ensure adequate access and support before implementing microlearning on technologies some students may not possess. In addition, there are subject areas that are too complicated for the use of microlearning alone. Poorly designed objectives can have less-than-desirable outcomes when using Web 2.0-based learning [54]. Faculty and student privacy may also be a concern with the adoption of social media in the classroom [55]. There is potential for



information to be misconstrued regarding an individual, an institution, or the facts provided. To prevent learning bonds from being eroded, sound pedagogical principles and rules for respectful communication need to be in place.

### Limitations and Future Directions

This review has several limitations. First, the definition of microlearning is not universal, which limits the search terms and results. Studies that were included in the review utilized microlearning without mentioning the term or its definition. Thus, despite the extensive search, some literature may have been missed. Second, research was limited to English-language publications. According to the search results, more than half of the studies (9/17, 53%) were conducted in a country that uses languages other than English as the primary language. Therefore, there may be other microlearning studies that were not referenced because they were not in English. Finally, the younger age of the study participants might limit the ability to generalize the methods to older and less technologically savvy students.

Microlearning is a relatively new educational paradigm that has potential for both educators and students. Future research in this field should look at higher levels of learning outcomes from various microlearning modalities by designing studies that evaluate Kirkpatrick level 3 and 4 outcome measures. One characteristic of microlearning is that the learner is a prosumer and cocreator of content. This particular characteristic has not

been applied widely in previous studies. Learners' active engagement through their prosumer role and classroom interaction, combined with Web 2.0 and mobile technology, will allow health professions educators to provide more meaningful outcomes for students. Future studies should also incorporate larger and more diverse samples including traditional and adult learners with various degrees of technological ability. Future research might compare microlearning modalities and determine if one type of microlearning is more effective than another method.

### Conclusions

The aim of this review was to synthesize evidence on the use of microlearning in health professions education. As an education strategy, microlearning has the potential to change the way education is delivered to health professions students. Microlearning not only has the potential to change the way education is delivered to health professions students, but it is also a response to the novel methods that students learn, socialize, and communicate. By bringing the classroom to where students congregate and using methods based on theories of how the brain stores and retrieves information, microlearning can facilitate and enhance student learning. The findings of this scoping review will inform educational researchers, faculty, and academic administrators on the application of microlearning, pinpoint gaps in the literature, and help identify opportunities for instructional designers and subject matter experts to improve course content.

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### Conflicts of Interest

None declared.

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### Multimedia Appendix 1

Search strategy.

[[DOCX File, 20KB - mededu\\_v5i2e13997\\_app1.docx](#)]

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### Multimedia Appendix 2

Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews flowchart for the article search.

[[PNG File, 75KB - mededu\\_v5i2e13997\\_app2.png](#)]

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### Multimedia Appendix 3

Summary of studies reviewed on microlearning in health professions education.

[[DOCX File, 24KB - mededu\\_v5i2e13997\\_app3.docx](#)]

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### Multimedia Appendix 4

Presence of characteristics in each study (✓ concept was found in the study; — concept was not found in the study).

[[DOCX File, 16KB - mededu\\_v5i2e13997\\_app4.docx](#)]

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## Abbreviations

**e-learning:** electronic learning  
**IPT:** information processing theory  
**JBI:** Joanna Briggs Institute  
**JITT:** just-in-time training  
**MMBC:** mobile messaging-based case studies  
**SMS:** short messaging service

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Viewpoint

# Opportunities and Obstacles for Providing Medical Education Through Social Media

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## Abstract

Social media has infiltrated almost every sector of life, and medical education is no exception. As this technology becomes mainstream within society, an increasing number of health care students and professionals are using it for learning. Several important considerations for the risks of this technology are discussed here.

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**KEYWORDS**

medical education; social media; innovation

Social media has drastically altered how the world communicates. No longer a matter of science fiction, large quantities of public and private data can now be exchanged in minutes. A recent Journal of Medical Internet Research report examined the successes of the YouTube channel “Not Just a Medical Student,” which attempts to innovatively apply social media for the advancement of medical education [1]. As a recently graduated doctor and current undergraduate medical student who regularly use social media for medical education, we would like to share our perspectives on this report and future advances within this field.

Medical school curricula often lack teaching on leadership, teamwork, and innovation, all of which could be taught through social media. Despite saturated curricula, these elements are key to health care advancement and of particular importance when undertaking leadership or innovation roles after graduation. More broadly, the benefits of educational social media are clear. By overcoming geographical and time barriers, it allows students equal access to teaching and is associated with higher levels of student satisfaction [2]. Social media platforms have a further advantage over conventional communication methods, in that these online spaces are already accessed as part of users' daily routines [2,3]. For example, it is estimated that 44.5% of medical trainees and 64.3% of medical students have active Facebook accounts [4].

The application of social media to medical education is not without risks. Professionals and patients alike are susceptible to false information, and such content can easily be distributed if time is not taken for validation and peer review. These strategies are further important to safeguard the professional reputations of individuals and institutions. Without considering regulation and the need for a clear distinction between personal and professional opinion, public perception of medical practice may be affected and patients could be dissuaded from choosing truly beneficial treatments. Lack of regulation further permits the spread of biased information, such as exaggerated or misleading claims from industries with financial interests. Finally, discussion of real cases risks physicians accidentally sharing personal information and thereby breaching confidentiality. A survey of 1600 health science staff and students found that the greatest barriers to educational social media use were concerns about policies and professionalism [3]; hence, training is required to address these concerns and prevent doctors from becoming liable for damages. Overall, a compromise on speed is warranted to ensure that all content adheres to guidance from regulatory bodies before publication.

Future work should address the lack of quantitative evidence to support claims that social media is an effective educational tool [5]. The presently used metrics, such as the number of likes, shares, and comments a post receives, require assessment to decipher why exactly an audience deems a video favorable or

shareable, and research into whether these metrics are indicative of educational value is needed. We believe that social media is a powerful tool with the potential to improve medical education and the lives of patients worldwide. We thank the “Not Just a Medical Student” team for producing such innovative content and look forward to seeing how this field progresses.

### Conflicts of Interest

None declared.

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Viewpoint

# Introducing Artificial Intelligence Training in Medical Education

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## Abstract

Health care is evolving and with it the need to reform medical education. As the practice of medicine enters the age of artificial intelligence (AI), the use of data to improve clinical decision making will grow, pushing the need for skillful medicine-machine interaction. As the rate of medical knowledge grows, technologies such as AI are needed to enable health care professionals to effectively use this knowledge to practice medicine. Medical professionals need to be adequately trained in this new technology, its advantages to improve cost, quality, and access to health care, and its shortfalls such as transparency and liability. AI needs to be seamlessly integrated across different aspects of the curriculum. In this paper, we have addressed the state of medical education at present and have recommended a framework on how to evolve the medical education curriculum to include AI.

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**KEYWORDS**

algorithm; artificial intelligence; black box; deep learning; machine learning; medical education; continuing education; data sciences; curriculum

## Trends in Health Care

Global health care expenditure has been projected to grow from US \$7.7 trillion in 2017 to US \$10 trillion in 2022 at a rate of 5.4% [1]. This translates into health care being an average of 9% of gross domestic product among developed countries [2,3]. Some key global trends that have led to this include tax reform and policy changes in the United States that could impact the expansion of health care access and affordability (Affordable Care Act) [4], implications on the United Kingdom's health care spend based on the decision to leave the European Union [5], population growth and rise in wealth in both China and India [6-8], implementation of socioeconomic policy reform for health care in Russia [9], attempts to make universal health care effective in Argentina [10], massive push for electronic health and telemedicine in Africa [11], and the impact of an unprecedented pace of population aging around the world [12].

From clinicians' perspective there are many important trends that are affecting the way they deliver care of which the growth in medical information is alarming. It took 50 years for medical information to double in 1950. In 1980, it took 7 years. In 2010, it was 3.5 years and is now projected to double in 73 days by 2020 [13]. This growth is posing a challenge to health care professionals to both retain and use it effectively to practice medicine.

## Rise of Artificial Intelligence in Health Care

**Artificial Intelligence in Health Care**

Artificial intelligence (AI) is a scientific discipline that focuses on understanding and creating computer algorithms that can perform tasks that are usually characteristics of humans [14]. AI is now gaining momentum in health care. From its early

roots in Turing's seminal paper, Computing Machinery and Intelligence [15], where he proposed the question "Can machines think?", AI has come a long way. Examples of advances in AI include natural language processing (NLP) [16], speech recognition [17], virtual agents [18], decision management [19], machine learning [20], deep learning [21], and robotic process automation [22].

Today, AI is being piloted in health care [23] for faster and accurate diagnosis, to augment radiology [24], reduce errors due to human fatigue, decrease medical costs [25], assist and replace dull, repetitive, and labor-intensive tasks [26], minimally invasive surgery [27], and reduce mortality rates [28].

### Challenges With Artificial Intelligence

The rise of AI in health care and its integration into routine clinical practice is going to be a challenge. Along with changing the conventional ways physician work, the *black box problem* [29] and liability issues [30] are some of the most anticipated challenges.

#### Black Box

Researchers at Mount Sinai Hospital have created a deep learning algorithm that was trained on the data of 700,000 patients. This algorithm was able to predict onset of a disease such as schizophrenia with high accuracy [31]. This is even more impressive considering the fact that this condition is difficult to diagnose even for experts. The main problem with this algorithm is that there is no way to know how the system created this prediction and what factors were taken into consideration. This phenomenon is called the *black box* phenomenon. It would not be a precedent in medicine, nevertheless it is difficult to trust a system when there is no understanding on how it works. The physician needs to understand the inputs and the algorithm and interpret the AI-proposed diagnosis to ensure no errors are made. We also need to understand what the consequences or unintended side effects are of black box medicine, even when good outcomes can be demonstrated against a standard of care.

Finally, many of the AI systems attempt to mimic aspects of human and animal central nervous systems that are, at large, still a black box. In a recent paper, Zador [32] argued that we have much more to learn from animal brains to unravel this phenomenon.

#### Privacy and Control Over Data

The development of AI algorithms almost as a rule requires data from a large number of patients. Google, for example, is using 46 billion data points collected from 216,221 adults' deidentified data over 11 combined years from 2 hospitals to predict the outcomes of hospitalized patients [33,34]. This raises many concerns including relating to patient privacy and control. What happens if a patient does not want to participate in a study where their information is used in algorithm development? In the European Union, the Right to be Forgotten would allow personal data to be erased when the patient has withdrawn their consent [35]. In situations where patient data are limited, algorithm developers train the models on synthetic or hypothetical data, with the risk of generating unsafe and

incorrect treatment recommendations [36]. Finally, AI systems are also vulnerable to cybersecurity attacks that could cause the algorithm to misclassify medical information [37].

### Lack of Standards for Use of Artificial Intelligence in Patient Care and Liability

Another unresolved question related to the use of AI in health care is liability for the predictions of an algorithm. It is unclear who is liable when a patient experiences serious harm because of an inaccurate prediction. One could argue for any of the involved parties: the physician, the hospital, the company that developed the software, the person who developed the software, or even the person who delivered the data. Standards for use of AI in health care are still being developed [38,39]. New standards for clinical care, quality, safety, malpractice, and communication guidelines have to be developed to allow for greater use of AI. A recently launched AI system for autonomous detection of diabetic retinopathy carries medical malpractice and liability insurance [40,41].

As use of AI and proactive use of tools such as chatbots [42] increases, physicians and patients will need to be aware of strengths and limitations of such technologies and be trained in how to effectively and safely use them [43,44].

### How Can Artificial Intelligence Address Today's Physician Challenges?

With medical information growing at a breakneck speed, physicians are having trouble keeping up. This is leading to information overload and creates pressure to memorize all this content to pass the United States Medical Licensing Examinations (USMLE) to qualify for residency positions. Physicians today are working longer hours and are also expected to deliver coordinated care [45,46] in an aging society with complex conditions and comorbidities where health care costs are increasing and regulations are putting an additional burden on administrative processes.

AI could help physicians by amalgamating large amounts of data and complementing their decision-making process to identify diagnosis and recommend treatments. Physicians in turn need the ability to interpret the results and communicate a recommendation to the patient. In addition, AI could have an impact by alleviating the burden from physicians for performing day-to-day tasks [47]. Speech recognition could help with replacing the use of keyboards to enter and retrieve information [48]. Decision management can help with sifting enormous amounts of data and enable the physician to make an informed and meaningful decision [49,50]. Automation tools can help with managing regulatory requirements such as Protecting Access to Medicare Act and enable physicians to review the appropriate criteria before making a cost decision [51]. Finally, to help with the acute shortage of health care professionals, virtual agents could, in the future, help with some aspects of patient care and become a trusted source of information for patients [52].



## Artificial Intelligence Training in Medical Education

### State of Medical Education Today

Physicians go through extensive periods of training before they can eventually register as specialists. Although medicine has seen major changes over the last decades, medical education is still largely based on traditional curricula [53]. The specific length of training differs between countries, but the core competencies of these curricula are globally similar [54]. After a core phase of preclinical didactics, training is mostly centered around practice-based learning [53]. Medical education is often based on 6 domains: patient care, medical knowledge, interpersonal and communication skills, practice-based learning and improvement, professionalism, and systems-based practice

[55]. These fields were introduced by the Accreditation Council for Graduating Medical Education (ACGME). A large part of medical training focuses on consuming as much information as possible and learning how to apply this knowledge to patient care. This process is still largely memorization based [56]. Less time is spent on familiarizing medical students or residents with new technologies such as AI, mobile health care applications, and telemedicine [53,55,56]. In the United States, USMLE does not test on these subjects [57]. However, change seems inevitable since the 2018 annual meeting of the American Medical Association (AMA) saw the adoption of AMA's first policy on augmented intelligence, encouraging research into how AI should be addressed in medical education [58]. In Table 1, several initiatives for incorporating AI in medical education are shown, as presented by the AMA [58].

**Table 1.** Initiatives for artificial intelligence in medical education.

Institution	Project
Duke Institute for Health Innovation	Medical students work together with data experts to develop care-enhanced technologies made for physicians
University of Florida	Radiology residents work with a technology-based company to develop computer-aided detection for mammography
Carle Illinois College of Medicine	Offers a course by a scientist, clinical scientist, and engineer to learn about new technologies
Sharon Lund Medical Intelligence and Innovation Institute	Organizes a summer course on all new technologies in health care, open to medical students
Stanford University Center for Artificial Intelligence in Medicine and Imaging	Involves graduate and postgraduate students in solving health care problems with the use of machine learning
University of Virginia Center for Engineering in Medicine	Involves medical students in the engineering labs to create innovative ideas in health care

Another important technology-related aspect that is often overlooked in medical training is working with electronic health records (EHRs). EHRs have many benefits, such as improved patient safety, but also assist the implementation of AI in health care. AI algorithms use information from the EHR, and therefore, the knowledge on how to input unbiased data into the EHR is essential. Otherwise, the AI algorithm will likely be biased as well [59]. At present, training on use of EHRs for medical students and physicians is not commonly incorporated in the medical curriculum [60], resulting in the medical professional using the EHR as a replacement to capture information on paper without understanding the true potential of this technology [61]. Training on the use of EHRs usually consists of ad hoc brief introductory courses that just teach the basic skills to use the hospital's system in practice. Quality of data and concerns on the impact of the computer on the patient-physician relationship are rarely addressed [60] and the USMLE does not test on these subjects either [57].

### How Clinical Practice Is Changing

With the rapid digitization of health care, EHRs facilitate new ways to acquire and process valuable information that can be used to make an informed decision [62]. These advances and transitioning from an information age to the age of AI [56] change clinical practice and patient outcomes for the better. Physicians of the future will have to add to the armory of their

skills and competencies, the ability to manage data, supervise AI tools, and use AI applications to make informed decisions.

Physicians will have a crucial role in deciding which of these tools is best for their patients. In turn, this will likely change the physician-patient relationship [63]. When information processing is done mainly by computers, this highlights one of the major benefits of AI in medicine: it allows the physician to focus more on caring for and communicating with patients [64]. Finally, in the age of AI, "the physician should combine narrative, mechanistic and mathematical thinking in their training and consider the biopsychosocial model of the disease with the patient at its center." "Computers will never substitute for self-reflective medical expert who is aware of the strengths and limitations of human beings and of an environment characterized by information overload" [65,66].

### What Will Be Asked From Physicians in the Future?

Future physicians will need a broad range of skills to adequately use AI in clinical practice. Besides understanding the principles of medicine, physicians will also need to acquire satisfactory knowledge of mathematical concepts, AI fundamentals, data science, and corresponding ethical and legal issues. These skills will help them to use data from a broad array of sources, supervise AI tools, and recognize cases where algorithms might not be as accurate as expected [67]. Furthermore, communication and leadership skills as well as emotional

intelligence will be more important than ever as AI-based systems will not be able to consider all the physical and emotional states of the patient [56]. These traits are hard to master for computers and will characterize a great physician in the age of AI.

### Practical Considerations

Some of the time that was originally spent on memorizing medical information will now have to be devoted to other skills. This will have a major impact on the way students and residents will experience their training. The system has to change in such a way that competence will no longer be judged based on factual knowledge but rather on communication skills, emotional intelligence, and knowledge on how to use computers.

With an overfull curriculum, there is limited interest in adopting new topics [68], although a 2016 survey by AMA shows that 85% of physicians perceive benefits from new digital tools [58]. The integration of AI-oriented education into the medical curriculum will take time as the technology evolves. A new infrastructure for learning has to be introduced, and new educators from disciplines such as computer sciences, mathematics, ethnography, and economics will need to be hired. At the moment, these subjects are not even covered by the core competencies of ACGME, but these competencies “are robust enough to adapt to changing knowledge” [69].

To achieve a change in curriculum, many political and bureaucratic hurdles have to be overcome. *Educational systems, program structures, and objectives* have to change to create new learning outcomes [70]. A change can only be implemented when large amount of evidence is generated. We have not reached that stage of implementing changes for AI. Furthermore, many other fields within medicine argue that they have not received the attention they deserve [71,72]. AI needs to prove its benefits and also justify that it is an important topic for medical curriculum over other important subjects that lack adequate medical training at present.

However, one of the most compelling arguments for the implementation of AI training in medical education is that this training will augment existing curriculum rather than replace existing coursework. When students are trained to use AI tools, focus should shift from acquiring basic knowledge on how to use the tool to a basic understanding of the underlying principles. This will enable the students to use this fundamental knowledge when current tools get outdated and new tools are introduced.

Another practical problem is that traditional medical training revolves mainly around the interactions between an attending physician and the residents or medical students. When AI is increasingly introduced into clinical practice, this could be problematic. Many senior physicians have little to no experience with AI. AI training could be delivered via Continuing Medical Education (CME) programs and might need to be also taught by educators from outside the medical community. For example, a 2-credit CME course on AI and the Future of Clinical Practice is delivered by a computational biologist and business economists [73].

## Recommendations

### Framework

The traditional medical curriculum, which is mostly memorization based, must follow the transition from the information age to the age of AI. Future physicians have to be taught *competence in the effective integration and utilization of information from a growing array of sources* [56]. To embed this knowledge into medicine, it is of the essence to start introducing these concepts from the beginning of training. In many countries, a Medical College Admission Test (MCAT) has to be taken to be admitted into medical school. The current US MCAT exam, for example, focuses on biology, chemistry, physics, psychology, sociology, and reasoning [78]. These exams could start testing on mathematical concepts such as basis of linear algebra and calculus. These concepts are vital to the elementary understanding of AI and will set the tone for the rest of the curriculum.

In the core phase of preclinical didactics, time should be devoted to working with health data curation and quality [79], provenance [80], integration [81], and governance, working with EHRs [60], AI fundamentals, and ethics and legal issues with AI [82,83]. Course work in critical appraisal and statistical interpretation of AI and robotic technologies is also important [84]. First, these subjects could be taught in self-contained courses to teach about the fundamentals of these subjects that can be used even after current applications become outdated [68]. These self-contained courses could potentially replace and augment courses on medical informatics and statistics in the current curriculum. Second, they should also recur in clinical courses to familiarize students with the clinical applications of AI and work with EHRs in diverse settings [68]. An approach to introducing AI could be to incorporate this technology during courses such as Evidence Based Medicine [85]. As the student is taught to appraise evidence through databases such as PubMed or diagnostic tests or systematic reviews, this process could be augmented by applying concepts from data sciences, applying AI technologies such as NLP and analyzing scenarios to test them on questions of ethics and liability [86]. In addition, the students should also be trained in the fundamentals of computer and software engineering to understand the semantics behind real-world AI applications. For example, basics of hardware and software development and user experience design may also be valuable.

During clinical rotations and residency, focus should shift toward relevant applications of AI in practice. With advancements in digital biomarkers [87] and digital therapeutics [88], students should also be trained in these technologies as they rely on AI. They have the potential to enable large-scale diagnostics and treatments in in-home environments in the near future [89]. At the end of training, the USMLE should include a substantial number of questions on data science and AI fundamentals in their final exams. Attendance of conferences on health care AI could be incentivized, so that health care professionals stay up-to-date with the latest developments. For attending physicians, extensive courses on AI and data science should be part of CME. See Table 2 for more details.

**Table 2.** List of Continuing Medical Education programs on artificial intelligence in health care.

Program	Faculty; organization	Number of Continuing Medical Education credits
Artificial Intelligence and the Future of Clinical Practice [73]	Computational biologist, Business economist; Massachusetts Medical Society	2.0
Intro to AI and Machine Learning: Why All the Buzz [74]	Medical Informatics, Radiology; The Radiological Society of North America	1.0
Current Applications and Future of Cardiology [75]	Healthcare Technologists, Bioinformatics, Cardiology; Mayo Clinic	10.0
Artificial Intelligence and Machine Learning: Application in the Care of Children [76]	Pediatric Medicine; University of Pittsburgh School of Medicine	1.0
Artificial Intelligence in Healthcare: The Hope, The Hype, The Promise, The Peril [77]	Medical Informatics, Business Administration; Stanford University School of Medicine	6.0

AI skills must also be balanced with nonanalytics and person-centered aspects of medicine to develop a more rounded doctor of the future. Other skills such as *communications, empathy, shared decision making, leadership, team building, and creativity are all skills that will continue to gain importance for physicians*. At the Dell Medical School at the University of Texas, Austin, the curriculum in basic sciences has been reduced in duration to accommodate training in soft skills such as leadership, creativity, and communication [63].

To enable clinicians to think innovatively and create technology-enabled care models, multidisciplinary training is needed in implementation science, operations, and clinical informatics. The Stanford medical school has created such a program to train clinician-innovators for the digital future by introducing a human-centered design approach to graduate medical education [90]. At the Healthcare Transformation Laboratory at Massachusetts General Hospital in Boston, a 1-year fellowship is offered in health care innovation exposing resident trainees to topics in data sciences, machine learning, health care operations, services, design thinking, intellectual property, and entrepreneurship [91]. These projects are new developments and are the first steps taken to introduce AI in medical education.

### First Steps

As not all of these interventions can be introduced simultaneously, we suggest a few first steps that will lay the

foundation for the upcoming years. We suggest to start off by introducing questions on mathematical concepts into the MCAT similar to the mathematics section in the Graduate Record Examination. High quality Web-based courses on data sciences and AI fundamentals should be freely offered in the core phase of medical education. This might lead to students focusing on applications of these subjects more naturally in following years of training.

For residents and medical students who have already finished this phase of training, courses on the fundamental subjects should be available and mandatory throughout the remaining part of their medical education. For students interested in creating new technology-enabled care models, dedicated training in health care innovation during a gap year during the clinical years or after residency should be encouraged. For attending physicians, introductory courses and refresher courses should also be made available. Extensive training is especially necessary for this group so that they can partly take back the task of educating medical students and residents on these subjects in the future. Table 3 lists suggested content that can be added to the various phases of medical education. Table 4 lists a small subset of rapidly evolving AI in health care conferences that physicians and trainees can attend to learn more about this technology and its applications in health care.

**Table 3.** Recommendations per stage of medical education.

Medical education stage	Recommendations	Suggested content
MCAT <sup>a</sup>	Introduce questions on linear algebra (vectors, linear transformations, and matrix, solutions for linear systems), calculus (limits, differential calculus, and integral calculus), probability (joint, conditional, and distribution)	<ul style="list-style-type: none"> <li>Education Testing Services' Graduate Record Examination mathematics test [92]</li> </ul>
Medical school—core phase	Working with medical data sets (curation, quality, provenance, integration, and governance), EHRs <sup>b</sup> , AI <sup>c</sup> fundamentals, and Ethics and Legal	<ul style="list-style-type: none"> <li>Datasets:</li> <li>HealthData [93]</li> <li>Public datasets in health care [94]</li> <li>University of California San Francisco Data Resources [95]</li> <li>AI fundamentals</li> <li>AI 101 course from MIT<sup>d</sup> [96]</li> <li>Ethics and Law</li> <li>Teaching AI, Ethics, Law and Policy [97]</li> <li>AI Law [98]</li> <li>EHR training [99]</li> </ul>
Medical school—clinical phase	Familiarize with AI-based clinical applications and expand knowledge beyond basic principles of data and AI	<ul style="list-style-type: none"> <li>Clinical utility:</li> <li>Overview of Clinical applications of AI [100]</li> <li>AI for Health and Health Care (US Department of Health and Human Services) [101]</li> <li>Center for AI in Medicine and Imaging [102]</li> <li>AI in Healthcare Accelerated Program [103]</li> </ul>
USMLE <sup>e</sup>	Introduce questions on data sciences, AI, and working with EHRs	<ul style="list-style-type: none"> <li>Data science courses [104-106]</li> </ul>
Residents	Detailed knowledge on clinical applications and attend conference in health care AI	<ul style="list-style-type: none"> <li>Table 4</li> </ul>
Specialist	Stay up-to-date on data/AI through CME <sup>f</sup> credits and attend conference in health care AI	<ul style="list-style-type: none"> <li>Tables 2 and 4</li> </ul>

<sup>a</sup>MCAT: Medical College Admission Test.

<sup>b</sup>EHR: electronic health record.

<sup>c</sup>AI: artificial intelligence.

<sup>d</sup>MIT: Massachusetts Institute of Technology

<sup>e</sup>USMLE: United States Medical Licensing Examinations

<sup>f</sup>CME: Continuing Medical Education.

**Table 4.** List of artificial intelligence in health care conferences.

Name of conference	Topics
Ai4 AI <sup>a</sup> Healthcare Conference [107]	Exploring top use cases of AI and ML <sup>b</sup> in health care
AI in Healthcare [108]	Business value outcomes of AI and experience in clinical care and hospital operations
Machine Learning and AI forum (Healthcare Information and Management Systems Society—HIMSS) [109]	Data, analytics, and real-world applications of ML and AI
AI in Healthcare @ JP Morgan Healthcare Conference [110]	AI applications—drug discovery, secure data exchange, insurer coordination, medical imaging, risk prediction, at-home patient care, and medical billing
Radiology in the age of AI [111]	AI in medical imaging
American Medical Informatics Association Clinical Informatics Conference [112]	AI in medical informatics
Association for the Advancement of AI [113]	“Increase public understanding of AI, improve the teaching and training of AI practitioners, and provide guidance for research planners and funders concerning the importance and potential of current AI developments and future directions”

<sup>a</sup>AI: artificial intelligence.

<sup>b</sup>ML: machine learning.

## Conclusions

Physicians and machines working in combination have the greatest potential to improve clinical decision making and patient health outcomes [114]. AI can curate and process more data such as medical records, genetic reports, pharmacy notes, and environment data and in turn retain, access, and analyze more medical information. However, it cannot replace the art of caring. As AI and its application become mainstream in health care, medical students, residents, fellows, and practicing physicians need to have knowledge of AI, data sciences, EHR fundamentals, and ethics and legal issues concerning AI.

Medical schools will need to include them as part of the curriculum. A staged approach to educating the medical student through their journey is recommended.

AI will enable faster and accurate diagnosis, augment radiology, reduce errors due to human fatigue, decrease medical costs, assist and replace dull, repetitive, and labor-intensive tasks, minimally invasive surgery, and reduce mortality rates.

With the global health care expenditure projected to reach US \$10 trillion by 2022, AI has the invaluable potential to advance the quadruple aim in health care—enhance the patient experience, improve population health, reduce costs, and improve the provider experience [115,116].

## Conflicts of Interest

KP has written this paper as part of his PhD studies. He is a vice president at Roche. There is no conflict of interest with his employment at Roche. None of the rest of the authors declare any conflicts of interest.

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## Abbreviations

- AI:** artificial intelligence  
**ACGME:** Accreditation Council for Graduating Medical Education  
**AMA:** American Medical Association  
**CME:** Continuing Medical Education  
**EHR:** electronic health record  
**MCAT:** Medical College Admission Test  
**NLP:** natural language processing  
**USMLE:** United States Medical Licensing Examinations

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Original Paper

# Why Medical Students Choose to Use or Not to Use a Web-Based Electrocardiogram Learning Resource: Mixed Methods Study

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## Abstract

**Background:** Electrocardiogram (ECG) interpretation is a core competence and can make a significant difference to patient outcomes. However, ECG interpretation is a complex skill to learn, and research has showed that students often lack enough competence. Web-based learning has been shown to be effective. However, little is known regarding why and how students use Web-based learning when offered in a blended learning situation.

**Objective:** The aim of this paper was to study students' use of Web-based ECG learning resources which has not previously been studied in relation to study strategies.

**Methods:** A qualitative explanatory design using mixed methods was adopted to explore how medical students reason around their choice to use or not to use a Web-based ECG learning resource. Overall, 15 of 33 undergraduate medical students attending a course in clinical medicine were interviewed. Data on usage of the resource were obtained via the learning management system for all students. At the final examination, all the students answered a questionnaire on study strategies and questions about internet access and estimated their own skills in ECG interpretation. Furthermore, study strategies and use patterns were correlated with results from an ECG Objective Structured Clinical Examination (OSCE) and a written course examination.

**Results:** In total, 2 themes were central in the students' reasoning about usage of Web-based ECG: assessment of learning needs and planning according to learning goals. Reasons for using the Web resource were to train in skills, regarding it as a valuable complement to books and lectures. The main reasons for not using the resource were believing they already had good enough skills and a lack of awareness of its availability. Usage data showed that 21 students (63%) used the Web resource. Of these, 11 were *minimal users* and 10 were *major users* based on usage activity. Large variations were found in the time spent in different functional parts of the resource. No differences were found between users and nonusers regarding the OSCE score, final examination score, self-estimate of knowledge, or favoring self-regulated learning.

**Conclusions:** To use or not to use a Web-based ECG learning resource is largely based on self-regulated learning aspects. Decisions to use such a resource are based on multifactorial aspects such as experiences during clinical rotations, former study experiences, and perceived learning needs. The students' own judgment of whether there was a need for a Web-based resource to achieve the learning goals and to pass the examination was crucial for their decisions to use it or not. An increased understanding of students' regulation of learning and awareness of variations in their ECG learning needs can contribute to the improvement of course design for blended learning of ECG contexts for medical students.

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**KEYWORDS**

learning; medical; teaching; electrocardiogram

## Introduction

### Background

Web-based learning has been shown to be effective when implemented as a primary mode of teaching or as a complementary resource in a blended learning setting [1,2]. The advantages of Web-based complementary resources are user control over content, learning sequence, pace, and chosen time to study. However, other strengths of a computer resource have been described in the study by Bond et al [3]. This flexibility allows learners to adapt their usage to meet course objectives and personal learning objectives in varying medical education contexts [4].

Knowledge in electrocardiogram (ECG) interpretation is a core competence for physicians and can make a significant difference to patient outcomes [5,6]. However, ECG interpretation is a complex skill to learn, and research has shown that some students have a lack of competence [7]. There is an ongoing discussion about how to perform effective ECG teaching. A recent review showed that no single method or format of teaching is superior in enhancing ECG interpretation skills [8], thereby implying a need for flexible ECG learning activities. Most studies regarding ECG education include reports of skill shortages, measurements of education or student experience, or demonstration of opportunities with a type of education. Thus, they do not help to understand why and to what extent students make use of various educational resources. In the evaluation of Web-based resources, the importance of the student perspective has been stressed [9]. According to Illeris, learning can be studied from different perspectives: environment, content, and incentive [10]. From the incentive perspective, it is important to understand how students perceive the content and what drives their choice of ECG learning resources. Students' use of Web-based ECG learning resources has not previously been studied in relation to study strategies. To our knowledge, students' decision-making process has not been studied in settings where students have the opportunity to use a Web-based complementary ECG learning resource. Theories of self-regulated learning shed light on students' incentives and approaches to flexible learning tools [11,12]. The self-regulated learning process is described as being directed by monitoring one's own learning needs and using necessary tools to support the learning process [13-15]. Brydges and Butler argue that self-regulation should be studied and understood across a variety of learning contexts available in medical education [16]. Using the self-regulated learning perspective to understand the use of a Web-based ECG learning resource means taking the learners' perspective as the point of departure.

### Study Aim

The primary aim of this study was to explore medical students' rationales for choosing to use a Web-based supplementary

resource for ECG learning. With this aim, we conducted a mixed methods study.

## Methods

### Overview

In this exploratory mixed methods study (see Figure 1), we used a combination of interviews and quantitative data. Data analysis from interviews is the dominant source of data for interpretation according to the overall research question. By using a qualitative method, we can, through interviews, explore in a deeper way the decision-making process and the reasons for using Web-based education. At the same time, we wanted to investigate whether there are any objective data that reinforce the possible model that students use in decision making. This can be achieved by comparing results from questionnaires and from examinations at the group level.

