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Original Paper

Undergraduate Medical Students Using Facebook as a Peer-Mentoring Platform: A Mixed-Methods Study

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Abstract

Background: Peer mentoring is a powerful pedagogical approach for supporting undergraduate medical students in their learning environment. However, it remains unclear what exactly peer mentoring is and whether and how undergraduate medical students use social media for peer-mentoring activities.

Objective: We aimed at describing and exploring the Facebook use of undergraduate medical students during their first 2 years at a German medical school. The data should help medical educators to effectively integrate social media in formal mentoring programs for medical students.

Methods: We developed a coding scheme for peer mentoring and conducted a mixed-methods study in order to explore Facebook groups of undergraduate medical students from a peer-mentoring perspective.

Results: All major peer-mentoring categories were identified in Facebook groups of medical students. The relevance of these Facebook groups was confirmed through triangulation with focus groups and descriptive statistics. Medical students made extensive use of Facebook and wrote a total of 11,853 posts and comments in the respective Facebook groups (n=2362 total group members). Posting peaks were identified at the beginning of semesters and before exam periods, reflecting the formal curriculum milestones.

Conclusions: Peer mentoring is present in Facebook groups formed by undergraduate medical students who extensively use these groups to seek advice from peers on study-related issues and, in particular, exam preparation. These groups also seem to be effective in supporting responsive and large-scale peer-mentoring structures; formal mentoring programs might benefit from integrating social media into their activity portfolio.

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KEYWORDS

medical education; peer mentoring; social media; Facebook

Introduction

Peer mentoring is a well-established core element for creating supportive learning environments and facilitating successful careers in medicine at different stages of medical training [1-3]. Studies in other areas of higher education have shown that students might have a particular need for peer mentoring during the first time of transition to another academic institution in order to adapt to the new learning and teaching environment and the specific struggles they face [4,5]. It has also been acknowledged that peer mentoring is essential for a satisfying medical school experience by junior students in particular [6,7].

There are promising data on how medical students who are involved in peer teaching benefit from these programs [8-11]. However, the difference between peer teaching and peer mentoring remains unclear in the context of medical students, and aspects such as mutual emotional support and empowerment usually are not addressed in these studies.

At the same time, there is an important change in terms of how undergraduate students in different disciplines use and take advantage of virtual platforms and networks such as Facebook within formal and informal mentoring contexts [12-16]. Studies in other contexts of higher education indicate that social media might play an important role for becoming part of a community in a new environment and forming educational microcommunities [17-19]. Educators are increasingly becoming aware of the potential of integrating social media into formal teaching and learning environments for a diverse range of activities [20-23].

However, there is a paucity of data that provide information on whether and how undergraduate medical students use Facebook for peer mentoring in a way that goes beyond peer teaching. It also remains unclear whether Facebook as a potential peer mentoring tool merely serves as an information-sharing platform or whether its affordances actually provide an effective peer-mentoring environment and might support, counteract, or replace institutional learning-management systems and face-to-face peer mentoring.

The purpose of this mixed-methods study is to provide a definition of peer mentoring in the context of undergraduate medical education as well as to quantify and explore the use and perspectives of medical students with regard to Facebook as a virtual peer-mentoring environment. The data might help medical educators to leverage the potential and spotlight limitations of social media for peer-mentoring programs and provide guidance for formulating best practice recommendations for integrating social media into formal peer-mentoring programs.

Methods

Overview

A mixed-methods approach was chosen to provide a multidimensional representation of peer-mentoring activities of medical students on Facebook [24]. An expert group consisting of medical educators, clinicians, and undergraduate and graduate medical students discussed and reviewed the literature [11,25-28] to develop the following peer-mentoring definition and derive coding anchors.

Peer mentoring is a form of mentoring that involves informal dynamic relationships within a group of individuals who are similar in experience and rank. It is based on the premise that there is a pool of skills, experiences, and resources within the group that is deliberately or subliminally used to support and empower one another and to foster everyone's development. Because of the equality among group members, relationships are generally personal and mutual, and ideally, each participant has something of value to contribute and gain.

The personal experience of the authors with using Facebook groups and word-of-mouth advice from currently enrolled preclinical students was used to identify the relevant Facebook groups; these were initiated and used by undergraduate medical students at Ludwig-Maximilians-Universität (LMU) Munich, Germany, in the first (PCY1) and second preclinical year (PCY2). Several small Facebook groups and two large groups were found. The authors identified one Facebook group per preclinical year as the main group, based on structure and number of members as compared to the currently enrolled student cohorts. All posts and comments in both groups of a complete academic semester—from September 2013 through February 2014—were included in the analysis. The two identified member groups in Facebook were both initiated by peers of undergraduate students, who commenced their medical studies in October 2013 (referred to as preclinical year 1, PCY1) and in October 2012 (referred to as preclinical year 2, PCY2). Both groups had self-identifying names and new members needed to apply and then be accepted by persons already in the group. All posts and comments in these groups were extracted and exported into Microsoft Excel. We then conducted a quantitative analysis of submissions per week and month.

A social constructivist perspective was applied to identify emerging peer-mentoring themes that are relevant for undergraduate medical students and reflect social norms, values, and needs of medical students in this context. Based on the working definition of peer mentoring, the authors additionally developed a coding scheme for content analysis of posts and comments (see Table 1) [29]. Anchoring examples were defined for each peer-mentoring subcategory and the final coding scheme was applied to three critical weeks of each preclinical year with particularly high or low posting frequency, as well as at the time of high-stakes exams. The research team agreed on analyzing data from the beginning of each semester, time periods directly correlating to critical written and oral exams, and to contrast these weeks with posting-behavior between examination periods.

Table 1. Peer-mentoring coding scheme[a].

Categories and subcategories	Anchoring example
Study related	
Knowledge/skills	“In the beginning you should focus on learning the musculoskeletal structures instead of worrying about electives”
Experiences	“I have done my first preclinical rotation in the university hospital on a neurology ward and was amazed by the attendings’ willingness to teach”
Resources	“You can find a selection of preparatory exams in the anatomy exam folder on the online-learning platform Moodle”
Emotional support	“It’s absolutely normal to be afraid of the terminology exam and the Latin grammar questions, but it is really easier than you think”
Nonstudy related	
Social activities	“Let’s meet at my place before going to the freshmen party”
Advertising	“Medical education books at a special discount for new students”

[a]All posts were additionally coded in the categories “Exams and learning,” “Study logistics and organization,” and “Extracurricular activities.”

Quantitative analysis of posting patterns in Facebook groups was used to describe the posting behavior across academic semesters. Thematic content analysis of Facebook posts and focus group transcripts was used to explore posting content and perceptions of undergraduate medical students with regard to peer-mentoring categories (see Table 1). Some posts and comments included more than one peer-mentoring theme and consequently were coded for all identifiable subcategories. After familiarization with the full qualitative and quantitative dataset, data were contrasted and used to enhance and strengthen the final interpretation, as well as to inform the discussions on emerging differences with regard to interpretation of data and applying the coding scheme. All differences were discussed and resolved.

Participants for focus groups were recruited through email invitations at LMU (total n=21) and two focus groups with medical students enrolled in different semesters were conducted. Both focus group discussions were based on a written protocol, facilitated by an experienced researcher, recorded, and documented. The recordings of both focus groups were fully transcribed and coded. The selected dataset was coded twice in an independent manner. Interrater reliability and Cohen’s kappa were calculated [30] using Stata software version 12 (StataCorp LP).

Ethics

The LMU ethics committee reviewed the research design and exempted the study from additional ethical approval. Confidentiality and anonymity with regard to electronic data was maintained throughout the study. Any names or potentially identifying information were removed before analyzing the data and quotes were all translated from German to English for this manuscript. Pseudonyms were used to maintain confidentiality and anonymity.

Results

Characteristics of Analyzed Facebook Groups

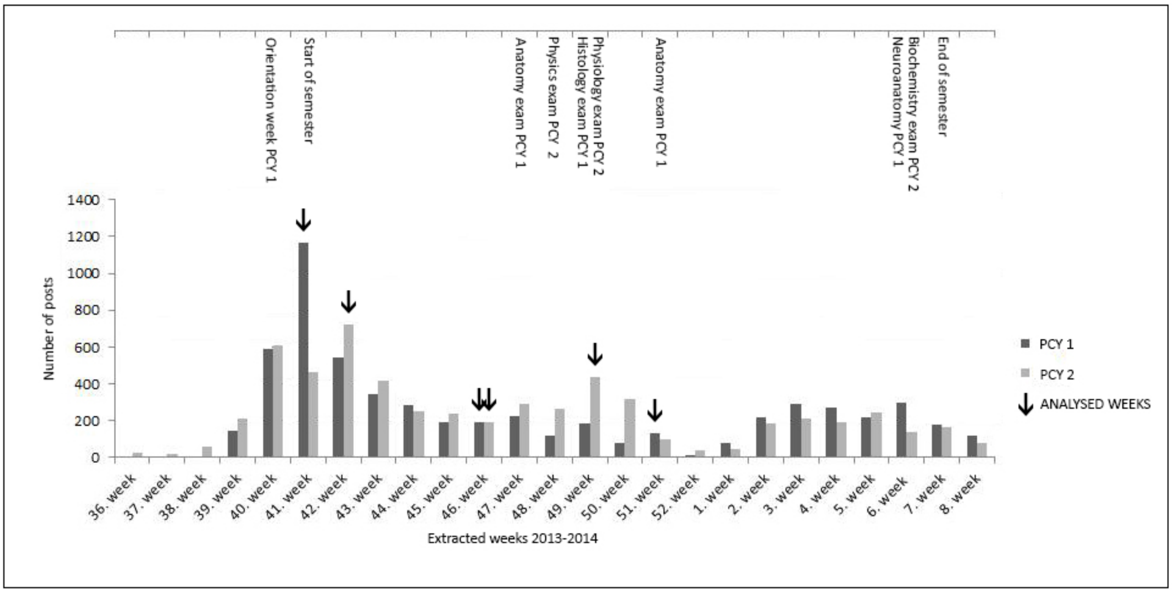
At the time of collecting the data, the PCY1 Facebook group had 1149 members, of which 728 (63.36%) were active users who contributed at least one post throughout the semester. The PCY2 group had a total of 1213 members, of which 863 (71.15%) were active users who contributed at least one post throughout the semester. The combined groups consisted of 2362 counted group members, with several individuals being members in both groups, however. The corresponding student cohorts enrolled at the LMU Munich in the respective preclinical years consisted of 561 female and 389 male students in PCY1 (total of 950), and 569 female and 397 male students in PCY2 (total of 966). The full sample of enrolled undergraduate medical students therefore consisted of 1916 individuals.

Posting Activity of Preclinical Medical Students

A total of 5939 posts, of which 1168 (19.67%) represented primary posts, were extracted from the PCY1 Facebook group. The total number of posts (n=11,853) is the sum of primary posts and all reply posts and comments. Out of all posted questions in the PCY1 group, 79.5% (116/146) were answered in a satisfactory way by peer students. Similarly, a total of 5914 posts with 1246 (21.07%) primary posts were extracted from the PCY2 Facebook group. A total of 76.8% (116/151) of all posted questions in the PCY2 group were answered in a satisfactory way. With regard to posting frequency of group members, 79.70% (1268/1591) of active users in both groups posted 1-10 posts during the extracted period, accounting for 36.11% (4280/11,853) of all posts. A total of 16.40% (261/1591) of active users accounted for another 38.56% (4570/11,853) of posts (11-30 posts) and, finally, a minority of 3.90% (62/1591) of active users accounted for the remaining 25.34% (3003/11,853) of posts (>30 posts).

All posts were charted over time and relevant curriculum elements—orientation week, exams, and duration of semester—were identified (Figure 1). Based on the posting activity during the semesters, 3 relevant exemplary weeks in each group were identified (marked in Figure 1) and used for detailed thematic content analysis: one week showed a particularly high posting activity (the beginning of each semester), a second week showed low posting activity (not correlating with any critical exam), and a third week was directly correlated to an exam period. In addition, we found that students in both Facebook groups started posting 2 weeks (PCY1) and 5 weeks (PCY2) before the official beginning of the semesters, respectively.

Figure 1. Facebook posting pattern by undergraduate medical students.



Peer-Mentoring Elements in Facebook Groups

Our final peer-mentoring coding scheme showed good reliability—average Cohen's kappa of .77 (SD .16) and 94% agreement across all main categories, and Cohen's kappa of .62 (SD .27) and 82% agreement for all subcategories. Peer-mentoring elements of all categories were identified in both Facebook groups. The dominant themes in both preclinical years were knowledge- and skills-related posts and comments, as well as resources-related posts (see Table 2).

Table 2. Frequency of peer-mentoring elements in posts and comments.

Categories and subcategories	PCY1[a], % average frequency[b] (SD)	PCY2[c], % average frequency[b] (SD)
Study related	76 (5)	75 (4)
Knowledge/skills	10 (4)	65 (3)
Experiences	14 (15)	1 (1)
Resources	68 (18)	33 (3)
Emotional support	8 (7)	1 (2)
Nonstudy related	24 (5)	25 (4)
Social activities	99 (2)	84 (3)
Advertising	1 (2)	16 (3)

[a]First preclinical year (PCY1).

[b]Percentages represent the averages across all analyzed weeks in each preclinical year.

[c]Second preclinical year (PCY2).

The following excerpts (translated from German) illustrate how students discuss educational and coursework aspects, which are relevant for choosing their anatomy books, and what strategies work in order to prepare for the anatomy exams:

> *Alright...so meanwhile, I can go and get the lecture notes...and I just walk in there and say, “I would like to have the lecture notes for anatomy?” :D Would you also recommend that I buy or borrow an atlas of anatomy?* [Student F, PCY1]
>
> *Yes that’s how you do it :D Borrowing never hurts, I would say.* [Student W, PCY2]
>
> *Alright, thanks :)* [Student F, PCY1]
>
> *I would definitely recommend [brand name]! Although it’s a bit more expensive, it is way better from a didactic perspective, and it has better*

> *illustrations, which are really helpful =)...you might not even need any other textbook if you really work with it...and the different levels are illustrated in a way so that they match, like the images of muscles exactly fit the images of bones and so forth, and that really helps to get the picture.* [Student C, PCY2]

All other nonstudy-related posts—24% (SD 5) and 25% (SD 4)in PCY1 and PCY2, respectively—were coded as social activities, such as extracurricular activities or any other type of social events:

> *Hey everyone, so I think I missed some things. I just found...that there is a newbies party tonight at [bar's name], anything else that I have missed?* [Student D, PCY1]

With regard to posting patterns, we observed a shift of both frequency and content focus in both preclinical years. In PCY1, undergraduate students started off posting questions predominantly related to learning strategies; later during the semester they changed the focus of posts to questions on written and oral exams—72.4% (105/145) versus 19% (6/32) of all posts on learning strategies, and 11.0% (16/145) versus 56% (18/32) of all posts on exams, comparing early and late weeks of semesters, respectively:

> *Ahhh! I don't get the physics lecture notes! :'(Are the problems' solutions available somewhere within the notes? Or a self-help/study group, with a free spot?* [Student E, early post in PCY2]

> *You have to...be able to do the math in front of the class, if those problems are part of your oral test. But here's some advice: You can find physics tutorials online on Moodle [learning management system] and you can also find most of the solutions there as well ;)* [Student G, response to student E, PCY2]

> *Hey, another question—do striated muscle cells have a calcium-dependent plateau phase? Thanks guys, without you it would be quite tough here :)* [Student Y, late post in PCY2]

> *Nope, only the heart muscle cells as far as I know* [Student Q, response to student Y, PCY2]

> *NO! That is typical for heart muscle cells!!!* [Student P, response to student Y, PCY2]

> *Puh, thanks—that is a huge piece of the puzzle that I was missing ;)* [Student Y, response to students Q and P, PCY2]

Peer-Mentoring Elements in Medical Students' Perspectives of Facebook

The thematic content analysis of the focus group discussions confirmed our findings from direct Facebook group analysis and exploration. All peer-mentoring categories emerged in the focus group discussions.