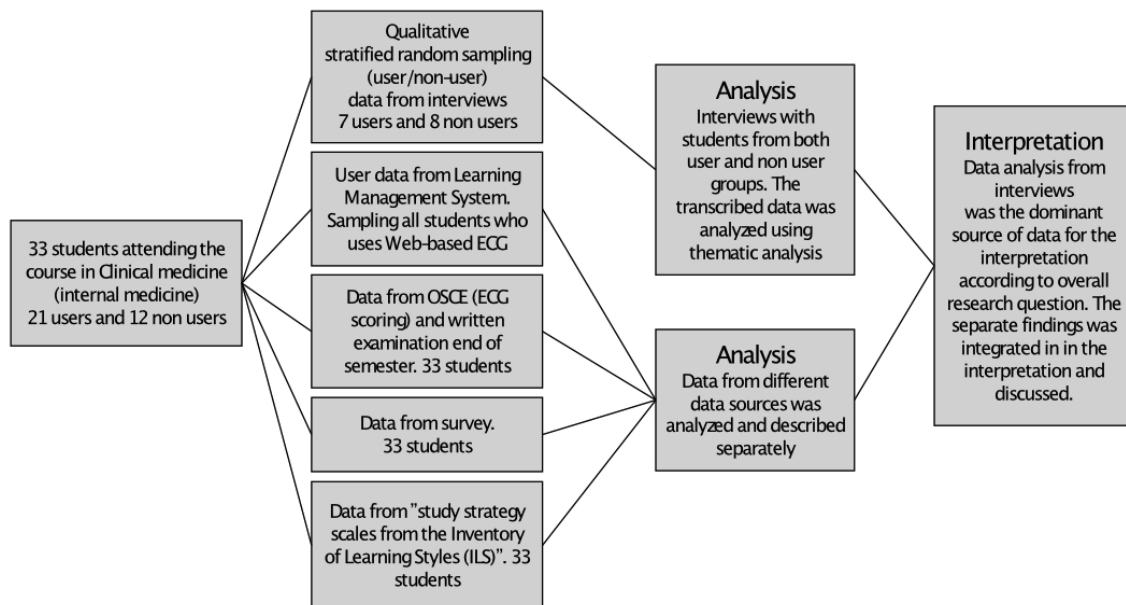
The study group comprised all third-year medical students studying internal medicine at 1 of 4 teaching hospitals at Karolinska Institutet (KI), Stockholm, Sweden. All students had passed a basic course in ECG interpretation 2 semesters before the period under study. The course in internal medicine combines theory and practice, in that approximately 50% of the course consists of lectures and seminars, and the other part is spent in clinical rotations.

All students were given access to a Web-based ECG learning program 8 weeks before their final examination. Development and structure of the Web-based ECG resource has been described in detail elsewhere [17,18].

A part of the course examination was an Objective Structured Clinical Examination (OSCE) test with 1 station examining ECG interpretation skills. The students received an email explaining the study and how they could access the Web-based ECG learning program approximately 8 weeks before the OSCE. The email contained detailed information on program structure but no directions about how to plan learning activities. The examiner (coauthor JÖ) also discussed the program during a lecture. The regional ethics review board in Stockholm approved the study (2009245-314).

A total of 33 students attending the course in internal medicine received information about the study and introduction to the Web-based ECG learning resource. Of the 33 students, 21 chose to use the resource. For those students, the learning management system collected usage data. Students were chosen alphabetically to be interviewed. After 15 interviews, data saturation was achieved. In addition to the course examination, students performed an ECG interpretation OSCE station. Results from the OSCE station and final examination were collected. During the examination, students were asked to fill in a questionnaire, which all 33 students completed.

**Figure 1.** Flowchart of the study design. In total, 33 students attended the course in internal medicine and received information about the study and introduction to the Web-based electrocardiogram (ECG) learning resource. Of the 33 students, 21 chose to use the resource. For those students, the learning management system collected usage data. Students were chosen alphabetically to be interviewed. After 15 interviews, data saturation was achieved. In addition to the course examination, students performed an ECG interpretation Objective Structured Clinical Examination (OSCE) station. Results from the OSCE station and final examination were collected. During the examination, students were asked to fill in a questionnaire, which all 33 students completed.



## Interviews

An interview guide was created based on pilot interviews with 7 students. From the group of the 33 medical students, 15 participants were selected to be interviewed (Figure 1). The intention was to interview both students who used and did not use the Web-based program. Students were selected alphabetically from the course list, adjusting for equal numbers of users and nonusers of the Web-based program. Overall, 7 users (4 women and 5 men) and 8 nonusers (2 women and 6 men) were interviewed by the first author or a student administrator 3 months after the examination. The first interview was performed collaboratively by the author and the administrator to synchronize the interviewers and make final adjustments to the interview guide. Students were informed that both interviewers were independent from the course management and that participation or nonparticipation in the study would not affect their grades. During the interview, students were asked to share their thoughts and reasoning behind their choices of using or not using the Web-based program. They were also asked to share general thoughts about Web-based learning and traditional media, such as textbooks and lecture notes. Furthermore, the students were asked to explain if and how they used the Web-based ECG learning program. The semistructured interviews were completed by telephone, recorded digitally, and transcribed verbatim.

## Analysis of the Interviews

Data were analyzed using thematic analysis ([16,18]). In addition, 2 of the authors (MN and UF) performed the primary analyses, which were then discussed with the other authors. Initial readings of the transcribed texts were then coded and grouped according to the research question. The codes were analyzed

for variability, consistency, and emerging patterns. The final codes were analyzed iteratively in a process of reading and rereading, leading to broader themes. The themes are exemplified by transcript quotations.

## Questionnaire

All 33 students answered a questionnaire on the final examination day. The first part consisted of an estimation of ECG interpretation knowledge in relation to the course objectives and the availability of computer and internet access; the second part consisted of questions about individual study strategies. For the latter part, study strategy scales from the Inventory of Learning Styles (ILS) by Vermunt were used [19]. The regulation strategy scales consist of 28 items forming the 3 variables: *self-regulated*, *external regulated*, or *lack of learning strategies*.

The self-regulated items relate to how students plan learning activities, how they test their progress, and how they direct themselves toward self-generated learning objectives. The external regulated items relate to how students may let themselves be led by didactic aids, such as learning objectives, assignments, or teacher-/supervisor-generated questions. The lack of learning strategy items relates to how students may have problems assessing mastery and comprehension or lack clear ideas about relevant objectives and problem-solving approaches.

The scales have previously been successfully used in medical studies as well as in other higher-education student groups [14,20]. The Swedish translation of the scales has previously been validated in a Swedish medical context [20].

We also collected user activity logs from the learning management system used by KI (Ping Pong) during the time the students used the Web-based ECG learning program.

An *active user* was defined as a student who had been logged on for at least 30 min in the system. For further analyses, the user group was divided into 2 parts based on the median user time of 2 hours and 46 min. Group 1 students logged in less than the median time, and group 2 students logged in for the median time or longer.

The OSCE included 2 ECGs representing life-threatening conditions. A total of 20 points were distributed for correct interpretation, with 12 points for an ECG showing an ST-elevation myocardial infarction with atrial fibrillation and 8 points for an ECG showing ventricular tachycardia. The final written examination contained questions covering the entire field of internal medicine with a maximum of 100 points given.

**Statistical Analysis**

We used SPSS 17.0 for descriptive data calculations. Time was described in hours and minutes (h:mm). Tests of normality for OSCE ECG were done using both Schapiro-Wilk and Skewness methods showing non-normal distribution data.

The level of statistical significance was set to  $P < .05$ . All statistical tests were 2-sided. Correlations were measured by the Spearman rho. Cronbach alpha was calculated for each scale of the ILS using the SAS System 9.1.

**Results**

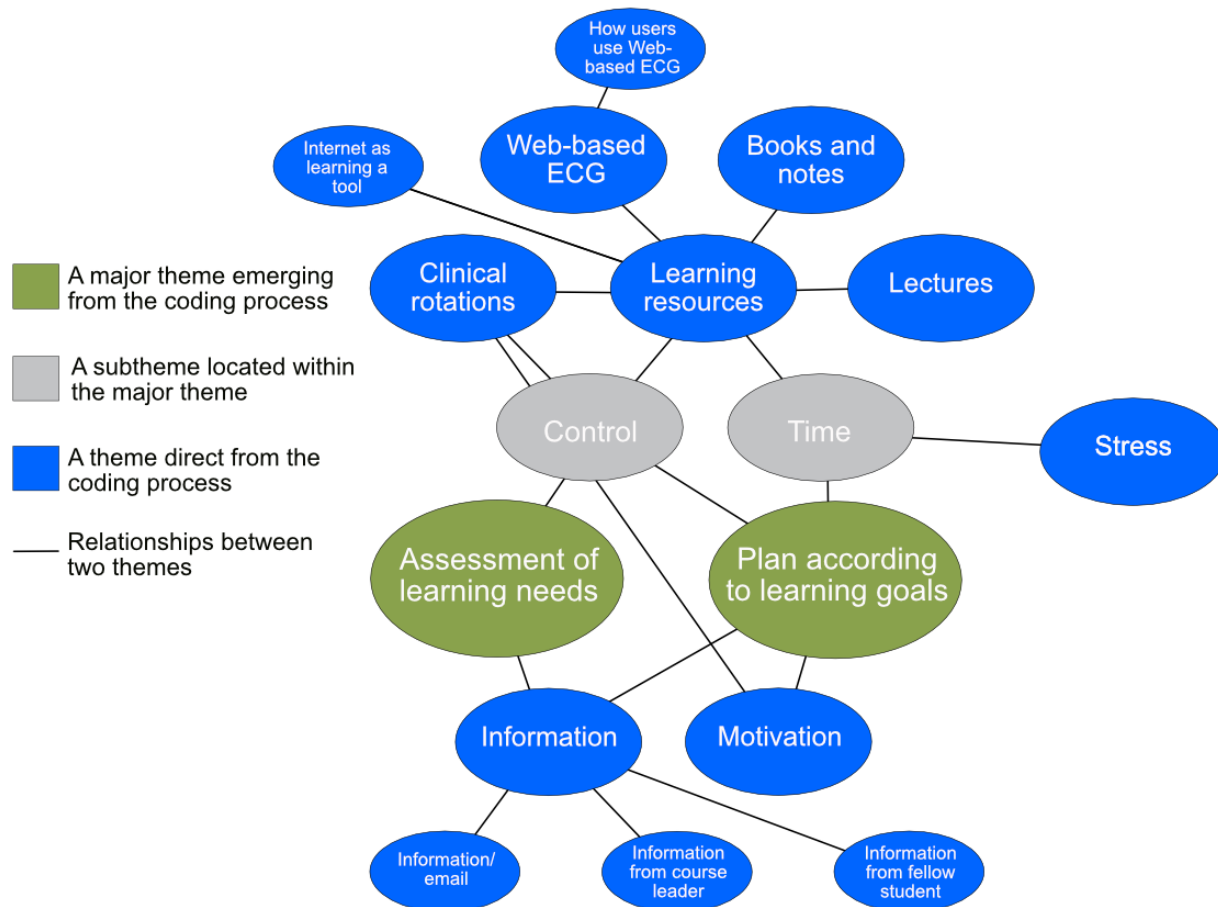
**Interviews**

In the thematic analysis of the 15 interviewed students, 2 overarching themes were identified: *assessment of learning needs* and *planning according to learning goals*. Figure 2 describes a thematic map of the interview results.

**Assessment of Learning Needs**

All students considered ECG interpretation to be important in their future roles as physicians. All students also identified ECG interpretation as a learning objective of the ongoing course in internal medicine as well as part of the OSCE and written examinations. Assessment of learning needs was a consistent theme for the majority of students. The students talked about it sometimes as more of an intuitive feeling but more often as a conscious process involving concrete interaction with some practical experience of control from other persons or self-control. Most students described assessment of learning needs as a recurrent theme involving the other central theme, *planning according to learning goals*. Assessment of learning needs is associated with 2 subthemes: *information* and *control*.

**Figure 2.** Resulting themes and their relationships after interview analysis. Blue objects represent themes derived directly from interviews and connect either to another “blue” theme or directly to an overall perspective. Two important themes—assessment of learning needs and plan according to learning goals—are key factors affecting the decision to use or not use the Web-based learning resource. ECG: electrocardiogram.



### Information to Students About the Web-Based Program

Students reported receiving information from email and verbal information from the examiner (JÖ) about the availability of the Web resource. Several students believed this was important information from the examiner and a reminder of the previous information via email. Email information was perceived to be useful for some students. Occasionally, students learned about the Web-based program through friends. One student reported finding the program via the learning management system and forgot he had received the information by email:

*My course director (JÖ) strongly encouraged us to use the system. He was responsible for the course. He's an authority that you listen to, but he also came especially to a lecture to inform. [S16]*

*First, we got the information through email, but then JÖ also informed after a lecture, so we got the information in two different ways... [S3]*

*I forgot most of it anyway when we receive information by email, it's so much mail. Maybe not daily, but say, it will be two school-related emails a day then it will be like you are drowning in information there... [S1]*

### Control and Assessment of Learning Needs

The students related to control in interaction with the main themes and sometimes as a loop with learning resources. Practical experiences included assessing ECGs during clinical rotations and using the Web-based program. The Web-based program was thought to stimulate control for users by making ECG cases and formative tests available.

Clinical rotations were thought to be important for the students, both in evaluating their knowledge of ECG interpretation in clinical practice and as an important learning resource. Students reported experiences during clinical rotations as an important part of their decision about how to learn to interpret ECGs. Many reported a perceived lack of *good enough* knowledge in ECG interpretation in the clinical environment as a major reason for using the Web-based program. For most students, usage was not affected by access to books on ECG interpretation, lecture notes, and exercise examples of ECG.

### Users

Both users and nonusers affirmed the importance of repetition to reach the learning objectives. The user group described a need for repetition and thus chose to use the Web program:

*Because I felt that I had forgotten too much of the previous ECG teaching. I needed to brush up skills... We had a lot of experience from clinical rotations, when you stand there and look at an ECG and were asked: What do you see? How do you interpret this? So I felt that I had lack of knowledge... The test at the basic ECG-course in the semester before went great, but because we don't use the knowledge so much in a period I lost quite a lot, and then I felt that I needed that refresher... [S17]*

### Nonusers

Some students had a positive learning experience during the rotation in cardiology and, afterward, felt only a minor need for repetition with their books or other study material. Although most students had a positive attitude toward internet resources for studies and social contacts, some students did not like using the internet for learning or for social contacts:

*Right then I did not see the need (for the Web-based program). I used the book I got for the clinical diagnostics course of ECG interpretation and a book with examples. It was sufficient for me. So quite honestly, I was not even inside and watched the Web-based training but I knew it was there... [S12]*

*I looked at old exams and things like that so I know that everything was OK. I will probably get through the course with a passing grade. [S12]*

### Planning According to Learning Goals

Planning according to learning goals was a consistent theme. The students talked about it as a conscious process in interaction with the other central theme, *assessment of learning needs*. Planning according to learning goals is associated with 2 themes: *time* and *control*. The other associations also mentioned were information and motivation.

### Time

The curriculum is extensive, and the students described a need to plan their studies. Some students mentioned that their knowledge in ECG interpretation had been very good from a previous course in clinical diagnostics, but their knowledge had declined markedly.

Students described various clinical rotations during which they were offered a Web-based program. The time lag after the course in clinical diagnostics was reported as a reason for requiring repetition. A few students had a prolonged time lag because of a pause in studies for reasons such as maternity leave, further amplifying the need for repetition.

### Nonusers

Nonusers often described lack of time or sometimes a more negative attitude to computer-based training as contributors to their decisions not to use the program:

*No, I have not used it. No, I do not really like this computer-based training and it doesn't work so well for me... [S2]*

*No, I learn more from reading a real book that you can hold on and sit back and flip in... [S2]*

*Then I didn't practice so much on the ECG, it was more a matter to look up single items, but those I knew already where they were in the book... [S2]*

### Users

Users mentioned the need for repetition as an important element, and they saw the usefulness of the program to reach the learning goal:

*Because I had a need of repetition and it seemed like an easy way to repeat it... [S3]*

*Because I was nervous before the exam, probably. Had I missed something, or forgot something. A good repetition...* [S4]

### How Users Use the Program

Students reported using the program to varying extents and in different ways. Most students used the interactive parts of the ECG cases. Some students described that they used the program sequentially, in an A-to-Z manner. Other students jumped back and forth between different parts of the program. Some students felt they needed more time to repeat or learn ECG interpretation than was available:

*I completed some of the self-assessment questions, I then mostly practiced with interactive interpretations...* [S16]

*I probably followed all the steps pretty accurately. I read the information contained in each section. Then I did the test that was linked to as well to see that I had understood...* [S17]

*I guess I thought everything in the program was good. I cannot remember that I felt annoyed that anything was strange or wrong, I thought it was great that one could, only assimilate information and then directly get confirmation that one had known what it was about...* [S17]

*I used mainly the ECG interpretation training section. The other parts I did not check very much, I thought I had read it enough recently and did not have enough*

*time to sit down and go through them more carefully.* [S15]

### Questionnaire

All 33 students participated in the survey and completed the OSCE and final general examination. The participants included 16 women (48%) and 17 men (52%). All students had access to a broadband internet connection, making it possible to run the Web system if they wanted.

A total of 21 (64%) students were classified as users (>30 min of usage) of the Web-based resource. Median time that users logged onto the system was 2:46 (h:mm, interquartile range [IQR] 1:28-6:37). In addition, 57% of the users were women compared with 33% women in the nonuser groups. The user and nonuser groups were similar regarding their results at the ECG question at the OSCE station and the final examination (Table 1). Self-estimated knowledge of ECG interpretation and learning strategy was also similar between groups.

We further divided the users into 2 groups based on the 2:46 median time value of the user group (Table 2). Among them, 12 students were determined as minor users (median time 1:34, IQR 0:47-2:17) and 9 students were major users (median time 6:38, IQR 5:12-9:21). The major user group included 8 females and 1 male. There was a difference in performance on the ECG test in the OSCE (median females 18.0 p, IQR 16.0 p-18.8 p; median males 16 p, IQR 14.5 p-16.5 p;  $P<.001$ ), but a gender difference was not seen in the final general examination (females median 74.5, IQR 69.2-80.9; males median 74.0, IQR 68.8-77.5;  $P=.68$ ).

**Table 1.** Student characteristics, self-ratings, scores in the electrocardiogram (ECG) Objective Structured Clinical Examination (OSCE), final general examination scores, and results from strategy scales from the Inventory of Learning Styles.

Characteristics	User	Nonuser
Total students, n (%)	21 (64)	12 (36)
<b>Gender, n (%)</b>		
Female	12 (75)	4 (25)
Male	9 (53)	8 (47)
Total activity in Web-based ECG learning resource time (h:mm), median	2:46	— <sup>a</sup>
OSCE ECG test, median points	16	16
Final general examination, median points	74.5	71.8
Students estimated their knowledge of ECG interpretation as 0%-100% of the course objectives, median percentage	80	80
Self-regulation scale, median	3	3
External regulation, median	3	3
Lack of regulation, median	2	2

<sup>a</sup>Not applicable.



**Table 2.** Student characteristics, self-ratings, activity in Web-based electrocardiogram (ECG) learning resource, and results from strategy scales from the Inventory of Learning Styles.

Characteristics	Minor user (30 min-2:46 h)	Major user (>2:46 h)
Total students, n (%)	12 (57)	9 (43)
<b>Gender, n (%)</b>		
Female	4 (33)	8 (67)
Male	8 (89)	1 (11)
Total activity in Web-based ECG learning resource time (h:mm), median	1:38	6:38
OSCE <sup>a</sup> ECG test, median points	16	18
Final general examination, median points	74.5	74.5
Students estimate their knowledge of ECG interpretation 0-100% of course objectives, median percentage	80	85
Self-regulation, median	3	3
External regulation, median	3	3
Lack of regulation, median	2	2

<sup>a</sup>OSCE: Objective Structured Clinical Examination.

**Table 3** shows results from the Spearman rank-order correlation between ECG results in OSCE, activity in the Web-based ECG learning resource, and strategy scales from the ILS. There was no correlation between the OSCE results and activity time in the Web-based ECG resource (**Table 3**). We also tested for association between the regulation strategy scales (self-regulated, externally regulated, or lack of learning strategies). There was a correlation between OSCE results and

self-regulation ( $r_s=0.37$ ;  $P=.03$ ), as well as a negative correlation between OSCE results and lack of regulation ( $r_s=-0.56$ ;  $P=.004$ ). No correlation was seen between OSCE results and external regulation. There was also no correlation between regulation strategy scales and time in interactive ECG interpretation (**Table 3**).

**Figure 3** shows the distribution of time in each part of the Web-based ECG program for all users based on server logs.

**Table 3.** Results from the Spearman rank-order correlation between electrocardiogram result in Objective Structured Clinical Examination, activity in Web-based electrocardiogram learning resource, and strategy scales from the Inventory of Learning Styles.

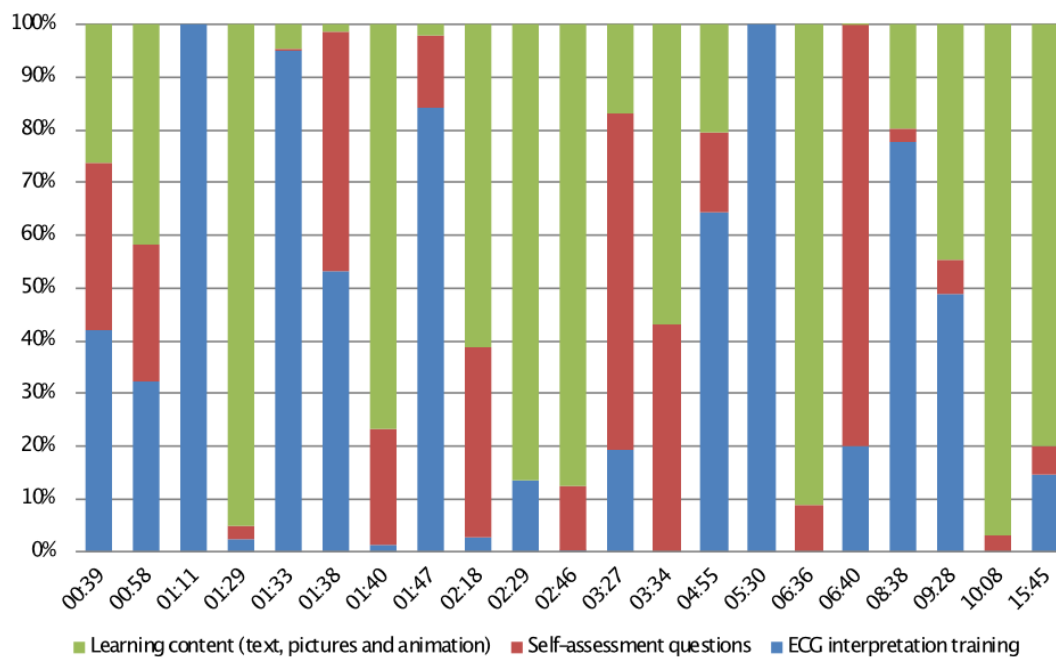
Variable	Spearman rho	P value
OSCE <sup>a</sup> result and total activity in Web-based ECG <sup>b</sup> learning resource	.14	.52
OSCE result and time in interactive ECG interpretation	.29	.20
OSCE result and self-regulation	.37	.03 <sup>c</sup>
OSCE result and external regulation	.10	.58
OSCE result and lack of regulation	-.56	<.001 <sup>c</sup>
Time in interactive ECG interpretation and self-regulation	-.11	.64
Time in interactive ECG interpretation and external regulation	-.06	.80
Time in interactive ECG interpretation and Lack of regulation	-.20	.36

<sup>a</sup>OSCE: Objective Structured Clinical Examination.

<sup>b</sup>ECG: electrocardiogram.

<sup>c</sup>Statistical significance  $P<.05$ .

**Figure 3.** The 21 students' distribution of time in each activity in the Web-based ECG learning resource. Each bar represents 1 student. Total time=hh:mm. ECG: electrocardiogram.



## Discussion

### Overview

In this study, we explored how medical students decided to use or not to use a Web-based ECG learning resource in a blended learning situation. The findings suggest a pattern largely driven by students' incentives in a self-regulated learning process (Figure 4; adapted from Zimmerman [21]).

The interviews highlighted different aspects behind the students' decisions to what extent, and how, they used (or did not use) the Web-based training resource. To plan their own learning or decide what resources they should use for acquiring or refreshing skills in ECG interpretation, the students seemed to use 2 overarching questions to regulate their use of available resources. First, what is my current level of knowledge? Second, what learning outcomes must I reach?

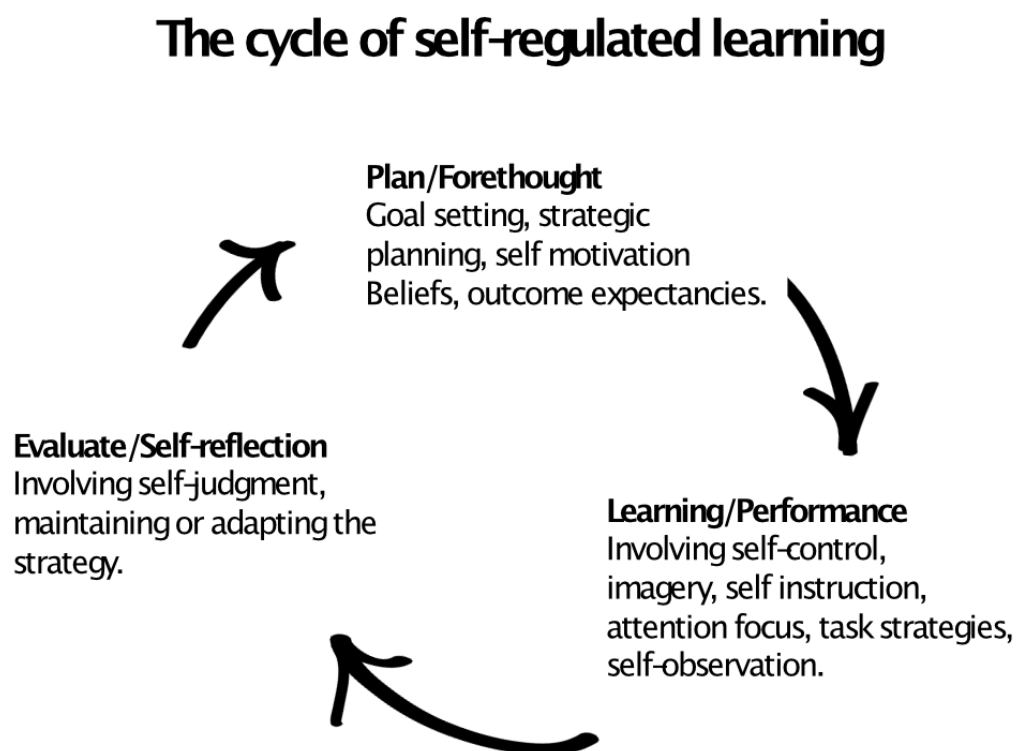
Students seemed to have a sense of their own level of ECG interpretation skills based on their past experiences from clinical rotations, old lecture notes, and more recent lectures during the course. The clinical rotations seemed to be an important opportunity for students to discover their actual levels of knowledge. On the basis of this, the students continued using the accessible learning resources to reach their learning goals. A majority of all the students were positive toward Web-based education in general as an on-demand resource. The users were positive to the Web-based ECG resource, which is in line with our previous results [17,18]. A quality measure and one of the factors that contributed to the decision to use the Web-based program was influence from fellow students who used the resource or if a teacher spoke positively about the program.

According to Illeris' learning model, all learning will always involve the 3 different perspectives: environment, content, and incentive [10], which is in line with our findings. However, the interviews show an emphasis on the *incentive* dimension in Illeris' learning model. The above-described interaction between the student, a fellow student, and/or the teacher in the decision-making process represents the *incentive* dimension interacting with the *environment* dimension. Being able to integrate various social influences from the environment may be an important ability in the process of self-regulated learning [16].

The students were active in constructing their own meanings and goals from various influences (clinical rotations and earlier experience of ECG examinations). The individuals were capable of monitoring and controlling various aspects of learning (from fellow students, teachers, and Web-based ECG). Individuals set goals for their learning and monitored the learning process toward these goals (clinical rotations and testing knowledge from old course examinations).

Winters et al emphasized the control of learning as an important factor for students in the context of computer-based learning [11]. The students presented evidence that different learner and task characteristics (eg, previous knowledge, goal orientation, and learner control) and types of learner support are related to self-regulated learning when using computer-based learning. Our results are in line with previous studies showing that higher abilities of self-regulated learning are linked to better academic performance [22,23], as students with higher scores on *self-regulation* had better results at the OSCE station, whereas students scoring high on *lack of regulation* had lower scores at the OSCE (Table 3).

**Figure 4.** The cycle of self-regulated learning adapted from Zimmerman [21]. The student's were active in constructing their own meanings and goals from various influences (clinical rotations and earlier experience of electrocardiogram [ECG] examinations). The individuals were capable of monitoring and controlling various aspects of learning (from fellow students, teachers, and the Web-based ECG). Individuals set goals for their learning, and monitored the learning process towards these goals (clinical rotations, testing knowledge from old course examinations).



However, the level of performance (high vs low) in these strategies did not influence the use of the Web-based ECG learning resource. There was no difference in OSCE results between groups of users and nonusers of the Web-based resource, which is in line with the pattern that emerged in the interviews, suggesting a process of self-regulated learning based on learning needs instead of preference for a certain learning strategy. Interview data showed that students do not seem to prioritize *overlearning* as a learning objective before the written general examination and the OSCE. Their goal in general was not to maximize knowledge but to pass the examinations. In Swedish medical education, there is only a pass/fail grade, which could possibly explain this pattern.

Our observed lack of correlation between the time using the system and the results at the OSCE test strengthens the findings from the interviews that students plan their own learning and decide what resources they should use for acquiring or refreshing skills in ECG interpretation. These findings also partly confirm data from a similar context in a blended learning situation in medical education. In a study of online volume training of interpreting ECG strips, there was no clear relation between the number of ECGs studied during the training period and marks obtained by medical students in the examination [24].

In a recent review, no single method or teaching format was considered more effective than the others in delivering ECG interpretation knowledge [8]. However, research considering self-studies in learning ECG interpretation shows contradictory results. In a controlled study, the authors found lower test results in the self-study group compared with other forms of study methods [25]. In contrast, Kopec et al found that ECG knowledge in students during the last year of medical education was superior in the student group who used self-studies to learn ECG. Our data suggest that in a realistic training situation, it is not the primary method of learning that is decisive but the ability to use available methods based on motivation. From this perspective, the findings from the study by Raupach et al become interesting. They found that the students' valuation of an assessment affected the gained knowledge more than the specific method itself [26].

### How the Students Used the Web-Based Electrocardiogram Learning Program

The differences in usage patterns of the Web resource were large, as illustrated by our log-file analysis. Users occasionally changed patterns of use after some time spent in the system. The main reason, according to the interviews, is lack of time. In a previous study, the choice to use the Web-based ECG

learning program was not related to individual learning styles [18].

Further research is needed to identify why students, from a self-regulating perspective, chose to use different parts of the Web-based learning content (text, pictures, and animation), self-assessment questions, and an interactive ECG interpretation training section. A better insight into students' general learning strategies and increased awareness of learners' specific needs of ECG skills can improve further design of blended ECG learning contexts.

### Limitations

There are 2 major limitations to this study. First, the OSCE test contained only 2 ECGs, so the ability to differentiate ECG knowledge was limited. Second, the students' activity in each part of the ECG program was measured through a learning management system. Although the system logged out when idle, we cannot know with certainty how active students were during training sessions in the program.

### Strengths of the Study

In this study, we used a mix of qualitative and quantitative methods to achieve a broader perspective and a nuanced picture. The interviews contributed depth and provided rationales for the students' choices and their strategies on how to use, or not use, the Web-based ECG program.

### Conclusions

A supplementary Web-based ECG resource contributes to student learning based on principles of self-regulated learning in which students make their decisions based on a multitude of factors. These factors include experiences during clinical rotations, former study experiences, and their individual strategy for regulating their learning. An overarching aspect of usage of the resource is the relation to individual learning goals and needs to pass the examination was the students' judgment of whether there was a need for a Web-based resource to achieve their learning goals. On the basis of individual variations, the usage patterns of ECG resources are not predictable. However, a better understanding of variations in regulating learning and perceived needs of ECG knowledge can improve the course design of blended learning ECG contexts for medical students.

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### Conflicts of Interest

MN is a shareholder in the company that has developed the Web-based ECG learning resource. There are no other conflicts of interest in relation to this manuscript.

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## Abbreviations

- ECG:** electrocardiogram  
**ILS:** Inventory of Learning Styles  
**IQR:** interquartile range  
**KI:** Karolinska Institutet  
**OSCE:** Objective Structured Clinical Examination

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Original Paper

# Media Use Among Students From Different Health Curricula: Survey Study

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## Abstract

**Background:** Mobile devices such as smartphones, tablets, and laptop computers enable users to search for information and communicate with others at any place and any time. Such devices are increasingly being used at universities for teaching and learning. The use of mobile devices by students depends, among others, on the individual media literacy level and the curricular framework.

**Objective:** The objective of this study was to explore whether there were differences in media use in students from various curricula at the Faculty of Health, Witten/Herdecke University.

**Methods:** During the 2015-16 winter term, a survey was conducted at the Faculty of Health, Witten/Herdecke University, in which a total of 705 students (out of 1091 students; response rate: 705/1091, 64.61%) from 4 schools participated voluntarily: medicine (346/598), dentistry (171/204), psychology (142/243), and nursing science (46/46). The questionnaire developed for the study included 132 questions on 4 topics: (1) electronic and mobile devices (19 questions), (2) communication and organization of learning (45 questions), (3) apps/programs/websites/media (34 questions), and (4) media literacy (34 questions). The questionnaire was distributed and anonymously completed during in-class courses.

**Results:** Students from all 4 schools had at least two electronic devices, with smartphones (97.4%, 687/705) and laptops (94.8%, 669/705) being the most common ones. Students agreed that electronic devices enabled them to effectively structure the learning process (mean 3.16, SD 0.62) and shared the opinion that university teaching should include imparting media literacy (mean 2.84, SD 0.84). Electronic device ownership was the highest among medical students (mean 2.68, SD 0.86) and medical students were the only ones to use a tutorial (36.1%, 125/346). Dental students most widely used text messages (mean 3.41, SD 0.49) and social media (mean 2.57, SD 1.10) to organize learning. Psychology students considered mobile devices to be most ineffective (mean 2.81, SD 0.83). Nursing science students used emails (mean 3.47, SD 0.73) and desktop computers (39%, 18/46) most widely.

**Conclusions:** The results show that almost all students use electronic learning (e-learning) tools. At the same time, different profiles for different degree programs become apparent, which are to be attributed to not only the varying curricula and courses but also to the life circumstances of different age groups. Universities should, therefore, pay attention to the diverse user patterns and media literacy levels of students when planning courses to enable successful use of e-learning methods.

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**KEYWORDS**

social media; medical education; computers; interprofessional relations; distance education; health occupations

## Introduction

### Background

The ubiquitous distribution of mobile devices and internet access support mobile learning as a new and global trend in education [1,2]. The use of mobile devices such as smartphones, tablets, and laptop computers for obtaining information and communicating course content enables users to learn at any place and time, in different contexts, various situations, and by interacting with others [3-5]. Mobile learning occurs when the learner is not at a permanent and fixed location or if he/she uses mobile technologies for learning [6]. In this context, mobility comprises 3 aspects: technology mobility, learners' mobility, and learning process mobility [7] and is thus understood as a part of electronic learning (e-learning).

By means of electronically arranged digital learning tools, course content is presented as multimedia content and thus supports interactive and self-directed learning [8,9]. This may take place within given instruction structures or in network structures for self-directed learning, such as virtual learning spaces and blended learning. Virtual learning spaces facilitate a physical separation between teachers and learners by means of the internet as a communication medium. Traditional lectures are combined with the advantages of e-learning [10]. Blended learning merges Web-based phases with in-class teaching and makes use of networking opportunities via the internet using conventional learning methods [11,12]. Modern learning environments and apps even allow the mobile use of virtual reality and augmented reality in medical learning [13].

The use of mobile devices in teaching and learning, however, also gives rise to controversy as, in addition to its advantages, it may also involve disruptive components, such as distraction, mingling of private and professional matters, inadequate technologies, students owning different equipment, or cognitive overload of users [14-16]. Some lecturers recoiled from the effort and the creation of learning apps or believed that computers and the internet were sources of distraction, which disrupted teaching and learning and thus impaired the understanding of the subject matter [17-19]. Most commonly, however, the reason for problems in technology-enhanced learning is inadequate didactics [20]. Educational challenges to be met are the adaptation of instruction type and content, as well as a joint creation of learning tools by teachers and students according to the students' learning levels [21,22]. Sustainable embedding of digital learning elements in higher education teaching, therefore, requires also the development of teachers' digital literacy, as well as an adapted and innovative culture of teaching and learning [23-25].

### Objective

Given the fact that Witten/Herdecke University (UW/H) strives to break new educational ground and provide impetus for research-based development of teaching and learning [26], this study aims to cast a glance at the status quo regarding the equipment and digital media learning at the Faculty of Health. While being the only university in the German-speaking region with a Faculty of Health comprising the 4 schools of medicine, dentistry, psychology, and nursing science, UW/H places special

emphasis on interprofessional education when designing the curricula of the individual degree programs. To facilitate digitally supported interprofessional education, students were surveyed to identify similarities and differences between the individual disciplines with respect to media use and develop profiles of the respective schools and curricula.

## Methods

The Ethics Committee of UW/H voted in favor of the concept of this study (application number: 144/2015).

### Study Design and Participants

The cross-sectional study was conducted at UW/H at the beginning of the 2015-16 winter term at the Faculty of Health, which comprises the 4 schools of medicine, dentistry, psychology, and nursing science. The questionnaires were distributed to the students in the schools at different times, with the aim of generating the greatest possible response rate: medicine and psychology during the compulsory progress test and dentistry and nursing science during course-specific compulsory courses. Students completed the questionnaire voluntarily and anonymously during in-class courses. No other personal data other than the degree program, gender, and age group were collected to avoid reidentifiability of individuals, which would otherwise have been possible because of the small cohorts per semester (medicine: 42 students, dentistry: 44 students, psychology: 35 students, and nursing science: 15 students) and the family study situation at the UW/H with learning in small groups.

Of the 1091 students of the Faculty of Health, 705 students completed the questionnaire (medicine: 346/598, dentistry: 171/204, psychology: 142/243, and nursing science: 46/46; total response rate of 65% students); 20 incomplete questionnaires were excluded. There were significant differences regarding the gender ratio ( $\chi^2_3=30.4$ ;  $P<.001$ ) between the schools. Most students at the school of nursing science were women (>90%, 42/46), whereas the schools of medicine and dentistry had the largest share of men, with more than 40% each (137/346 and 72/171, respectively). Schools also differed significantly regarding the age groups ( $\chi^2_{12}=438.1$ ;  $P<.001$ ). Although more than half of the medical, dental, and psychology students interviewed were aged between 21 and 25 years, more than 90% (43/46) of the nursing science students were aged >26 years. More than 90.8% (129/142) of the psychology students were aged <25 years.

### Questionnaire Development

A questionnaire was developed to answer the research questions. The questionnaire was compiled in a multiple-sample process based on the literature, brainstorming sessions, and discussions, as well as results and experiences from a pilot study of mobile learning at UW/H in the 2015 summer term. Semistructured, personal-expert interviews were conducted until saturation of categories was reached with 10 psychology and 8 medical students. Results of content analysis made it clear that e-learning media were used (ie, computers, smartphones, and apps). On the basis of these results in this study, the research question is



being extended to learning with digital media. The developed questionnaire included open and closed questions (4-point Likert scale from 1=no, not at all to 4=yes, absolutely) on the following topics: (1) electronic and mobile devices, with 19 questions on the possession of devices and their use in everyday life, (2) communication and the way learning is organized, with 45 questions on the search for information and the organization of learning, (3) apps/programs/websites/media, with 34 questions on the apps used, and (4) media literacy, with 34 questions on students' assessment of whether they consider mobile learning as impeding or useful.

The focus of this study was on the topics (2) communication and learning organization and (4) media literacy, here, especially the evaluation of UW/H duties. Both scales show a very good internal consistency with Cronbach alpha of .926 for communication and learning organization and .869 for media literacy.

### Statistical Analysis

The data were analyzed first by descriptive statistics (means and standard deviations) using the SPSS software package (Statistical Package for the Social Sciences, version 24 for Windows, IBM Corporation). Nonparametric group comparisons between the schools were carried out using the chi-square test in case of categorical response formats and the Kruskal-Wallis test for several independent groups in case of 4-point scale formats. Results were considered significant with an error probability of 5% ( $P < .05$ ). Effect sizes (Cohen *d*) were calculated on the Web [27] and interpreted as small (0.20), medium (0.50), or large (0.80) [28].

## Results

### Similarities Between the Schools of the Faculty of Health

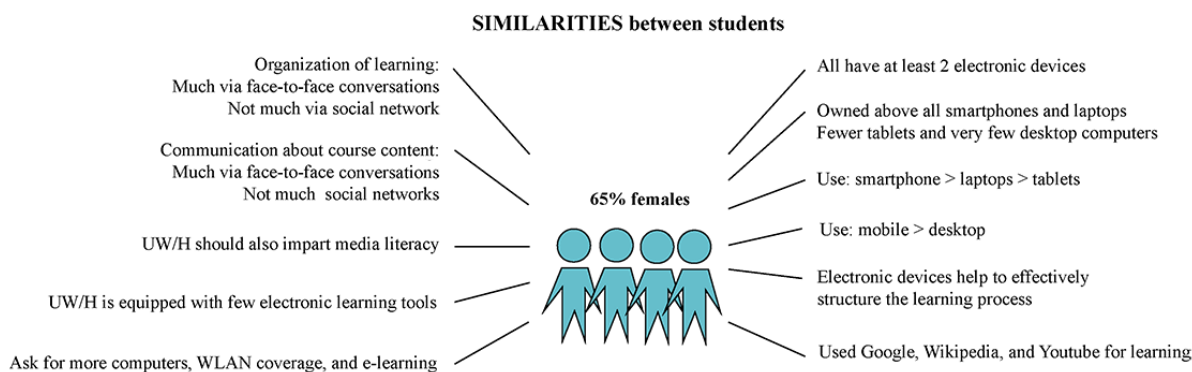
Students from the various schools showed some similarities, as shown in Figure 1. Students of all 4 schools owned at least 2 electronic devices on average; smartphones (97.4%, 687/705) and laptop computers (94.8%, 669/705) in particular were most

common. Fewer students had tablet computers (45.9%, 324/705), and very few still owned desktop computers (16.0%, 113/705). All agreed that electronic devices help to effectively structure the learning process (mean 3.16, SD 0.62; range 1=no, not at all to 4=yes, absolutely). Students used mobile devices to look up and search for information (mean 3.18, SD 0.68), as well as Google, Wikipedia, YouTube, PubMed, and DocCheck. Mobile devices were less frequently used for organizing the learning process (mean 2.63, SD 0.94) and communicating about the course content (mean 2.54, SD 0.88). The same applies to social networks regarding organization (mean 2.17, SD 1.14) and communication (mean 1.95, SD 1.07). Face-to-face conversations were preferred most by the students for organization (mean 3.39, SD 0.82) and communication (mean 3.81, SD 0.48). Students from all schools shared the opinion that teaching at UW/H should also comprise imparting media literacy (mean 2.84, SD 0.84). However, there was, above all, a shortage of computers ( $n=58$  of a total of 171 mentions), wireless local area network coverage ( $n=28$ ), and e-learning courses ( $n=103$ ).

### Differences Between the Schools of the Faculty of Health

Despite these similarities, however, there were also significant differences between students from different schools. These differences are elaborated in the form of profiles and demonstrated in Figures 2-5. Medical students owned the most electronic devices (mean 2.68, SD 0.86; range 1=no, not at all to 4=yes, absolutely), had the most tablet computers (52.8%, 183/346), and used them most frequently (mean 2.55, SD 1.24). Medical students were the only ones to use a uniform learning program called Amboss (36.1%, 125/346). They most clearly felt that mobile learning contributes to successful learning (mean 3.14, SD 0.77). Together with the dental students, they least agreed that UW/H is sufficiently equipped with electronic devices (mean 2.06, SD 0.81). Medical students participated the most in answering the question on what is missing at UW/H (88/346, 25.4%) and mentioned, above all, apps and access, in particular to the Amboss learning software (23/346, 6.6%), in addition to computers and e-learning.

**Figure 1.** Similarities between students from all 4 schools of the Faculty of Health regarding their media use ( $n=705$ ). UW/H: Witten/Herdecke University; WLAN: wireless local area network.



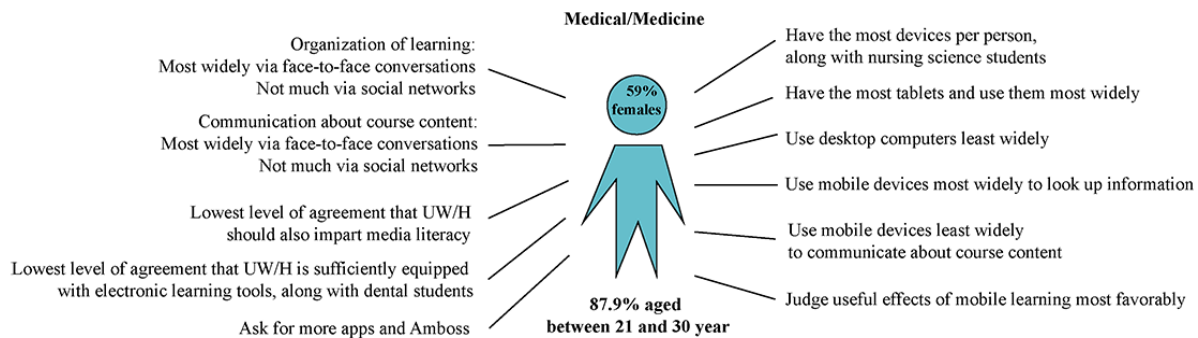
All *dental students* had at least one smartphone and used it most often (mean 3.94, SD 0.25). They used mobile devices most frequently to search for and look up information (mean 3.27, SD 0.81), organize learning (mean 2.96, SD 1.12), and communicate about course content (mean 2.77, SD 0.84). Dental students were the only ones to mention the UW/H learning platform Moodle. Compared with the other schools, they used text messages (mean 3.41, SD 0.49) and social networks (mean 2.57, SD 1.10) most widely to organize learning. Along with psychology students, they showed the highest level of agreement that mobile devices distracted from learning (mean 2.77, SD 0.94). They asked for more databases (11/171, 6.4%) and mobile devices (8/171, 4.6%).

*Psychology students* had the least devices (mean 2.42, SD 0.75) and used them least widely in everyday life (mean 3.20, SD 0.56). They had the lowest share of tablets (23.2%, 33/142) and showed the lowest level of agreement about using mobile devices to search for and look up information (mean 2.89, SD 0.63) and organize learning (mean 2.43, SD 0.74). Very few

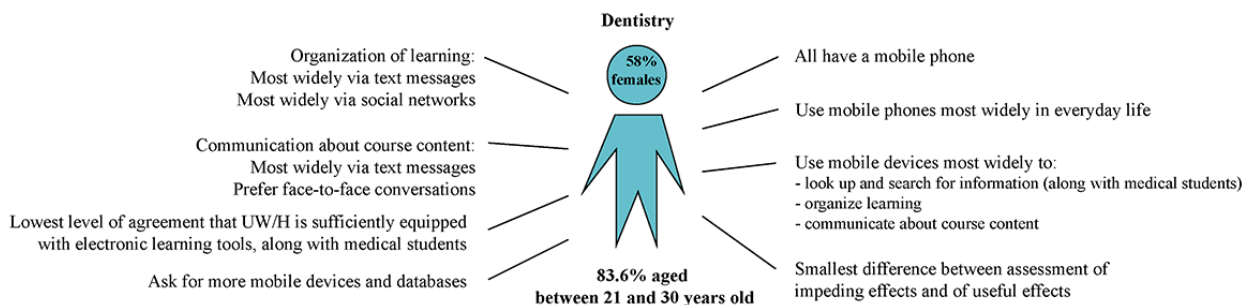
thought that electronic devices support the learning process (mean 2.81, SD 0.83). Along with nursing science students, psychology students rated the contribution of mobile learning to successful learning as the lowest (mean 2.71, SD 0.72). They showed the highest level of agreement that UW/H is sufficiently equipped with electronic devices (mean 2.57, SD 0.80).

*Nursing science students* owned, along with medical students, the most devices per person (mean 2.67, SD 1.01). They had the most desktop computers (39%, 18/46) and used them most widely in everyday life (mean 2.06, SD 1.29). They showed the highest level of agreement that electronic devices support the learning process (mean 3.17, SD 0.95), and most of them shared the opinion that UW/H should also impart media literacy (mean 3.33, SD 0.69). Nursing science students used emails most widely for organization purposes (mean 3.47, SD 0.73) and communication about course content (mean 3.18, SD 0.96). They used social networks least widely for organization (mean 1.32, SD 0.84) and communication purposes (mean 1.19, SD 0.70).

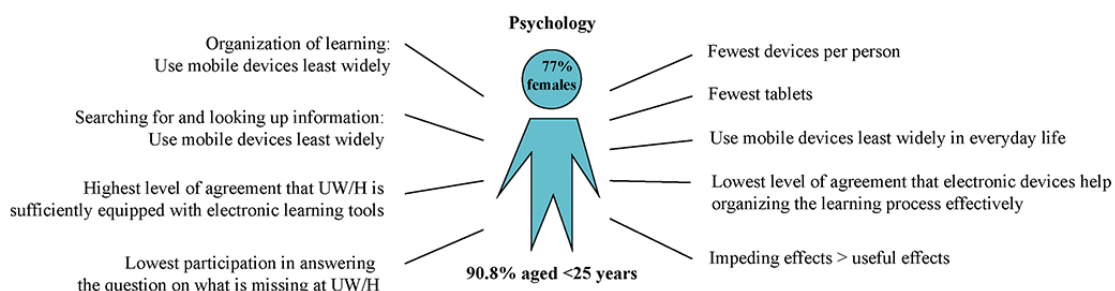
**Figure 2.** Media use characteristics of students from the School of Medicine, Faculty of Health (n=346). UW/H: Witten/Herdecke University.



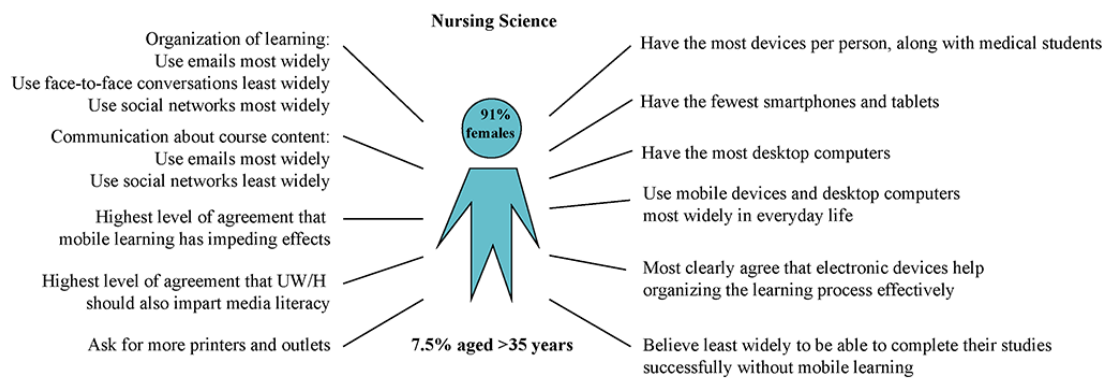
**Figure 3.** Media use characteristics of students from the School of Dentistry, Faculty of Health (n=171). UW/H: Witten/Herdecke University.



**Figure 4.** Media use characteristics of students from the School of Psychology and Psychotherapy, Faculty of Health (n=142). UW/H: Witten/Herdecke University.



**Figure 5.** Media use characteristics of students from the School of Nursing Science, Faculty of Health (n=46). UW/H: Witten/Herdecke University.



**Communication and Learning Organization Such as Media Literacy**

A direct comparison of the 4 schools showed some differences in the 2 considering scales of the questionnaire (see Table 1). The 4 categories of the scale Communication and Learning (CL), based on 3 items each, are as follows: CL learning, for example, “ Electronic devices help me to make my learning process more effective.”; CL organization, for example, “I use the devices to organize my studies.”; CL communication, for example, “ I use the devices to communicate and discuss learning content with others . ”; and CL information, for example, “I use devices to look up and search for information for my studies.” The difference with the largest effect size is clear for CL learning. For CL organization and CL

communication there are only weak effect sizes, and the results for CL information do not differ between the schools. There are 2 categories of the scale Media Literacy (ML): ML positive with 8 items, for example, “I think electronic learning on mobile devices foster the learning success.” and ML negative with 10 items, for example, “Electronic learning on mobile devices is rather inhibitive.” Both categories of the scale ML show slight differences between the schools with weak effect sizes. Comparisons concerning the UW/H equipment (“The UW/H is sufficiently equipped with electronic learning media.”), media literacy (“The University teaching at the UW/H should, therefore, provide the mediation of media literacy.”), and lecturers (“I was helped handling mobile devices by my lecturers.”) resulted in slight differences with weak effect sizes, too.

**Table 1.** Differences between students from all 4 schools of the Faculty of Health regarding their media use.

Scales	Medicine, mean (SD)	Dentistry, mean (SD)	Psychology, mean (SD)	Nursing science, mean (SD)	Chi-square value (df)	P value	Cohen d
CL <sup>a</sup> learning	1.96 (1.04)	1.40 (0.72)	1.19 (0.53)	1.33 (0.73)	88.4 (3)	<.001	0.747
CL information	3.16 (0.60)	3.11 (0.59)	2.88 (0.48)	2.86 (0.69)	4 (3)	.26	0.076
CL organization	2.49 (0.78)	2.61 (0.69)	2.46 (0.57)	2.51 (0.69)	30.3 (3)	<.001	0.403
CL communication	2.20 (0.87)	2.53 (0.70)	2.39 (0.59)	2.37 (0.83)	21.6 (3)	<.001	0.330
ML <sup>b</sup> positive	2.50 (0.51)	2.46 (0.47)	2.24 (0.68)	2.23 (0.60)	25.9 (3)	<.001	0.367
ML negative	2.73 (0.57)	2.54 (0.58)	2.50 (0.60)	2.74 (0.70)	20.6 (3)	<.001	0.321
UW/H <sup>c</sup> equipment	2.06 (0.81)	2.04 (0.70)	2.57 (0.80)	2.15 (0.73)	31.3 (3)	<.001	0.410
UW/H media literacy	2.74 (0.85)	2.99 (0.79)	2.75 (0.84)	3.33 (0.69)	26.1 (3)	<.001	0.369
UW/H lectures	1.33 (0.64)	1.27 (0.56)	1.43 (0.76)	1.83 (1.12)	10.4 (3)	.02	0.206

<sup>a</sup>CL: Communication and Learning.

<sup>b</sup>ML: Media Literacy.

<sup>c</sup>UW/H: Witten/Herdecke University.

**Discussion**

**Summary**

The objective of the study was to identify differences in media use between different curricula at the Faculty of Health, UW/H.

Our findings describe profiles that show that the students of medicine, dentistry, psychology, and nursing science clearly differ in media literacy and user behavior. All had in common that media literacy was not, or rarely, taught by the UW/H lectures. For successful use of electronic devices, the faculty

has to take into account that participants of interprofessional groups may differ in media affinity and media literacy when implementing mobile learning. This may be considered disadvantageous with respect to initial training and coordination, regarding peer-to-peer learning; however, it can also be seen as an advantage, if this challenge of developing professionalism in compliance with one's own Web privacy and that of patients is accepted by the students and faculty together. Therefore, the following guiding principle has been defined: *Know your students, use their skills, and guide their way* [29].

### Principal Findings

Medical students generally have a wide range of mobile devices [30]. Among the students of the Faculty of Health of UW/H, mobile devices were more common than at other universities, for example, at the Faculty of Medicine of the University of Münster [31] or students of Polytechnic State University of California [15]. This may be explained, on the one hand, by the rapid progress of media use and, on the other, by differences in income. For young people with a formal higher background, the internet is a much more important research and information medium that they use more frequently and more extensively for information search than people with low socioeconomic status [32]. UW/H is a private university and thus charges tuition fees that are rather high compared with other German universities, so that a relatively high socioeconomic status of the students can be assumed.

Many similarities between students became apparent. All mobile devices have been used in everyday life and for learning purposes, especially for looking up and quickly searching for information because clear information is easier to communicate through digital media [33]. To an extent comparable with that of the students at the University of Münster [31] and the University of California [30] and adolescents of the JIM study [32], UW/H students primarily used Google as an internet search engine to obtain information. YouTube played an important and Wikipedia played an even more increasingly important role in learning [34]. When students get the opportunity to learn how to use the technology, mobile devices and apps can be conducive to learning and improve learning [35]. However, lecturers should also be supported in the development of media literacy, so that they have the digital skills and abilities required to provide appropriate learning materials and tailor their courses to them [5,36,37]. The imparting of media literacy by the lecturers and the faculty is an important wish of the UW/H students, too.

There was less agreement about the use of mobile devices for organizational purposes in learning contexts. For these purposes, students most often preferred face-to-face conversations, despite the fact that a central digital program is available for organizing their studies [38]. However, the small number of students admitted per term, the course format (small group teaching and problem-based learning), and the favorable student-teacher ratio encourage students to organize learning via face-to-face conversations. Lessons and content that require interpretation and discussion, and that may also be ambiguous, cannot be communicated as effectively through mobile media as through traditional face-to-face contact [33]. When this study was conducted during the 2015-16 winter term, the UW/H Faculty

of Health comprised 38 lecturers, 150 research assistants, and 341 contract lecturers for 1091 students [39].

There were significant differences with small effect sizes between students from the schools of medicine, dentistry, psychology, and nursing science of the Faculty of Health, which have to be discussed in the context of age and study conditions.

Medical students most frequently use mobile devices to search for and look up information and believe that mobile learning is crucial to their learning success. More than one-third of students already use the Amboss learning program, and one-quarter would like UW/H to provide the program. Dental students in particular used mobile learning most frequently to communicate about course content via text messages and organize learning. According to Walsh [25], students are increasingly expecting that all e-learning services will work well on mobile devices. The frequent use and handling of the mobile devices and programs, thereby, creates an awareness of their advantages and disadvantages and trains the use of technology [35]. Accordingly, the best-equipped students of medicine in this study wished the least for impairment of media literacy.

Psychology students were the youngest students within the cohort and used mobile devices least often in their everyday life and for learning. Nursing science students pursue a degree program for working professionals; hence, they are older than students from the other 3 schools and are, therefore, no digital natives [40,41]. Both studies have in common the large proportion of women with a known gender effect on the use of mobile devices [37]. In addition, it is generally assumed that today's students, because of their young age in information technology (IT), have much more experience and are better educated than former students and faculty members aged >40 years [37]. However, this is a fallacy, as today's students recognize their need for advanced IT skills and want to learn the skills needed for the digital age [42], as shown in this sample.

### Limitations

On the basis of a response rate of 64.61% (705/1091) with a gender ratio comparable with the total student sample, the authors assume that the findings are representative for the Faculty of Health, UW/H. Unfortunately, no additional information on the student semester could be given to look at any differences between undergraduate and postgraduate students. In combination with the person variables age and gender, it would, otherwise, be possible to reidentify individuals, because of the small cohorts per semester. However, this study's findings cannot be generalized easily as the cohort surveyed was very small, and the curricular offers correspond to those of a university with model curricula.

### Conclusions

Mobile learning is being applied at UW/H. Electronic devices, mobile devices in particular, are very popular among the Faculty of Health students and used for learning purposes. Since 2015, the recommendations for existing e-learning modules are collected and evaluated by lecturers and made available [43]. Thus, in addition to self-directed learning, confidence in the reliability of Web-based materials is promoted [44]. However,

it has just turned into an integral part of studies, with the introduction of a new model curriculum. The conditions for expanding digital education at UW/H are favorable as, for example, 1 of the foci of the new medicine model curriculum (as of the 2018-19 winter term) is on digital medicine. In addition, the university offers the new master's degree program Digital Transformation and Social Responsibility (Master of Arts). Regular public events on digitization (called *Digitaler Salon*) have taken place since 2016, as well as a cross-faculty

course for imparting digital literacy [45]. Synchronous interaction with one another and face-to-face conversations are still the most important for learning, owing, on the one hand, to the student-teacher ratio and, on the other hand, to Humboldt educational concept being implemented at UW/H. In this respect, too, student digital helpers are increasingly being used for organization and implementation with the aid of a university's most important resource: its students!

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## Conflicts of Interest

None declared.

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**Abbreviations**

**CL:** Communication and Learning  
**e-learning:** electronic learning  
**IT:** information technology  
**ML:** Media Literacy  
**UW/H:** Witten/Herdecke University

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Original Paper

# Students' Experiences of Seeking Web-Based Animal Health Information at the Ontario Veterinary College: Exploratory Qualitative Study

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## Abstract

**Background:** Although searching for health information on the internet has offered clear benefits of rapid access to information for seekers such as patients, medical practitioners, and students, detrimental effects on seekers' experiences have also been documented. Health information overload is one such side effect, where an information seeker receives excessive volumes of potentially useful health-related messages that cannot be processed in a timely manner. This phenomenon has been documented among medical professionals, with consequences that include impacts on patient care. Presently, the use of the internet for health-related information, and particularly animal health information, in veterinary students has received far less research attention.

**Objective:** The purpose of this study was to explore veterinary students' internet search experiences to understand how students perceived the nature of Web-based information and how these perceptions influence their information management.

**Methods:** For this qualitative exploratory study, 5 separate focus groups and a single interview were conducted between June and October 2016 with a sample of 21 veterinary students in Ontario, Canada.

**Results:** Thematic analysis of focus group transcripts demonstrated one overarching theme, *The Overwhelming Nature of the Internet*, depicted by two subthemes: *Volume and Type of Web-based Health Information* and *Processing, Managing, and Evaluating Information*.

**Conclusions:** Integrating electronic health information literacy training into human health sciences students' training has shown to have positive effects on information management skills. Given a recent Association of American Veterinary Medical Colleges report that considers health literacy as a professional competency, results of this study point to a direction for future research and for institutions to contemplate integrating information literacy skills in veterinary curricula. Specifically, we propose that the information literacy skills should include knowledge about access, retrieval, evaluation, and timely application of Web-based information.

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**KEYWORDS**

veterinary education; internet; computer literacy; focus groups; perception



## Introduction

### Seeking Health Information on the Internet

The phenomenon of health care consumers searching for health or medical information on the internet has been widely documented in the academic literature [1-3]. Furthermore, students enrolled in health care programs (eg, medicine, nursing, and dentistry) have been investigated extensively and are reported to use the internet for health-related information [4-6], for supporting their learning in junior years [7], and to help with their understanding of content during senior clinical years [8]. Presently, the use of the internet for health-related information, and particularly animal health information, in veterinary students has received far less research attention [9]. As a recent report from the Association of American Veterinary Medical Colleges (AAVMC) considers health literacy a professional competency [10], exploring students' internet search experiences for animal health information may offer deeper insight about students' digital health literacy.

### Health Information Overload

Although searching for health information on the internet has offered clear benefits of rapid access to information for seekers such as patients [11], medical practitioners [12], and medical students [13], detrimental effects on seekers' experiences have also been documented [14]. One example of a negative outcome associated with Web-based health information seeking is so-called *cyberchondria* [15,16], where Web-based information seekers are reported to become overly concerned and anxious about their health signs and symptoms, and subsequently experience health information overload (HIO) [17-19].

Information overload (IO) involves having "access to more useful information than can be processed in a useful way" (p. 266) [20]. Similarly, HIO describes the phenomenon that occurs when an individual receives excessive amount of health-related messages such that potentially useful content becomes a burden rather than beneficial to the recipient [21]. Some researchers suggest that the internet is a major contributor to HIO in today's society [14] with implications of potentially undesirable outcomes for information seekers [22]. For example, information seekers with HIO may develop a long-term unwillingness to seek information online, feel reluctant to further develop Web-based information search skills [23], or develop psychological effects such as anxiety [24,25].

Multiple studies suggest that HIO may be related to seeker health information literacy (HIL) [21,26]. HIL is defined as the degree to which individuals can obtain, process, understand, and communicate about health-related information needed to make informed health decisions [18,27]. HIL pertaining to health content delivered by means of the internet is termed electronic health information literacy (EHIL) [28,29]. Research suggests that academic institutions include EHIL training within their health care programs to address HIO potentiated by the internet [30].

HIO has been documented among human health care professionals [30,31], with potential impacts on patient care [32]. For example, Singh et al [33] reported physicians missing

or overlooking patient test results as a consequence of being overloaded by a continual stream of information from internet-based electronic health records (EHRs). EHRs contain vast amount of medical content about individuals or populations, retrievable to stakeholders such as medical patients and providers [34]. The internet also contains other types of digital medical content accessible to health care professionals that are often used for training and educational purposes. Some researchers argue that students training in health care professions are also at risk of HIO [35]. Further supporting this concern are results from a survey of medical students [36], where 91% of the 100 respondents reported feeling overloaded by medical information. In addition, the same surveyed students indicated that they felt medical IO caused over 80% of their stress.

Stress among medical students has been well documented [37]. Similarly, stress, mental health, wellness, and their respective relationships to student life among veterinary students have also received research attention [38-43]. One qualitative study reported that upper-year Australian veterinary students' primary source of stress came from IO [41], although information from the internet was not explicitly mentioned. Given that veterinary students today have ready access to the internet for animal health information [44], similar to their medical counterparts, veterinary students may also be at risk of HIO. Previous research shows that vast volumes of information may be a predisposing factor to HIO for postsecondary students with internet access [45] and potentially for veterinary students who reported searching for content using Google to support their studies [44]. Further research indicates that some veterinary students report their training as a chronic stressor [38], which Laakonen and Nevgi [39] suggest may arise from academic demands such as the overwhelming volumes of information students are expected to learn and assimilate. Moreover, HIO may negatively impact student learning as some researchers speculate IO reduces learners' ability to process information, especially at a deep level [46].

To understand the effects of using Web-based health information, and the potential for HIO, one must first understand students' experiences. The purpose of this study was to explore veterinary students' Web-based animal health information search experiences. Specifically, we wanted to investigate how students perceived the nature of information generated from internet searches and how these perceptions influence students' management of Web-based information.