Theme 1: Similarity in Experience and Rank

Participants confirmed the high intensity of use of Facebook groups among peers within one semester in particular during the time of exams:

> *Well, you know, before exams, I really liked that people discussed the questions from previous exams, and that people tried to find the right answers, that was really helpful when preparing for exams.* [Person 6]

> *I really found it cool, because there were always people who made an effort, and provided awesome summaries for exams and so forth.* [Person 8]

In addition, students developed a strategy to form course-specific groups for each academic course during a semester in order to make the content more specific to their needs:

> *You know...it really has advantages...like in Module 23 or Module 4 [refers to courses in different semesters], there are so many subjects and fast changes. If that would be one big Facebook group, it would be pure chaos.* [Person 3]

Students also agreed that group members were more or less similar in rank and experience, which in their opinion was reflected in intense contextual discussions:

> *Yeah, it also happens...like when two students...that is when one thinks he is right and the other one thinks it's wrong, then they really get a discussion going...like with 30 comments or so...but usually it's only a few posts until the right answer is online.* [Person 4]

Theme 2: Pool of Skills, Experiences, and Resources Within the Group

One participant outlined the importance of Facebook membership in particular when students missed lectures or did not like to go to lectures in general, and relied on the relevant information and resources being shared within the Facebook groups:

> *You know...those students who never go to lectures definitely benefit from other students who share their knowledge [in Facebook groups] from having gone to the lectures.* [Person 2]

In addition, participants seemed to perceive Facebook predominantly as a tool to navigate their studies and to manage access to relevant information:

> *Well, I am basically only in study Facebook groups...so that you get all the information for the clinical rotations or for the exams, and so that you don't miss deadlines, because there are always some students who nicely post everything, so that you don't miss anything...that's pretty nice.* [Person 1]

Some comments from participants indicated that Facebook groups are an important source to learn about the hidden curriculum and have an impact on the learning strategy and behavior of students:

> *You know...like the unofficial information, like...do they really check whether you are present or not, or is it rather a seminar, where people don't realize that you are absent, I mean...it's pretty easy to get that*

kind of information through Facebook groups and you wouldn't know that otherwise. [Person 5]

Yeah right, and students who have done the course already...you know, they share tips and tricks...which is particularly helpful when preparing for oral exams like in anatomy...like people posting lists with the main questions that are being asked, you know. [Person 10]

Comments on feeling mentored in the Facebook groups referenced the peer group sources as "swarm intelligence" and feeling "swarm mentored" as a consequence of it:

You know, in pharmacology...there were one or two brains [refers to very good students] and they went back and forth...even with literature searches, only so that they could answer the question [refers to pharmacology questions posted in a Facebook group] it was like...I would say swarm intelligence...and that's [refers to feeling mentored] sort of swarm mentoring...just like swarm intelligence. [Person 4]

Theme 3: Empowerment and Emotional Support

Empowerment and emotional support as elements of peer mentoring were present as well in the perceptions of participants:

[Talking about advantages of being a member of the Facebook groups] You know, sort of team work, like people are not working against each other but with each other. So that you can find the solutions or exchange thoughts and helping, you know [Person 1]

One participant described the Facebook groups as a "system" of support:

Well, I sort of feel taken care of, like when I have the feeling that there is a system, that helps me become more self-confident, so that I can understand how things work and I am being prepared [refers to exams]. [Person 10]

However, the exposure of personal information and making a fool of oneself in front of a larger group were partly perceived as difficult in the context of Facebook groups:

It's also kind of a data safety question. Who really wants personal things to be in the Internet forever? [Person 10]

You know, and maybe...you actually know each other, and you don't want to show yourself up, sort of. [Person 2]

At the same time, there seemed to be some sort of self-regulation present within the groups as well:

Usually, those posts that are like bad low blows...those are usually removed quickly, although you find those, too. [Person 10]

Discussion

Principal Findings

Our data indicate that all peer-mentoring elements as defined above and that are based in the literature on mentoring in medical education [11,25-28] are present in Facebook groups that are formed by preclinical undergraduate medical students. The fact that many, if not most, preclinical medical students are already members of Facebook and can make use of its multiple affordances, such as forming closed groups and exchanging diverse online media, makes Facebook an interesting supportive platform for peer-mentoring programs. The content of these informal groups, generally formed by students with similar rank and experience, seems to be beneficial for all members of the group. A pool of skills, experiences, and resources is built through these groups in order to facilitate access for all members. The posting pattern within these groups reflects the curriculum design, and exams seem to be a trigger for increasing posting intensity.

The differences in Facebook group sizes most likely result from some students not leaving the Facebook groups after completing the semesters. However, students constantly seem to adjust the form of these groups according to their educational needs. Further studies are needed to better characterize the life cycle of these groups.

A rather small group consisting of 3.90% (62/1591) of students was accountable for about 25.34% (3003/11,853) of all posts, indicating that some students might function as social media drivers. The vast majority (1268/1591, 79.70%) of students showed less active posting behavior, still membership was identified as essential during focus group discussions in order to have access to all relevant information. The vast majority of all questions, that is 78.1% (232/297), posted in both groups (PCY1 and PCY2) were answered satisfactorily and demonstrate a responsive and functional network.

However, more complex peer-mentoring elements such as empowering and fostering personal development seem to be underrepresented in these groups. Further research is needed to better understand the specific role of formal peer-mentoring programs in this context and how formal peer-mentoring programs should be combined with online social networks.

Social network sites like Facebook might provide useful affordances for peer-mentoring programs, in particular for large medical faculties. Based on the observation that Facebook groups of undergraduate medical students are used more in order to share resources and experiences as compared to emotional support, we assume that real-life social networks play an at least equally important role for peer-mentoring activities. Furthermore, our data showed that students start forming these groups even before the official start of semesters. Medical faculties might thus also use these groups for communicating relevant orientation information to preclinical students, although official involvement of faculty might alter the acceptance and dynamics of these groups.

Specifically trained social media educators might thus help to support a positive learning culture and guide students more effectively toward relevant resources and faculty members, since informal Facebook groups rather lack structure, organization, and quality control of information. Finally, aspects like data privacy and digital professionalism need to be considered carefully [31]. Further research is needed to better understand involvement and perceptions of medical students with regard to Facebook and to what extent formal involvement of faculty is needed and accepted as compared to other forms of peer mentoring [15].

Conclusions

Our findings indicate an extensive use and, so far, not well-understood role of social network sites in the context of peer mentoring for undergraduate medical students. The fact that many, if not most, preclinical medical students are already members of Facebook and can make use of its multiple affordances, such as forming closed groups and exchanging diverse online media, makes Facebook an interesting supportive platform for peer-mentoring programs.

Although Facebook might not be able to replace all face-to-face elements of peer-mentoring programs, we found that medical students' extensive informal use of Facebook could be leveraged to support formal peer-mentoring programs for undergraduate medical students. The typology and behavior of subgroups within the identified Facebook groups are not fully understood and the adequate roles of faculty members and official mentoring programs in the context of social media require further exploration.

Conflicts of Interest

None declared.

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Abbreviations

LMU: Ludwig-Maximilians-Universität
PCY1: first preclinical year
PCY2: second preclinical year

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Original Paper

Developing a Curriculum to Promote Professionalism for Medical Students Using Social Media: Pilot of a Workshop and Blog-Based Intervention

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Abstract

Background: As the use of social media (SM) tools becomes increasingly widespread, medical trainees need guidance on applying principles of professionalism to their online behavior.

Objective: To develop a curriculum to improve knowledge and skills regarding professionalism of SM use by medical students.

Methods: This project was conducted in 3 phases: (1) a needs assessment was performed via a survey of medical students regarding SM use, rationale for and frequency of use, and concerns; (2) a workshop-format curriculum was designed and piloted for preclinical students to gain foundational knowledge of online professionalism; and (3) a complementary longitudinal SM-based curriculum was designed and piloted for clinical students to promote both medical humanism and professionalism.

Results: A total of 72 medical students completed the survey (response rate 30%). Among the survey respondents, 71/72 (99%) reported visiting social networking sites, with 55/72 (76%) reporting daily visits. Privacy of personal information (62/72, 86%) and mixing of personal/professional identities (49/72, 68%) were the students' most commonly endorsed concerns regarding SM use. The workshop-format curriculum was evaluated qualitatively via participant feedback. Of the 120 students who participated in the workshop, 91 completed the post workshop evaluation (response rate 76%), with 56 positive comments and 54 suggestions for improvement. The workshop was experienced by students as enjoyable, thought provoking, informative, and relevant. Suggestions for improvement included adjustments to timing, format, and content of the workshop. The SM-based curriculum was evaluated by a small-scale pilot of 11 students, randomized to the intervention group (participation in faculty-moderated blog) or the control group. Outcomes were assessed quantitatively and qualitatively via personal growth scales, participant feedback, and analysis of blog themes. There was a trend toward improvement in total personal growth scores among those students in the blog group from 3.65 (0.47) to 4.11 (0.31) (mean [SD]) with no change observed for the students in the control group (3.89 [0.11] before and after evaluation). Themes relevant to humanism and professionalism were observed in the blog discussion.

Conclusions: Most medical students surveyed reported using SM and identified privacy and personal-professional boundaries as areas of concern. The workshop format and SM-based curricula were well-received by students whose formative feedback will inform the refinement and further development of efforts to promote professionalism among medical students.

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KEYWORDS

medical education; medical students; professionalism; social media; social networking

Introduction

Social media (SM) tools have become an increasingly common means of communication and are changing the flow of information in the field of medicine [1-3]. SM tools, which include Facebook, Twitter, wikis, and blogs, are Web-based technologies designed for sharing user-generated content and facilitating collaboration and networking. Most medical students today are part of the "net generation" and have grown up with these tools [4]. Surveys estimate that up to 98% of medical students have mobile phones [5] and between 60% and 70% of medical students have Facebook accounts [6-9]. Students use SM for a variety of positive purposes, such as sharing experiences and forming supportive peer networks [10]. In response to these trends, medical educators have begun to harness the potential of SM to promote active, collaborative learning [11-14].

Innovative SM curricula designed to enhance both medical humanism and professionalism are being piloted at medical schools in the United States and in other countries [15-18]. In particular, blogs have been used to combat the potential influences of the "hidden curriculum" in undermining medical students' development of humanism and professionalism [19-21]. Through positive online interactions, medical students can develop skills to foster personal growth by reflecting upon powerful clinical experiences, encouraging introspection and sharing of information, and forming a support network of helping relationships [22-24]. SM tools can extend the benefits of reflective practices to reach trainees who may be unable to participate in in-person sessions due to the timing or geography of their training [15,16].

However, concerns have been raised regarding SM use and medical professionalism [5,25-27]. Traditional boundaries between patients and physicians, and between students and faculty, may be blurred by online interactions [28-30]. In addition, the public availability of information on patients and physicians represents a threat to privacy [31-33], with the potential for a negative impact on patient-physician relationships [34,35]. As much as 60% of medical schools responding to a survey reported incidents of medical students posting unprofessional content online [36]. Although many medical schools lack policies specific to SM use [37], guidelines are available from professional societies [38,39] and expert recommendations have been disseminated [40-42]. Little information is available on how to teach these guidelines to students and help them apply principles of professionalism to SM use. Medical educators have called for more opportunities for preventing misuse and engaging in critical analysis of SM activity [43,44]. Students have also expressed a desire for more practical recommendations and help with gray areas where there may be disagreement on what is appropriate [45].

The study's 2 co-investigators (TEF and MSC) performed a targeted needs assessment regarding SM use among Johns Hopkins University School of Medicine first- and second-year students. Because of the concerns surrounding professionalism and SM usage, the investigators then aimed to design, pilot, and evaluate a workshop-format curriculum for students to gain knowledge relating to online professionalism. Second, the investigators aimed to design, pilot, and evaluate an SM-based curriculum to enhance overall medical student humanism and professionalism, via a focus on online behavior. Specifically, the investigators aimed for medical students to develop critical thinking regarding professionalism and SM use, gain skills of reflective practice in self-assessment and in peer interaction, and foster attitudes of empathy as a key relational aspect of professionalism.

Methods

Needs Assessment

The general needs assessment for this curriculum development included a systematic review of the literature regarding the use of SM in medical education [11]. The targeted needs assessment included meetings with the key stakeholders of student leaders, medical educators, and administrators. There was a perceived need for guidance on issues of online professionalism and an opportunity to address this topic during orientation activities for incoming medical students.

To gain more specific information on the targeted learners, a survey was designed for the first- and second-year medical students to assess their frequency of SM use, reasons for use, and concerns regarding use. Questions were adapted from previously published surveys [46,47]. Content validity was assessed by piloting and refining the survey with an expert focus group. The survey was administered online using SurveyMonkey; nonresponders were reminded once to complete the survey. Descriptive statistical analyses were performed, using frequencies and percentages and review of students' free-text responses to open questions. Institutional Review Board's approval was obtained for this study.

Workshop-format Curriculum

Design

The educational methods were based on information from the needs assessment, and on *Adult Learning Theory*, which engages students in self-directed, problem-based learning with relevance to their needs and experiences, and on *collaborative learning*, which promotes learning through interaction and the construction of knowledge from experience. Best practices for SM use available from other medical centers [40] were adapted to develop cases specific to dilemmas for medical students.

The workshop was conducted as two 90-minute sessions, with 60 students each, during the required orientation sessions for the incoming first-year medical students. The medical school computer laboratory was chosen as the setting, so that each student could have a computer and the ability to share their screen with the large group via a projector. The investigators served as cofacilitators. Small groups of 8-10 students participated in activities, using their computers' Internet search engines to locate relevant resources, and shared their findings first within their small group and then with the large group. These activities were to share examples of (1) medical students using SM to post about medical topics; (2) medical students being reprimanded for inappropriate posts on online social networks; and (3) guidelines from medical organizations regarding SM use by physicians and/or physicians-in-training. After sharing each group's findings, all students participated in a large-group discussion about the sites that were found and issues raised. Multimedia Appendix 1 shows the outline used by the facilitators to plan the workshop sessions, including objectives, timing for activities, and resources needed.