## Methods

### Study Design and Participants

This exploratory qualitative study involved a series of 6 interviews with students enrolled in the 4-year Doctor of Veterinary Medicine program at the Ontario Veterinary College in Guelph, Ontario, Canada. All focus groups were conducted between July and September 2016. The study protocol was approved by the University of Guelph Research Ethics Board (REB #016AP002).

A total of 21 students were interviewed in 5 separate focus groups and a single individual interview. The mean number of

participants for each focus group was 4 (range 3-5). Each focus group discussion ranged from 60 to 90 min. Students' ages ranged from 21 to 34 years (median=23 years); 20 (95.2%) were female. At the time of data collection, participating students were enrolled in years 1 to 4 of the Doctor of Veterinary Medicine program.

### Recruitment

All student participants were recruited using an electronic mail listserv, physical posters displayed on bulletin boards located within school buildings, and snowball sampling. Snowball sampling involved requesting students to recommend peers or acquaintances who may also qualify for participation [47]. Students were informed of the study purpose and format and were offered an honorarium (\$10 CAD gift card) and meal for participating. All participants were informed as to the risks, benefits, and repercussions of their involvement in the study, and accordingly consented to their involvement before the start of each focus group discussion.

### Data Collection

At the students' convenience, interviews took place at the Ontario Veterinary College and followed a semistructured question guide (Multimedia Appendix 1) developed by the first and second authors to discuss the topics of: most recent internet searches for animal health information; internet resources accessed for investigating animal health information; challenges experienced when searching for animal health information on the internet; methods used by students for evaluating quality and validity of internet-based animal health information; and opinions about animal health information on the internet. Focus group questions were open-ended and designed to stimulate discourse among students. Before data collection, the question guide had been assessed using a pilot focus group consisting of a convenience sample of 3 graduate students at the University of Guelph.

Discussions between participants allowed the moderator (first author) to explore a range of perspectives and shared practices among students involving Web-based searches for animal health information. Data saturation [48] was achieved by the 6th interview as few insights emerge beyond 20 participants [49].

Field notes documenting observations and nonverbal behaviors were taken by the moderator during all focus group discussions. All discussions were audio recorded, transcribed verbatim, and deidentified to ensure that transcribed material could not be linked to individuals. Individual speakers were identified as S#####. The prefix S indicates the speaker was a student, and ##### consists of a unique number assigned to the student. Participants completed a short demographic questionnaire post interview to collect data on gender and age to describe the study population.

### Data Analysis

All transcripts were systematically checked against the audio recordings for accuracy of representation by the first author. The computer software QSR NVivo 11 was used to facilitate organization of transcripts for thematic analysis [50]. In brief, each transcript was read multiple times to facilitate

familiarization of the data, and open codes were applied to sections of text illustrating common ideas across different student focus groups. Common codes occurring across groups were then organized into themes and subthemes and described in a codebook (Multimedia Appendix 2). The themes were then systematically reviewed, named, and defined. For consistency and clarity, naming and defining themes and subthemes were reviewed and cross-checked with codes by the second author. Any inconsistencies were discussed and resolved between the first and second authors. The third and fourth authors were responsible for approving the themes finalized by the first and second authors. Demographic data were analyzed using descriptive statistics (eg, means, median, and proportions) using Microsoft Excel.

## Results

### Theme: The Overwhelming Nature of the Internet

#### Subtheme: Volume and Type of Web-Based Health Information

A general perspective shared by students about seeking animal health information on the internet pertained to the volume of content they had encountered from past searches:

*There's just too much (information) out there.* [S1453]

Another student declared:

*If I'm looking I sometimes get overwhelmed by the amount of information that is out there.* [S1660]

The students' views about the overwhelming nature of animal health information online appeared to be related to the students' search behaviors such as why they needed information.

#### Seeking Companion Animal Health Information

Expectedly, students searched on the internet because of concerns or questions about their personal companion animals' health. These experiences reflect the students' comments about being overwhelmed by large quantities of animal health information on the internet, as depicted by one participant:

*[My search results] would list a whole bunch of symptoms that overlap with so many things. So, then you're like my pet has this, and this, and this because everything kind of overlaps...so you're not actually sure.* [S1350]

This statement also illuminated that amassing large volumes of content from the internet may confuse students.

#### Building Background Knowledge

Another reason driving students to the internet involved searching for foundational knowledge requiring exploration or understanding:

*It's a quick way to have a bit of a reference guide, or just background information on a topic that you've got no clue about.* [S1658]

Despite the speed with which foundational information could be retrieved, students agreed this increased the volume of

content they needed to manage. This was best exemplified by one student's comments:

*Sometimes when we're learning these new things...I don't think it's beneficial having all the resources...because there is so much more behind it that maybe we don't understand...we have an end point but there's so much back research behind it that you...need to know to understand and be able to explain the disease and why it happens. But you don't have enough time to approach that. [S1245]*

This comment accentuated the problem of the internet facilitating students' roundabout research efforts in navigating vast amounts of information because they felt that they *need to know to understand*. Similar to road traffic travelling through a circular intersection, students appeared to meander continuously in circles on the internet. These roundabout searches began with students gathering information to enhance their understanding, but the information collected also contained other ideas students were unfamiliar with. In attempting to clarify these other ideas, the students would then search for additional information. Ultimately, the students appeared to find themselves in a continuous research cycle that seemed to carry on infinitely, best described by one student:

*It's...an endless black hole of information that you can find out there. [S1660]*

Another student reported experiencing similar difficulties which began from being unable to recall the exact terminology depicting the desired information, owing to the limitations of previous knowledge:

*You can't find the original thing that the teachers threw out in class and you're like I really want this...but you don't remember how to write it and you look it up...and you can't find anything that helps support what you're trying to find. [S1244]*

### **Searching for Veterinary Information via Google**

How students searched for information appeared to contribute to the students' perceptions about large quantities of Web-based contents being overwhelming. In particular, almost all participants referenced using the Google search engine:

*I'll admit I started with a Google search on (a subject) and then weeded through the websites I thought seemed more legitimate. [S0628]*

Google searches also occurred within more specific settings such as during classes:

*If...a professor says a word you don't understand you can quickly Google the definition. [S1660]*

However, students quickly recognized multiple undesired consequence of searching on Google while attending lectures, as depicted by the following account:

*I found so many really deep histo(logy) things...that doesn't help. I found things that were basically just what (the professor) said on the slide and that doesn't help either. I know the part I want is one step further but not five steps further... I couldn't find something*

*that was in-between to my own understanding. [S1352]*

As this participant's words indicate, students were not only concerned about the volume of information Google may retrieve from the internet but were also encountering challenges in finding relevant information that correlated with what they required to enhance their understanding of a subject. However, students often found content appearing to contain levels of detail beyond what was needed for their stage of understanding.

Similarly, students recognized an undesired consequence of using Google to retrieve information:

*[I] have a hard time narrowing down what you actually need to know and learn at this point. [S1660]*

Another participant shared a related belief, expressing the desire:

*To know how to limit down the search to find exactly what you want. [S1244]*

Students clearly expressed a sense of being overwhelmed by the quantity of information generated by a Google search, and also shared experiences of frustration because the volumes of information generated was deemed irrelevant to their needs.

Beyond the Google search engine, students offered reasons as to why they may feel overwhelmed by the volume of information generated by a Web-based search, for example:

*I think just some part of human nature...if you have a question you want the answer. And you don't necessarily always want to sift through details. [S1661]*

Correspondingly, students unanimously expressed the desire to get immediate answers in a simple form rather than having to dig deeper through large volumes of detailed information.

### **Subtheme: Processing, Managing, and Evaluating Information**

Related to students' descriptions and efforts of acquiring large volumes of information, students across focus groups appeared weary when describing the need to further process their search results. One student specified that textual Web-based information presented personal challenges for the following reason:

*I can only seriously read for so long and it's just too much. [S1246]*

Similarly, a fellow student stated the following:

*I have a really hard time looking at pages and pages of words. [S1661]*

Still another student shared experiences about encountering large volumes of text-based information on the internet, mentioning a specific medium:

*Forums...I don't like them at all. I try to stay away from forums...the thought for me reading through blog post upon blog post...I find maybe one word that will lead me to something else...just...really tedious. I find that...frustrating. [S1245]*

Another aspect students presented about their frustrations with internet content involved managing conflicting information, as demonstrated by one individual describing his search experience:

*I would just go to the search bar, type in...eosinophilic granuloma complex, hit enter and then look at all these message board posts, which you spend hours ciphering through. Some people say treat with this, some people say treat with that. It's just—it's frustrating. [S1557]*

The apparent frustration expressed by students seemed related to becoming confused by Web-based content, which added another level of cognitive effort. This was depicted by one student's comments:

*Something like PetMD. Sometimes they can give you potential diagnoses...is this really reliable because it really fits all the symptoms that we were talking about? Or is it that...I'm just getting ahead of myself and it is listing a bunch of other things that it could be, that it really is? [S1349]*

### **Assessing Information Reliability**

The student's comment indicated that a large part of processing internet content entailed students evaluating information reliability.

Information processing and evaluation often involved students comparing internet information with their existing knowledge. For example:

*I use my own background knowledge to decide whether...to read through it. And say...this sounds like a good information. [S1661]*

Using existing knowledge to compare against information found online appeared to be a common strategy among participants for discerning accuracy and validity of the information, as indicated by another student:

*My roommate and I were finishing up a POD (Principles of Disease) assignment so we were looking up, we're trying to differentiate between primary and secondary hemostasis and coagulation factors and stuff involved...things like that, where...I've learned it, and I have...a little bit of knowledge on it so I can...use that to help me guide whether or not...it's truthful or not on the Internet. [S1453]*

This same student further explained her information assessment strategies:

*It seemed to be the most reliable information just based on what knowledge I have already. It seemed relatively consistent with what we're learning in therio(genology). And what I know just from past experience. [S1453]*

When the moderator asked the same student to describe her process referring to past experiences, the student further elaborated as follows:

*I've worked for 4 years in a small animal practice, I volunteered for two years at large animal practices and I volunteered for five years at another small*

*animal practice. Just comparing...cases we've seen at work...the outcome of the cases and the treatment protocol... then comparing that to what the forums and the websites would say. [S1453]*

Other students spoke about utilizing a similar strategy, where they referred to cases they had encountered in the past for assessing the legitimacy of content or claims presented online.

Yet, many students declared that they felt unsure about what might be considered trustworthy information, since their typical search results contained what they thought to be reliable information mixed in with what they deemed to be information written based on personal opinions, as depicted by one student's comments:

*I have found some websites where...I really want to be like "oh wow this is really good information." And some of the things they have said are so outlandish I'm like "oh this must be written by...somebody who isn't truly involved in the industry." And then [the content] has a veterinarian as an author...it's discouraging. [S1661]*

Another student noted that with animal health content on the internet:

*There's so much information and so much different information. Especially in the vet field there's a lot of different institutes of thought and not a lot of things agree all the time when you're trying to get information. [S1245]*

These comments highlighted that even within Web-based resources affiliated with the veterinary profession, views presented could differ vastly.

### **Handling Conflicting Information**

From the students' perspective, conflicting ideas presented by multiple internet resources affiliated with the veterinary profession and assumed to be reputable appeared to complicate their attempts at evaluating information quality.

When discussing information quality and the evaluation criteria students applied, one commonality observed seemed to be the importance students placed on authorship. This was well exemplified by the comments of one student describing her information assessment process:

*Looking at who published it, is it actually a veterinarian, is it just someone with a really strong opinion and a platform using the Internet. [S1549]*

Related to skepticism about authorship, students discussed taking into account the format in which the veterinary messages are presented when evaluating information. In particular, students described blogs as less reliable sources for information:

*I try to avoid blogs, and that kind of stuff and try to find sources like some veterinary hospitals have a lot of great resources online...government web pages. Things like that, I try to stick with if I'm actually looking for valid information. [S1660]*

Accentuating the apparent caution students applied when reading blogs, some students expressed a belief that authors of blogs

may be writing to publish opinions, as depicted by one participant:

*A lot of blogs and websites where they write for the sake of an outlet. [S1658]*

However, one student would consider blogs as an information source depending on authorship, stating the following:

*I know there's some blogs that are written by veterinarians...So if it's written by someone who seems credible, who has the educational background...it'd be more credible. And is information I'd feel more comfortable trusting. [S1660]*

Overall, students appeared to consider authorship and whether the author may be a veterinarian, as depicted by one participant:

*There are a few websites where I know the veterinarians personally that publish onto them...So if I can I try to look for them because I know a little bit more about that veterinarian. [S1551]*

Elaborating on authors being veterinarians, nearly all students' information evaluation criteria involved examining authors' credentials:

*The first thing I do before reading...is look at the author's signature... 'Cause it'll say oh, Dr. \_\_\_\_\_ and it'll say board-certified veterinary dermatologist. I see that and I'm like okay, whatever he says is probably more weighty than someone else's comment. [S1557]*

One student acknowledged the following with animal health information on the internet:

*You can't just take everything you read for granted. You have to...take it with a grain of salt. [S1661]*

## Discussion

### Principal Findings

Findings of this study offer an understanding of veterinary students' perceptions about the nature of Web-based animal health information, and how their search experiences may impact the way in which that information is managed. Students in this study clearly indicated that they were overwhelmed by the volume of Web-based animal health information. These findings are consistent with studies of students in human health sciences programs being inundated by increasing amounts of health-related content from the internet [51,52]. The apparent staggering effect from searching the internet for animal health information appears to stem from the students' search strategies, specifically search engine use. Using search engines for seeking health information produces massive volumes of content for seekers, with 38% in one study reporting feeling overwhelmed as a result [53]. In another study, search engine use for seeking health content among college students found that 19% felt overwhelmed by the search results [54]. Consistent with findings from this study, primarily turning to Google for health content quickly produces unmanageable quantities of information [16,55,56].

Feeling swamped by search engine results may be linked to the students' frustration and emotional responses to seeking Web-based health information. According to Spink et al [57], "Internet users are often frustrated and emotional during their Web search engine interactions. They wish to engage in an advice-seeking interaction, but may be frustrated by the inability of the system to respond to their personal medical and health needs and concerns for health information" (p. 49). Similarly, veterinary students may experience feelings of frustration from using search engines because these tools may not give precise responses to students' specific animal health inquiries. In this study, this claim is supported by students' reports of using search engines during lectures. The circumstance of being in class also highlights the fact that students needed information immediately imposing some degree of urgency, which may contribute to feelings of frustration. During these searches, students entered just 1 or 2 terms into the search engine, generating large volumes of content which did not meet the students' immediate information needs [58,59]. Understandably, individual students may experience frustration or emotional reactions given the situation—the lecture would be continuing, while the student continued not understanding the materials presented earlier in the same lecture. In addition, the students in this study expressed that they simultaneously tried to manage the information generated from the internet and remain engaged in the ongoing lecture content, causing confusion and potentially increasing that individual's knowledge gap [60].

As students accepted into a veterinary medical program have robust records of academic achievement [61], becoming aware of one's knowledge gaps while being unable to quickly ameliorate the situation may further contribute to an individual student's experiences of frustration. Research on medical students suggests an association between individual anxiety and concerns about mastering knowledge [62]. Given the similarities between medical and veterinary students such as being elite academic performers [63], the latter group presumptively also experiences concerns toward mastering knowledge. Added to this, anxiety related to concerns about academic performance has been documented in veterinary students [60]. Veterinary students' learning experience may be enhanced and supported by furthering their HIL skills, such that the students feel more confident in their abilities to retrieve and utilize Web-based information.

Students in this study voiced frustration at the time and effort it takes to retrieve relevant Web-based health information and made specific mention of their use and reliance on the Web search engine Google. Among the first-year dental students, research indicates that the reliance on Web search engines such as Google indicates lower levels of EHIL [64]. Other studies of veterinary students have suggested the need to integrate EHIL into curricula [9,28,65], such that graduates will possess adequate research skills compliant with accreditation standards 5 and 12 of the American Veterinary Medical Association that will benefit graduates in either research or clinical practice. The results of this study also support facilitation of Web-based HIL skills. Students' apparent frustration may be ameliorated if they receive more opportunities to use their existing EHIL

capabilities, along with receiving feedback from instructors about their information retrieval strategies [65-67].

Paradoxically, while the students from this study expressed being frustrated, and at times confused in their information retrieval efforts, they discussed in detail their skills in evaluating information reliability. Being skeptical appeared to be a common approach for students when assessing information from the internet, as depicted by mentions of critically appraising Web-based content. Students recognized that their skepticism included questioning their own assumptions about information reliability on the basis of past knowledge, acknowledging that some Web-based research findings may conflict with what they had considered to be pre-existing reliable information. These findings appear consistent with research on fourth- and fifth-year medical students judging medical information from the internet according to their own knowledge, while maintaining awareness of their assumptions about information validity [68].

Searching for information on the internet appears to facilitate students building multiple layers of knowledge. The students in this study discussed how the internet affords a quick resource for students to conduct searches for basic content to facilitate learning of more advanced materials. Learners acquiring information using Web-based inquiry for achieving higher level knowledge has been termed technology-enhanced scaffolding [69]. From research on teaching methods, scaffolding provides an individual learner with just enough knowledge to make progress on his or her own [69,70]. However, Web-based scaffolding appeared to also initiate veterinary students' circular research behavior. The circular research behavior identified in this study is consistent with previous research, which reported that information-seeking processes depended on how an individual perceived the tasks he or she needed to complete [71]. As suggested by these findings, a veterinary student may face the task of understanding a novel concept presented during a lecture. The student may perceive this learning task as a problem that could be resolved by collecting information, where information potentially offers a positive change in the student's knowledge [72]. How the student obtains information to solve the perceived problem depends on his or her previous knowledge, which also determines how complex they view the task at hand. Expectedly, the less previous knowledge the student possesses, task complexity increases as the student first needs to assimilate basic ideas for comprehending the more advanced content or *need to know to understand*. In turn, this increases how much information the student will need to acquire for accomplishing the original task.

### Implications

Developing EHIL as part of veterinary curricula may reduce student's feelings of IO. Having enhanced information skills may allow students to rely less on the Google search engine and potentially conduct more efficient, exhaustive content searches in shorter periods of time. For example, a study by Grant et al [28] involving third-year pharmacy students found statistically significant differences in student search strategy test scores after the students received repeated training in Web-based search methods, where the participants were given both a lecture and demonstration on search strategies. Perhaps

having similar EHIL training exercises as part of veterinary curricula will confer similar positive experiences for veterinary students. A *protective factor* conferred by EHIL training was suggested by Chemers et al [72] in a longitudinal study of college students, where positive effects of student experiences including EHIL training were strongly associated with academic performance and coping perceptions on stress, health, and overall satisfaction and commitment to remain in school. Similarly, EHIL training may help to support veterinary students' academic experience and potential subsequent positive outcomes on stress levels and learning satisfaction—making this an important consideration for curricula design.

Ideal curricular design would integrate advancing veterinary students' knowledge about access, retrieval, evaluation, and practical application of Web-based content on the basis of tasks. Students also appear to need guidance about the depth and breadth of knowledge required of them throughout the training process. Guidance with search strategies may support student learning to distinguish relevant from irrelevant information when conducting Web searches to clarify course materials or new content. Repeated opportunities for students to learn information literacy skills may optimize how these skills become integrated into student cognition. Previous studies of students in professional human health care programs found ongoing training sessions in information literacy over a school year improved information retrieval skills compared with isolated training events such as single workshops during the school year [28].

### Limitations

Limitations of this study include possible selection bias as there is a chance that students who agreed to be interviewed may have wished to specifically voice that they were less comfortable or proficient in searching for Web-based health information. This study aimed to explore experiences and viewpoints and was not designed for establishing statistical generalizability. Outcomes of this study provide depth of understanding in a previously underexplored phenomena and will be used to guide the development of a quantitative questionnaire for measuring the frequency and distribution of some of the observed phenomena in a larger student population.

### Suggestions for Future Work

Empirical studies to investigate relationships between veterinary student HIO, stress, and the role of the internet are warranted. Studies of veterinary students in Australia and the United States have reported higher levels of perceived stress in veterinary students compared with the general population [39]. Presently, however, few publications exist specifically investigating a relationship between information literacy and students' perceived stress levels. More research into this area appears to be a rational next step, and a direction for future research.

Students' views and experiences in searching for Web-based pet health information suggest that large volumes of information and the need for evaluation and processing information are 2 aspects that students are negotiating in their efforts to accumulate meaningful content for their learning and understanding. Given a recent AAVMC report considers health

literacy as a professional competency [9], future studies may consider investigating student perspectives about HIL. In particular, research focusing on veterinary student confidence and competence toward their existing levels of information literacy may offer an increased understanding about veterinary students' educational experiences.

### Conclusions

Veterinary students' perceived experiences of being overwhelmed after searching the internet for animal health

information appears to be a discipline-specific manifestation of HIO. Similar to other health professional students reporting experiences of HIO from internet searches for biomedical content, veterinary students' HIO may be related to their EHIL skills. The findings of this study point to a need for veterinary curricula designers to consider integrating EHIL skill development throughout study semesters for providing students with strategies to manage information.

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### Conflicts of Interest

None declared.

#### Multimedia Appendix 1

Interview question guide.

[[PDF File \(Adobe PDF File\), 184 KB - mededu\\_v5i2e13795\\_app1.pdf](#)]

#### Multimedia Appendix 2

Thematic analysis code table.

[[PDF File \(Adobe PDF File\), 126 KB - mededu\\_v5i2e13795\\_app2.pdf](#)]

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## Abbreviations

**AAVMC:** Association of American Veterinary Medical Colleges

**EHIL:** electronic health information literacy

**EHR:** electronic health record

**HIL:** health information literacy

**HIO:** health information overload

**IO:** information overload

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Original Paper

# A 9-Step Theory- and Evidence-Based Postgraduate Medical Digital Education Development Model: Empirical Development and Validation

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## Abstract

**Background:** Digital education tools (e-learning, technology-enhanced learning) can be defined as any educational intervention that is electronically mediated. Developing and applying such tools and interventions for postgraduate medical professionals who work and learn after graduation can be called postgraduate medical digital education (PGMDE), which is increasingly being used and evaluated. However, evaluation has focused mainly on reaching the learning goals and little on the design. Design models for digital education (instructional design models) help educators create a digital education curriculum, but none have been aimed at PGMDE. Studies show the need for efficient, motivating, useful, and satisfactory digital education.

**Objective:** Our objective was (1) to create an empirical instructional design model for PGMDE founded in evidence and theory, with postgraduate medical professionals who work and learn after graduation as the target audience, and (2) to compare our model with existing models used to evaluate and create PGMDE.

**Methods:** Previously we performed an integrative literature review, focus group discussions, and a Delphi procedure to determine which building blocks for such a model would be relevant according to experts and users. This resulted in 37 relevant items. We then used those 37 items and arranged them into chronological steps. After we created the initial 9-step plan, we compared these steps with other models reported in the literature.

**Results:** The final 9 steps were (1) describe who, why, what, (2) select educational strategies, (3) translate to the real world, (4) choose the technology, (5) complete the team, (6) plan the budget, (7) plan the timing and timeline, (8) implement the project, and (9) evaluate continuously. On comparing this 9-step model with other models, we found that no other was as complete, nor were any of the other models aimed at PGMDE.

**Conclusions:** Our 9-step model is the first, to our knowledge, to be based on evidence and theory building blocks aimed at PGMDE. We have described a complete set of evidence-based steps, expanding a 3-domain model (motivate, learn, and apply) to an instructional design model that can help every educator in creating efficient, motivating, useful, and satisfactory PGMDE. Although certain steps are more robust and have a deeper theoretical background in current research (such as education), others (such as budget) have been barely touched upon and should be investigated more thoroughly in order that proper guidelines may also be provided for them.

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**KEYWORDS**

postgraduate medical e-learning; instructional design; e-learning; distance education; design model; education, medical; education, distance; models, educational

## Introduction

### Background

Medical educators have the responsibility to promote learning and create interventions and innovations to effectively help students develop proficiency in a broad spectrum of competencies [1]. One way of achieving this is by using digital education instruments, sometimes called e-learning or technology-enhanced learning. Digital education instruments can be defined as any educational intervention that is electronically mediated [2]. Some of these digital education instruments are theoretically grounded and are evidence based [3,4]. Studies have shown that digital education tools are at least as effective as other methods of training in psychomotor and nontechnical skills [5] and that the benefits are unparalleled accessibility and no time or location restriction [6]. However, there has been no consensus about the added value of digital education [2]. We postulate that this is partly because the focus of most studies has been on the learning goal (whether the learner achieved the curriculum goals or not), whereas we believe that the scope of outcomes should be broadened [7]. Our recent review showed that, apart from effectiveness, 4 other important aspects are looked at in postgraduate medical digital education (PGMDE): efficiency, motivation, usefulness, and satisfaction [8]. It is obvious that digital education has to be effective as well: learners must achieve the learning goal. But when evaluating digital education, aspects apart from the learning goal should be taken into account.

The abovementioned evaluated aspects depend on the content, but also on the instructional design (ID). In 1974, Snelbecker introduced the term “instructional design” as a link between the science of how people learn and daily practice as a process for designing instruction based on empirical principles [9]. Kemp et al described ID as a systematic method to manage the instructional process effectively so as to ensure competent performance by students [10]. In 2002, Merrill provided a very useful overview of various ID theories and models, concluding that they all shared a series of first principles, although no one theory or model included all principles. Differences can be based on different theoretical insights or in the details following the first principles, depending on, for example, the target audience [11]. Several such models are available to help experts in their quest to create, implement, and evaluate a digital learning experience [12], but none to date has aimed at PGMDE. Most models have been directed mainly toward educators, using abstract terms and theories that might not be useful for content experts with little educational experience.

### Objective

Previous literature has suggested that aiming an educational intervention at a specific target audience is most effective [13]. In line with this, we postulated that ID models should also be targeted as specifically as possible. We aimed this study at postgraduate medical professionals who work and learn after graduation. Arguments for such a specific target audience can be that adults might have different learning goals, working professionals might have specific motivational needs, and medical graduates might have a unique combination of clinic

work and learning by doing [14-16] With this study, we aimed at providing a stepwise ID model for anyone planning to create PGMDE, to help them cover all important steps based on theory and current evidence.

## Methods

Intervention mapping is a process for developing theory- and evidence-based health education programs [17]. Analogous to the method of this model, we used our previous work to determine quality indicators, describe a working model, and compare that model with other available ID models.

### Quality Indicators

To create a specific ID model, we started in 2016 with an integrative literature review to evaluate which indicators, determining quality in PGMDE, were already available [18]. We searched a series of databases (PubMed, Web of Knowledge, CINAHL, PsycINFO, and Education Resources Information Center) and reviewed 11,093 articles. Ultimately, we used 36 relevant articles to gather 72 specifications that we found to be important for PGMDE. We divided these specifications into 6 domains, based partly on the International Organization for Standardization standard ISO-19796 [18,19]. We called this the postgraduate medical e-learning model (postgraduate MED model). These domains were preparation, software design and system specifications, communication, content, assessment, and maintenance.

In 2017, we discussed these 72 specifications in a series of focus group discussions with the most important stakeholders: medical education experts, postgraduate users, and commercial digital education creators [20]. The aim was to select which items were most relevant and which items experts and users would add to the list. The template analysis of these interviews provided us with 6 domains (preparation, motivators, barriers, learning enhancers, learning discouragers, and real-world translators) and 57 items. These domains gave us important insight into the main principles of PGMDE. This led to 3 main themes: motivate, learn, and apply.

To determine an international consensus on the 57 items from the focus group discussion, we performed a Delphi study in 2018 [21], aimed at identifying an empirically founded set of quality indicators for PGMDE. We asked a group of 13 international medical digital education experts and 10 experienced postgraduate users to rate the 57 items, explain why they would include or exclude the items, and add new items. After the first round, the group did not reach consensus on 20 items and added 15. After 2 rounds, the Delphi study produced a list of 37 indicators that we thereafter used as the basis for an ID model. For more details about the consensus rounds, refer to the previously published Delhi study [21].

### The Working Model

The abovementioned studies provided us with 3 themes, 6 domains, and 37 indicators. We then used our previous experience with creating PGMDE (eg, in gynecological ultrasound [22]) to order the items chronologically. The aim was to order them in such a way that model developers can follow the steps of the model without having to go back and

forth in the creation process too often. The decisions in step 1 should be reflected in step 2, not the other way around.

### Comparing the Model With Other Instructional Design Models

The working model had to have two further characteristics: it had to add value to existing models, and it had to be as complete as possible. To determine the added value and to find possible missing steps, we compared the working model with 7 other ID models. We chose these models because our earlier systematic review showed that only these had been used in the evaluation or description of PGMDE [8]. The models with which we compared the steps are Kern's 6 steps of curriculum development; the 4-component instructional design model (4C/ID) cognitive load principle; the ADDIE model (analysis, design, development, implementation, and evaluation); Gagné's 9 events of instruction; the ASSURE (analyze the learner, state

objectives, select media and materials, use media and materials, require learner participation, and evaluate and revise) model by Heinrich and Molenda; Merrill's principles of instruction; and the Kemp ID model.

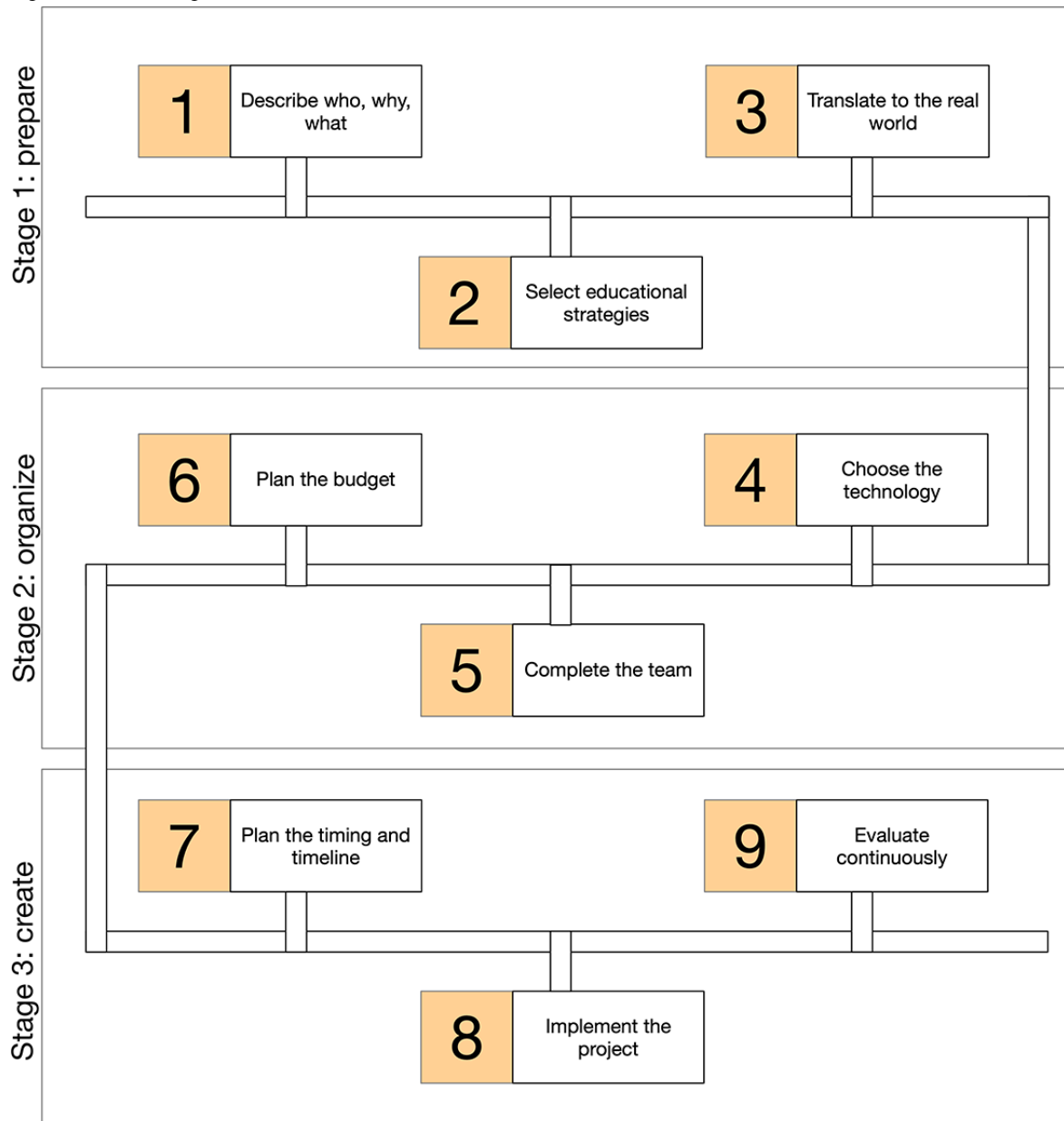
## Results

### Summary of Stages and Steps

Three stages and 9 steps can be followed in chronological order to ensure that all 37 items are thought through and, when applicable, used for creating digital education interventions. [Table 1](#) lists all the items from these previous studies, with the corresponding stages and steps. Stage 1 is *prepare*, stage 2 is *organize*; and stage 3 is *create*. We investigated each of these stages, explain the steps, and list the original items in each. [Figure 1](#) summarizes all of the steps.

**Table 1.** The stages, steps, and principles of the postgraduate medical digital education model

Stages and steps	Principles
<b>Stage 1: Prepare</b>	
Step 1. Describe who, why, what	<ol style="list-style-type: none"> <li>1. Know your target audience</li> <li>2. Create a feeling of importance</li> <li>3. Convey a feeling of responsibility</li> <li>4. Take your user seriously</li> <li>5. Do not stress your user</li> <li>6. Do not force your user</li> <li>7. Define goals and objectives</li> <li>8. Inform the user about the goals and objectives</li> <li>9. Provide an overview of all lessons to be learned</li> </ol>
Step 2. Select educational strategies	<ol style="list-style-type: none"> <li>10. Provide feedback</li> <li>11. Provide interactive elements</li> <li>12. Provide summaries</li> <li>13. Provide assessments</li> </ol>
Step 3. Translate to the real world	<ol style="list-style-type: none"> <li>14. Provide real-world translation of the content</li> </ol>
<b>Stage 2: Organize</b>	
Step 4. Choose the technology	<ol style="list-style-type: none"> <li>15. Ensure ease of navigation</li> <li>16. Design a clear layout</li> <li>17. Do not distract</li> <li>18. Make content adaptive</li> <li>19. Choose a flexible platform</li> <li>20. Make it easily accessible</li> <li>21. Make it safe and secure</li> <li>22. Have fast use and loading times</li> <li>23. Allow for nonlinear learning</li> <li>24. Personalize the learning path</li> <li>25. Show progress</li> <li>26. Select a learning environment</li> <li>27. Inform the user about optimal use</li> <li>28. Provide technical support</li> </ol>
Step 5. Complete the team	<ol style="list-style-type: none"> <li>29. Add a content expert, medical educator, and information technology expert</li> <li>30. Prevent concern about the quality</li> <li>31. Identify the authors</li> <li>32. Provide references and sources</li> </ol>
Step 6. Plan the budget	<ol style="list-style-type: none"> <li>33. Plan your budget</li> </ol>
<b>Stage 3: Create</b>	
Step 7. Plan the timing and timeline	<ol style="list-style-type: none"> <li>34. Create a timeline</li> <li>35. Maintain</li> </ol>
Step 8. Implement the project	<ol style="list-style-type: none"> <li>36. Update regularly</li> </ol>
Step 9. Evaluate continuously	<ol style="list-style-type: none"> <li>37. Evaluate</li> </ol>

**Figure 1.** The postgraduate medical digital education model.

### Stage 1: Prepare

One of many incentives may have pushed the creator to make the digital education intervention, for example, having been asked to do so by management, but it may also be the result of an internal motivation to share something or due to many other reasons. However, once the need is present, the first step should be to determine the goal of the digital education intervention, how it will educate, and its use for the learner. We called these domains motivate, learn, and apply.

#### *Step 1: Describe Who, Why, What*

The first step is to determine who, why, and what, which has a direct relation to motivating users. The *who*, or the target audience, must be defined as narrowly as possible. The more specific the definition, the better the content can be adapted. The first thing to realize is that the target audience is a digital learner who is not merely a consumer of technology, but who should realize the possibilities and potentials of digital

technology and recognize the opportunity that it presents in their daily life [23]. Learner characteristics that can be used in the design should be taken into account, for example, online experience, age, cultural and social context, and educational culture [24]. It should, however, be kept in mind that the most important user factor is previous or existing knowledge, as this can then be properly built on [13].

When the target users have been identified, it is necessary to consider and communicate the *why*. This can be done by creating a feeling of importance for those users. When your users believe that undertaking the digital education intervention is important, they will be much more determined to do so. Attributing importance also helps to convey a feeling of responsibility not just for starting but also for completing the digital education intervention. These messages may be communicated when the digital education intervention is introduced or when people are invited to take part in it. Knowing your target audience will also help to prevent discouragement. Users can be discouraged by

not being taken seriously (principle 4; eg, by childish syntax or drawings) or by being stressed (eg, by tight deadlines) or forced (eg, by being obliged to do something they consider not to be useful).

Creators must then carefully consider the *what*, that is, the goal and objectives of the digital education intervention (principle 7). Goals are broad or general and inform users about the aim of the whole curriculum or e-learning module. Objectives are specific and measurable and may include knowledge, skills, or attitudinal or behavioral goals [25]. When a clear goal and objectives have been set, it is crucial to inform users about them and provide an overview of all lessons to be learned. This should be done at the beginning of the digital education intervention, so the learner knows what to expect, but also during the digital education intervention to keep up with expectations.

### **Step 2: Select Educational Strategies**

The second step is to consider *how* the targeted users will learn and which learning strategies are to be used. This depends greatly on the objectives defined in step 1, above. Instruments that may help in this process, as described in previous PGMDE studies, are problem-based learning [26], cognitive load theory [27], and multimedia learning [28]. Which strategy is the most effective for which goal will long remain a matter of debate; however, a guiding strategy must be chosen. According to previous studies, 4 instruments help creators facilitate efficient learning: feedback, interactive elements, summaries, and assessments.

### **Step 3: Translate to the Real World**

The last step of the first stage is *apply*: translating the digital education intervention to the real world. Users want the digital education intervention to be useful. This can be achieved by different means, but the digital education intervention has to add something new to users that they can actually use in daily practice. This, therefore, concerns not only the learning goal and objectives but also the examples used in the digital education intervention. Questions to be considered are whether the feedback is written in a way that can be related to the users' daily tasks and whether assessments not only serve an educational purpose but also give results that may be used when users return to work the next day.

### **Stage 2: Organize**

Completion of the first stage yields a good overview of the content of the digital education intervention: whom you target, what they should learn, how they can learn it best, and how the digital education intervention is to be kept as close as possible to the daily practice of the user. The next step entails organizing whatever is deemed necessary for the process of creating this digital education intervention. This may include the appropriate technology and a team to realize the plan; the financial recourses necessary must also be considered.

### **Step 4: Choose the Technology**

When stage 1 is complete, the creator will have an idea of the technological needs, that is, how the technology should enable the previously set goals to be achieved. This is highly dependent on stage 1, but certain factors are universal. The aim of the

technology should always be to achieve the stated curriculum goal by using the attributes of the supporting features. These are affordances (features that provide a potential for action), whereas constraints are those features that provide the structure of and guidance to those affordances [29]. Design elements must therefore always be borne in mind, such as ease of navigation and a layout that is clear, is not too distracting, and prevents nonadaptive content (content that does not change layout and design according to the device used). Decisions about the features should include consideration of a flexible platform that can be used on several devices and operating systems; be easily accessible, safe, and secure; have fast use and loading times; allow for nonlinear learning; personalize the learning path; and show progress. Finally, a learning environment must be selected and the user must be informed about the platform and the optimum device on which to access it, and technical support must be available.

### **Step 5: Complete the Team**

Most digital education creators will probably already be working as part of a team. However, once a proper insight has been gained into the content and the technology needed, the team may be supplemented. It should contain at least one content expert, one medical educator, and one information technology expert. When the team is complete, its members must be asked to commit time and effort before the development is started. To prevent concern on the part of users about the quality of the digital education intervention, the identity of the authors should be clearly communicated alongside an explanation of their relevant expertise, and source information should be provided.

### **Step 6: Plan the Budget**

To create any educational experience, a budget is necessary. This is determined by many factors. Little has been written about this and, to our knowledge, there is nothing specific for PGMDE. However, person-hours, materials, licensing, and technology are important topics to consider, and designers, editors, marketing, maintenance, evaluation, consultants, and overhead costs must also be borne in mind. It is estimated that 1 hour of digital education costs about 100 to 160 hours to create, with an average of US \$18,750 in costs [30]. There are, however, ways to save on these costs, such as using free or low-cost recourses that already exist, making shorter courses that work on multiple devices, or using open source platforms and in-house faculty for the content [31].

### **Stage 3: Create**

When the above 2 important stages have been completed, creators will know what they want, what is necessary to achieve their aims, and who will help them. It is now necessary to plan the actual creation of the digital education intervention and start considering what will be necessary upon its completion. At this stage, a realistic timeline should be drawn up and planning for the implementation and evaluation should begin.

### **Step 7: Plan the Timing and Timeline**

It will be necessary to plan and create a timeline for the creation of the digital education intervention to ensure the team meets that deadline. The timeline should not only be for the creation of the digital education intervention but should also be extended



to consider its expiry date and the communication of that to the user, as well as the intervals at which the digital education intervention is to be maintained and updated. These are important subjects to consider at this stage: they might force a reconsideration of the budget, and communicating these dates and planned update logs to the learners is highly recommended.

### Step 8: Implement the Project

The project can be implemented on several levels, but a minimum of 2 things must be determined. First to be determined is which factors are required for the digital education intervention to be implemented in the existing curriculum (eg, how the learners will be invited, whether management will offer support, whether any sort of marketing is necessary, or whether there will be a public introduction). Second to be determined is whether enough has been done to help learners implement their newly learned lessons in practice. (This has an overlap with real-world translation, but it is worth reconsidering how a user will actually use the digital education intervention.) This can be considered to be the same as other change management strategies or innovation implementation methods.

### Step 9: Evaluate continuously

The final step is to evaluate (principle 37) and implement the plan. Our recent systematic review showed that PGMDE is mainly evaluated in terms of educational objective rather than design. In this review, only 4% of PGMDE studies used any form of evaluation of the curriculum design [8]. An evaluation strategy should be planned to answer the questions of what is desired, what must be evaluated, and what will be done with the resulting information, given that one part of the evaluation should be evaluating the implementation strategy itself.

## Comparing the Model With Other Instructional Design Models

Comparing the above 9 steps with the above-described other models, we found that the 9-step plan covered all the steps in other models, but that no other model covered all these steps. [Table 2](#) overviews the steps in comparing the models. It shows

how many items the models scored per step; [Multimedia Appendix 1](#) shows which item was scored.

Kern's 6 steps of curriculum development were described for the first time in 2002 and were aimed at curriculum developers responsible for the educational experience of students, residents, fellows, and faculty [25]. The 6 steps cover most of our 9-step model (see [Table 1](#)), but Kern's program was not aimed at digital education. Therefore, there is little to no information on topics such as technology, budgets, updating, and the team required for digital education.

The 4C/ID model was initiated in 1992 and was aimed at prescribing how to develop educational programs that contain a mix of educational media, including text, images, speech, manipulative materials, and networked systems [27]. The 4C/ID cognitive load principle builds upon models of human memory and can be used to design training programs for complex learning. The focus of this model is therefore on learning aspects and how to make learning as efficient as possible. The model does not focus on any of the other domains.

The ADDIE model [32] was originally created to evaluate software and was first published in 1988 by Grafinger. As a more generic software development model, it relates closely to the 9-step model. The 5 steps of the ADDIE model can be split up into smaller steps, and the only thing left unconsidered by the ADDIE model is budget. Even though the design step considers educational strategies, the focus is much more on technology than learning and therefore misses domains such as budget and maintain.

Gagné's 9 events of instruction were introduced in their first form in 1992. This is a very complete model for learning, taking into account several learning theories, the ADDIE model, Keller's ARSC (attention, relevance, confidence, satisfaction) model, and evaluation instructions [33]. Although the ADDIE model refers to evaluation, the 9 events of Gagné do not. Neither does the Gagné model discuss implementation, updates, team, or budget.

**Table 2.** Comparison of instructional design models by score (number of steps covered).

Model	Stage 1: prepare	Stage 2: organize	Stage 3: create
9-step model	5/5	3/3	4/4
Kern	5/5	0/3	2/4
4C/ID <sup>a</sup>	3/5	0/3	0/3
ADDIE <sup>b</sup>	5/5	2/3	3/4
Gagné	5/5	1/3	0/4
ASSURE <sup>c</sup>	5/5	1/3	2/4
Merrill	2/5	1/3	0/4
Kemp	4/5	1/3	1/4

<sup>a</sup>4C/ID: 4-component instructional design model.

<sup>b</sup>ADDIE: analysis, design, development, implementation, and evaluation.

<sup>c</sup>ASSURE: analyze the learner, state objectives, select media and materials, use media and materials, require learner participation, and evaluate and revise.

The ASSURE model was developed by Heinich and colleagues in 1999 and “is an instructional model for planning a lesson and the technology that will enhance it” [12,34]. It consists of 6 steps aiming to produce more effective learning and teaching. Although the design step does consider technology, it is not aimed at digital education, with all its technological challenges. Steps such as budget, timeline, and team are not included in the ASSURE model.

The first principles of instruction by Merrill is a series of 5 principles common to various theories aiming to promote learning [11], published in 2002. The 5 principles focus on the learning domain almost exclusively, although technology can be considered to be covered by the demonstration principle. Domains as learning goals and educational strategies are not mentioned.

The Kemp ID model from 2007 is the result of several disciplines in ID [10]. It is distinguished by its circular approach, allowing for continuous evaluation of all steps, which is more dynamic and fluid than the linear approach taken by other models. Although it covers behavioral and cognitive approaches, it does not cover real-world translation or technology-related domains such as budget, team, timeline, updates, or implementation.

## Discussion

### Principal Findings

The postgraduate MED model is, to our knowledge, the first ID model for PGMDE. Compared with other models, it is unique in two ways. First, it is based on 37 building blocks, which are evidence-based items based on 3 empirical studies and on the collaboration of experts and experienced users. While most other models are combinations of theories and expert opinion, the 9-step model presented here combines theory with published reports, expert opinions, and consensus. Second, it is the only model that covers a wide range of steps aimed directly at digital education and postgraduate education. It can be debated whether such a model may also be used for other kinds of target audiences. We aimed to make the stages and steps broad, but the 37 indicators we used are quite specific. Whether these indicators are also applicable to other audiences, which might be missing, such as graduates, has not yet been investigated. The broad subjects of this model, on the other hand, make it very suitable for content experts with little experience in creating a curriculum. Educators may find many of the steps to be obvious. Even so, the aim was to stimulate debate within the development team about each step. There might not be an optimal educational strategy for each scenario, but the use of cognitive load theory and multimedia learning theory seems useful in daily practice [27,35,36]. We believe that the benefit of these models is not only in the sound theory behind them, but also that they are specific enough to provide easy-to-follow instructional principles. Following these principles, the 4 mentioned instruments appear promising: feedback, interactive elements, summaries, and assessments. According to the cognitive load theory, learning occurs when the information is chunked, which is done in the feedback, assessment, and summaries. Another way is repetition, which can also be found

in feedback, summaries, and assessments. According to cognitive load theory, using the information actively helps to move the information into long-term memory. This is done by using feedback, interactive elements, and assessments. Therefore, these instruments not only seem to have been effective in published reports [37,38], but are also grounded in theory.

Another promising aspect of digital education is adaptive learning environments. Unique to digital learning is that each individual can have an experience based on her or his own needs and desires, a form of individual learning without the time and costs of one-on-one human tutoring. Digital learning allows a more intelligent system to interpret the learner’s previous use. It can then adapt content, nonlinear learning paths, multimedia, and tools to a personalized learning experience. Studies have shown an increasing interest in the added value of adaptive learning environments [39,40].

Other reviews have shown the added value of creating a curriculum with the help of learning and designing models [7]. It is clear that the planning of an educational experience is far from simply adding some online presentations and that the lack of ID leads to unanticipated and unexplained learning outcomes. Educational theory can be used to create the ID to develop effective, appealing, consistent, and reliable instruction [41]. The structure of a model like this also helps to identify those points that are efficient and those that require improvement [42].

### Limitations

The biggest limitation of the postgraduate MED model will be the ways in which an educator can interpret each step. A model like this implies that a curriculum may be designed by simply following a few steps. However, the whole is much more complex, and each step is worth a great deal of thought, consideration, and awareness of other theories and models. Much can be said to focus a model on a specific part of a learning experience, for example, pedagogic theory. Yet we wanted to provide an overview so that educators might realize how complex digital learning is and should be. This model may be considered different from other models perhaps because the people making those other models wanted an in-depth focus on a certain subject, rather than trying to create an all-in-one solution. We do not believe this 9-step model is such a solution, although danger lies in oversimplification.

### Further Research

Having an overview of these 9 steps reveals the gaps in the literature. While many theories and studies have been performed on the effectiveness of learning [1], almost nothing is known of other subjects. Our insight into the budgets needed or expected to create digital education interventions has rarely been described. More should be written on the experience of others, for example, the number of hours taken, the main costs, and the personnel or team chosen to limit these. Little is also known of the ways to properly evaluate the design. Most models tell users to evaluate, but there are no validated evaluation instruments that look at the design. The same is true for implementation. We should consider how to implement the

digital education intervention into the working life of the learners, but little is known of how to do that and what may be used as outcomes for successful implementation. Implementation of digital education has an analog with implementing innovations. There are models for the implementation of innovations, such as Kotter's 8-step model [43] and Rogers' model of diffusion of innovation [44]. To our knowledge, these models have not been used for the implementation of digital education, but it seems a very interesting future research path.

## Conclusion

We have described a complete set of evidence-based steps, expanding a 3-domain model (motivate, learn, and apply) into an ID model that can help every educator in creating efficient, motivating, useful, and satisfactory PGMDE. The postgraduate MED model is underpinned by aspects derived from other dominant models and should provide enough basics to start the journey of creating digital education. Much remains to be learned, and the next most logical step would be to validate an evaluation instrument of the digital education design.

## Conflicts of Interest

None declared.

## Multimedia Appendix 1

Comparison of design models.

[DOCX File, 17KB - [mededu\\_v5i2e13004\\_app1.docx](#) ]

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## Abbreviations

**4C/ID:** 4-component instructional design model

**ADDIE:** analysis, design, development, implementation, and evaluation

**ARSC:** attention, relevance, confidence, satisfaction

**ASSURE:** analyze the learner, state objectives, select media and materials, use media and materials, require learner participation, and evaluate and revise

**ID:** instructional design

**postgraduate MED model:** postgraduate medical e-learning model

**PGMDE:** postgraduate medical digital education

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Original Paper

# Association of Online Learning Behavior and Learning Outcomes for Medical Students: Large-Scale Usage Data Analysis

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## Abstract

**Background:** Digital learning environments have become very common in the training of medical professionals, and students often use such platforms for exam preparation. Multiple choice questions (MCQs) are a common format in medical exams and are used by students to prepare for said exams.

**Objective:** We aimed to examine whether particular learning activities contributed more strongly than others to users' exam performance.

**Methods:** We analyzed data from users of an online platform that provides learning materials for medical students in preparation for their final exams. We analyzed whether the number of learning cards viewed and the number of MCQs taken were positively related to learning outcomes. We also examined whether viewing learning cards or answering MCQs was more effective. Finally, we tested whether taking individual notes predicted learning outcomes, and whether taking notes had an effect after controlling for the effects of learning cards and MCQs. Our analyses from the online platform Amboss are based on user activity data, which supplied the number of learning cards studied and test questions answered. We also included the number of notes from each of those 23,633 users who had studied at least 200 learning cards and had answered at least 1000 test exam questions in the 180 days before their state exam. The activity data for this analysis was collected retrospectively, using Amboss archival usage data from April 2014 to April 2017. Learning outcomes were measured using the final state exam scores that were calculated by using the answers voluntarily entered by the participants.

**Results:** We found correlations between the number of cards studied ( $r=.22$ ;  $P<.001$ ) and the number of test questions that had been answered ( $r=.23$ ;  $P<.001$ ) with the percentage of correct answers in the learners' medical exams. The number of test questions answered still yielded a significant effect, even after controlling for the number of learning cards studied using a hierarchical regression analysis ( $\beta=.14$ ;  $P<.001$ ;  $\Delta R^2=.017$ ;  $P<.001$ ). We found a negative interaction between the number of learning cards and MCQs, indicating that users with high scores for learning cards and MCQs had the highest exam scores. Those 8040 participants who had taken at least one note had a higher percentage of correct answers (80.94%;  $SD=7.44$ ) than those who had not taken any notes (78.73%;  $SD=7.80$ ;  $t_{23631}=20.95$ ;  $P<.001$ ). In a stepwise regression, the number of notes the participants had taken predicted the percentage of correct answers over and above the effect of the number of learning cards studied and of the number of test questions entered in step one ( $\beta=.06$ ;  $P<.001$ ;  $\Delta R^2=.004$ ;  $P<.001$ ).

**Conclusions:** These results show that online learning platforms are particularly helpful whenever learners engage in active elaboration in learning material, such as by answering MCQs or taking notes.

**KEYWORDS**

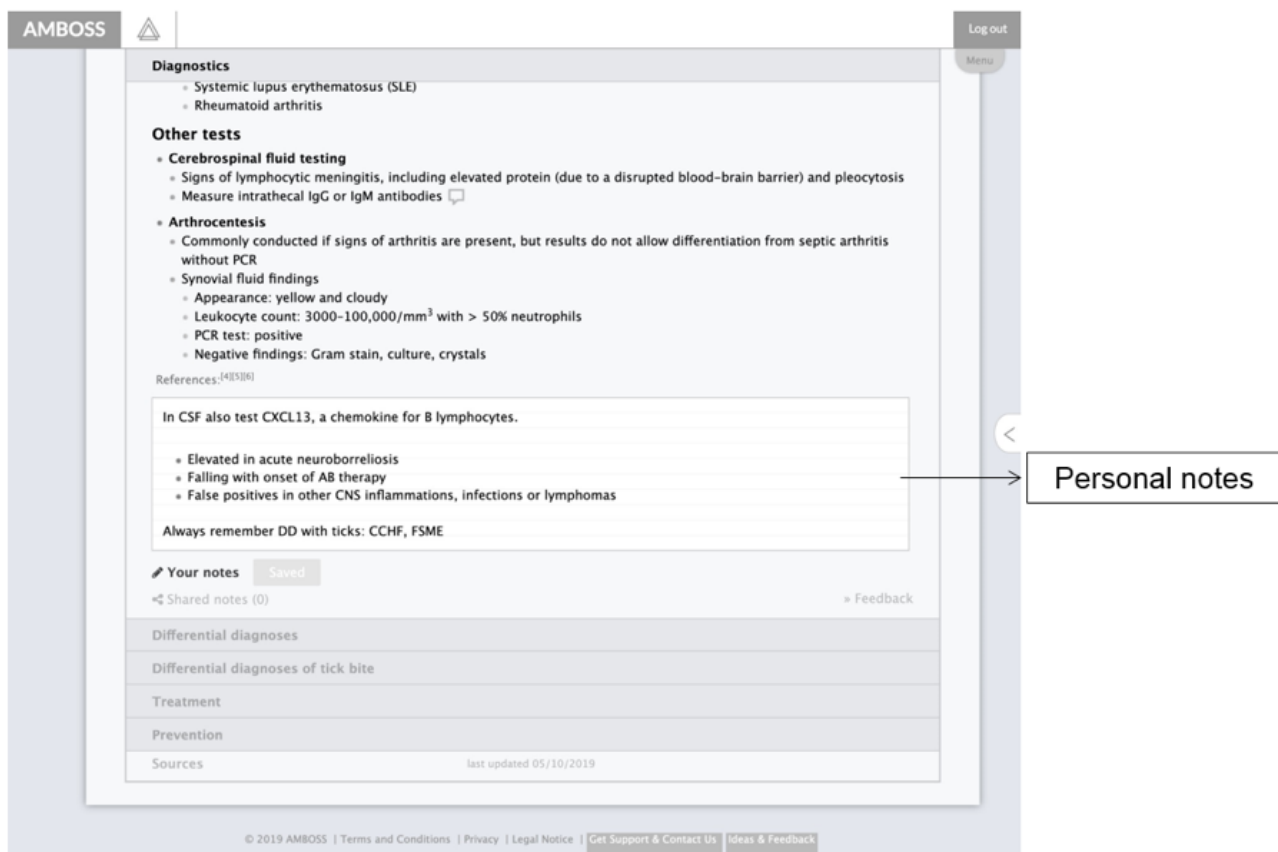
learning engagement; medical online learning platform; big data analytics; writing notes; learning outcomes

**Introduction****Background**

Digital learning environments are used with increasing frequency in medical education [1]. They are often integrated as teaching formats into the didactic concept of medical studies [2-4] and are also extensively used by students for exam preparation [5,6]. Multiple choice questions (MCQs) are a common format for medical exams and are therefore preferentially used by students to prepare for their medical exams [7]. In response to the high demand for practicing with MCQs, several online platforms that provide students with both medical information and the opportunity to answer MCQs

relevant to various exams have become available. These platforms also give immediate feedback on the correctness of their answers. A prominent example of such a platform is AMBOSS [8], which is provided by the company AMBOSS, and is available in both English and German. The central concept of the platform is to provide MCQs that are linked to extensive medical information needed to answer relevant exam questions correctly (learning cards). Thus, the platform connects textbook content directly to the common format of MCQs used in the actual final exam. In addition, the platform offers the option of taking personal notes about the learning content. These personal notes can be written directly onto the corresponding learning cards on the computer screen (Figure 1).

**Figure 1.** Example of personal notes on a learning card from the AMBOSS platform.



The first and second parts of medical studies in Germany are completed by taking two final state exams (1st and 2nd Staatsexamen) that are made up of MCQs. The AMBOSS platform provides its users with the MCQs used in the final state exams in recent years. On the official exam days, AMBOSS provides a preliminary statistical prognosis of an individual's real exam results in cooperation with the learning platform Medi-learn [9]. In order to use this service, students enter their answers from their actual final exams into the platform to get immediate feedback on the number of correct answers. In the study presented here, we used the results of the participants'

second state medical exam, voluntarily provided by them, to measure learning performance. One aim of the study was to apply insights from educational psychology to the setting of an online learning platform in order to test specific hypotheses with a large sample of medical students. We also aimed to examine whether particular learning activities contributed more strongly than others to users' exam performance. User activity records and their comparison to actual final exam results were utilized to achieve these research goals.

## Impact of Engagement on Learning

There is a long tradition of research dealing with the influence of learning activities on learning outcomes [10-12]. Time spent on learning is a predictor of learning outcomes in both offline and online settings [13]. The time spent with actual learning activities as opposed to time merely being present in a certain setting is particularly important [10,12]. Thus, hypothesis 1 was that the number of learning cards viewed are positively related to learning outcomes.

It is also known that active cognitive engagement with learning material is an essential factor of learning. Active learning as opposed to only passively receiving information increases students' performance [14,15]. One way to engage in learning actively is to answer MCQs. Therefore, hypothesis 2 was that the numbers of MCQs answered are positively related to learning outcomes.

As an exploratory research question, we also examined whether viewing learning cards or answering MCQs was more effective in terms of learning outcomes.

Another way to elaborate on learning material is to take individual notes on the learning content [16]. Taking notes can have several advantages [17,18], such as that, in many cases, note taking demands that learners make a connection with their previous knowledge (encoding benefit). In addition, learners

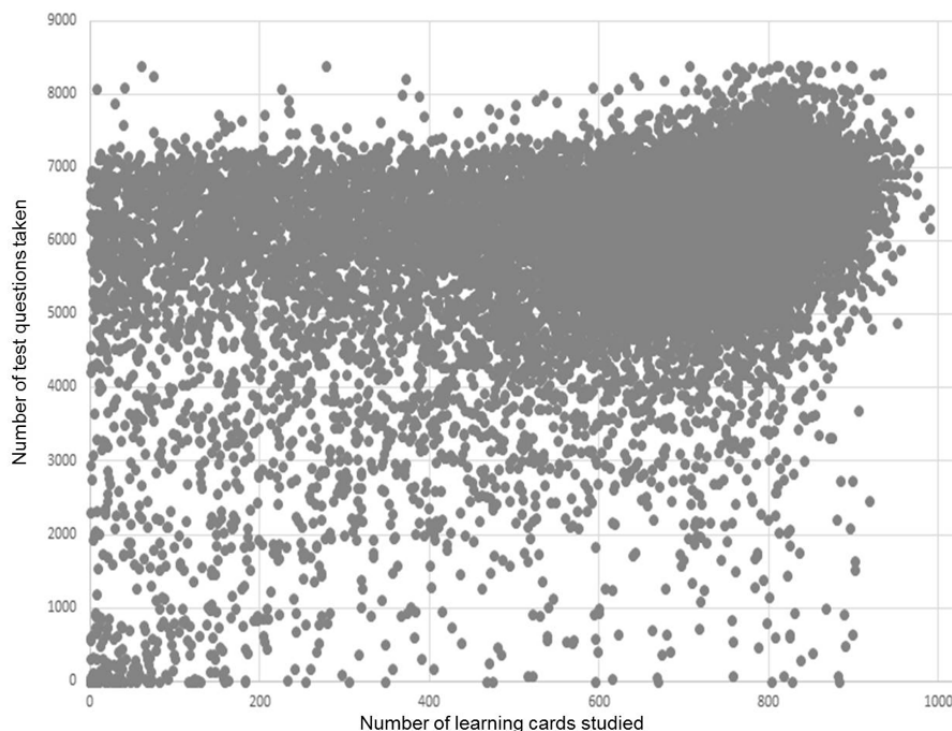
also have the opportunity to study their notes after they have made them (external storage). Based on these considerations, hypothesis 3a was that better learning outcomes are shown for learners who took notes than for learners who did not take notes.

Moreover, we assumed that the level of engagement in taking notes had an influence on learning over and above the effect of other general learning activities. Thus, hypothesis 3b was that the numbers of notes the learners had taken would predict the learning outcome even when controlling for the effects of answering MCQs and studying learning cards.

## Methods

For the present study, the data of AMBOSS users who had taken their final state medical exams between October 2014 and April 2017 was evaluated. Users were included in the analysis if they had entered the results of their exams, had previously opened at least 200 learning cards, and had answered at least 1000 MCQs, resulting in a sample of 23,633 AMBOSS users (for the CONSORT flow diagram see [Multimedia Appendix 1](#)). This procedure eliminated users who did not seriously use AMBOSS for exam preparation ([Figure 2](#)), while keeping as many usable cases as possible to represent a wide range of different usage patterns. Learning cards, test questions, and notes for all accepted users were utilized in further analyses ([Textbox 1](#)).

**Figure 2.** Distribution of the numbers of learning cards studied and test questions taken among the participants.





**Textbox 1.** Learning features included in the analysis.

Learning cards:
<ul style="list-style-type: none"> <li>The number of unique learning cards that were opened by the user.</li> </ul>
Test questions (MCQs: multiple choice questions):
<ul style="list-style-type: none"> <li>The number of unique test questions that were answered by the user.</li> </ul>
Notes
<ul style="list-style-type: none"> <li>The number of a user's notes that refer to a specific learning card that comprised five or more characters (a threshold of five characters was chosen to exclude notes that only served the function of marking a learning card as read).</li> </ul>

We used the percentage of correct answers in the final state exam, as entered by the participants, as our main dependent variable. All statistical analyses were done with SPSS 22. The interaction analysis (see Table 1 and Figure 3) was done with the Microsoft Excel Macro from Jeremy Dawson's website [19,20].

Data retrieval for this study was conducted with permission of registered users of AMBOSS who agreed to the usage and privacy terms in the registration process. The AMBOSS system generates usage data about accessing MCQs, using learning

cards, and taking notes to provide statistical analysis functions to its users. The data gathered is analyzed to give individual users recommendations for their learning. Besides individual recommendations, anonymous usage data is analyzed in user research settings to improve the quality of the product. AMBOSS agreed to share its anonymous archival data while preserving the privacy of individual user data, according to the rules of General Data Protection Regulation in Germany (Datenschutzgrundverordnung [DSGVO]). This procedure is in line with the requirements of the local ethics committee.

**Table 1.** Hierarchical regression analysis with the number of learning cards and test questions (MCQs; Step 1) and the interaction between the two (Step 2) as independent variables, and the percentage of correct answers as dependent variable.

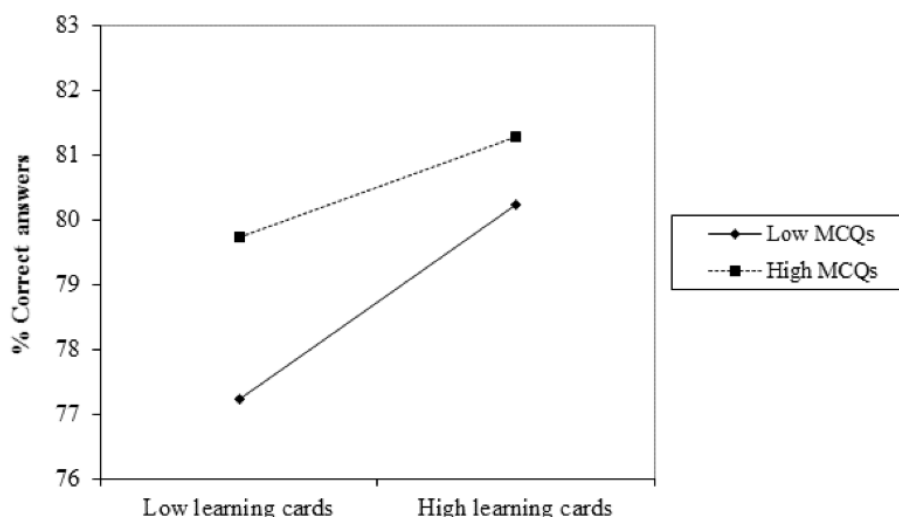
	<i>B</i>	<i>SE B</i>	$\beta$	$\Delta R^2$
<b>Step 1</b>				.067 <sup>a</sup>
Learning cards	0.747	0.038	.14 <sup>a</sup>	— <sup>b</sup>
Test questions	1.094	0.054	.20 <sup>a</sup>	—
<b>Step 2</b>				.001 <sup>a</sup>
Learning cards × Test questions <sup>c</sup>	0.064	0.016	.05 <sup>a</sup>	—

<sup>a</sup>This denotes a value with  $P < .001$ .