At the end of the session, students were provided with a handout that included (1) principles of professionalism [38]; (2) guidelines for SM use [39]; and (3) selection of cases to think about guidance from best practices [40]. Multimedia Appendix 2 provides a copy of the handout.

Evaluation

The primary goal of the evaluation was to gain formative feedback on the pilot phase of the workshop itself, rather than a more rigorous assessment of learners. Learner satisfaction and feedback were assessed by collecting anonymous written comments at the end of each session. Qualitative analysis of the comments was performed and common themes were extracted.

SM-Based Curriculum

Design

In addition to the knowledge-based workshop, an SM-based experiential curriculum was designed to address attitudes and skills, using a private, chaperoned blog. The information in the needs assessment was used to help tailor the blog to students' level of familiarity with the technology and address students' concerns. To investigate the usefulness of this blog, Internal Medicine clerkship students were randomized either to the intervention or control group. The intervention group was encouraged to post their own narrative reflections about powerful clinical experiences on the blog and to submit comments in response to peer- and investigator-written reflections and comments. All participant submissions were screened to ensure that all reflections and comments were Health Insurance Portability and Accountability Act compliant. The investigators served as blog moderators and posted their own reflections and comments to model medical humanism and professionalism and promote discussion. Members of the control group performed their usual clerkship without access to the study blog.

Evaluation

The intervention trial compared personal growth between the intervention and control conditions, measured using a questionnaire of self-reported change in 9 domains such as self-understanding, clarity of goals, values, and/or direction, and self-confidence on a 5-point Likert scale. The personal growth scale has demonstrated reliability and has been previously validated for assessment of change in Internal Medicine residents and was adapted for use in the Internal Medicine clerkship [22]. Scores on the personal growth scale survey were analyzed using *t* tests to compare mean scores in the intervention group with those in the control group.

It was hypothesized that, compared with control participants, intervention participants would have higher scores on the personal growth scale at the end of the clerkship; and that intervention participants would demonstrate an increase in personal growth between the beginning and end of the clerkship. In addition, it was hypothesized that blog posts and comments would contain themes of humanism and professionalism.

Humanism and professionalism were assessed among intervention participants by qualitative analysis of blog posts and comments exploring emerging themes. The analysis employed an inductive approach and was informed by prior qualitative analyses of medical students' written and online reflections [15,16,48]. Institutional Review Board's approval was obtained for the study.

Results

Needs Assessment

A total of 72 students responded (30.0%, 72/240) to the survey. Figure 1 shows students' frequency of using SM; of these, 71 respondents (71/72, 99%) visit social networking sites (eg, Facebook) and 55/72 (76%) do so daily. As much as 97% of respondents (70/72) post their own original content to social networking sites, with the majority doing this once a week. Students showed a wide range of familiarity with blogs: 11/72 (15%) had never visited a blog, 26/72 (36%) visited less than monthly, 12/72 (17%) monthly, 14/72 (19%) weekly, and 9/72 (13%) daily. A total of 28 students (28/72, 39%) had posted their own original content to a blog. Figure 2 shows students' reasons for using SM. The most common reason cited was to connect with family and friends (67/72, 93%), followed by sharing their own experiences with others (31/72, 43%) and networking with medical professionals (8/72, 11%). Figure 3 shows students' concerns regarding SM use. The most common concerns were privacy of personal information (62/72, 86%), mixing of personal and professional identities (49/72, 68%), time (44/72, 61%), and privacy of patient information (13/72, 18%). However, 10% of students (7/72) reported having no concerns at all.

Figure 1. Medical students' frequency of using SM tools.

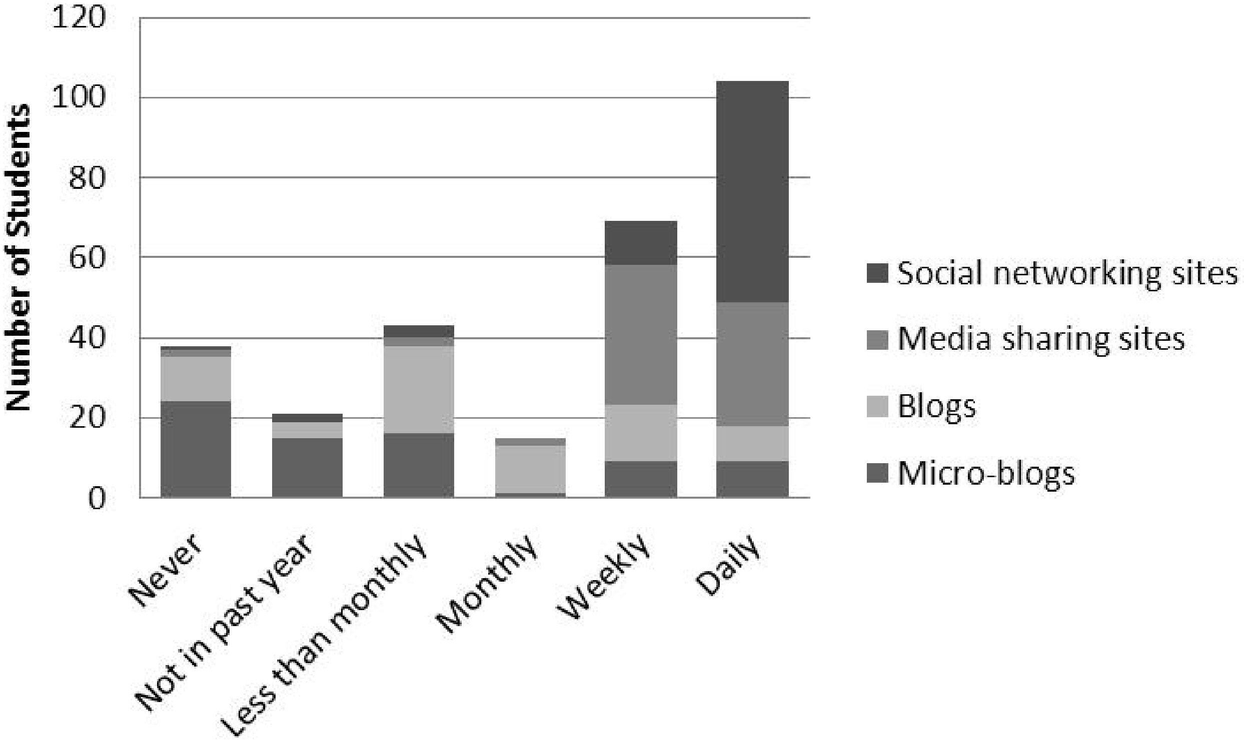


Figure 2. Medical students' reasons for SM use.

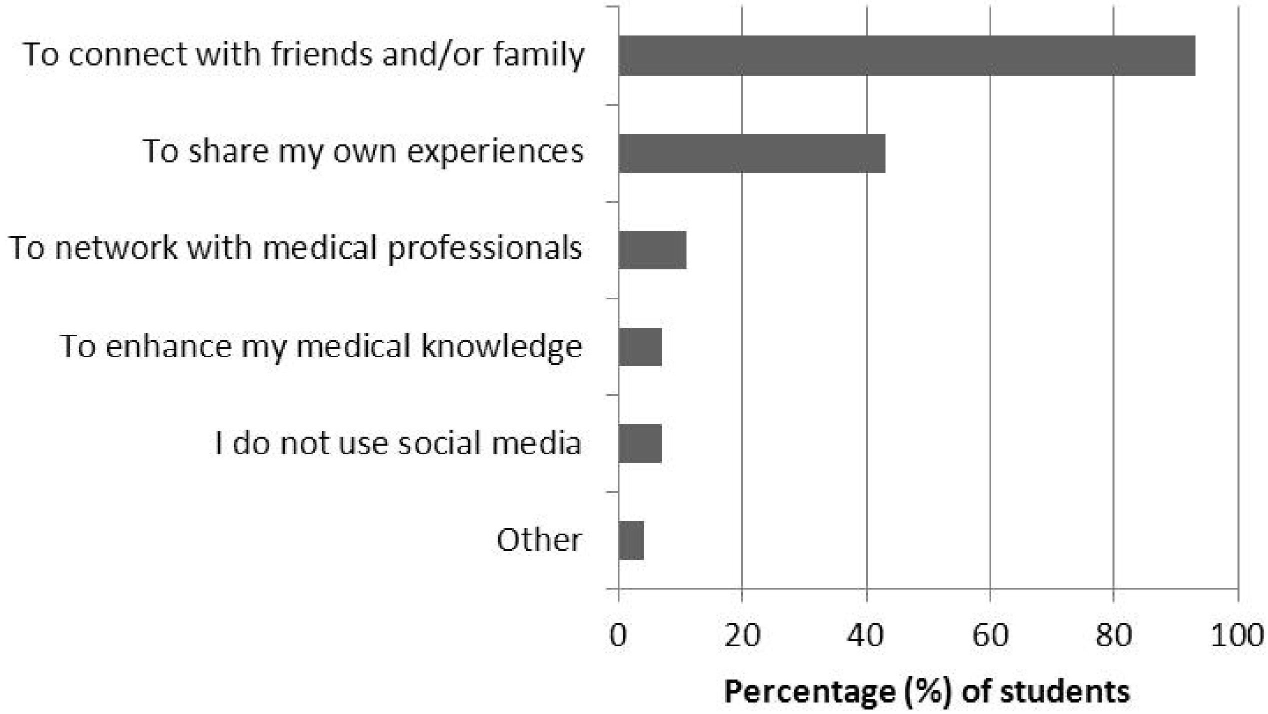
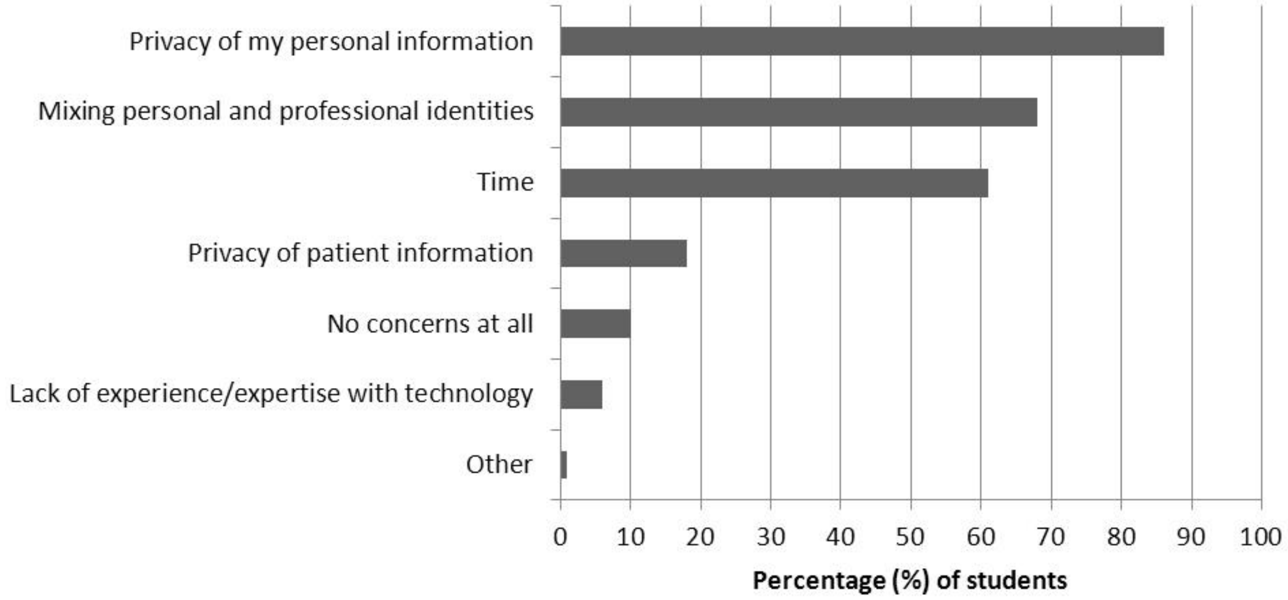


Figure 3. Medical students' concerns regarding SM use.



Workshop-Format Curriculum

Using information from the survey, the workshop was tailored to meet students' needs. Case examples focused on the SM tools most used by students. Group discussion addressed ways to maximize the benefits of SM identified by students (such as connectivity and sharing) while avoiding risks to privacy and personal-professional boundaries.

The workshop was feasible to accomplish in the time allotted. The cofacilitators had prepared backup examples to use for each small-group activity; however, students had no difficulty in searching for relevant resources on their own and sharing them with each other. Students found examples of blogs, YouTube videos, and Twitter feeds that appeared to be posted by physicians or physicians-in-training. They also shared online news articles about examples of unprofessional behavior by medical personnel, including posting inappropriate photographs or potentially identifiable patient information. They were also able to find policy guidelines from several organizations, including the American Medical Association and Federation of State Medical Boards. In the large-group discussion, they were prompted to think critically about how to apply these guidelines to the real-world situations that their peers had found. During the discussion, facilitators emphasized critical thinking about principles of professionalism applied to each case shared by students. For example, when one participant shared a report of a medical student posting photos of a stabbing victim cared for in an emergency department rotation, facilitators prompted the group to discuss implications for patient privacy, which could be violated even if the patient's name was not revealed. When another participant shared an article about "friending" patients on SM networks, the group reflected on the challenges of patient-clinician boundaries.

As much as 75.8% of students (91/120) submitted comments after the workshop. Categories and examples of comments are shown in Table 1. Categories were not mutually exclusive and many students provided both supportive comments and suggestions of elements they would like to be expanded or adjusted. Students found the session to be enjoyable, interesting, thought provoking, informative, and relevant. Particular aspects that they endorsed positively were the group discussion, small-group activities, and case-based format. Suggestions for improvement included adjustments to the time distribution, clarifying instructions, and providing additional resources. In particular, many students requested more discussion of challenging cases of SM use and additional practical advice on how to apply professionalism principles in these situations.

SM-Based Curriculum

The study to evaluate the SM-based curriculum enrolled 11 participants, 8 in the blog group and 3 in the control group (using 2:1 randomization). Participants were 25.3 (2.0) years of age (mean [SD]); 8/11 (73%) were male; and 8/11 (73%) were white; 82% (9/11) were married and none had children. There were no significant demographic differences between the blog and control groups.