<sup>b</sup>Not applicable.

<sup>c</sup>Learning cards and test questions (MCQs) were z-standardized for the analysis.

**Figure 3.** Interaction between the number of learning cards and the number of test questions (MCQs). The dependent variable is the percentage of correct answers in the final exam. MCQs: multiple choice questions.



## Results

### Descriptives

On average, the users had studied 645.91 learning cards ( $SD=222.06$ ) and answered 5981.87 test questions ( $SD=1309.52$ ). A total of 8040 users took at least one note, with a mean of 94.31 ( $SD=293.89$ ). In addition, users reported an average of 79.48% ( $SD=7.75$ ) correct answers in their state exams.

### The Number of Learning Cards and Multiple Choice Questions as Predictors of Learning Outcomes

Both the number of learning cards studied ( $r=.22$ ;  $P<.001$ ) and the number of MCQs answered ( $r=.23$ ,  $P<.001$ ) were substantially correlated with the percentage of correct answers in the state exam. We used hierarchical regression analysis to answer the question as to whether the number of MCQs answered explained the percentage of correct answers in the exam over and above the number of learning cards studied. The number of test questions answered still yielded a significant effect even after controlling for the number of learning cards studied (see [Table 2](#), step 2).

**Table 2.** Hierarchical regression analysis with the number of learning cards (Step 1), test questions (Step 2), and notes (Step 3) as independent variables and the percentage of correct answers as dependent variable.

	<i>B</i>	<i>SE B</i>	$\beta$	$\Delta R^2$
<b>Step 1</b>				.043 <sup>a</sup>
Learning cards	0.011	0	.21 <sup>a</sup>	— <sup>b</sup>
<b>Step 2</b>				.017 <sup>a</sup>
Learning cards	0.008	0	.16 <sup>a</sup>	—
Test questions	0.001	0	.14 <sup>a</sup>	—
<b>Step 3</b>				.004 <sup>a</sup>
Learning cards	0.008	0	.15 <sup>a</sup>	—
Test questions	0.001	0	.14 <sup>a</sup>	—
Notes	0.003	0	.06 <sup>a</sup>	—

<sup>a</sup>This denotes a value with  $P<.001$ .

<sup>b</sup>Not applicable.

### The Interaction Between Multiple Choice Questions and Learning Cards

As a means of answering the exploratory research question on the relative effectiveness of learning cards and MCQs, we calculated a moderated regression analysis [21] in order to analyze possible interaction effects. We found a small, albeit significant, negative interaction between the numbers of learning cards and MCQs, indicating that those users who neither studied learning cards nor took MCQs scored worse in their final exam. Users with high scores for learning cards as well as for MCQs had the highest scores (see [Table 1](#) and [Figure 3](#)).

### The Number of Notes as a Predictor of Learning Outcomes

A two-tailed independent sample t-test showed that those 8040 participants who had taken at least one note had a higher percentage of correct answers (80.94%;  $SD=7.44$ ) than those who had not taken notes (78.73%;  $SD=7.80$ ;  $t_{23631}=20.95$ ;  $P<.001$ ).

A stepwise regression showed that the number of notes the participants had taken still predicted the percentage of correct answers over and above the number of learning cards studied and the numbers of MCQs answered (see [Table 2](#), Step 3).

## Discussion

### Principal Findings

Engaging with online learning materials, in the form of studying learning cards or answering test questions, was related to positive learning outcomes reflected in final grades on a state medical exam. Combining the learning activities of reading learning cards and answering MCQs resulted in the highest test scores on the final exams. The integration of both features on one learning platform appears to be a good way to support the learning activities of medical students. Moreover, taking electronic notes also went along with a higher percentage of correct answers on the medical exams. This finding held even when controlling for the effect of a number of other learning activities. Presumably, taking notes led to a deeper understanding of the learning material and hence to better retention.

### Limitations

AMBOSS was originally created specifically for medical students in Germany, but there is also an English version available. It is possible that the combination of using learning cards and answering MCQs could be helpful for exam preparation in general. As MCQs are a common examination format not only in Germany but also in other countries, it is

evident that our study questions are also relevant to other places in the world. Therefore, the question of how widely our findings can be generalized to other online platforms in different educational systems remains open. More research is needed to assess the robustness and generalizability of our main findings.

It is an established finding that time spent on learning can be a predictor of learning outcomes. For technical reasons, it was not possible to control for time spent in our analysis. Future studies should take this variable into account to differentiate between the impact of time spent on learning and the impact of specific learning activities, such as answering MCQs, reading learning cards, and writing notes. Another question for future research will be to figure out how tools that allow learners to share their knowledge, and mutually support each other [22-24], can improve the effectiveness of online learning platforms in the field of medicine.

However, we cannot rule out the possibility that the relationship between a greater use of learning cards, test questions, and notes with better performance on a test may be influenced by another variable. For example, it may be that medical students with a particularly high level of achievement motivation like to use

these learning opportunities and are at the same time the ones who already perform better. Future studies could address this limitation by, for example, allowing one group of students to make use of those tools and comparing them with those who did not have this opportunity. Finally, the question arises of whether or not the type of examination performance recorded here is in fact a good indicator of knowledge acquisition. MCQs are highly controversial in this respect. Students who have learned a lot with MCQs are better in the exam, which also uses MCQs, but whether this better performance leads to better, actually applicable knowledge has not yet been fully clarified.

## Conclusions

Online resources can play an important role in the training of medical professionals [25-27]. Studying learning material online is more effective whenever learning platforms offer their users ways of individualizing their environment [28] and of engaging more deeply with the learning topics [29]. One way of engaging more deeply could involve, for example, providing practice test questions or the technical means of attaching individual notes to the learning materials, which would reinforce the learning process.

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## Conflicts of Interest

EH is an employee of the AMBOSS Gesellschaft mit beschränkter Haftung (GmbH).

## Multimedia Appendix 1

Consort flow diagram.

[[PDF File \(Adobe PDF File\), 9KB - mededu\\_v5i2e13529\\_app1.pdf](#)]

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## Abbreviations

- DSGVO:** Datenschutzgrundverordnung  
**GmbH:** Gesellschaft mit beschränkter Haftung  
**MCQ:** multiple choice question
-

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Original Paper

# Building a Medical Education Outcomes Center: Development Study

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## Abstract

**Background:** Medical education outcomes and clinical data exist in multiple unconnected databases, resulting in 3 problems: (1) it is difficult to connect learner outcomes with patient outcomes, (2) learners cannot be easily tracked over time through the education-training-practice continuum, and (3) no standard methodology ensures quality and privacy of the data.

**Objective:** The purpose of this study was to develop a Medical Education Outcomes Center (MEOC) to integrate education data and to build a framework to standardize the intake and processing of requests for using these data.

**Methods:** An inventory of over 100 data sources owned or utilized by the medical school was conducted, and nearly 2 dozen of these data sources have been vetted and integrated into the MEOC. In addition, the American Medical Association (AMA) Physician Masterfile data of the University of Minnesota Medical School (UMMS) graduates were linked to the data from the National Provider Identifier (NPI) registry to develop a mechanism to connect alumni practice data to education data.

**Results:** Over 160 data requests have been fulfilled, culminating in a range of outcomes analyses, including support of accreditation efforts. The MEOC received data on 13,092 UMMS graduates in the AMA Physician Masterfile and could link 10,443 with NPI numbers and began to explore their practice demographics. The technical and operational work to expand the MEOC continues. Next steps are to link the educational data to the clinical practice data through NPI numbers to assess the effectiveness of our medical education programs by the clinical outcomes of our graduates.

**Conclusions:** The MEOC provides a replicable framework to allow other schools to more effectively operate their programs and drive innovation.

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**KEYWORDS**

outcome measures; data analysis; physicians; medical students; database management systems; data linkage

## Introduction

**Background**

In this era of *big data* and advanced data analytics, medical education must more effectively utilize data to enhance pedagogy, advance scholarship, and link educational outcomes

to clinical outcomes [1-8]. This involves the integration of noneducational data, such as clinical practice data, into the evaluation of medical education programs [3-8]. An essential goal of medical education evaluation is to ultimately determine the quality of our medical education programs by the quality of care delivered by our graduates and trainees. Data should also be used to develop and guide teaching and learning,

facilitate curricular development, and optimize educational experiences to develop future physicians who are diverse, meet workforce needs, and can positively impact health outcomes.

The vast amount of data generated and collected by medical schools has the potential to transform innovation in medical education. However, these valuable data often languish in siloed databases, making them inaccessible to those who need them the most. In addition, many of these databases lack standardized methodology and processes to guarantee that data are of high quality and that data security is maintained [1,2,8,9]. A system for tracking learners as they progress along the medical education continuum and into practice remains a challenge, as does determining which clinical practice outcomes are most sensitive to educational intervention effectiveness.

## Objectives

In response to these challenges, we developed the Medical Education Outcomes Center (MEOC) to connect educators, researchers, and other stakeholders to education researchers, datasets, data experts, and innovative analyses. We sought to collect, integrate, and manage data to enhance medical education programs, including strategic decision making and quality improvement, and to advance medical education scholarship. As part of these efforts, we developed a data request framework to efficiently and ethically receive and fulfill requests for medical school data. Finally, we identified a need to connect education data to practice data of our graduates. The purpose of this paper is to describe how we created MEOC, so that other institutions might replicate our process to meet the challenges of data integration, access, and utilization.

## Methods

### Resourcing and Personnel

As we considered tracking outcomes as a fundamental operational issue of a medical school, we resourced MEOC through medical school operational funds. Therefore, the MEOC team's structure is lean, and many members wear several hats. During the developmental phase of the project, the project team comprised a project sponsor, project manager, technical owner, business owner, website developer, and 1 analyst each from the Office of Medical Education and the Office of Health Sciences Technology. Aside from the analyst, none of the project team members were dedicated more than half-time to the MEOC project. This lean team structure provides a model for other institutions that may also wish to develop an outcomes center on a limited budget. Now that the MEOC has been launched, the team is growing and is exploring additional avenues for funding, including extramural grants.

The developmental phase of the MEOC project, including convening the initial team, inventorying of data sources, devising the request and data governance framework, and building the website, lasted approximately 1 year. Much of the work creating the request framework could be short-circuited by other institutions by following the model already devised by MEOC.

### The Medical Education Outcomes Center's Data Framework

One of the goals of the MEOC is to provide a centralized resource for all data and data-related services within the medical school. As the requesters' data-related needs can be varied, specific, and occasionally unpredictable, the data model followed by the MEOC was initially developed to be flexible and responsive to the unique needs of every requester. Therefore, instead of collecting multiple data elements into a single, highly structured database as in a traditional data warehouse model, under the initial MEOC model, all data continue to reside in their original data sources. By using standardized, reusable code and logic when feasible, these data are accessed and combined on an ad hoc basis by the MEOC data analysts. MEOC provides structure to the data model by inventorying, documenting, vetting, and validating the data sources to integrate them into the MEOC data framework. Furthermore, every fulfilled data request is carefully documented, which allows for increasingly efficient replication of frequently used data combinations. This model allows for bespoke combinations of data sources and elements as well as on-the-fly integration of new data sources as necessary. In addition, this initial approach allowed us to move forward with the MEOC development efforts relatively quickly and allowed us to understand and assess how frequently and in what ways the various data sources and data elements were routinely utilized. Through this approach, we are now able to assess and understand the needs, requirements, and resources to potentially develop a data warehouse.

### Data Elements and Sources

To lay a strong foundation for the data framework described above, the MEOC staff conducted a comprehensive inventory of over 100 data sources owned or utilized by the medical school, and nearly 2 dozen of these data sources have been vetted and integrated to date (Table 1). Disparate data sources were integrated with one another using common identifiers, data feeds, structured query language, and database views. Data sources were also connected using Tableau Server (Tableau Software, Inc, Seattle, WA) [10], a software tool that allows us to easily connect to and link together a variety of different data formats and relational database management systems.

We performed quality assurance of the data by applying data normalization and cleaning techniques to minimize or eliminate redundant data; to standardize data to account for the changes in how values were captured within certain data fields over the years; to account for inconsistencies in data owing to migration issues in which data were previously imported incorrectly; and to convert numeric, date, or character data types where necessary. Part of this process involved arranging data into logical groupings and promoting standardization across data sources. Potential limitations, constraints, anomalies, or notable exceptions about the data were identified, and the best practices for the use of the data were suggested. We captured this information as *meta-references* for each data source within an administrative metadata section of our MEOC website and also created data dictionaries and other supporting metadata documentation for each data source. We worked with subject

matter experts to translate key definitions into data terms to establish and document accurate, shared data definitions.

**Table 1.** Examples of data integrated into the Medical Education Outcomes Center.

Data types	Data sources (examples)
Prematriculation data	<ul style="list-style-type: none"> <li>American Medical College Application Service</li> <li>Integrated Postsecondary Education Data System</li> <li>Medical Scientist Training Program—includes admissions and assessments data</li> <li>MedAdmissions—University of Minnesota Medical School admissions data, including supplemental applications, interview, and other selection information</li> </ul>
Undergraduate medical education	<ul style="list-style-type: none"> <li>BlackBag—learning management system containing assignment, assessment, and curriculum data</li> <li>CoursEval—course and instructor evaluations, year-end evaluations, self-assessment, peer assessment, midcourse feedback, and curriculum mapping</li> <li>E*Value—clerkship rotation assessments</li> <li>MyProgress—observational assessments of student clerkship performance</li> <li>Medical Education Information System—includes all relevant undergraduate medical education student data such as scholastic standing, wellness participation and surveys, honors and awards, demographics, and biographics</li> <li>PeopleSoft—medical student financial aid data, demographics, and course and grade data</li> </ul>
Graduate medical education	<ul style="list-style-type: none"> <li>ACGME<sup>a</sup> milestone scores and subcompetency scores</li> <li>Scholarly work (eg, publications and conference presentations)</li> <li>Demographic and biographic data</li> <li>Residency information</li> </ul>
Practice data	<ul style="list-style-type: none"> <li>American Medical Association Physician Masterfile and National Provider Identifier</li> </ul>

<sup>a</sup>ACGME: Accreditation Council for Graduate Medical Education.

Within the administrative metadata section of our MEOC website, we created an *Acceptable Use* section to capture a summary of the ethical and appropriate use for each data source. We also identified data owners and data stewards for each data source. The data owners are the individuals ultimately responsible for the ethical and appropriate use of the data included in each source, and the data stewards are the individuals most familiar with the given data source and the context surrounding the data. For example, for admissions-related data sources, the associate dean for admissions is the data owner, and the admissions business analyst is the data steward. Final decisions regarding best practices and acceptable use were decided by the MEOC leadership team after consultation with the data owners and data stewards. Finally, as new data sources were formally vetted and integrated into the MEOC framework, we updated the internal and public data inventory documentation and communicated with the MEOC requestors, data owners and stewards, and other stakeholders.

### Data Request Framework

A comprehensive data request governance framework was created to standardize the intake and processing of requests. The framework was designed to provide a single point of entry for requesters; to provide a method of documenting requests and fulfillment efforts; and to ensure compliance with data privacy, ethical conduct, and human subjects research protections. Every requestor completes a request form, including sign off to a data use agreement that outlines their responsibilities regarding protection of the data. Before any data are released to the investigators for research purposes, documented institutional review board (IRB) approval or exemption is required. When developing our request framework, we identified factors related to requestor expectations: ease of

understanding, simplicity of the request Web form and processes, consistency in experience from request to request, reasonable turn-around time, transparency, and ability to see previous requests.

Although advances in technology have led to exponential growth in the ability of medical schools to collect and mine student data, this growth has also led to valid concerns regarding student data privacy [1,9]. One important goal was to apply the current best practices and standardized data protection measures for all our learner data. Example practices followed by the MEOC include providing all data as deidentified, except under specific circumstances; requiring requesters to complete trainings for Family Educational Rights and Privacy Act, Health Insurance Portability and Accountability Act, and information security awareness; requiring evidence of IRB approval or exemption for any data requests related to research; and ensuring that the relevant data owner(s) have the opportunity to approve or deny each request. For research-related requests, the IRB determines requirements for the learner's consent based on the specific project.

### Data Delivery

MEOC's default data analysis and delivery method is via Tableau Server [10], a data analytics, reporting, and visualization tool. In addition to being recognized as an industry leader in the space of data analytics platforms, Tableau Server allows technical and nontechnical users alike to easily explore data by using click-and-drag features and filter options. Furthermore, users can easily export data from Tableau Server for import into other tools such as statistical software programs.



## Communication About Medical Education Outcomes Center

A *slow rollout* strategy to communicate about MEOC was implemented. This began with the key internal stakeholders and was then extended to the broader medical school community, including our faculty. We established a dedicated website and intake process as described. A major component of this communication work was done through informational meetings with multiple departments, educational committees, and other key stakeholders. We have also conducted dedicated educational and research-in-progress sessions open to all faculty and staff to discuss the MEOC and to present the research performed using the MEOC resources.

### Ethical Approval

Ethical approval for dissemination of the MEOC model has been granted by the IRB of the University of Minnesota, study number: STUDY00005865. Each research request requires and has received an individual IRB application and approval.

## Results

### Overview

Since fall 2017, the MEOC has fulfilled over 160 data requests, with another 40-plus requests currently in the pipeline. These requests have culminated in a wide range of outcomes analyses, including peer-reviewed publications and support of accreditation and quality improvement work. Building MEOC was an enabling step to accomplish the goals outlined in the Introduction section. Much of this work is currently in progress.

### Examples of Medical Education Outcomes Center's Projects

#### *Predicting Student Outcomes*

Data analysis through the MEOC has fostered several projects examining the predictors of medical students' performance. These projects have used demographic, prematriculation, and exam data to predict performance in medical school as assessed by the grades in foundational science courses, performance on United States Medical Licensing Examination 1 and 2 [11,12], selection to Alpha Omega Alpha Medical Honor Society [13], and the type and location of residency [14].

#### *Liaison Committee on Medical Education Accreditation*

The MEOC has been used as the data clearinghouse for information needed for the data collection instrument (DCI) as

part of the Liaison Committee on Medical Education's (LCME) reaccreditation work. Requests for DCI data utilized the MEOC's data request framework and were tracked and completed as described above. These requests have provided a mechanism to complete the DCI's data tables and to track our current reaccreditation efforts. By standardizing this process, we will be able to prospectively update DCI-related data between LCME accreditation visits and more effectively monitor and report progress addressing any citations. The MEOC has also been used for ongoing continuous quality improvement work for the University of Minnesota Medical School (UMMS).

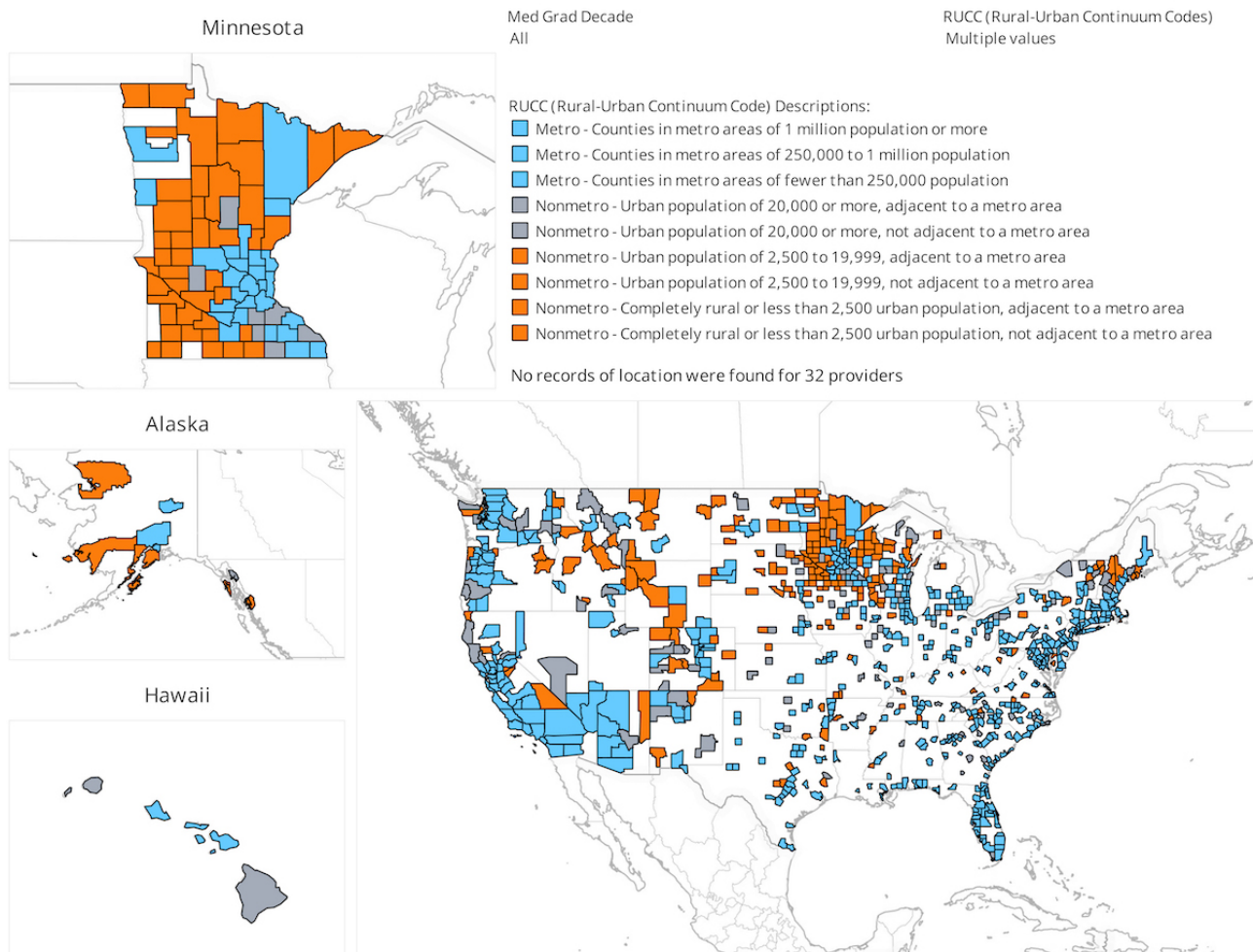
#### *Tracking Graduates*

Work has begun on integrating clinical outcomes data into the MEOC to link the effectiveness of medical education programs to future clinical outcomes of UMMS graduates once they enter practice [2-8]. As an initial step in this process, we needed a method to track the UMMS graduates to determine their geographic location and specialty. We used the American Medical Association (AMA) Physician Masterfile, which contains recent practice and training information, including current practice locations, training milestone dates, and certifications. We purchased a subset of the Masterfile, containing 13,092 UMMS graduates, from Medical Marketing Service (Schaumburg, IL), which has been licensed by the AMA to distribute these data.

Of the 13,092 UMMS graduates in the Masterfile, National Provider Identifier (NPI) numbers were available for 10,443 individuals. The NPI numbers are issued by the Center for Medicare and Medicaid Services and are used by Medicare and commercial insurers to identify the specific provider of health care services. NPI numbers provide the *key* to link with clinical databases. The geographic distribution of the practice locations for these UMMS graduates with an NPI number is displayed in Figure 1.

Detailed digitized records of our students are kept in the UMMS's internal Medical Education Information System, with records dating back to 2002. Using data from the NPI registry and a matching algorithm, the MEOC has thus far been able to link 3983 of these student records to the AMA/NPI dataset. With this connection between UMMS-held educational records and AMA/NPI data established, we will be able to link educational measures to clinical databases through NPI numbers to study the effects of medical education on future clinical outcomes down to the level of individual physician data.

**Figure 1.** Practice location by county of the University of Minnesota Medical School graduates listed in the American Medical Association Physician Masterfile and that have National Provider Identifier numbers linked to them (n=10,443). Each shaded area represents a single county and may be the location for multiple providers. This figure is created using Tableau software with map data from OpenStreetMap contributors. OpenStreetMap data are licensed under the Open Data Commons Open Database License.



## Discussion

### Principal Findings

We developed the MEOC to integrate education data and to build a framework to standardize the intake and processing of requests for using these data. The MEOC has several strengths,

as summarized in [Table 2](#). Through the MEOC, requests for data are generated, documented, and tracked in a formal, streamlined, and consistent manner. Prior requests for similar data or for similar purposes are leveraged, leading to greater efficiency. Formalization of these processes mitigates security concerns surrounding data delivery, privacy, and access.

**Table 2.** Strengths of the Medical Education Outcomes Center (MEOC). This table outlines the common problems faced before and after the development and implementation of the MEOC framework.

Problem	MEOC's solution
Uncertainty about where and how to request and obtain data	Single point of entry for all data requests
Inconsistent, informal, or undocumented processes for requesting and providing data	Formal, documented, streamlined, and consistent processes to generate and track all data requests, including associated approvals, rationale, and permissions tracking
Uncertainty regarding what data are needed or are available and relevant for a requestor's specific needs	Knowledge and guidance in identifying proper data sources and data elements
Use of the same data for similar purposes, resulting in potential duplication of effort and inefficiencies	Prior requests for similar data or purposes are leveraged, leading to greater efficiency, consistency, and potential opportunity for collaboration
Independent or solo analysis and interpretation of data, potentially with limited context or experience	Full range of services to assist in analyzing and interpreting data
Errors or inconsistencies in the definition, use, and interpretation of data	Development of standardized data definitions, fostering the consistency in use, definition, and interpretation of data throughout the school
Data residing in siloed databases	A framework for the integration of disparate data sources
Potential for privacy and security concerns surrounding data delivery and access	Secure data delivery methods with ethical, data privacy, and human subjects research protections compliance, including proper deidentification protocols
Difficulty tracking learners as they progress along the medical education continuum into practice	Use of the American Medical Association Physicians Masterfile and National Provider Identifier numbers to link learner data and educational measures to clinical outcomes

## Challenges and Limitations

An initial challenge in building the MEOC was related to stakeholder engagement. For example, we needed to formalize the roles of data owners and data stewards, demonstrate the value of this project to them, develop an effective communication strategy, and streamline the work they needed to do. An important component of this initial work was to define the governance structure for the use of the data. Initial technical challenges included identifying and integrating the many sources of data that are owned or utilized by the medical school; optimizing our website and data request framework; and conducting back end data work including establishing or optimizing databases and performing data quality assurance, normalization, and cleaning efforts.

Procurement of resources for supporting the work in the MEOC was another challenge. Since its inception, the MEOC has been supported by operational funds, as discussed above. As the MEOC became more established, we experienced capacity issues. As stakeholders throughout the medical school became aware of the MEOC, the number of data requests has increased, and we have required more personnel to be able to meet these increased demands. Furthermore, although the MEOC data framework has worked very well to date to provide flexibility in the data model, the process of combining data sources for every request is resource heavy and limits the scalability of the center. Therefore, we are now exploring the possibility of also building a data warehouse, which would include the elements most frequently needed by our users.

## Next Steps

The major next step is to link educational measures and outcomes data to clinical databases using the NPI numbers of our students and residents. This will allow us to develop

predictive models for future career choice, practice location, and, ultimately, clinical performance of our graduates. We will be able to begin assessing the effectiveness of our medical education programs by the quality of care delivered by our graduates [2,4,5,7,8]. Linking the medical education continuum to clinical practice will be a powerful tool to facilitate the design of educational experiences that positively impact patient outcomes, a link of utmost importance that has yet to be broadly formed. We will be able to determine if educational experiences, such as rural longitudinal integrated clerkships, are a more effective training model with lasting effects (ie, *educational imprinting*) and whether this model impacts rural versus urban practice location. We will be able to determine whether it matters where one trains and how long the training effects persist. We will be able to study the impact of specific curricular elements on future practice patterns and apply predictive analytics to prematriculation data to select students who meet the goals of our school. Many additional questions will now be accessible for study, and the MEOC will also aid in the design of future studies to ensure these questions and the studies to answer them are well designed.

Several publicly available clinical practice data are available on a local and national level such as Medicare data, clinical registries, and health system databases [2,7]. Linking educational and clinical data raises important challenges such as the attribution of outcomes in complex and interprofessional health systems, the lag time between education and practice, the tracking of learners across institutions, and the long-term impact and sensitivity of educational interventions on clinical outcomes [2,3,5,7,8].

Despite the challenges of linking education data to practice data, some associations between medical education and clinical outcomes have been reported, illustrating the power and

potential of this type of work. Asch et al have evaluated obstetrical residency programs using maternal complication rates and demonstrated that residents trained in programs with low maternal complication rates had lower complication rates in subsequent practice [4,15]. Chen demonstrated a relationship between the spending patterns in the region of a resident's Graduate Medical Education program and the subsequent mean expenditure per Medicare beneficiary by that resident, once they entered the internal medicine or family medicine practice [16]. Associations have also been demonstrated among the licensing exam scores, delivery of lower-intensity clinical care, quality of surgical residency programs, and the future practice performance of graduates [17-19]. To more effectively link

medical education to clinical practice, a uniform system for collecting and analyzing outcomes and greater availability of prospectively designed databases that can be used across institutions are needed.

## Conclusions

In summary, the MEOC provides a model for the development of an educational outcomes center that can be adapted to other institutions. The MEOC's integration of data sources and data request framework provides greater accessibility to data to inform medical education practice and research. By using the MEOC framework as a model, medical schools can leverage their data and related analytic resources to more effectively operate their programs and drive innovation.

## Acknowledgments

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## Conflicts of Interest

None declared.

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## Abbreviations

- AMA:** American Medical Association  
**DCI:** data collection instrument  
**IRB:** institutional review board  
**LCME:** Liaison Committee on Medical Education  
**MEOC:** Medical Education Outcomes Center  
**NPI:** National Provider Identifier  
**UMMS:** University of Minnesota Medical School

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Original Paper

# Understanding the Use and Perceived Impact of a Medical Podcast: Qualitative Study

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## Abstract

**Background:** Although podcasts are increasingly being produced for medical education, their use and perceived impact in informal educational settings are understudied.

**Objective:** This study aimed to explore how and why physicians and medical learners listen to The Rounds Table (TRT), a medical podcast, as well as to determine the podcast's perceived impact on learning and practice.

**Methods:** Web-based podcast analytics were used to collect TRT usage statistics. A total of 17 medical TRT listeners were then identified and interviewed through purposive and convenience sampling, using a semistructured guide and a thematic analysis, until theoretical sufficiency was achieved.

**Results:** The following four themes related to podcast listenership were identified: (1) participants thought that TRT increased efficiency, allowing them to multitask, predominantly using mobile listening platforms; (2) participants listened to the podcast for both education and entertainment, or "edutainment"; (3) participants thought that the podcast helped them keep up to date with medical literature; and (4) participants considered TRT to have an indirect effect on learning and clinical practice by increasing overall knowledge.

**Conclusions:** Our results highlight how a medical podcast, designed for continuing professional development, is often used informally to promote learning. These findings enhance our understanding of how and why listeners engage with a medical podcast, which may be used to inform the development and evaluation of other podcasts.

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**KEYWORDS**

podcasts; grounded theory; medical education

## Introduction

### Background

The increasing popularity of medical podcasts in the era of free open access medical education [1-3] has led to a demand for research to evaluate these materials. Evidence based on opinions and consensus from experts [4-6] suggests that educators should consider credibility and podcast length in their listening choices and development of educational materials [4]. A tool for predicting successful anesthesia podcasts has also recently been developed [7] based on literature review because of a paucity of user rating data. There are also expert-defined quality indicators for social media-based research and educational materials [5]. For example, emergency medicine specialists have recently created a system for assessing and curating credible podcasts for graduate medical education [6]. Empirical research on the use of medical podcasts is needed to inform these expert recommendations and future research.

### Podcast User Experience

Despite an increase in podcast development and uptake in medical education, little is known about user motivation and experiences with podcasts as part of ongoing personal learning in medical education and continuing professional development. Particularly, available podcast literature on this topic is largely based on survey data, and it focuses on medical students [8] or residents [9], rather than including practicing medical professionals. The literature that does include practicing physicians is related to social media more generally, including but not limited to podcasts [10-14]. Surveys of medical students or residents have revealed preliminary insights into podcast users' listening habits, motivation, and perceived impact on practice. For example, a recent survey of medical student listeners suggested that listening while engaging in other activities was common [8]. Another study surveying emergency medicine resident podcast listeners found a primary motivator for listening was to "keep up with current literature" [9]. Despite these insights, survey-based studies limit the depth of responses obtained, and currently, there is limited knowledge on how intrinsic podcast factors, such as content and style, affect user experience.

### Objectives

A greater understanding of how and why individuals across the training spectrum incorporate podcasts into ongoing personal learning in medical education and professional development is required. As an increasingly expanding resource in medical education, a richer understanding of medical podcast consumer experience, from students to independent clinicians, is essential for effective podcast development. Using a locally produced weekly internal medicine podcast as an example of medical podcasting, the objective of this study was to explore how and why physicians and medical trainees listen to podcasts.

## Methods

### Approach

The objective of this study was to identify, through interviews and thematic analysis [15], key factors influencing podcast usage and user experience. The sampling and analytic approach was informed by the principles of constructivist grounded theory, a qualitative methodological approach [16,17]. Web-based podcast analytics were also used to collect preliminary information on podcast use and listening habits, and this information provided the context for qualitative interviews.

### Context

The Rounds Table (TRT) is a free weekly podcast, produced by physicians at the University of Toronto, which summarizes, analyzes, and contextualizes new research in internal medicine. Approximately 100 episodes have been published on the Web since March 2014. Most episodes follow a typical format: 2 cohosts (1 fixed and 1 guest) discuss 2 recently published research studies with broad implications for adult medicine. Each episode concludes with a "good stuff" segment, in which the cohosts briefly recommend something from popular media or scientific literature that has captured their attention and listeners may find interesting. Episodes typically last approximately 30 min. At the time of the study, cohosts were predominantly senior residents or early career staff physicians based at the University of Toronto. The Web-based podcast analytics data were obtained from Blubrry [18], one of the industry's leading podcast analytics providers. All download, streaming, and play requests were captured to provide a comprehensive statistic of the number of downloads, excluding bots, Web crawler, or machine downloads. This study reported download statistics, including trends over time, geographic distribution of listenership, and listening platforms used.

### Interviews

A total of 21 semistructured interviews with TRT listeners were conducted from June 2016 to March 2017. Purposive and convenience sampling was used to recruit participants varying in geographic location and level of familiarity with the podcast hosts. Listeners were invited first by email in the initial purposive sampling phase and subsequently by announcement during the podcast in the convenience sampling phase. In the purposive sampling phase, 12 of 15 (80%) known podcast listeners invited agreed to participate. In the convenience sampling phase, 10 listeners contacted the podcast hosts to participate after hearing the announcement. Of the 6 medical learners or staff, 5 (83%) were interviewed. A total of 4 volunteers were not medical learners or physicians, and they were therefore excluded after the interview, resulting in a final sample size of 17. All interviews were conducted by the first author (SM), via telephone, Skype audio, or in person, using a semistructured interview guide, which was developed on the basis of group discussion and literature review ([Multimedia Appendix 1](#)). The interview guide specifically included questions about TRT podcast, as well as questions regarding general podcast use. Before starting the interview, all participants were asked 4 demographic questions: age, level of

training, geographic location of residence, and how many episodes of TRT they had listened to (less than 5, 6-15, more than 15, or all episodes to date). The study was approved by the University of Toronto Research Ethics Board. Participants were offered a nominal gift card for participation.

### Data Analysis

Interviews were recorded and transcribed verbatim. Authors SM and LM, who were not involved with the creation or dissemination of the podcast, analyzed the data using line-by-line coding facilitated by NVivo version 11 (QSR International) to identify initial codes that were subsequently grouped into themes. Analysis proceeded alongside data collection, using an iterative, constant comparative approach [16]. SM and LM met frequently to discuss the evolving coding structure and themes. The interview guide was modified as interviews progressed to elaborate upon themes identified in the earlier interviews. Discussions related to some questions (ie, 1 and 8, [Multimedia Appendix 1](#)) were diverse and ultimately did not contribute additional themes or understanding to the data. Data were collected and analyzed until theoretical sufficiency was reached [19]. Subsequently, the coding framework was shared with KQ, NZ, SG, and AAV, who each read a sample of 2 transcripts and provided feedback and comments. The entire team then met to review and finalize the

themes. Each member of the research team brought varying perspectives to the analysis. A total of 4 authors (AAV, FR, NZ, and KQ) were the creators or hosts of the podcast, and they may have had preexisting notions about how it was perceived by listeners. To mitigate any potential bias, authors SM and LM, who were not involved in podcast development or dissemination, led the coding and analysis.

### Ethical Approval

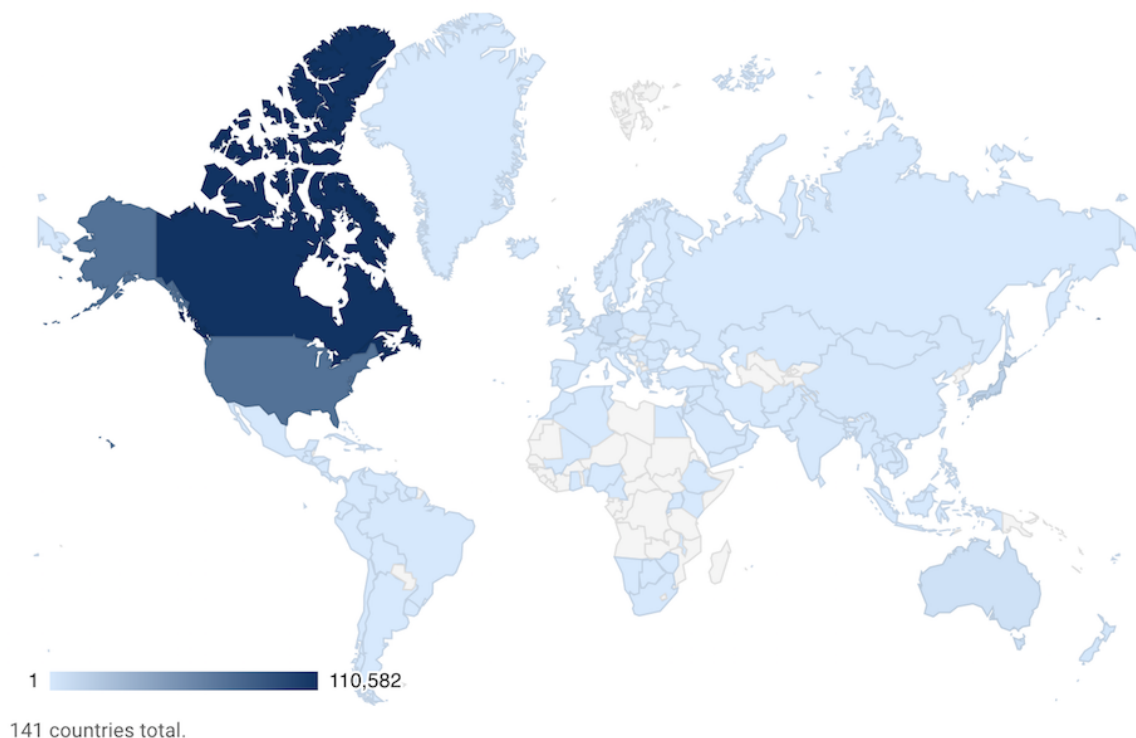
The University of Toronto Research Ethics Board reviewed and approved the research (protocol reference #32948).

## Results

### Podcast Use Statistics

TRT has had more than 160,000 unique downloads in 141 countries ([Figure 1](#)). More than three-fourths (182,526/227,518, 80.22%) of total downloads are from North America, and the remaining minority are predominantly from Japan (5.92%), Germany (2.69%), the United Kingdom (2.15%), and Australia (2.14%). TRT listenership has grown since its inception, presently averaging 8000 to 10,000 monthly downloads. Most listeners use mobile devices, running Apple iOS or Android operating systems to access TRT (168,363/227,518 total downloads, 73.87%, [Table 1](#)).

**Figure 1.** Density map of downloads of The Rounds Table podcast in each country.



**Table 1.** Devices used to download The Rounds Table podcast (N=227,518).

Device	Total downloads, n (%)
Mobile	168,060 (73.87)
Desktop	48,253 (21.21)
Other	11,205 (4.92)



## Interview Sample

The sample comprised 8 (47%) men and 9 (53%) women, whose ages ranged from 21 to 49 years. Participants were at varying levels of medical training or practice (2 medical students, 8 residents, and 7 staff physicians). The residents were primarily internal medicine residents, with 1 neurology resident and 1 obstetrics resident. Staff physicians were all internists (general internal medicine or subspecialty trained), with the exception of 1 family medicine-trained hospitalist. Most interviewees (13/17, 76%) resided in Canada, whereas 2 resided in the United States, 2 in the United Kingdom, and 1 in Switzerland. A total of 14 out of 17 (82%) of the interviewees had listened to more than 15 episodes of TRT.

## Themes

Thematic analysis of participant discussions yielded 4 main themes with respect to podcast usage and listenership: to increase efficiency, for keeping up to date, “edutainment,” and to indirectly impact clinical practice. Although our focus was on TRT, participants often discussed podcast use in a more general way, which helped to develop a greater understanding of podcast use in general.

### Theme 1: Podcast Use to Increase Efficiency

Podcast use was often described as a way of optimizing efficiency, injecting education into otherwise mundane or routine tasks such as commuting, cooking, and cleaning. Many saw this as “multitasking”:

*Podcasts are the best way for me to be able to basically study as I go through my morning... [P15, resident]*

*I prefer to listen to [podcasts] during what I would consider to be time which would be otherwise ineffective. So for instance, just commuting to work, or if I have to go for a drive somewhere. And I wouldn't be doing anything else in that time. I like to be able to put on podcasts and make use of that time and learn something. [P8, resident]*

Listeners described matching their task to the podcast length. To overcome a mismatch in podcast length to chosen task, 1 participant described listening to TRT at double speed:

*They tend to be a good length for what I do. I listen double time so the length tends to be ok for my subway trip. [P4, staff]*

### Theme 2: Podcast Use for Keeping Up to Date

Respondents universally described that listening to TRT was a part of their continued efforts to stay up to date in the medical literature:

*I find it a very convenient way to continue to keep up with emerging studies and exciting findings in my field. [P5, resident]*

Some respondents felt that the “journal-club” style format of TRT, in which the podcast hosts critically analyze and discuss the literature, saved them time by eliminating the need to read the article and critique it themselves. Many listeners appreciated the educational value of a critical analysis of recent literature:

*I like how they went through each paper in a critical way like you would at a journal club, but it wasn't presented in such intense detail that you lost the greater picture of what was done or what the results were clinically...In addition to that, the way that some of the papers are presented has helped me be more critical of papers that I read in terms of limitations and strengths. [P10, resident]*

### Theme 3: Podcast Listening as “Edutainment”

Participants also reported enjoying the experience of listening because of the entertainment value of TRT, referred to as “edutainment”:

*It's sort of something that I do...it doesn't feel to me like it's a lecture. It's more of a form of entertainment but I'm also at the same time getting educated. So “edutainment.” [P11, medical student]*

This was reflected in participants' discussion of their enjoyment in listening to a friendly discussion among colleagues, blended with banter and humor. For example, 1 listener felt a benefit of the conversational style was that it created a sense of “eavesdropping on a conversation” (P2, staff). A conversational style also engendered a sense of familiarity with the hosts. In addition, several participants reported that they either knew one or more of the hosts because of their local reputation or because they were personally acquainted with the hosts. Personal familiarity and local context created a sense of trust or credibility in the information being relayed, as well as a feeling of wanting to support colleagues by listening:

*I trusted [Host] that if I listen to this podcast, most likely I am not going to be missing really big landmark trials. So I didn't have to worry too much not reading Lancet and all these other journals I used to read. [P6, staff]*

*I know a lot of the people that are on it so it seems like if they know this I should know this too-it's more relevant...the other ones like in the UK, yes it is about geriatric medicine and should be more relevant to my practice but I feel like I don't really know those people. [P2, staff]*

As a result of this early finding, the research team actively sought out listeners who did not know the hosts personally to explore the concept of credibility. These listeners reported a varying approach to gauging the credibility of the hosts. Some listeners appeared to determine credibility based on the hosts' credentials:

*I determine their credibility...just from their experience. So, their profiles online. The fact that they're residents in the field I think just gives them their credibility automatically. [P1, medical student]*

Others described a comfort with the presentation style and material:

*They just sound quite credible, don't they? [laughing] They sound very comforting...they sound like they know what they're talking about and they can have a reasonable argument. That to me is more credible*

*than having a list of accolades that you've done this x, y and z. [P18, staff]*

#### **Theme 4: Podcast Impact on Individual Practice**

Listeners felt that TRT indirectly or over time affected their practice by helping them increase their overall knowledge rather than directly or immediately changing their clinical practice. Specifically, listening to the podcast facilitated their awareness of scientific literature, including major trials and clinical practice guidelines. Listeners described that they may use the podcast as a starting point from which to delve further into a subject or return to read in detail the article discussed on the podcast:

*I think it overall just makes you a more well-rounded clinician and not so narrow minded about one way to do things. Makes you come from a different perspective sometimes. So I think that, in a subtle way, likely helps. [P9, resident]*

Practicing physicians used the podcast to enhance awareness, process scientific information, and determine applicability to clinical practice:

*So when I listen to these things does it directly change my practice right away? Probably not because I'm someone who is a little more conservative to my approach in adopting new stuff anyway. But is it information that ultimately changes my mind down the road? For sure... [P4, staff]*

One physician also noted applicability to teaching:

*Sometimes they review papers before they came out [in print]...So I could teach trainees earlier... because I could listen multiple times, I remembered things better so I could apply to my patient care. [P6, staff]*

On the other hand, trainees described the podcast as a means to develop well roundedness and preparation for potential questions “that you actually get asked about by staff” (P7, resident) on the wards, that is, from supervisors on ward-based rotations:

*I remember certain articles that I picked up...being able to recall that and discuss that with my attendings. I don't know if it actually went to the point where it came down to patient care. [P16, resident]*

## **Discussion**

### **Principal Findings**

This paper explored how and why listeners engaged with a specific medical podcast, TRT, by reporting both Web-based analytics involving more than 160,000 unique downloads and in-depth qualitative interviews with 17 listeners. We found a steady growth in the use of TRT over time, and it can now be classified as a moderate-impact educational intervention [20], suggesting that there is a demand for a general adult medicine podcast. Listeners predominantly engage with the podcast by using mobile devices, which corresponds with our interview findings. We also found that the podcast was perceived to increase efficiency and permit users to multitask by using mobile platforms. This study confirms and extends the findings from survey-based studies of single learner categories [8,9], demonstrating that listeners across all stages of training and

practice turn to a medical podcast to expand their knowledge in a way that integrates into their daily lives, enhancing efficiency while simultaneously providing entertainment. We explored intrinsic podcast features that enhance motivation for listening, which has not been previously reported. A key finding of this study was that the enjoyment of listening to a podcast, as well as the consequent motivation for listening, is related to features such as the use of humor, banter, and active critical appraisal of the literature. Listeners of this podcast make credibility judgments based on assumptions related to familiarity and credentials of the cohosts and their presentation style. The results also shed light on what listeners could mean when they say that listening has an impact on their learning and practice [9]. The participants largely used the podcast to augment knowledge, as part of their desire to stay up to date with medical literature. Trainees tended to use the podcast to prepare for ward-based questions from supervisors, whereas practicing physicians used it for teaching or to build a knowledge base and rationale to change future practice. In total, these findings highlight how a podcast developed for continuing professional development is often used informally by its listeners to promote learning.

### **Implications for Medical Podcast Development**

Although the study focused on 1 podcast in particular, participants also spoke of medical podcast use more generally. Thus, our findings may be useful when considering the development and uptake of medical podcasting in continuing medical education. The finding that podcast use is a way to increase efficiency suggests that medical podcasts should be designed for pairing with common multitasking activities. Similar to other studies [4,21], we found that concise and modular podcasts are preferred. We also found that listeners actively task match, choosing a podcast to suit the length of a task. Our work suggests that in addition to topic complexity [4], discrepancy in listening time preferences may be related to the length of the concurrent task, such as a commute to work, rather than the podcast itself. Podcast developers can use this information to actively design podcast length and features to align with common concurrent tasks to optimize user uptake.

Listeners' descriptions of using the podcast as a means to keep up to date with the medical literature suggest that podcasts, such as TRT, serve as a supplement in informal medical education. This finding was consistent between medical trainees and practicing physicians. Although podcasts have been used in medical curricula as part of formal education [2], this study reveals that learners across the spectrum of training and into practice also use podcasts as a means to increase overall knowledge, as well as to fill specific gaps that may be identified. Understanding what “gaps” may exist for different populations of medical trainees and clinicians [22] could thus help podcast developers identify content to better target end users. It makes intuitive sense that listeners want to be entertained, especially if they are reaching for a podcast in their downtime. The concept of “edutainment,” the combination of education and entertainment, is popular in educational programming, dating back to television shows such as Sesame Street [23]. The entertainment value of podcasts emerged as a prominent theme in our interviews among medical learners, residents, and staff,

extending the findings of an earlier study [9]. Listeners enjoyed active discussions between hosts, along with jokes and banter, which they found to be more engaging than a single host reading a manuscript. Along these lines, they reported enjoying the “good stuff” segment, a portion of the podcast that was included largely for entertainment value. Such intrinsic and modifiable podcast features can be readily adapted across the spectrum of medical podcasts to enhance listener experience and motivation for listening. We did not examine potential differences in the value placed on entertainment between trainees and practicing physicians [12], but this may be an interesting area for further research. The concept of podcast and host credibility was explored in our interviews. Our results suggest that interest and enjoyment in listening itself may engender a sense of familiarity to the hosts, which seems to then lend credibility to the podcast. There may also be intrinsic benefit to having a local podcast, where listeners are more immediately familiar with the hosts from the local context. Interest and familiarity are concepts in current theories on “motivation to learn” [24]. Task value, including interest, is a key influencer of behavior in expectancy-value theory. Self-determination theory outlines intrinsic motivation for a task and the importance of a sense of relatedness or social connection [24]. Further work should explore the interactions among interest, familiarity, and credibility and their relative impact on podcast user motivation to add to existing theory. Creators of medical podcasts may want to consider how to deliberately cultivate a sense of familiarity when a podcast is used beyond a local context. Finally, this study illuminates how the use of a single podcast contributes indirectly to practice by supplementing knowledge. Trainees describe this knowledge in generic terms, whereas practicing physicians describe it as one of multiple sources of potentially practice-changing information. Podcast use is one of several strategies for medical trainees and practicing clinicians to enhance their knowledge. However, the results of this study demonstrate the complexities of using a form of social

media for knowledge dissemination. The use of podcasts in informal or multitasking settings may limit their educational impact, as it is not known how engaging in concurrent tasks affects retention of podcast material. In fact, little is known about how podcast information is retained and applied over longer periods [1,8]. Thus, future work should be focused on directly evaluating the effectiveness of continuing professional development podcasts in helping users learn and retain information or skills, such as critical appraisal of scientific literature.

### Strengths and Limitations

Web-based podcast analytics permit comprehensive capture of podcast use statistics; however, they are limited in their ability to understand listener motivation and experience. A strength of this study was using semistructured interviews that elicited rich responses from listeners, allowing us to better contextualize the Web-based data, as well as expand on the mode, purpose, and impact of listening [8,9]. This study’s results are also strengthened by triangulating the experience of multiple listeners, inclusive of trainees and practicing professionals, from different countries. However, the volunteer participants in this research were engaged listeners of a single podcast, which may limit transferability. Future research should explore the experiences with more than 1 medical podcast to determine if the findings of this study can be transferred to another context. The user experiences and motivation of residents versus faculty are also areas for further exploration.

### Conclusions

This study highlights how and why medical trainees and clinicians use a medical podcast in informal medical education. Understanding how emerging technologies can be optimized for medical education and professional development will facilitate design of educational materials at any stage of medical education.

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### Authors' Contributions

AV and LM contributed to this study equally as co-senior authors.

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### Conflicts of Interest

AV, FR, KQ, and NZ have been directly involved with creating and producing The Rounds Table podcast, a not-for-profit educational initiative.

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### Multimedia Appendix 1

Semistructured interview guide.

[PDF File (Adobe PDF File)69 KB - [mededu\\_v5i2e12901\\_app1.pdf](https://mededu.v5i2e12901_app1.pdf) ]

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## Abbreviations

**TRT:** The Rounds Table

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Original Paper

# Introduction of Ultrasound Simulation in Medical Education: Exploratory Study

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## Abstract

**Background:** Ultrasound is ubiquitous across all disciplines of medicine; it is one of the most commonly used noninvasive, painless diagnostic tools. However, not many are educated and trained well enough in its use. Ultrasound requires not only theoretical knowledge but also extensive practical experience. The simulated setting offers the safest environment for health care professionals to learn and practice using ultrasound.

**Objective:** This study aimed to (1) assess health care professionals' need for and enthusiasm toward practicing using ultrasound via simulation and (2) gauge their perception and acceptance of simulation as an integral element of ultrasound education in medical curricula.

**Methods:** A day-long intervention was organized at the American University of Beirut Medical Center (AUBMC) to provide a free-of-charge interactive ultrasound simulation workshop—using CAE Vimedix high-fidelity simulator—for health care providers, including physicians, nurses, ultrasound technicians, residents, and medical students. Following the intervention, attendees completed an evaluation, which included 4 demographic questions and 16 close-ended questions based on a Likert scale agree-neutral-disagree. The results presented are based on this evaluation form.

**Results:** A total of 41 participants attended the workshop (46% [19/41] physicians, 30% [12/41] residents, 19% [8/41] sonographers, and 5% [2/41] medical students), mostly from AUBMC (88%, 36/41), with an average experience of 2.27 (SD 3.45) years and 30 (SD 46) scans per attendee. Moreover, 15 out of 41 (36%) participants were from obstetrics and gynecology, 11 (27%) from internal medicine, 4 (10%) from pediatrics, 4 (10%) from emergency medicine, 2 (5%) from surgery and family medicine, and 5 (12%) were technicians. The majority of participants agreed that ultrasound provided a realistic setting (98%, 40/41) and that it allowed for training and identification of pathologies (88%, 36/41). Furthermore, 100% (41/41) of the participants agreed that it should be part of the curriculum either in medical school or residency, and most of the participants approved it for training (98%, 40/41) and teaching (98%, 40/41).

**Conclusions:** All attendees were satisfied with the intervention. There was a positive perception toward the use of simulation for training and teaching medical students and residents in using ultrasound, and there was a definite need and enthusiasm for its integration into curricula. Simulation offers an avenue not only for teaching but also for practicing the ultrasound technology by both medical students and health care providers.

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**KEYWORDS**

medical education; simulation training; ultrasonography

**Introduction****Background**

Ultrasound is ubiquitous across all disciplines of medicine; it is one of the most commonly used noninvasive, painless diagnostic tools. However, not many are educated and trained well enough in its use. In obstetrics and gynecology (OB/GYN), for instance, ultrasound is the primary method of imaging [1]. Its use encompasses screening as well as expert examination of normal and abnormal cases [2]. It has become an essential part of medical practice, often irrespective of the ability, competence, and experience of the operators [3,4]. The lack of standardization in training and assessment of skills has become a matter of concern worldwide [5].

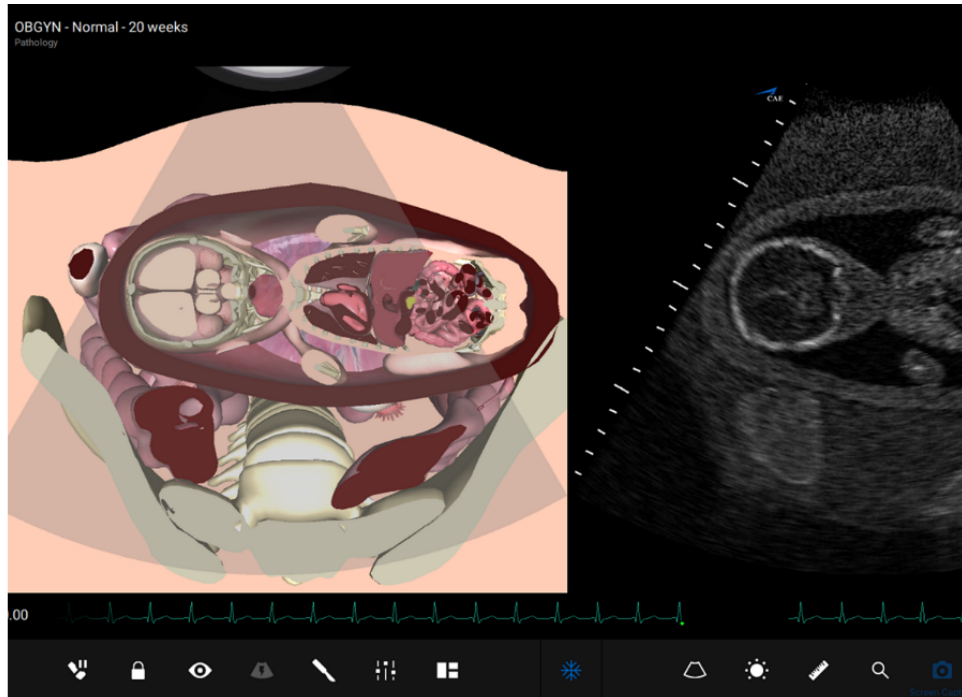
Currently, theoretical knowledge of ultrasound technology and application is sometimes insufficient, and practical training has traditionally been patient-dependent, that is, achieved on actual patients or volunteers [6]. However, this conventional approach has numerous challenges, especially during the initial phase of training; it adds undue pressure on trainees interacting with patients, potentially distracting them from correctly handling the ultrasound probe and/or accurately interpreting the images [6]. Furthermore, developing competency in ultrasound is largely dependent on the variety and number of cases encountered during clinical practice [7]. Finally, the more important issue is the challenge of patients not willing to be examined by trainees [8]. Ultrasound training is time-consuming and requires extensive teaching resources [3,4]. Consequently, some trainees may never acquire the basic skills and knowledge needed for independent practice [5]. The lack of sufficient operator skills can lead to diagnostic errors that may compromise patient safety. The increased focus on medical errors and patient safety calls for development of alternative methods for continuous education and assessment of skills [9].

These changes in the context of medical education and training have paved the way for a somewhat new concept of learning, that is, simulation, focused mainly on learners' needs and patient safety [10]. The emerging field of simulation-based education has been shown to improve basic ultrasound training [2-5]. Simulation provides a safe, controlled, and learner-centered environment, which allows for repeated practice without any patient discomfort or harm [6,7]. Simulation-based training may enable trainees to become familiar with image optimization, probe orientation, as well as practicing a systematic approach to ultrasonography before beginning clinical training [5-8].

Ultrasound simulators are integrated simulators, generally composed of a human mannequin, a mock probe, and a computer. Usually, the mock probe is connected directly to a monitor that displays the ultrasound image depending upon the probe's position and movements. Most of these simulators use electromagnetic tracking systems to define the probe's position. The mock probe usually contains a 3-dimensional sensor, capable of acquiring virtual position data instantaneously [7,11-15]. These simulators have been applied mainly in teaching the basic skills of cardiac ultrasound examination to students and residents in emergency medicine and in internal medicine. Over the last few years, several studies have investigated the effectiveness of simulation-based echocardiography training compared with conventional methods such as theoretical lectures and hands-on training on patients. Findings of these studies suggest that the use of echocardiographic simulators gave very positive results regarding motivation and a decrease in anxiety compared with examination of real patients [16]. The use of transesophageal echocardiographic simulation proved not only to be realistic and helpful [17] but also to be superior to conventional methods of teaching [16-18]. Simulation has also been found to be helpful for introducing surgery residents to the use of ultrasound in trauma cases [19]. It has been established that there is improvement in knowledge and better recognition of clinical scenarios after training sessions on the simulator [20]. However, a study by Cawthorn et al [21] underlines the importance of supervised training using simulation, stating the necessity of combining both teaching methods.

**Objectives**

To justify the expenses of adding a costly, albeit proficient and high-fidelity simulator, the authors needed to assess stakeholders' interest and institutional need for the investment. Therefore, a day-long workshop was organized to provide a free-of-charge interactive ultrasound simulation training—using CAE Vimedix high-fidelity simulator (see [Figure 1](#))—for health care providers, including physicians, nurses, ultrasound technicians/sonographers, residents, and medical students. Our aim for this intervention was to assess the readiness and need of health care professionals to practice using ultrasound via simulation and to estimate their perception and acceptance of simulation as an integral element of medical education curricula, particularly in relation to teaching and practicing the use of US.

**Figure 1.** CAE Vimedix high-fidelity simulator.

## Methods

### Design

The study is an experimental intervention, that is, an ultrasound simulation workshop provided at the American University of Beirut Medical Center (AUBMC).

### Participants

An open invitation to the event was circulated via email; participants included physicians, nurses, ultrasound technicians/sonographers, residents, and medical students.

### Procedures

CAE Vimedix high-fidelity simulator was used for the workshop. This simulator facilitates engaging and intuitive learning in cardiac, pulmonary, abdominal, and OBGYN US—all in 1 common platform. With its state-of-the-art manikin-based system and innovative software tools, CAE Vimedix accelerates the development of essential psychomotor and cognitive skills for ultrasound probe handling, image interpretation, diagnoses, and clinical decision making (CAE Healthcare, Corp, 2019).

The workshop was divided into 4 modules. All modules started with a short didactic presentation of the theoretical basis to ultrasound relating to that specific module (10 min). The first module contained adult cardiology scenarios (pulmonary stenosis, cardiac tamponade, heart failure, and aortic regurgitation). The second module contained emergency medicine topics (pneumonia, acute myocardial infarction, pleural effusion, pneumothorax, and acute abdomen). The third module contained pediatric cardiology topics (Ebstein anomaly, valvular diseases, and single ventricle physiology). The fourth module was tailored for OBGYN and emergency medicine providers, and it contained scenarios on ectopic pregnancy (8 weeks), normal fetus (8 weeks and 12 weeks), and cleft lip (20 weeks).

The participants got a 1-hour hands-on practice with direct one-on-one feedback during each module.

Following the intervention, the attendees were asked to complete an evaluation, which included 4 demographic questions and 16 close-ended questions based on a Likert scale (agree-neutral-disagree).

### Measuring Impact

Novel training strategies should ideally create a chain of impact at several levels. The most widely used training evaluation methodology is the Kirkpatrick and Phillips model [22,23], which measures training outcomes at 5 levels, starting at reaction/planned action and ending with return on investment (ROI):

1. *Level 1—Reaction and satisfaction:* this measures participants' reaction to and satisfaction with the training, usually measured in surveys, and their planned action (their plans to use what they have learned).
2. *Level 2—Learning:* this assesses how much participants have learned (with pre- and posttests).
3. *Level 3—Behavior, application, and implementation:* this assesses whether the skills and knowledge gained in training are applied and practiced in the workplace or have changed learners' behavior.
4. *Level 4—Results:* this measures the extent to which the institutions' measures (output, quality, costs, and time) have improved after training; although this can be considered as the goal of a strategy, it is important to go beyond this level of evaluation to verify that the program's costs do not outweigh its benefits.
5. *Level 5—Return on investment:* this compares the benefits from the program with its cost [24,25] and is the ultimate level of evaluation.



The evaluation of ultrasound simulation has until now remained mainly at levels 1 and 2. Most studies have evaluated reaction, satisfaction [25], or learning [17,22]. Currently, several ultrasound simulators measure time to complete tasks and accuracy of procedure; however, most studies have not yet evaluated the transfer of knowledge acquired during simulation training into clinical practice [26]. In addition to these measurable benefits, most training programs have intangible benefits, including stress reduction and increased commitment of trainees, improved patient satisfaction, less patient complaints, as well as decline or avoidance of conflict [25]. Our study primarily targeted level 1.

### Analysis

Data collected from the evaluations were entered, coded, and analyzed via the Statistical Package for Social Sciences version 24 (IBM Corp). Descriptive analyses were performed using the number and percentage for categorical variables or mean and SD for continuous ones. To avoid redundancy, the 5-point Likert scale was collapsed into 3 points: strongly agree and agree were combined under “agree,” and similarly, strongly disagree and disagree were combined under “disagree;” therefore, analyses were performed on the scale agree-neither agree nor disagree-disagree.

**Table 1.** Results of the evaluation forms (N=41).

Evaluation questions	Agree, n (%)	Neither, n (%)	Disagree, n (%)
In terms of complexity...pathologies on the simulator seemed significantly less complex	39 (95)	1 (2)	1 (2)
Simulation-based assessment of US <sup>a</sup> skills is an acceptable method for evaluation	39 (95)	1 (2)	1 (2)
The US simulation gives realistic images, and the pathologies are represented realistically	38 (93)	2 (5)	2 (5)
The US simulation gives a realistic sensation of probe manipulation	38 (93)	2 (5)	1 (2)
The US simulation should be introduced as part of the US training in the medical school curriculum	41 (100)	— <sup>b</sup>	—
The US simulation is a good tool for training	40 (98)	1 (2)	—
The US simulation is a good tool for teaching	40 (98)	1 (2)	—
The US simulation allows training and identification of complex or /rare pathologies	36 (88)	3 (7)	2 (5)
On the basis of this session, I do not see any added value of the US simulation, and there is no justification for its use in medical school environments	9 (22)	1 (3)	31 (75)
The US simulation allows for good auto-evaluation of health care professionals	39 (95)	2 (5)	—
Handling of the US session on the simulation requires the same level of care and meticulousness as the process with a real patient	25 (62)	8 (20)	7 (17)
Handling a case on the US simulation is as stressful as real-life patients	11 (27)	4 (10)	26 (63)
Simulation-Based Assessments should be used for future licensing exams	35 (85)	6 (15)	—
An US simulation allows exposure of students/professionals to a wider range of pathologies	39 (95)	1 (2)	1 (2)
This session was satisfactory	39 (95)	1 (2)	1 (2)
Participation in future simulation initiatives	40 (98)	1 (2)	—

<sup>a</sup>US: ultrasound.

<sup>b</sup>Cells with 0 responses. For example, when 100% of participants responded with “agree” and none with “neither” or “disagree.”

## Results

### Participant Demographics

A total of 41 participants attended the workshop (46% [19/41] physicians, 30% [12/41] residents, 19% [8/41] sonographers, and 5% [2/41] medical students), mostly from AUBMC (88%, 36/41), with an average experience of 2.27 (SD 3.45) years and 30 (SD 46) scans per attendee. Moreover, 36% (15/41) of participants were from OBGYN, 27% (11/41) from internal medicine, 10% (4/41) from pediatrics, 10% (4/41) from emergency medicine, 5% (2/41) from surgery and family medicine, and 12% (5/41) were technicians.