Students completed the personal growth scale, which asks them to rate the extent to which they have changed on 9 items on the following scale: 1=much worse, 2=worse, 3=no change, 4=better, and 5=much better. Mean (SD) total scores for both groups were 3.72 (0.41) at baseline and 4.04 (0.26) at follow-up. As can be seen in Figure 4, there was a trend toward improvement in the blog group from 3.65 (0.47) to 4.11 (0.31) (mean [SD]) with no change in the control group 3.89 (0.11) (mean [SD]). Interestingly, the item of "more humanistic in my approach to patients" showed a trend toward improvement (mean [SD]) in the blog group (3.25 [0.71] to 4.50 [0.71]) and no change in the control group (4.00 [0.00]). These trends were consistent with the study hypotheses. However, the number of participants was too small to demonstrate significant differences.

Table 1. Students' feedback on the workshop.

Themes		Examples
Supportive comments (N=56)		
	General comments	"Very informative. Made me think about my decisions. Really interesting and provocative. I think this is definitely something to be addressed with our generation. I really enjoyed it—eye opening."
	Group discussion	"Wonderful discussion. Loved the ethical dilemmas addressed. Love the crowd sourcing and collaboration."
		"It was useful to have a discussion, since I personally had not thought about these issues before."
	Small group interactions	"I enjoyed the interactive nature of the activities. It made a topic that many might have slept through (esp. with late in afternoon timing), quite exciting."
	Case-based format	"This was fun and a good was to meet the people in my group! I felt the review of questionable cases was helpful."
Constructively critical comments (N=54)		
	Timing	"Maybe shorten the session a little bit. Keep the interactive part."
		"I wish we had more time for the discussion at the end of the session."
	Format	"I would have liked it better if you had examples already for us. Not sure ours was the greatest."
		"It would have been nice to have some of the resources we found today available to us—possibly via email."
		"Instructions at the beginning were not exactly clear."
	Content	"Would have liked to be given more specific info regarding policy. I think it could be improved if we talked more about those "blurry" boundaries and how to negotiate with these issues"

Students randomized to the blog group also completed additional questions at follow-up. On average, students reported visiting the blog weekly to view posts or comments. All students agreed with the following statements: "I found it valuable to write my own posts/comments," "I found it valuable to view other people's posts/comments," "The blog had a positive impact on my understanding of professionalism," and "The blog had a positive impact on the professionalism of my behavior." Strengths of the blog experience included "Ability to communicate in a format that did not depend on being in the same place at the same time," "diversity of experience and viewpoints of contributors," and "quick responses from faculty." One student commented, "I'm normally not very interested in "reflecting," but the blog format, and limiting it to only a handful of students/faculty made me more comfortable in sharing my thoughts." The primary weakness of the blog experience was "not enough participation from other students."

Qualitative analysis of the blog posts and comments was also performed. Themes relating to aspects of humanism included developing compassion, dealing with "difficult" patients, appreciating patients' context, developing respect, and developing empathy for others (Table 2). For example, one post stated, "It's relatively easy to be...respectful when it goes both ways, but not when our efforts are met with resistance or even aggression." In the discussion, potential strategies were offered, including "I resist my impulse to think that I would behave any differently if I were in their shoes."

Themes also related to other aspects of professionalism. Some posts related to professionalism issues specific to SM use, such as deidentification of information, student/staff privacy, and patient privacy (Table 2). Other posts concerned professionalism more broadly, such as observations of the hidden curriculum and conflict with colleagues. No breaches of professionalism occurred on the blog itself. One exchange between a student and faculty did involve feedback on further deidentification of a patient story, in which certain details might have been recognizable to someone who knew them.

Figure 4. Change in medical students' overall scores on personal growth scale, comparing blog group with control group (no blog), preclerkship and postclerkship.

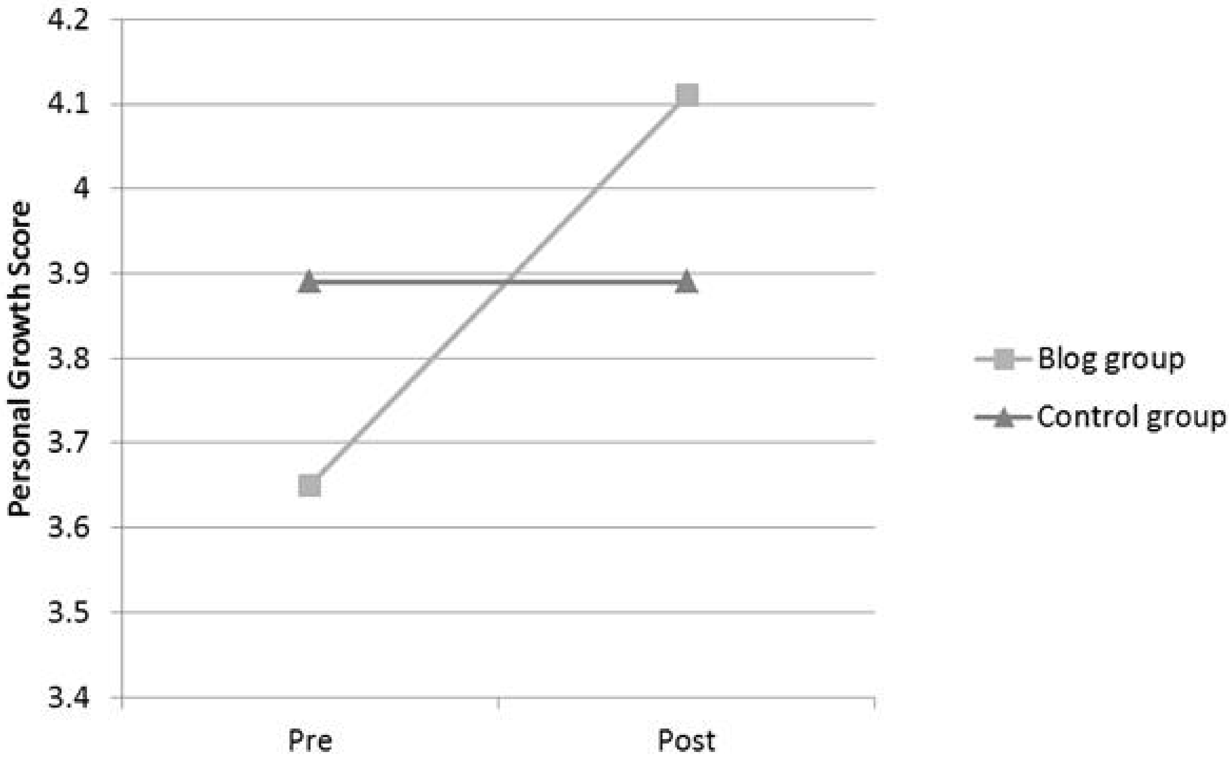


Table 2. Qualitative analysis of the blog posts and comments relating to aspects of humanism and professionalism.

Themes		Examples
Humanism themes		
	Dealing with "difficult" patients	"I have no idea how to work with these patients without rolling my eyes or biting my lip."
	Appreciating patients' context	"Understanding the origin of the problem...can help."
	Developing compassion	"I've learned that these patients require a new level of compassion."
	Developing respect	"It's relatively easy to be...respectful when it goes both ways, but not when our efforts are met with resistance or even aggression."
	Developing empathy for others	"I resist my impulse to think that I would behave any differently if I were in their shoes."
Professionalism themes		
	Deidentification of information	"We're all learning how to deidentify cases."
	Hidden curriculum	"This sort of talk is longstanding...and models a lack of collegiality."
	Student/staff privacy	"[Are] students wanting to keep their interactions with other students private from their professors, and vice versa?"
	Patient privacy	"It is still important to protect...patient privacy."
	Conflict with colleagues	"Do [they] truly resent the ED, or are their feelings a 'nothing personal' natural defense mechanism of venting?"

Discussion

Preliminary Findings

Most students at Johns Hopkins University School of Medicine responded to the survey report using SM at a level comparable to trainees at other institutions previously surveyed [6-9]. Respondents reported using SM for a variety of positive purposes, such as connecting with others and sharing their experiences. However, potential risks to professionalism were also expressed. They identified privacy and personal-professional boundaries as particular areas of concern. Data from the targeted needs assessment were used to develop a workshop to introduce students to professionalism guidelines in the use of SM and explored the application of these guidelines to challenging situations. Again using information from the needs assessment, an SM-based intervention was designed and piloted, in the form of a blog, to evaluate the opportunities and challenges of using SM to promote humanism and professionalism for physicians-in-training.

The piloted workshop was well-received by students, who particularly enjoyed the interactive style, case-based format, and opportunity for discussion. The workshop-based approach appears to be particularly valuable in engaging students in the topic of professionalism, which may otherwise seem too abstract for incoming trainees to discuss in a meaningful way. By emphasizing the development of critical thinking skills in applying professionalism principles to new challenges raised by SM, facilitators encouraged students to reflect on their roles as physicians-in-training and how their behavior in all aspects of their lives may reflect (positively or negatively) on their professional identities. The students provided formative feedback for the workshop, which can assist in refining future iterations of it. Later versions should include more rigorous evaluation of students' knowledge and attitudes, to gain a better understanding of the intervention's potential impact.

There was a trend toward increased personal growth in the intervention group and, specifically, an increase in participants' humanistic approach to patients, which were unchanged in the control group. This study was a pilot phase with a small sample size, which does not allow definitive conclusions of effectiveness. However, these preliminary data are promising. It is possible that future expansions of this curriculum could be used to combat the decline in empathy observed in prior studies of medical students during their clerkship training [49].

Further implementation on a larger scale will be needed before any firm conclusions can be drawn. However, the goal will be to allow students to apply the knowledge gained from the workshop while developing skills in using SM and, ultimately, promote medical humanism and professionalism. As with any new technology, it is important to weigh the risks versus benefits in incorporating SM tools into medical education. No breaches of professionalism were observed on the faculty-moderated blog; however, expansion of the intervention does carry a potential risk, particularly in violations of patient privacy. This pilot blog was accessible only to faculty moderators and study participants, to ensure that any possible inappropriate posts would not be public and could be removed. The moderators also worked closely with IT security consultants at their institution to minimize potential risks. Allowing students to practice using SM in a professional manner within a safe environment shows promise as a teaching method that balances the risks and benefits of SM use.

Limitations

This work has several limitations. For the needs assessment, there was a relatively low response rate. Although this is not atypical of survey studies of medical trainees' online behavior [50], there may have been some selection bias if the students who responded had different attitudes and behaviors regarding SM than those who did not respond. Students' SM use outside of the workshop setting was not observed. Therefore, it is not possible to say whether their use of SM was changed by the intervention. For the SM intervention, the major limitation was the small number of participants, which meant statistically significant differences were not observed. Recruitment was a challenge in terms of integrating the intervention with students' other activities. Blog participation was also affected by technological problems. This issue could be addressed by using a different platform for future blog interventions with links through systems that students already sign into (eg, blackboard). For both the workshop and SM-based curricula, it is difficult to say if incidents of unprofessional behavior have been prevented, when the baseline rate is rare and not precisely known.

Conclusions

This paper contributes an intervention that was useful at one institution, and could be adapted to others as well, to address emerging issues of professionalism and SM use among medical students. Modern medical students have grown up with SM and may take its use for granted, without fully realizing the implications of their online behavior in their new roles as physicians-in-training. Medical educators have an opportunity not only to provide valuable guidance to students in using SM wisely, but also to promote the development of professional identities by implementing SM interventions into the medical curricula.

Acknowledgments

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Authors' Contributions

Dr Flickinger and Dr Chisolm designed and conducted this study, performed data collection and analysis, and manuscript preparation. Dr O'Hagan assisted with manuscript preparation.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Workshop outline for facilitators.

[PDF File (Adobe PDF File), 9KB - mededu_v1i2e17_app1.pdf]

Multimedia Appendix 2

Workshop handouts for students.

[PDF File (Adobe PDF File), 133KB - mededu_v1i2e17_app2.pdf]

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Abbreviations

SM: social media

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Original Paper

A Novel Service-Oriented Professional Development Program for Research Assistants at an Academic Hospital: A Web-Based Survey

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Abstract

Background: Research assistants (RAs) are hired at academic centers to staff the research and quality improvement projects that advance evidence-based medical practice. Considered a transient population, these young professionals may view their positions as stepping-stones along their path to graduate programs in medicine or public health.

Objective: To address the needs of these future health professionals, a novel program—Program for Research Assistant Development and Achievement (PRADA)—was developed to facilitate the development of desirable professional skill sets (ie, leadership, teamwork, communication) through participation in peer-driven service and advocacy initiatives directed toward the hospital and surrounding communities. The authors hope that by reporting on the low-cost benefits of the program that other institutions might consider the utility of implementing such a program and recognize the importance of acknowledging the professional needs of the next generation of health care professionals.

Methods: In 2011, an anonymous, Web-based satisfaction survey was distributed to the program membership through a pre-established email distribution list. The survey was used to evaluate demographics, level of participation and satisfaction with the various programming, career trajectory, and whether the program's goals were being met.

Results: Upon the completion of the survey cycle, a 69.8% (125/179) response rate was achieved with the majority of respondents (94/119, 79.0%) reporting their 3-year goal to be in medical school (52/119, 43.7%) or nonmedical graduate school (42/119, 35.3%). Additionally, most respondents agreed or strongly agreed that PRADA had made them feel more a part of a research community (88/117, 75.2%), enhanced their job satisfaction (66/118, 55.9%), and provided career guidance (63/117, 53.8%). Overall, 85.6% of respondents (101/118) agreed or strongly agreed with recommending PRADA to other research assistants.

Conclusions: High response rate and favorable outlook among respondents indicate that the program had been well received by the program's target population. The high percentage of respondents seeking short-term entry into graduate programs in health care-related fields supports the claim that many RAs may see their positions as stepping-stones and therefore could benefit from a professional development program such as the one described herein. Strong institutional support and sustainable growth and participation are other indications of early success. Further evaluation is necessary to assess the full impact of the program, particularly in areas such as job satisfaction, recruitment, retention, productivity, and career trajectory, but also in reproducibility in other institutions.

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KEYWORDS

research assistant; research coordinator; community engagement; mentorship; preprofessional; training and development; workforce development

Introduction

Background

In 21st-century academic medicine, the prioritization of evidence-based clinical practice has led to the expansion of clinical and translational research and quality improvement projects. This shift has resulted in the increased hiring of an employee pool that includes research assistants (RAs), study coordinators, quality improvement assistants, and other similar positions (also identified in this paper as RAs) at academic hospitals [1]. Despite their essential role in the research team, RAs are often “invisible” when it comes to their own professional development [1-7]. A review of the medical literature demonstrates a lack of formal programming and career development structure directed toward RAs, which may lead them to feel isolated, undervalued, unrecognized, and undersupported in their work [1,4,7]. This lack of community, support, and recognition may compound additional job dissatisfaction related to the following: (1) low salary, (2) feeling unchallenged, and (3) not doing what they expected to be doing. Altogether, these factors may contribute to a decrease in motivation, performance, and retention [1,7,8], and may ultimately impact career trajectory.