### Participant Response to Ultrasound Simulation Training

Overall, Twenty participants had been previously exposed to simulation in general. The majority of participants agreed that ultrasound simulation provided a realistic setting (98%, 40/41) and that it allowed for training and identification of pathologies (88%, 36/41). In addition, 100% (41/41) of the participants agreed that it should be part of the curriculum either in medical school or residency, and most of the participants agreed that it was useful for training (98%, 40/41) and teaching (98%, 40/41; Table 1).

## Discussion

### Principal Findings and Conclusions

Our findings showed that participants unanimously supported the introduction of ultrasound via simulation in medical school curricula and residency programs. The importance of hands-on repeat-training and deliberate practice [27] until proficiency is reached has superseded and surpassed the outdated paradigm of “see one, do one, teach one” [28]. So far, there is no consensus or standardization of the teaching or training of ultrasound among different institutions and countries for educational purposes or for assessment of practitioners’ skills and accreditation [5]. Given the high variability between learners in the time and training needed to gain proficiency, it is unlikely that a minimum set number of scans can adequately reflect candidates’ skills; some trainees reach a level of competency that is suitable for clinical practice after a few scans, whereas others need more time to reach the same level [29,30]. Our intervention showed that simulation-based ultrasound training could provide a relatively realistic setting for training, assessment, and practice. However, further research is needed to assess the retention of knowledge and skills by the workshop participants.

There is broad consensus on the utility of integrating virtual reality into ultrasound education and into training programs [5].

It has been proposed as a valid and reliable method for assessment of skills [29,30]. Simulation, however, is not meant to replace clinical training and tutoring [26]; instead, it offers a complementary useful method for introducing trainees to ultrasound practice, allowing them to become familiar with image optimization and probe orientation, without being confronted with the stresses of the clinical setting.

There are a number of commercially available ultrasound simulators, but they remain expensive and require maintenance and adequate training for their use. These factors may limit the widespread adoption of the technology. Some practitioners believe that acquisition of simulators can be economically beneficial by allowing trainees to improve their performance without monopolizing ultrasound machines required in the clinical setting [5]. However, proper cost-effectiveness analyses have to be conducted to verify and substantiate these claims.

### Limitations

We acknowledge that the study has limitations, including the fact that it is an analysis of 1 workshop. The heterogeneity among participants in terms of disciplines, experience, and specialty lead us to consider our findings relatively sound in external validity. More importantly, future interventions and assessments need to be conducted to measure the long-term effects of such exercises on participants’ knowledge and skill retention.

### Conflicts of Interest

None declared.

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## Abbreviations

**AUBMC:** American University of Beirut Medical Center  
**OBGYN:** obstetrics and gynecology

**ROI:** return on investment

**US:** ultrasound

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Original Paper

# The Impact of Medical Students' Individual Teaching Format Choice on the Learning Outcome Related to Clinical Reasoning

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## Abstract

**Background:** Repeated formative assessments using key feature questions have been shown to enhance clinical reasoning. Key feature questions augmented by videos presenting clinical vignettes may be more effective than text-based questions, especially in a setting where medical students are free to choose the format they would like to work with. This study investigated learning outcomes related to clinical reasoning in students using video- or text-based key feature questions according to their individual preferences.

**Objective:** The aim of this study was to test the hypothesis that repeated exposure to video-based key feature questions enhances clinical reasoning to a greater extent than repeated exposure to text-based key feature questions if students are allowed to choose between those different formats on their own.

**Methods:** In this monocentric, prospective, nonrandomized trial, fourth-year medical students attended 12 computer-based case seminars during which they worked on case histories containing key feature questions. Cases were available in a text- and a video-based format. Students chose their preferred presentation format at the beginning of each case seminar. Student performance in key feature questions was assessed in formative entry, exit, and retention exams and was analyzed with regard to preceding exposure to video- or text-based case histories.

**Results:** Of 102 eligible students, 75 provided written consent and complete data at all study exams (response rate=73.5%). A majority of students (n=52) predominantly chose the text-based format. Compared with these, students preferring the video-based format achieved a nonsignificantly higher score in the exit exam (mean 76.2% [SD 12.6] vs 70.0% [SD 19.0];  $P=.15$ ) and a significantly higher score in the retention exam (mean 75.3% [SD 16.6] vs 63.4% [SD 20.3];  $P=.02$ ). The effect was independent of the video- or text-based presentation format, which was set as default in the respective exams.

**Conclusions:** Despite students' overall preference for text-based case histories, the learning outcome with regard to clinical reasoning was higher in students with higher exposure to video-based items. Time-on-task is one conceivable explanation for these effects as working with video-based items was more time-consuming. The baseline performance levels of students do not account for the results as the preceding summative exam results were comparable across the 2 groups. Given that a substantial number of students chose a presentation format that was less effective, students might need to be briefed about the beneficial effects of using video-based case histories to be able to make informed choices about their study methods.

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**KEYWORDS**

undergraduate medical education; case histories

## Introduction

### Teaching Clinical Reasoning

One of the most challenging aims in undergraduate medical education is to teach students about how to arrive at a correct diagnosis and to initiate adequate therapeutic steps. Even for experienced physicians, clinical decision making is a critical aspect of their performance and different theories trying to elucidate the underlying cognitive mechanisms have been put forward [1]. Clinical reasoning reflects the involved aspects for decision making in the clinical context, and case-based learning turned out to be both effective for teaching clinical reasoning and is preferred by undergraduate medical students [2,3]. Among other assessment formats, key feature questions can be used to measure student performance in this particular area of expertise [4-6]. However, this type of assessment may not only be used to serve a summative purpose but also be used in a formative manner, taking advantage of the so-called direct testing effect [7]. Research published in the past 10 years supports the hypothesis that repeated testing enhances long-term retention of knowledge [8], skills [9], and—perhaps most importantly—the clinical application of knowledge [10]. We recently reported superior long-term retention of clinical reasoning performance in students who had repeatedly been exposed to formative key feature questions compared with students who had restudied the same content without being prompted to answer questions [11]. In that study, all study-related material was presented in written form. After 9 months, students scored significantly higher on intervention items trained with key feature questions compared with control items (mean 56.0% [SD 25.8] vs 48.8% [SD 24.7];  $P < .001$ ). In a further study comparing key feature cases with text-based case histories with video-based ones, these results were confirmed in a postintervention exam (mean 76.2% [SD 19.4] vs 72.4% [SD 19.1],  $P = .03$ ) but not in a retention exam 9 months later (mean 69.2% [SD 20.2] vs 66.4% [SD 20.3],  $P = .11$ ) [12].

### Presenting Formats

Case histories can be presented in different formats including text-based and video-based displays or even in a simulated clinical setting using standardized patients. It might be hypothesized that greater authenticity of the learning material entails more favorable learning outcomes. In contrast, a prospective, randomized study with 133 students did not yield any significant differences between those 3 presenting formats with regard to improvement of clinical reasoning performance [13]. Another study with 256 students showed preference for video cases versus paper cases arguing that videos preserve the original language, avoid depersonalization of patients, and facilitate direct observation of clinical consultations [14]. Despite the reported preference for video-based case presentations in a study nested in a problem-based learning setting, the same study showed that the use of videos might be associated with a reduction of the depth of thinking by analyzing 5224 transcribed student utterances by a blinded coder [15]. Conversely, an analysis of student critical thinking skills following exposure to different case modalities suggested that video-based material was particularly effective in fostering these skills [16]. Thus, the available evidence on the effectiveness of

video-based instructional material for the training of clinical reasoning is equivocal.

### Learning Styles

One approach to understanding these conflicting data is the concept of *learning styles*, according to which characteristics of the way students learn predict the extent to which an individual student will benefit from specific teaching modalities [17]. Despite an ongoing debate on the usefulness of this approach [18], this concept is still underlying a considerable number of medical education research projects. Some of these studies refer to a model that distinguishes between different learning strategies, that is, visual, auditory, read and write, and kinesthetic [19]. In one study, individual learning styles of 62 applicants to general surgery were analyzed with respect to previous exam performance. Most applicants had a multimodal learning style, but aural and visual preferences were associated with significantly higher United States Medical Licensing Examination scores compared with read and write and kinesthetic preferences [20]. Owing to the lack of data supporting the idea that matching learning activities to individual learning styles does in fact lead to better learning outcomes, most intervention studies in the field of medical education did not assess the learning style, let alone account for it in their main analyses. At the same time, letting students choose their preferred learning modality (regardless of the *learning style*) may impact on the learning outcome, and this hypothesis has rarely been tested [13,21,22].

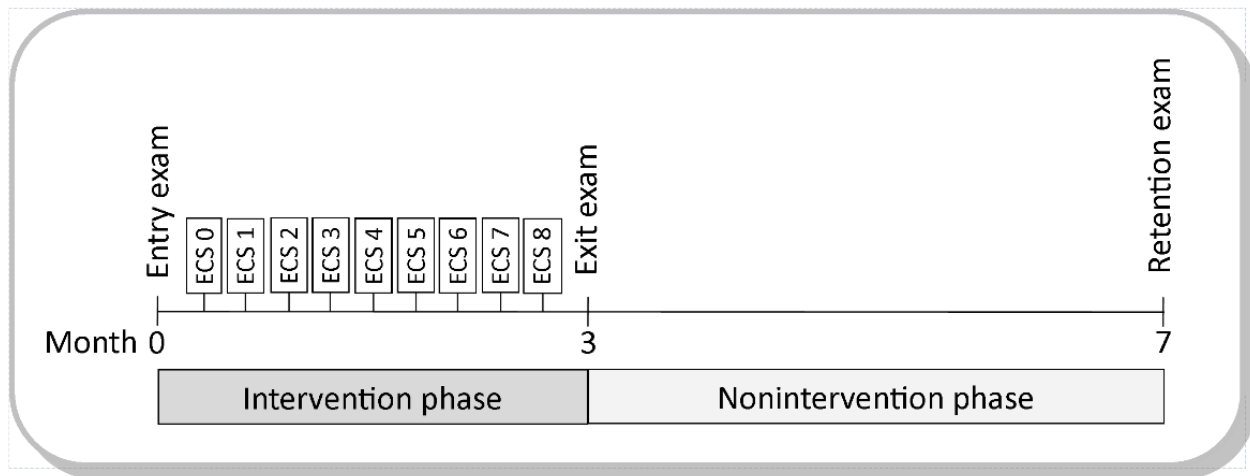
In summary, the available evidence supports the repetitive use of case-based key feature questions for teaching clinical reasoning. Furthermore, limited data indicate that medical students have individual preferences with regard to teaching modalities and that a higher degree of the authenticity of case presentations might foster the learning outcome in some students. However, it is unclear who will benefit most from using rich media and whether students are capable of identifying the method that works best for them. This study was designed to test the hypothesis that repeated exposure to video-based key feature questions enhances clinical reasoning to a greater extent than repeated exposure to text-based key feature questions if students are allowed to choose between those different formats on their own.

## Methods

### Study Design

This monocentric, prospective, nonrandomized intervention study investigated the impact of letting students choose their preferred learning format on the learning outcome with regard to clinical reasoning. The study consisted of a 3-month intervention phase followed by a nonintervention phase of 4 months. During the intervention phase, students attended 45-min weekly computer-based seminars (*electronic case seminars* [ECSs]) during which they worked on predefined patient case histories that were aligned to the learning objectives addressed in concurrent curricular teaching sessions. In the first and final weeks of the intervention phase as well as in the retention exam, students took identical formative key feature examinations.

**Figure 1.** Timeline of study design and assessments. After 1 electronic case seminar (ECS) introducing text- and video-based case presentations (ECS 0), 8 weekly intervention ECSs with the free choice of learning format were conducted (ECS 1-8).



Students sat the unannounced retention exam following the 4-month nonintervention phase (see Figure 1).

All patient case histories were available in a text-based and video-based format (eg, Multimedia Appendix 1). During the first ECS, 4 cases were presented, 2 of which were video-based whereas the other 2 were text-based. Following this, students had the free choice of attending the learning format they preferred at the beginning of each ECS. In the entry, exit, and retention exam, an equal number of items were presented in a text- and video-based format. ECS attendance was mandatory for students enrolled in general medicine teaching modules of the fourth year.

### Student Recruitment and Ethics Approval

Fourth-year medical students at Göttingen Medical School were informed about the study 4 weeks ahead via email and during the first lecture of term. Students enrolled in all modules in winter term 2015 were eligible for study participation. The study was approved by the local ethics committee (*Ethik-Kommission der Universitätsmedizin Göttingen*, application number 10/12/15), and all participants provided written consent.

### Study Procedure

A total of 31 case histories were selected to be presented in the ECSs. All of these had been piloted and used in a previous research project [11]. Learning objectives and the content of cases were identical regardless of the video- or text-based presentation format. Patient case histories were broken up into 5 to 8 sections with key feature questions at the end of each section. All items that were used in the entry, exit, and retention exam occurred in 2 different ECSs during the intervention phase. Patient case histories differed regarding the particular story, but the key feature items were identical. During the intervention phase, each of the 9 ECSs consisted of 3 case histories with 5 key feature questions each. Thus, students answered a total of 135 original key feature questions addressing specific learning objectives during the 9 ECSs between the entry and exit exam. The entry, exit, and retention exam were made up of 4 case

histories with a total number of 28 items, 14 of which were text based with the other 14 being presented as videos. Notably, for the 3 exams, the presenting format was set as default. As corresponding learning objectives to those 28 intervention items were taught twice during the intervention phase, and students had the choice between 2 different teaching formats at each time; there were 4 possible ways any one student could learn any of the 28 intervention items during the ECSs: text-text (sequence #1), text-video (sequence #2), video-text (sequence #3), and video-video (sequence #4).

### Data Analysis

The primary outcome of this study was the difference in percent scores in the exit and retention exam for students preferring text-based case presentations during the intervention phase compared with those preferring video-based case presentations. Having a total number of 8 ECSs with a free choice, the cutoff for allocation to the video-preference group was set to having chosen the video format at least four times (ie,  $\geq 50\%$  exposure to the video format). According to this, 2 groups of students were compared with each other by means of an independent *t* test. Data are presented as mean (standard deviation) or percentages (n) as appropriate. Significance levels were set to 5%.

Statistical analysis was performed using IBM SPSS Statistics, version 24.00 (SPSS Inc) and GraphPad Prism, version 5.0 (GraphPad Software Inc).

## Results

### Student Recruitment and Characteristics

A total of 100 out of 102 eligible students for study inclusion provided written consent. Of these, 25 students missed at least one study-related formative exam, resulting in a total number of 75 students with complete data for analysis (effective response rate=73.5%). According to their most frequent choice, 52 students were allocated to the text-preferring group and 23 to the video-preferring group. There were no statistical

differences between both groups regarding age at entry exam, attendance at intervention ECS, and percent score achieved in exams during the previous term, taking into account the number of points scored by a particular student as well as the maximum of available points for that same student in the preceding term (see Table 1).

### Format Attendance

The proportion of students choosing either format was calculated for each ECS. For text-based ECSs, this proportion ranged from

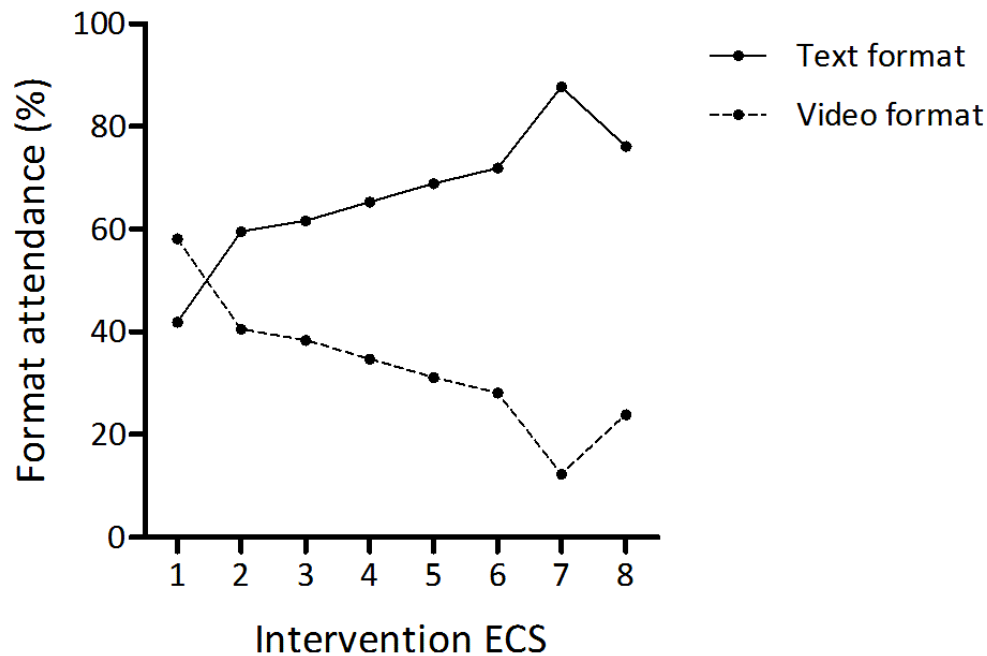
41.9% (n=31) to 87.7% (n=57), and for video-based ECSs, it ranged from 12.3% (n=9) to 58.1% (n=43; see Figure 2). The number of students preferring text-based over video-based items increased during the intervention phase.

For all items, the predominant learning sequence was *text-text*. The least common learning sequence for all items was *text-video* (see Table 2 for detailed results).

**Table 1.** Characteristics of text- and video-preference groups at entry exam.

Characteristics	Preference for text (n=52), mean (SD)	Preference for video (n=23), mean (SD)	P value
Age at entry exam (years)	24.87 (3.40)	24.04 (1.70)	.27
Number of attended intervention electronic case seminars	8.31 (0.64)	8.43 (0.59)	.42
Score achieved in exams of previous semester	82.40 (5.90)	83.50 (7.50)	.56

**Figure 2.** Format attendance. Proportion of students choosing either presentation format during electronic case seminars. ECSs: electronic case seminars.



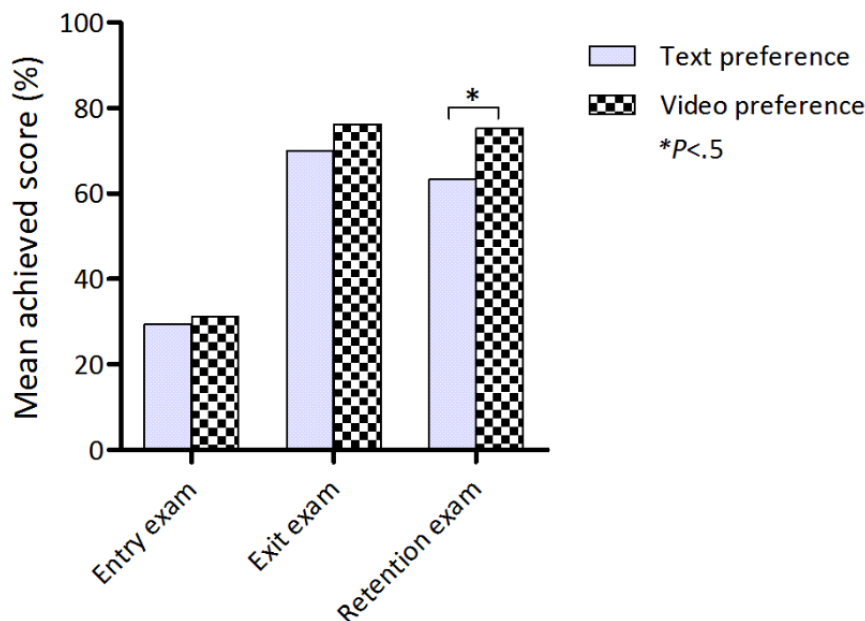


**Table 2.** Sequences of learning condition. Each item was learned in one of 4 sequences according to students' choice of presenting format. For study assessment at exit and retention exam, 28 items were assessed in a fixed format listed here.

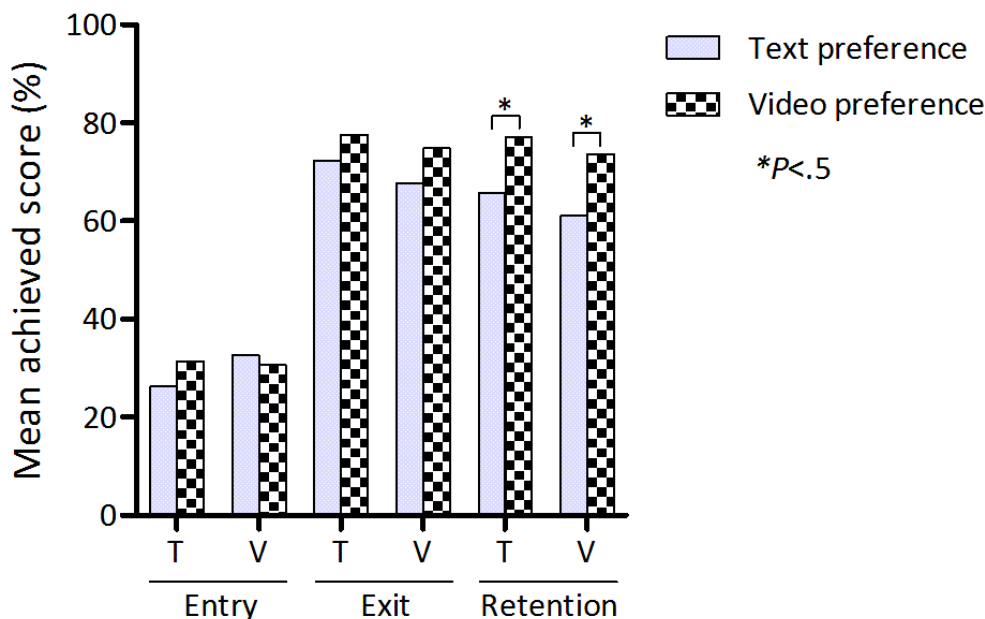
Item	Sequences of learning condition for each assessment item								Item assessment format
	text-text (#1)		text-video (#2)		video-text (#3)		video-video (#4)		
	Students, n (%)	Mean score at retention exam, %	Students, n (%)	Mean score at retention exam, %	Students, n (%)	Mean score at retention exam, %	Students, n (%)	Mean score at retention exam, %	
1	39 (63)	82	2 (3)	100	5 (8)	40	16 (26)	69	Text-based
2	39 (63)	74	2 (3)	100	5 (8)	80	16 (26)	88	Video-based
3	39 (63)	36	2 (3)	50	5 (8)	80	16 (26)	63	Text-based
4	39 (63)	46	2 (3)	50	5 (8)	40	16 (26)	56	Video-based
5	39 (63)	54	2 (3)	50	5 (8)	60	16 (26)	50	Video-based
6	37 (69)	76	2 (4)	100	9 (17)	89	6 (11)	100	Video-based
7	37 (69)	81	2 (4)	50	9 (17)	89	6 (11)	100	Text-based
8	37 (69)	86	2 (4)	100	9 (17)	89	6 (11)	100	Text-based
9	31 (52)	84	2 (3)	100	10 (17)	90	17 (28)	100	Text-based
10	31 (52)	55	2 (3)	50	10 (17)	70	17 (28)	71	Video-based
11	41 (63)	44	0 (0)	— <sup>a</sup>	16 (25)	50	8 (12)	88	Text-based
12	41 (63)	85	0 (0)	—	16 (25)	75	8 (12)	100	Video-based
13	31 (52)	58	2 (3)	50	10 (17)	70	17 (28)	53	Video-based
14	31 (52)	48	2 (3)	100	10 (17)	30	17 (28)	47	Text-based
15	25 (35)	52	6 (8)	83	19 (26)	53	22 (31)	68	Text-based
16	25 (35)	32	6 (8)	67	19 (26)	16	22 (31)	23	Video-based
17	24 (38)	96	3 (5)	100	21 (33)	100	15 (24)	100	Video-based
18	37 (64)	65	4 (7)	50	7 (12)	86	10 (17)	60	Video-based
19	37 (64)	92	4 (7)	100	7 (12)	100	10 (17)	90	Text-based
20	37 (64)	54	4 (7)	75	7 (12)	57	10 (17)	50	Text-based
21	39 (56)	72	5 (7)	60	7 (10)	43	19 (27)	63	Text-based
22	36 (58)	75	2 (3)	100	8 (13)	63	16 (26)	94	Video-based
23	37 (64)	81	4 (7)	100	7 (12)	86	10 (17)	90	Text-based
24	44 (59)	91	0 (0)	—	0 (0)	—	30 (41)	90	Video-based
25	44 (59)	64	0 (0)	—	0 (0)	—	30 (41)	67	Text-based
26	37 (69)	78	2 (4)	100	9 (17)	100	6 (11)	100	Video-based
27	37 (69)	84	2 (4)	100	9 (17)	89	6 (11)	100	Text-based
28	37 (69)	27	2 (4)	0	9 (17)	67	6 (11)	17	Video-based

<sup>a</sup>Not applicable as no student chose this sequence for this item.

**Figure 3.** Exam scores. Mean percent scores in the entry, exit, and retention exams for the text-preferring and video-preferring group.



**Figure 4.** Exam scores by presentation format in the formative exams. Mean percent scores in the entry, exit, and retention exams for the text-preference and video-preference groups. Data are presented as a function of exposure during the intervention phase (column texture) and item format in the formative exams (text vs video). T: text; V: video.



**Learning Outcome**

In the entry and exit exam, there was no significant difference in percent scores between students preferring video-based items and students preferring text-based items (entry exam: 31.1% [SD 12.3] vs 29.4% [SD 12.3];  $P=.59$ ; exit exam: 76.2% [SD 12.6] vs 70.0% [SD 19.0];  $P=.15$ ). In the retention exam, students who had preferred videos during the intervention phase scored significantly higher than students preferring text-based items (75.3% [SD 16.6] vs 63.4% [SD 20.3];  $P=.02$ ; see Figure 3).

Exam performance was further analyzed according to the way items were presented in the formative exams. As described above, 14 of the 28 items were displayed as videos whereas the

other half were presented in written form. The main effect of preferring videos during the intervention phase persisted, regardless of presentation format in the formative exams (see Figure 4): Mean percent scores in text-based items in the exit exam were 77.6% (SD 14.0; students preferring video) versus 72.4% (SD 20.2; students preferring text;  $P=.26$ ). For video-based items, these figures were 74.8% (SD 12.7) versus 67.6% (SD 20.0);  $P=.11$ ). Differences were significant in the retention test (text-based items: 77.0% (SD 18.8) vs 65.8% (SD 21.2);  $P=.03$ ; video-based items: 73.6% (SD 16.6) vs 61.0% (SD 21.2);  $P=.01$ ).

## Discussion

This study yielded 2 principal findings: First, the presentation format preferences of students changed in favor of the less time-consuming written format over the course of the intervention phase. Second, students preferring the video-based format outperformed students preferring text-based items in the retention exam, regardless of the item presentation format.

### Student Preferences

Several studies reported that students had a positive attitude toward videos for case presentations and that they preferred video- compared with text-based learning [14,15,23,24]. Thus, the current finding of a shift toward text-based items and the fact that almost 70% of enrolled students had to be allocated to the text-preference group is somewhat surprising. However, this finding is in accordance with results from a recently published study reporting a preference for text-based learning material in 65% of undergraduate medical students [25]. A detailed analysis of the differences between the 2 formats seems warranted as they relate to various aspects of the student experience that may well impact on the learning outcome. The most obvious differences relate to time, learner engagement, the amount of context given and the *presence* of virtual patients. With regard to time, the aforementioned study [25] concluded that one of the drawbacks of video use is that it slows down the pace of the seminar and does not allow students to review and critically appraise the presented information. Yet, students acknowledged that videos provide more detailed and contextual information than written material does. In fact, videos provide more complex information.

According to the cognitive load theory [26], medical students in one particular year of undergraduate education can still be regarded as a heterogeneous group of learners. Some may find it easier to deal with more complex material whereas learners lacking experience or exposure to clinical content might be overwhelmed by the wealth of audio-visual information contained in videos [27]. This might be the reason why some students appeared to prefer video-based case presentations at the beginning but switched to the text-based format in the course of the study. In addition, one recent study found that learner engagement was reduced in video-based training compared with other educational approaches [28], and video-based patient cases may even disrupt deep critical thinking [15]. Thus, the provision of more contextual information and a more realistic presence of virtual patients in the learning environment does not guarantee better learning outcomes. A qualitative approach may be warranted to explore learner experience when exposed to video- or text-based material. On the basis of the data collected in this study, we cannot comment on these aspects. Yet, findings in the field of learning in general [29,30] and specifically in medical education [31,32] strongly suggest that learner experience moderates learning outcome.

Another potential explanation for the shift in preferences observed in this study is that working with text-based case histories took less time than working with video-based case histories. In any case, the difference in time-on-task between the 2 preference groups might account for the net finding of

superior retention exam performance in students preferring video-based case presentations.

### Learning Outcome

The findings of this study confirm previous results regarding a positive effect of test-enhanced learning on clinical reasoning by using key feature questions for case-based learning [11]. Both study groups achieved a sustained performance gain compared with the entry exam.

The more favorable learning outcome observed in the video-preference group is in concordance with other studies [20]. Notably this advantage was independent of the way items were presented in the formative exams as students preferring video-based case presentations during ECSs also achieved higher scores in retention exam items that were assessed in written form. This is in line with the dual-coding theory which posits that as images and words are processed in different parts of the brain, the use of visualization with sound enhances learning and recall [33]. On the basis of this notion, Kamin et al demonstrated the superiority of video-enhanced learning material for the acquisition of critical thinking [16].

The importance of context for learning outcome was demonstrated over 40 years ago [34], and it could be argued that increased authenticity of the learning environment might help students achieve a better learning outcome. In fact, in a randomized study with 288 medical students, there was no overall advantage for more authentic formats, but in a subanalysis, authors showed that this effect was driven by a strong benefit observed in the top tertile whereas all other students scored fewer points following exposure to the more authentic format [21]. This supports the conclusion that video-based case presentations may only be more effective than text-based presentations for a specific subset of students who may or may not be aware of this.

### Implications and Perspectives

This study adds to the literature in that it helps curriculum planners, medical teachers, and students make informed choices about the design of instructional material. There is a strong rationale for using video-based case presentations combined with key feature questions for teaching clinical reasoning, but it has to be considered that not all students benefit in the same way and at the same time. About one-third of medical students seem to benefit from video-based case presentations. This might be explained by students having an individual preference for audio-visual learning, although other mechanisms cannot be ruled out and should be addressed in future studies. Giving students the opportunity to choose the presentation format they prefer at each single seminar seems to be a reasonable and feasible approach to avoid disadvantages for anyone and to take advantage of the potential of a more authentic format. Furthermore, this would also add up to the described use of mixed methods by being allowed to learn both text and video-based in the course of a curriculum [35]. In the context of computer-based learning, it should not be a huge challenge to implement such formats, and it could help each student use an appropriate format. One important question is how students who did not benefit from the intervention in this study may be

helped to capitalize on the merits of repeated testing. One earlier trial suggested that the effectiveness of the method can be enhanced by informing students about the effects of test-enhanced learning [8]. Apart from this, the role of assessments has to be reconsidered especially in the light of recent studies regarding test-enhanced learning and the important role of assessments on students' learning strategies [36,37]. However, students may need to be briefed about the pros and cons of each format [8]. Ideally, future studies will identify short test instruments providing students with individual feedback regarding the presentation format that is likely to be most beneficial to them. In addition, further studies should explore why the effect of different learning modalities might only become apparent after some time and not directly following exposure to the teaching material.

### Strength and Limitations

To the best of our knowledge this is the first prospective study using case-based key feature questions for teaching clinical reasoning, allowing students to select their individual learning material. The formative exit and retention exams contained both text- and video-based items to minimize potential effects of training to any format. The items themselves referred to relevant problems of general medicine, and the response rate was favorable.

However, this is a monocentric study with a selected group of students as only fourth-year medical students were allowed to

participate. Thus, findings of our study are not generalizable to other student groups and subject areas other than general medicine. Regarding ethical aspects, it was not possible to establish a study design without free choice of format as this study was conducted in the official curriculum and there was no way of knowing whether students randomized to either group would be disadvantaged. Hence, self-selection as a potential bias has to be taken into account when interpreting the findings of this study. Furthermore, we did not collect any quantitative or qualitative data on student experience during ECSs. However, as differences between the 2 presentation formats in terms of time, engagement, context, and the *presence* of virtual patients may impact on learning outcome, these aspects should be addressed in future studies. Finally, it was technically not feasible to measure the time individual students spent on every single item. However, it can be assumed that reading was less time consuming than watching the respective video.

### Conclusions

Although about two-thirds of medical students preferred text-based case presentations, those students who self-selected to work on video-based presentations achieved better long-term retention of procedural knowledge as assessed with key feature questions. As clinical reasoning is one of the most complex but important objective in medical education, more research is needed to identify the most effective approach to teaching and learning related skills.

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### Acknowledgments

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### Authors' Contributions

NS provided comments on all video scripts, participated in filming sessions, analyzed the data, and wrote the manuscript. SL coordinated and facilitated video productions, facilitated electronic case seminars, and helped to collect data and commented on various versions of the manuscript. SA helped to design the study, provided advice on data presentation, and commented on various versions of the manuscript. TR conceived of the study, developed its design, drafted key feature cases, and contributed to the manuscript. All authors read and approved the final manuscript.

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### Conflicts of Interest

None declared.

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### Multimedia Appendix 1

Presentation format. Screenshot of a text- (A) and a video-based (B) format. For reasons of privacy, faces are blurred out.

[[PNG File, 487KB](#) - [mededu\\_v5i2e13386\\_app1.png](#) ]

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## Abbreviations

**ECS:** electronic case seminar

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