Despite not being hired as trainees (eg, medical students, residents, and fellows), RAs may represent the next generation of medical and health care professionals [9]. The jobs they fill may serve as stepping-stones on their path to medical school and other graduate-level health care programs. As such, academic institutions that promote job satisfaction and professional development among this population may benefit not only from short-term research productivity, but also from long-term workforce sustainability. Interestingly, very little is written in the medical literature on such programs, suggesting that few, if any, exist [1,3,6,9].

The understanding that a large percentage of RAs at one particular academic hospital fit this demographic (ie, young adult, pregraduate) led to the development of such a program. This article details the impact that such a program can have on RAs' professional development as well as on the institutions they work for. By presenting the unique concept and the low-cost benefits of the program, the authors aim to encourage other hospitals to consider establishing similar programs.

Establishment

In 2010, a team of RAs at a large pediatric teaching hospital, mentored by a faculty physician, established the Program for Research Assistant Development and Achievement (PRADA) for the purpose of creating a structured learning environment similar to the institution-wide programs already in place for trainees, postdoctoral and clinical fellows, and faculty. The steps taken to implement the program included the following: (1) developing a clear mission statement and identifying goals, (2) receiving institutional endorsement, (3) creating a product of value to recruit RAs, (4) empowering RAs to run and expand the program, and (5) forming a means to evaluate the program's efficacy and impact.

Once the mission statement and goals were outlined (see Textbox 1), the program sought institutional endorsement. Initial pushback exposed concerns about productivity and whether this was an attempt, on the part of the RAs, to form a union. Given that the programming was set to occur during the lunch hour and after normal work hours, and the program would not be a venue for voicing employment-related issues, perceived pressures were alleviated and endorsement was ultimately received.

Textbox 1. PRADA mission statement and goals.

Mission statement

- To provide a structured and supportive learning community for research assistants, study coordinators, and other young professionals to develop into tomorrow's leaders in health care

Goals

- Enhance job satisfaction
- Create an inclusive environment
- Ease acclimation into an academic clinical environment
- Provide career insights through panel-style seminars
- Facilitate skills development through lectures, workshops, and formal presentation
- Foster a service-oriented mind-set and promote community engagement through service and advocacy endeavors directed toward the hospital and surrounding communities

The initial anchoring product and recruiting tool of PRADA was a monthly seminar series at which invited guest speakers would speak on topics of interest to RAs, including the following: (1) professional guidance and skills (eg, scientific writing, public speaking, stress management, and getting into graduate and professional school), (2) health care-related career talks given by panels of health care professionals (eg, physicians, medical students, nurse practitioners, clinical psychologists, and career researchers), and (3) relevant contemporary issues (eg, health care reform, disparities in health care, and interviewing high-risk patient populations).

Steadily increasing interest and participation prompted the creation of a unique email distribution list for PRADA. While used primarily as a way to broadcast programming, the email list would also serve as a tool for monitoring growth. Today, the list includes over 500 currently employed RAs at Boston Children's Hospital (BCH), over 50 RAs at neighboring institutions, and over 70 alumni (ie, former RAs) at medical schools and other health care professional training programs who expressed interest in continued involvement prior to leaving. Feedback, both solicited and unsolicited, from outgoing RAs indicated that many wished they had learned about the program earlier in their employment. This led to a partnership with the hospital's Department of Human Resources (HR), which now advertises the program throughout their hiring processes, not only to promote early engagement in PRADA, but also as a method to enhance recruitment.

Organization

One of the earliest goals of the program was to have it run entirely by RAs. This was accomplished in 2012 when an executive board, overseen by two codirectors and their faculty advisor, was formed with representation from each of the following subcommittees: (1) Seminar Series and RA Grand Rounds, (2) Schoolwork Assistance (a novel, RA-run tutoring service for patients, and their siblings, who do not meet criteria for public school tutoring), (3) Social Volunteerism (social events with volunteering themes), (4) Pre-Med Track (events corresponding with the annual application timeline), (5) Public Health, Community, and Advocacy (engages RAs in activities related to health care legislation advocacy along with community health outreach and education with stakeholders within, and outside of, the hospital), (6) Membership and Communications, (7) Alumni Affairs (connects current RAs with alumni to provide them with insights into particular programs), (8) Science Writing Mentor Program (pairs RAs with student authors who need help revising and submitting manuscripts to the Journal of Emerging Investigators: an open-source, peer-reviewed journal that publishes original science research performed by middle and high school students), and (9) Interactive Music Program (RAs, in collaboration with Child Life Services and music therapists, provide interactive musical performances to patients).

Sustainability

Despite the transient nature of RA employment, the structure of PRADA has remained stable and has seen continued growth and participation. To ensure a seamless transfer of responsibility across committee positions, new executive committee members are recruited from within subcommittees and new subcommittee members are recruited at events year-round. Low operational costs also contribute to PRADA's sustainability. Today, the only expenses that PRADA incurs are from the lunches served at noon seminars and the cost of running an annual summer conference for youth interested in health care-related careers.

Methods

In 2011, an anonymous quality improvement survey was administered to examine the demographics of PRADA's target audience, level of participation in and satisfaction with the programming (data not provided), career trajectory of members, and whether PRADA was meeting its goals. Respondents were invited through the PRADA email distribution list, which contained 179 unique institutional email addresses at the time of the survey. Regarding career trajectory, participants were asked to answer the multiple-choice question, "In three years I would like to see myself in: same position, continued research with increased responsibility, graduate school, medical school, or other." Subjects who selected *other* were given the option to elaborate in a space below, accessible through branching logic. To determine if PRADA was meeting its goals, a list of specific questions were asked with the stated goals of PRADA in mind (see Table 1). Subjects were asked to select responses from a 5-point Likert scale with 1 representing *Strongly disagree*, 2 representing *Disagree*, 3 representing *Neither disagree nor agree*, 4 representing *Agree*, and 5 representing *Strongly agree*. All study data were collected and managed using Research Electronic Data Capture (REDCap) electronic data capture tools hosted at BCH [10].

Results

A total of 69.8% (125/179) of invitees responded, with 100% (125/125) of them submitting completed surveys. A total of 5 out of 125 (4.0%) were excluded based on previously established exclusion criteria pertaining to employment status at BCH, leaving a final sample of 120. The majority of respondents were non-Hispanic white (89/114, 78.1%), were female (94/116, 81.0%), were 22-26 years old (101/115, 87.8%), had a bachelor's degree-level education (105/119, 88.2%), and were hired within the 2 years of survey administration (99/117, 84.6%). Most respondents (94/119, 79.0%) were seeking higher education, reporting their 3-year goal to be in medical school (52/119, 43.7%) or nonmedical graduate school (42/119, 35.3%). Only 8.4% (10/119) aimed to be in a research position with increased responsibility, 5.9% (7/119) were unsure, and 4.2% (5/119) aimed for a change in job with no research involvement. An additional 2.5% (3/119) selected *other* and no respondents selected an option to remain in the same position.

Respondents agreed or strongly agreed that PRADA had made them feel more a part of a research community (88/117, 75.2%), enhanced their job satisfaction (66/118, 55.9%), provided career guidance (63/117, 53.8%), and connected them with research assistants in other fields (56/117, 47.9%). Additionally, 35.6% (42/118) agreed or strongly agreed that PRADA made them a better research assistant. Overall, 85.6% of respondents (101/118) agreed or strongly agreed with recommending PRADA to other research assistants. See Table 1 for selected outcomes of the quality improvement survey.

Table 1. Selected outcomes of the anonymous quality improvement survey administered to PRADA membership in 2011.

Survey item	Strongly disagree/ disagree, n (%)	Neither agree nor disagree, n (%)	Agree/strongly agree, n (%)
Would recommend PRADA to other research assistants (n=118)	4 (3.4)	13 (11.0)	101 (85.6)
Feel like part of research community (n=117)	11 (9.4)	18 (15.4)	88 (75.2)
Enhanced job satisfaction (n=118)	12 (10.2)	40 (33.9)	66 (55.9)
Career guidance (n=117)	16 (13.7)	38 (32.5)	63 (53.8)
Connect with research assistants in the other fields (n=117)	28 (23.9)	33 (28.2)	56 (47.9)
Connect with research assistants in the same field (n=118)	37 (31.4)	40 (33.9)	41 (34.7)
Become a better research assistant (n=118)	20 (16.9)	56 (47.5)	42 (35.6)
Connect with a mentor (n=116)	43 (37.1)	48 (41.4)	25 (21.6)

Discussion

Principal Findings

The PRADA survey team set out to collect data for the purpose of quality improvement, as well as to assess career trajectory, and determine whether it was meeting its goals. The high percentage of RAs (94/119, 79.0%) indicating a 3-year goal of being in graduate or medical school supports the original hypothesis that many RAs see their positions as temporary posts along their way to higher education and more advanced positions. The premise that these RAs may find such a program valuable was supported by the large percentage of RAs who participated (125/179, 69.8%) and the large percentage of those who agreed or strongly agreed with recommending PRADA to others (101/118, 85.6%). Additional outcomes demonstrated that PRADA was meeting its first goal—to improve job satisfaction—with 55.9% (66/118) selecting *agree* or *strongly agree* on the Likert scale for this item. There was some indication that PRADA is on its way to meeting its second and third goals—to create an inclusive environment and to ease acclimation into an academic medical setting—given that 75.2% (88/117) of respondents indicated that they felt more a part of a research community and 47.9% (56/117) indicated that PRADA helped them meet RAs in other fields. However, further investigation is necessary to determine whether or not this has changed over time. Determining whether the final three goals—to offer career guidance, to facilitate skills development, and to promote a service-oriented mind-set through community engagement and advocacy opportunities—are being met requires further investigation, but high ratings of related programming (data not included) indicates that PRADA is on the right track toward meeting them. In all, outcomes indicate moderate success for PRADA bearing in mind the survey was conducted in 2011, 1 year prior to the expansion of the program into what it is today.

Other observable indicators of success include a recent attempt to replicate the PRADA model at a neighboring Harvard-affiliated academic hospital by an alumnus, endorsement from the Boston Children's Hospital Department of Human Resources, and inclusion of PRADA program materials in recruiting and hiring processes, which speaks to the value the institution sees in the program. In April 2015, the executive committee and the founding faculty physician received the 2015 Harold Amos Faculty Diversity Award, established to recognize and celebrate faculty who have made significant achievements in moving Harvard Medical School and Harvard School of Dental Medicine toward being a diverse and inclusive community.

Limitations

Limitations include a small sample size taken primarily from one institution. Additionally, the survey, having been designed for quality improvement purposes, did not have a control group, nor did the survey team obtain a baseline satisfaction for comparison. Additionally, the survey could not compare its demographic distributions against the hospital's records to demonstrate inclusivity. However, recent collaborations with HR have made this possible going forward.

Future Directions

In response to the limitations of the survey administered in 2011, PRADA's survey team created a more substantial, Institutional Review Board-exempt, longitudinal study of its membership to further evaluate whether its programming has a significant impact on job recruitment and retention, job satisfaction, commitment to the institution and/or the field of pediatrics, as well as career trajectory. Additional questioning is being employed to better assess PRADA's progress toward meeting its goals, and demographic data will be compared with HR records to ensure inclusivity. The team also plans to explore reproducibility at other academic institutions.

Conclusions

This program model offers RAs many unique and diverse opportunities to contribute to initiatives that they are passionate about without interfering with their work responsibilities. Organizing and/or participating in such activities facilitates the acquisition of skill sets considered desirable by admissions committees and expected of trainees [11-12]. These include the leadership, administrative, and team-building skills necessary to run, sustain, evaluate, and improve a program. These skill sets also include working with under-represented populations, learning how to engage community stakeholders, taking part in public health education and advocacy, and providing mentorship to the youth that will one day replace them; this promotes a service-oriented mind-set that encourages them to give back to their communities and effect positive change in their everyday and professional lives. At the same time, members have the opportunity to interact with patients, present their research, and learn about the various career paths that lay ahead of them while forming lasting relationships with colleagues and mentors.

Summary

PRADA is a low-cost, sustainable program that may improve overall job satisfaction by addressing areas of potential dissatisfaction for RAs. It also offers opportunities that promote growth, accomplishment, contribution, and corporate citizenship [8]. Preliminary data suggest that PRADA is moving in the right direction with its goals, but further evaluation is necessary to measure its full impact and the potential impact of such a program in other institutions. The authors encourage other institutions to consider implementing such a program as a means for improving the quality of training that RAs obtain on their paths toward becoming tomorrow's leaders in health care.

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Authors' Contributions

RLK, KJK, and JEH wrote the manuscript. CMM, EHH, QGN, CMT, and LNF performed literature reviews and provided substantive input. All authors participated in editing the manuscript in its current form and approved of its submission.

Conflicts of Interest

None declared.

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Abbreviations

BCH: Boston Children's Hospital
HR: Department of Human Resources
PRADA: Program for Research Assistant Development and Achievement
RA: research assistant (also research coordinator, research technologist, quality improvement assistant, data coordinator, and other similar young professional positions within academic hospitals).
REDCap: Research Electronic Data Capture

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Original Paper

Creating a Pilot Educational Psychiatry Website: Opportunities, Barriers, and Next Steps

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Abstract

Background: While medical students and residents may be utilizing websites as online learning resources, medical trainees and educators now have the opportunity to create such educational websites and digital tools on their own. However, the process and theory of building educational websites for medical education have not yet been fully explored.

Objective: To understand the opportunities, barriers, and process of creating a novel medical educational website.

Methods: We created a pilot psychiatric educational website to better understand the options, opportunities, challenges, and processes involved in the creation of a psychiatric educational website. We sought to integrate visual and interactive Web design elements to underscore the potential of such Web technology.

Results: A pilot website (PsychOnCall) was created to demonstrate the potential of Web technology in medical and psychiatric education.

Conclusions: Creating an educational website is now technically easier than ever before, and the primary challenge no longer is technology but rather the creation, validation, and maintenance of information for such websites as well as translating text-based didactics into visual and interactive tools. Medical educators can influence the design and implementation of online educational resources through creating their own websites and engaging medical students and residents in the process.

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KEYWORDS

Psychiatry; Internet; Online; Education; Website

Introduction

In the dynamic and rapidly advancing modern technological landscape, the role of digital learning tools in medical education is an emerging area of study. Although much has been written about online resources and learning in medical education, there is a lack of studies on physician’s role in the development of these digital tools. This paper describes the creation of a pilot psychiatric educational website, and relevant considerations about the present and future role of physician-developed Web technology in medical education.

Medical students and residents are increasingly relying on Web technologies as their primary educational resources. A recent survey of fourth-year medical students found that on a daily basis, for educational purposes, 76% used Google searches, 83% used Wikipedia, 57% used UpToDate, and only 8% used bibliographic databases. [1]. Another survey study of residents of psychiatry revealed that the majority of respondents relied on online resources instead of textbooks, with the most utilized website being UpToDate, closely followed by Wikipedia and PubMed [2].

The variables driving the preference for and selection of online educational resources are multifold. Although there are numerous novel and effective uses of technology in medical education including gamification [3], feedback dashboards [4], social media [5], and virtual reality [6], websites remain the most frequently utilized digital resource. The high rate of use of Wikipedia and similar resources suggests that medical trainees are relying in part on user-created content for their education. Furthermore, in a recent survey of pediatric residents about preferences for educational website functions, 100% of respondents wanted pictures, 93.2% interactivity, 88.9% digital videos, 88.6% links to articles and research, and 86.4% graphics and animation [7]. These reports suggest that medical trainees value the interactive and multimedia potential of Web-based educational resources for learning and understanding their subject materials.

Modern Web technology now offers a novel opportunity for medical educators and trainees to not only be consumers of educational websites, but also participate in their creation. Technology has evolved to make the development of custom websites affordable, feasible, and educationally valuable. Understanding the process of developing digital technologies for medical and psychiatric education provides an opportunity for physician educators to leverage technology to better engage learners around relevant and quality content. A firsthand narrative describing the construction of a novel educational website for psychiatry trainees, PsychOnCall, provides a lens through which one can understand the current barriers, capabilities, and future opportunities for physicians in integrating technology development and teaching.

The value of understanding the creation and development of websites is best understood and framed in the context of advances in medical education theory. Adult learning theory, which highlights the active role of the learners' aspirations, as applied to residents of psychiatry suggests they are motivated more by personal interests and clinical relevance of topics than by training requirements [8]. The flipped classroom model, in which residents learn foundational material on their own and then use didactic time to discuss or apply such knowledge, encourages active learning and self-discovery of knowledge [9]. In the same vein, while a website may classically be seen as source of knowledge for learning, in the flipped classroom model it can also serve as a source of knowledge through creating content. Using Web technology, collaboration and active learning are no longer limited to just physical space, and several successful educational websites, such as that of the Kahn Academy, have been developed to realize this potential. However, there currently does not exist any widely available psychiatry-specific resource.

When it comes to training faculties and trainees, the competency of technologically minded individuals varies significantly, just as the case with wide range in competency in clinical knowledge and research literacy among these individuals. The creation and maintenance of a Web-based educational tool with clinically sound educational material can potentially serve as a venue to merge bidirectional teaching and learning in all 3 realms, namely, technology, clinical knowledge, and research literacy. More technologically minded trainees could educate and engage faculty members on the use and benefits of technology through this endeavor, while faculty members can educate and engage the trainees in systematically reviewing the quality of clinical material to be used for the website. The latter thereby reinforcing the cliché "Do not believe everything you read on the Internet." It could also foster discussions on ways in which different learners learn and how to optimize the use of technology to benefit multiple learning styles. This endeavor may also help identify trainees and faculties who may benefit from or be interested in further training in biomedical and clinical informatics, which is a growing field in medicine.

Thus, it seems that advances in technology and educational theory offer the opportunity for medical trainees and training programs to play an active role in the creation of an educational website that is visually appealing, dynamic, and interactive, where both teachers and trainees can learn from each other. Our goal was not to build that website but to rather explore the process to provide a pilot experience for an eventual large-scale project recognizing the value in understanding the development of educational technologies [10]. While we discuss the process of constructing our single specific website, PsychOnCall, we believe that the process of creating this website could provide valuable generalized lessons regarding both the opportunities and barriers that any resident, clerkship director, or program director will likely face when trying to build their own educational website.

Methods

PsychOnCall: A Pilot Psychiatric Educational Website

A pilot psychiatric educational website (PsychOnCall) was created to better understand the options, opportunities, challenges, and processes involved in the creation of a psychiatric educational website. We sought to integrate visual and interactive Web design elements to underscore the potential of such Web technology. These elements are described in the following sections.

Thinking Visual

Web technology has advanced to a point where the barriers toward creating a visual, interactive, and dynamic website have been greatly reduced. Code to create such graphics is freely available at websites such as D3. However, the challenge now lies not in the coding, but rather in translating classically abstract and static psychiatric concepts into visual and dynamic templates.

For example, in planning how to present medications we did not want to just provide a list of medications but rather create an interactive branching tree that responds to users clicking on various levels of the tree (Figure 1). This dynamic approach allows the user to visualize the classification and hierarchy of a specific medication while still providing detailed information as well as making alternative choices apparent. A further advantage is the ability to provide customized links to the primary source literature, which can change with each click so that, for example, core papers on fluoxetine can be displayed when the user selects such a link (Figure 1).

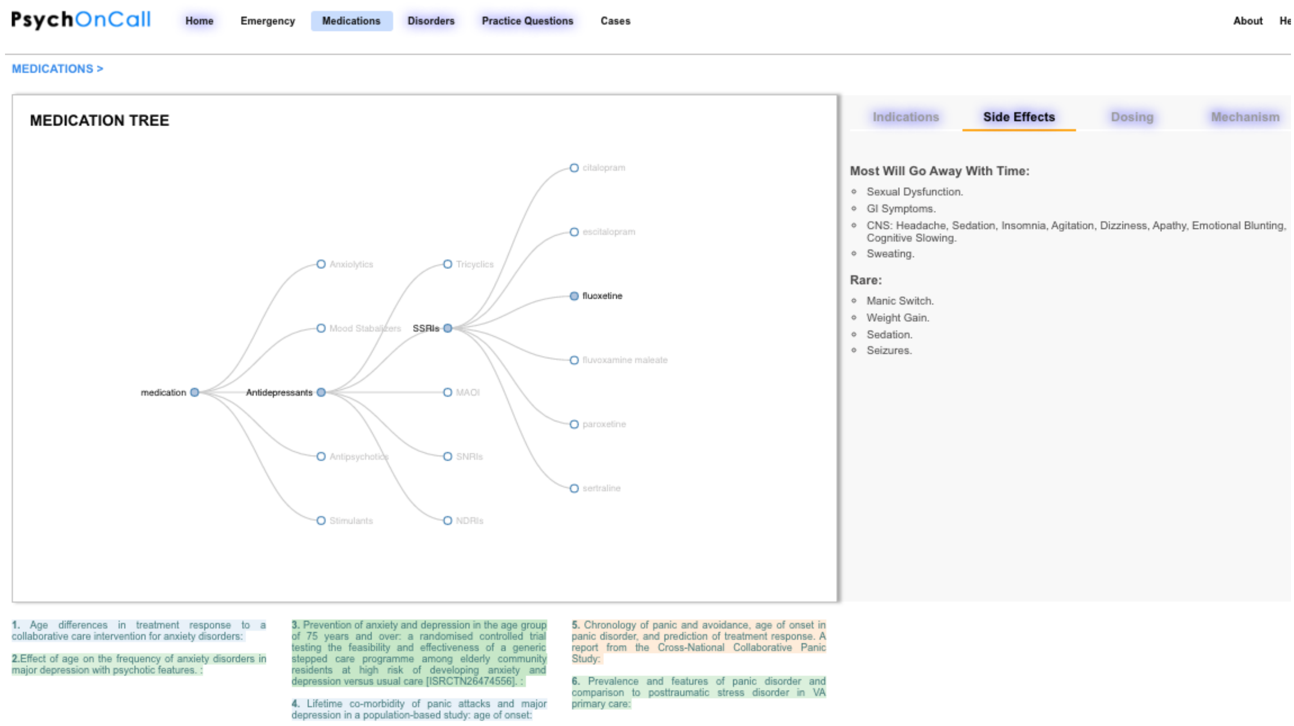
Another example of transforming more static data into a dynamic learning experience is seen in the presentation of lab value. Classically, lab reference data may be displayed on a printed chart; however, by using Web technology these data can be represented with a slider bar (Figure 2) that displays relevant differential diagnosis information depending on where the user moves the slider bar.

In addition, such a website can also be used for collaboration and information sharing between trainees. We created a page (Figure 3) designed for sharing video lectures, educational material, core papers, podcasts, and important websites. As trainees could easily upload their own resources, such a website has the potential to foster digital collaboration and empower residents to create and disseminate their own teaching materials.

Finally, the interactivity of websites is well suited to make treatment algorithms more engaging, dynamic, and educational. We collaborated with the psychopharmacology algorithm project at the Harvard South Shore Psychiatry to use one of their algorithms to pilot on our website (Figure 4). The ability to directly visualize the PubMed links related to each step in the algorithm may remind trainees to consider the evidence and literature that individual recommendations are based on, and to learn more by exploring individual papers.

The possibilities are broad and advances in Web technology will continue to offer new tools to visualize and interact with educational information. We do not claim to know the optimal way to display psychiatric material in a visual and dynamic manner but hope this will become an active area of study by educational experts.

Figure 1. A dynamic medication tree can offer a ‘big picture’ view of how a medication fits into a class/family while simultaneously presetting specific information for that medication.



XSL•FO
RenderX

Figure 2. Dynamic slider bars and other interactive features can present information on lab tests in a more engaging manner as seen above for a thyroid lab test.

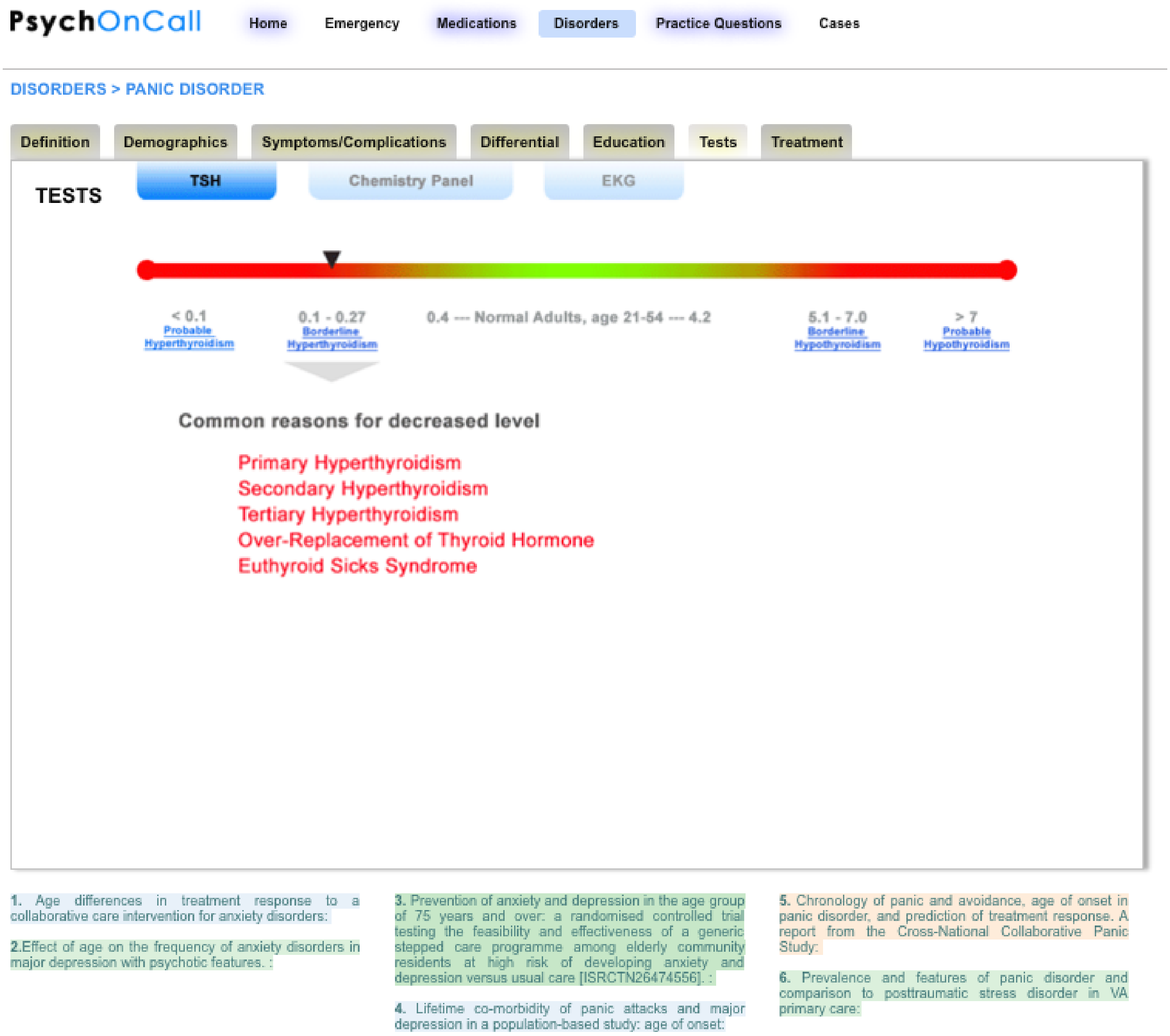


Figure 3. Web technology can make learning more social and offers the opportunity for trainees to contribute their own ideas and links in the form of papers, videos, audio, lectures, and more as seen above.

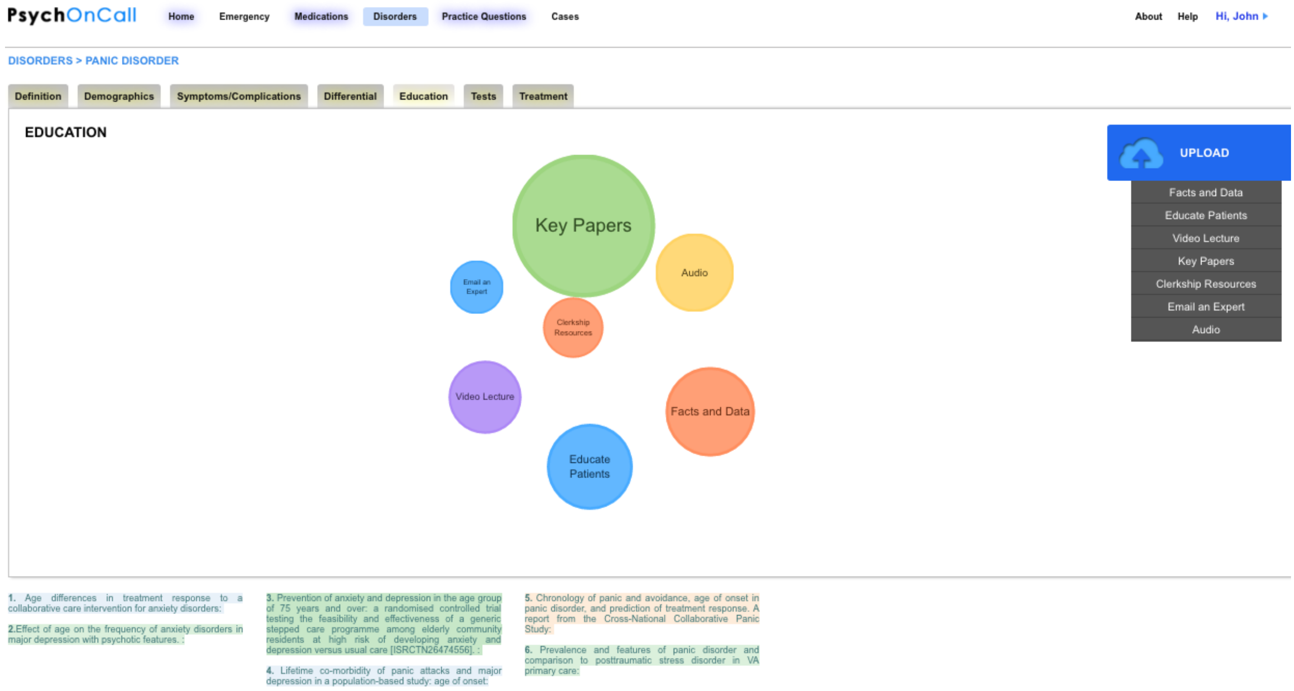
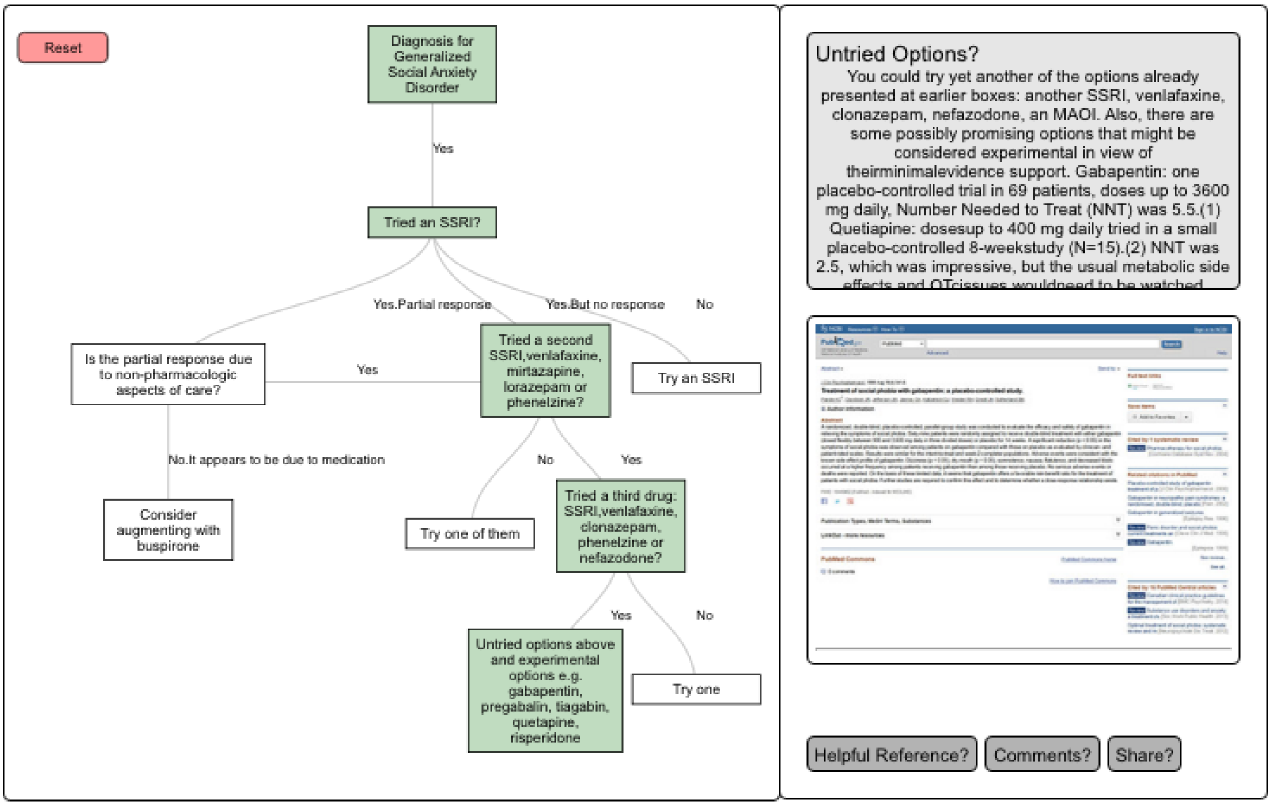


Figure 4. Algorithms can be programmed to be interactive and display relevant links to PubMed papers. This algorithm is derived from the social anxiety algorithm created by the psychopharmacology algorithm project at the Harvard South Shore Program.



Results

Overview

The pilot website (PsychOnCall) created demonstrated the potential of Web technology in medical and psychiatric education. With the created website, the opportunities, barriers, and process of creating a novel medical educational website were evaluated.

Challenges

Even given the pilot nature of our project and goal to explore the potential of Web technology for creating a psychiatric educational website rather than building a fully usable website, we ran into the following challenges, which would likely have to be well thought out before beginning a large-scale website project.

Cost

Although there are many approaches toward building a website, many of them will involve some direct cost. Utilizing template website services such as Weebly, WordPress, or Squarespace, it possible to both create and host a professional appearing website at low cost. Custom programming will cost more, although many academic departments or universities often have in-house programmers that may reduce cost. Finally, tech-savvy residents and educators may actually be able to accomplish the majority of required work. While cost is always an important issue, it is worth noting that 16 years ago, computer technology in a psychiatry residency was viewed as an investment [11], but today it is seen as a necessity.

Content

Finding a source of high-quality and accurate content related to psychiatry education can prove difficult as residents do not have the experience or credentials to create one alone. Active review and vetting by senior faculty members are necessary to ensure any uploaded information is accurate. Thus, before creating an educational website, it will be necessary to ensure good collaboration between faculty and residents with an agreed upon content review process.

Updating

As the knowledge base of psychiatry keeps rapidly expanding, it will be necessary to ensure that any information posted on an educational website is well curated and kept up-to-date. As the website expands in content, this updating process may become substantial and require dedicated efforts. Thus, before building a website, it is necessary to have a long-term framework for its continuation. While individual residents may graduate or faculty may leave, a plan should be in place to ensure that the website will remain updated and accurate in the long term.

Access

While an educational website offers the potential to easily share information with anyone in the world, understanding both who should and who can access the website is important. The risk of the public accessing the website and creation of an unintended patient-doctor relationship must be kept in mind and any website publicly posted should be well reviewed by the legal team of the hospital concerned and contain all necessary local, state, and federal disclosures. Password protecting the website, thereby limiting access to residents or medical students, is a potential solution. Fully understanding the desired accessibility before building the website would be important in shaping both its security and scope.

Discussion

While building our pilot website we focused on exploring the potentials of Web technology to enhance general medical as well as psychiatric education and the understanding of the process necessary to construct such a website. Online educational websites remain a nascent field and there are many exciting avenues for such to develop along. Although there are technological barriers to implementation, we believe that these barriers will continue to diminish and that the true barrier at this point is the design, translation, and validation of core psychiatric concepts presented on the page and their conversion into interactive and visual formats.

Rather than be flooded by a sea of websites, medical as well as psychiatric educators now have the opportunity to develop their own online resources as a hub of education. While the creation of websites is not novel, the increased reliance on them by trainees and the increased ease of creating them is novel and important. Using Web technology, now at a point where trainees can create websites as in our example, technology is no longer only a medium for educational knowledge but also a tool to be planned, developed, and learned.

While the potentials of digital learning to provide personalized adaptive or collaborative learning have been widely discussed and defined [12], actually implementing such in clinical education has been less well documented. Considering technology itself as a tool to be learned by medical trainees has been even less discussed. As we demonstrated, the actual creation of such a website even with a social/collaborative component is technically feasible and easily constructed. The challenge now is observing and understanding how trainees may actually use such a website and how various learning theories translate into an online reality. Medical and psychiatric educators now have the opportunity to conduct such studies and gather actual user data.

However, in order for such to succeed there should be several well-established processes before construction of any actual website. Understanding how content will be created and who will review and approve it are barriers that will likely become of increasing importance. Likewise, understanding how such content will be updated is another important consideration. A potential solution grounded in adult learning theory and the open classroom model is that trainees will provide the content and actively review the quality of the material with faculty as a shared process, which would simultaneously promote education in research literacy. However, the actual implementation of such remains unproven.

Despite the increasing prevalence of website use in medical education and psychiatry, much also remains unknown and unproven. While our paper does not present any user or subject data, our goal here is to not the highlight the merits or faults of any one unique website but rather consider the motivations and processes around creating such tools. Although there continues to be newer technologies, for example, virtual reality headsets and smart watches, websites currently remain the core technology that medical trainees continue to rely on. A better understanding of their use and the process of their creation is the important first step for medical education to better understand and utilize technology for teaching.

Although creating such processes will not be a simple task, starting to think of solutions now is important in ensuring that psychiatric educators will be able to influence the design and implementation of online educational resources. Following the recommendations of the Working Group on the 2011 conference "A 2020 Vision of Faculty Development Across the Medical Education Continuum," we agree that technology should be used to supplement but not replace face-to-face experience, that medical schools should allocate a variety of resources and support, and that national organizations should provide funding and leadership [13]. While it is impossible to define that tipping point where the investment and necessary resources decrease and the potential educational benefit increases, perhaps psychiatric education is now at that very tipping point with the future of online educational resources in motion. At one point in time, 16 years ago to be exact, it was noted that "software [for residency administration] will require both a financial and time investment before there can be dividends" [11] and today we would argue that online educational websites today are at that same crossroads.

Conflicts of Interest

None declared.

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Original Paper

Mobile Virtual Learning Object for the Assessment of Acute Pain as a Learning Tool to Assess Acute Pain in Nursing: An Analysis of the Mental Workload

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Abstract

Background: The inclusion of new technologies in education has motivated the development of studies on mental workload. These technologies are now being used in the teaching and learning process. The analysis enables identification of factors intervening in this workload as well as planning of overload prevention for educational activities using these technologies.

Objective: To analyze the mental workload of an educational intervention with the Mobile Virtual Learning Object for the Assessment of Acute Pain in adults and newborns, according to the NASA Task Load Index criteria.

Methods: A methodological study with data collected from 5 nurses and 75 students, from November of 2013 to February of 2014.

Results: The highest students' and specialists' means were in the dimensions of "Mental demand" (57.20 ± 22.27; 51 ± 29.45) and "Performance" (58.47 ± 24.19; 73 ± 28.85). The specialists' mental workload index was higher (50.20 ± 7.28) when compared with students' (47.87 ± 16.85) on a scale from 0 to 100 (*P*=.557).

Conclusions: The instrument allowed for the assessment of mental workload after an online educational intervention with a mobile learning virtual object. An excessive overload was not identified among participants. Assessing mental workload from the use of educational technologies at the end of a task is a key to their applicability, with the aim of providing a more effective, stimulating, and long-lasting experience of the learning process.

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KEYWORDS

nursing; nursing informatics; distance learning; computer-assisted instruction; educational technology; nursing education; acute pain; persuasive technology; mental workload

Introduction

Following the evolution of information and communications technologies (ICTs), the concept of the virtual learning object (VLO) has been emphasized in the educational scenario. It is defined as a unit that creates an educational context, is reusable in different learning contexts, and consists of an active and constructive teaching-learning strategy [1-3].

The interest in research on the organization of mental workload has gradually increased given the popularization of information and communications technologies (ICTs) in the workplace. The use of technology has also increased in teaching and learning, resulting in a growing interest for understanding the flow of information, as well as the mental workload generated by the use of these technologies [4].

Considering the current technological advances, some issues related to the teaching and learning process need to be reviewed; additionally, there is a need to establish metrics for the effective assessment of important parameters that can affect students' performance, such as mental workload.

Mental workload can be defined as the interaction between internal and external factors and the individual, resulting in a subjectively described experience [5]. This is the effect that a particular demand has on the individual in terms of mental and physical effort, which can be related to the amount of processed information, as well as the effort for the performance of that particular task [6].

It should be noted that the assessment of mental workload is subjective, namely, it is assessed from the perspective of the person performing the task, not the task itself. The assessment depends on individual characteristics that can increase or decrease this individual perception. These characteristics include the individual's knowledge for performing the task, experience with the activity, age, education, humor, etc. [7-9].

The assessment of mental workload assumes that an individual's burnout level is directly associated with his/her ability to perform a certain activity [10-12]. In this sense, the NASA Task Load Index (NASA TLX) has been more widely used, which is freely available to researchers (see Multimedia Appendix 1).

Although the interest in measuring mental workload as a means of understanding human-machine interfaces has been around for some years, only for the last 20 years has there been interest in the study of this effect on Web-based learning in humans [13-19].

By identifying the rates of the dimensions that construct the mental workload, it can be classified as either "overloaded" or "underloaded." Overload corresponds to a saturation of resource consumption, whereas underload results from the lack of stimulus to perform the task [20].

The calculation of mental workload through the NASA TLX combines the assessment rates of different dimensions and their weights, weighted according to their subjective importance for a given task [21]. In addition, studying the factors intervening in mental workload from a given task enables the planning of overload prevention during activities performed by these individuals [20], and can assist with the planning and developing of educational technologies.

The aim of this study was to analyze the mental workload of an educational intervention using the Mobile Virtual Learning Object for the Assessment of Acute Pain (m-OVADor) in adults and newborns, according to the NASA TLX criteria.

Methods

A methodological study [22] approved by the Research Ethics Committee at the Universidade Federal de Santa Catarina (UFSC) in 2012 (certificate 2456), with online data collection from November 1/2013 to February 15/2014.

A total of 170 students in the second to the eighth semesters of the undergraduate nursing course were eligible to participate in this study, of which 120 agreed to do so. The nonprobabilistic and intentional final sample, after applying the exclusion criteria, included 75 students and 5 specialist nurses, who completed all planned steps. All participants were identified by alphanumeric codes, students S1 to S75 and nurse specialists NS1 to NS5.

The inclusion criteria for students were (1) being regularly enrolled in the second to the eighth semester of the undergraduate nursing course at UFSC during the study period and (2) being available for online participation in the study during an extracurricular period. The inclusion criteria for nurse specialists were (1) minimum of a master's degree; (2) a nurse with minimum experience of 2 years in the critical care area, neonatology/pediatrics, and/or medical-surgical clinic; (3) experience with the use or development of ICTs in the teaching-learning process in nursing; (4) having a mobile device with Internet access (cell phone, smartphone, personal digital assistant, or tablet). The exclusion criterion was missing any of the study steps.

All participants received the instructions to participate in the study via email and Facebook. The m-OVADor was accessed from their own mobile devices (see Multimedia Appendix 2).

The technology developed for the study had 3 different simulated clinical scenarios (surgical clinic, adult intensive care, and neonatology; see Multimedia Appendix 3), which enabled the study of different variables involved in the assessment of acute pain (Figure 1).

Identification of the measures required for the analysis of mental workload of students and specialists (rate, weight, magnitude, and mental workload index) was performed by application of the NASA TLX instrument [11], according to the following protocol (Figure 2).

The NASA TLX used in the study is a version that was translated and adapted by the authors, available for free use on the NASA website (see Multimedia Appendix 1). Access to the electronic instrument for data collection was made available to participants through the Google Drive tool.

The application of the NASA TLX provides a subjective assessment of mental workload, namely, an assessment from the perspective of the person performing the task (self-assessment). This tool was chosen because of its ease of application, objectivity, and low cost of implementation [7].

The assessment of the participants' mental workload was performed in 3 stages: assessment of weights for each dimension, assessment of rates for each dimension, and calculation of mental workload index (overload).

Initially, for the assessment of the weights for each dimension, 15 pairs of combinations between 6 assessment dimensions were presented to the participants (effort and physical demand, mental demand and effort, temporal demand and frustration, frustration and effort, performance and frustration, temporal demand and mental demand, temporal demand and effort, physical demand and temporal demand, effort and performance, frustration and mental demand, physical demand and frustration, performance and mental demand, mental demand and physical demand, performance and temporal demand, and performance and physical demand). At this stage, only 1 option should be selected in each pair, which should be the most prominent one during the proposed activity [23].

The frequencies assigned to each dimension were summed up and the results were expressed on a scale of 0-5. Then the rates assigned to each dimension were identified from the participants' indication on a scale of 0-100 with 20 five-point equal intervals [23].

The weight of each dimension was multiplied by its respective rate, and the magnitude of mental workload was obtained. The magnitude values of the 6 dimensions were summed up, their results divided by 15, and the mental workload (overload) index was obtained [23].

The data were exported to electronic spreadsheets using Excel for Mac 2011 for data classification and analysis of the mental workload (overload) index. The dimensions comprising this mental workload were analyzed by descriptive (mean, minimum, maximum, standard deviation, and variance) and inferential (Student t test, analysis of variance [ANOVA] and Bonferroni) statistics. A significance level of P<.05 for a 95% confidence interval was used in this study.

Figure 1. m-OVADor structure for access and assessment of acute pain in clinical scenarios.

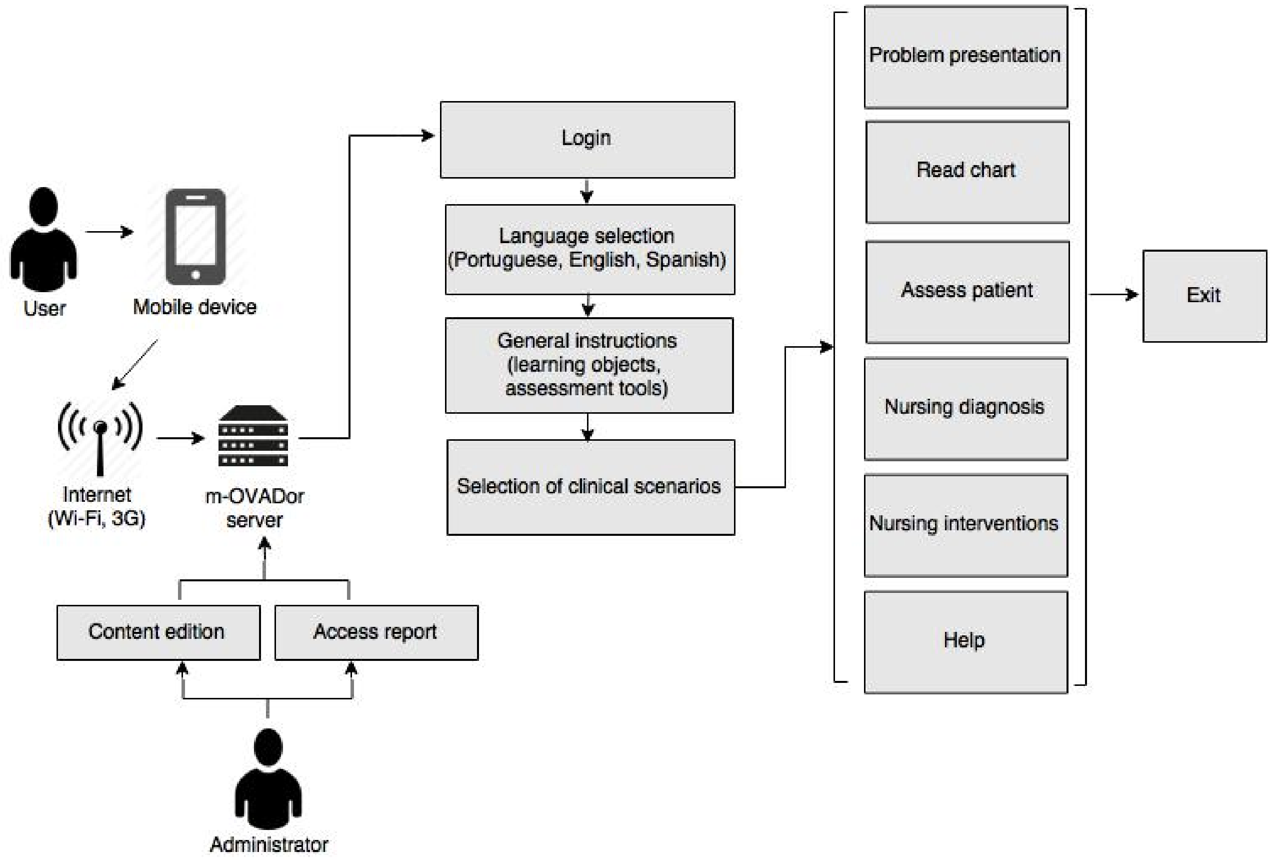
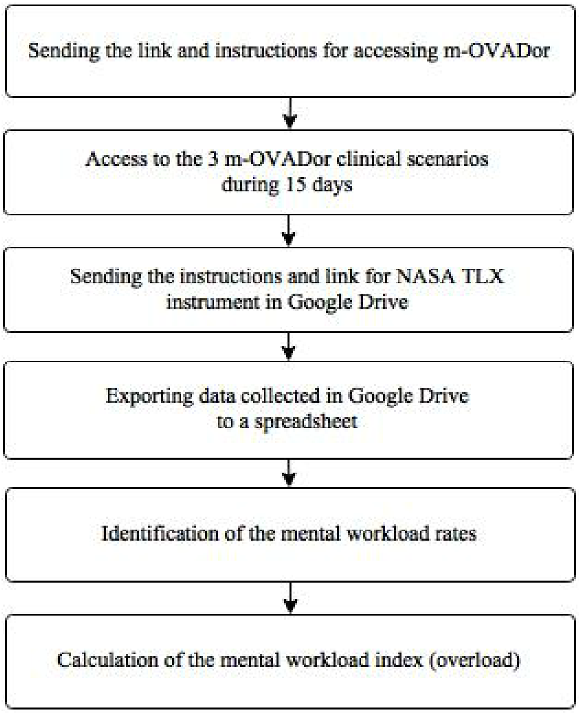


Figure 2. Protocol for the analysis of mental workload from the NASA TLX instrument.



Results

Students' and Specialist Nurses' Characteristics

The sample (n=75) comprised young students between 19 and 32 years of age (22.65 ± 3.12 years). Most were women (92%, 69/75) and exclusively dedicated to studying (79%, 59/75); only 8% (n=6) were working as nursing technicians.

Regarding the semester of the students (n=75) at the time of data collection, the following distribution was observed: 1% (n=1) in the second semester; 27% (n=20) in the third semester; 17% (n=13) in the fourth semester; 9% (n=7) in the fifth semester; 9% (n=7) in the sixth semester; 12% (n=9) in seventh semester, and 24% (n=18) in the eighth semester.

As for the use of the Internet in their personal and academic environments (multiple-choice questions), 131 answers were obtained, distributed as follows: 46% (60/131) accessed the Internet on their laptops; 34% (45/131) on mobile phones; 13% (17/131) on desktops, and 7% (9/131) on tablets.

The results draw attention to the issue of connectivity from small-sized mobile devices, thereby confirming the global trend of popularization of these technologies among young people [24].

Regarding the sociodemographic characteristics of specialist nurses (n=5), 100% (n=5) were female, 80% (n=4) had a master's degree, and 20% (n=1) had a doctorate. As for the area of experience, the participants were distributed in the following areas: education and/or providing care for pain (40%, 2/5), nursing informatics (40%, 2/5), and medical surgical (20%, 1/5). All used mobile technologies and the Internet for personal and academic reasons every day.

Mental Workload Assessment

The application of NASA TLX enabled identification of the rates, weights, and magnitudes assigned to 6 assessment dimensions, which were used to calculate the overload. Tables 1 and 2 show the results obtained from the assessment performed by students and specialists, as well as the mean overload for each group, respectively.

Table 1. Rate, weight, magnitude and mean overload[a] of students (n=75).

Dimensions	Rate		Weight		Magnitude	
	Mean	SD	Mean	SD	Mean	SD
Mental demand	57.20	22.27	3.80	.92	217.27	110.41
Physical demand	29.27	27.91	1.08	.93	30.47	42.83
Temporal demand	37.67	24.14	3.08	1.47	122.27	102.26
Performance	58.47	24.19	3.55	1.21	216.73	121.65
Effort	40.73	23.24	2.69	.84	112.13	72.75
Frustration	30.60	27.80	0.80	1.15	36.93	71.89

[a]Mean overload of the students is 47.87.

Table 2. Rate, weight, magnitude, and mean overload of specialists (n=5).[a]

Dimensions	Rate		Weight		Magnitude	
	Mean	SD	Mean	SD	Mean	SD
Mental demand	51	29.45	3.40	.89	175	110.79
Physical demand	10	8.66	.40	.55	2	2.74
Temporal demand	30	34.10	2.60	1.82	89	112.05
Performance	73	28.85	4	1	294	134.69
Effort	49	34.53	2.20	1.30	121	129.05
Frustration	21	19.49	2.40	1.82	72	80.44

[a]Mean overload of the specialists is 50.20.

Students and specialists obtained the highest means in these respective dimensions: “Performance” (58.47 ± 24.19, 73 ± 28.85) and “Mental Demand” (57.10 ± 22.27, 51 ± 29.45). It should be noted that the dimension “Physical Demand” (29.27 ± 27.91, 10 ± 8.66) was identified as the one that least contributed to mental workload during the educational intervention. In general, the distribution of rates assigned by the participants for each dimension had the same behavior (Figure 3).

The repeated measures one-way ANOVA was used to identify statistically significant differences in the mean values of the 6 dimensions of mental workload for the group of students (Table 3).

Table 3. Analysis of variance between means of assessments of the 6 dimensions of NASA TLX by students.

Assessment sources	Sum of squares	Degrees of freedom	Mean squares	Critical factor	*P* value
Factor 1 (6 dimensions)	61.053	5	13.570	29.45	<.001
Error	153.417	333	461	—	—

To identify the significant variables according to the ANOVA test, the Bonferroni test was applied, with no statistically significant difference in the mean values of the following pairs: “Mental Demand” and “Performance,” “Physical Demand” and “Temporal Demand,” “Physical demand” and “Frustration,” “Temporal Demand” and “Effort,” and also “Temporal Demand” and “Frustration.” For the other possible comparisons, significant differences between means were identified (Table 4).

Table 4. Comparison between the means of mental workload in 6 dimensions analyzed for students (n=75).[a]

Dimensions	Mean	95% Confidence interval
Mental demand	57.20[b]	52.07-62.35
Physical demand	29.27[c]	22.85-35.69
Temporal demand	37.67[cd]	32.11-43.22
Performance	58.47[b]	52.90-64.03
Effort	40.73[d]	35.38-46.09
Frustration	30.60[c]	24.20-37.00

[a]Equal lowercase letters do not statistically differ according to the Bonferroni test.

The ANOVA test could not be performed for comparison of means of assessment of the instrument dimensions due to the small number of specialist nurses. With regard to the mental workload index (overload), the specialists’ mean was higher (50.20 ± 7.28) when compared with the students’ mean (47.87 ± 16.85). Among the students, 2 outliers were identified (S47 and S67), which had high overload means (90.33 and 100), moving away from the means of most students (Figure 4).

Figure 3. Mean rates of students (n=75) and specialists (n=5) for the NASA TLX dimensions.

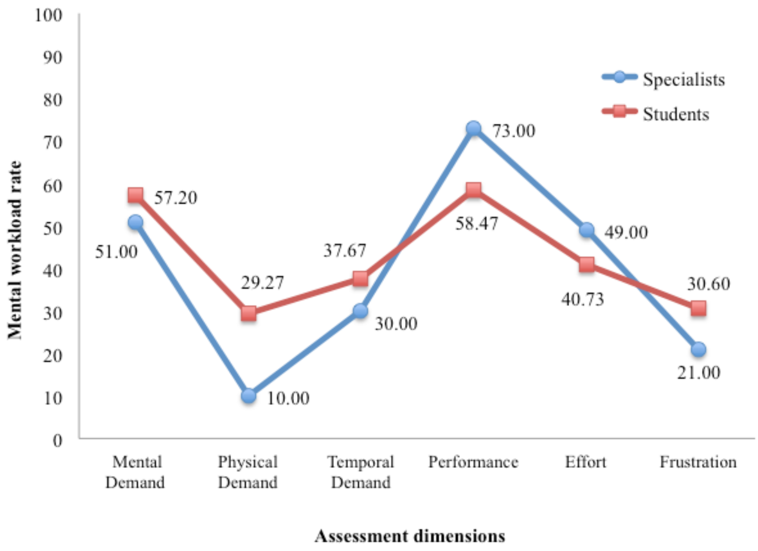
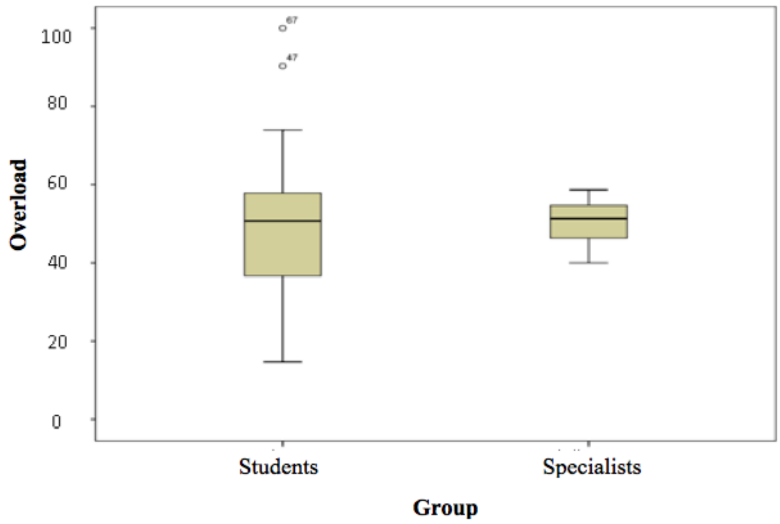


Figure 4. Box plot of the students' (n=75) and specialists' (n=5) overload means.



Discussion

Preliminary Findings

The increasing inclusion of VLOs and mobile devices for teaching and learning in nursing has also been raising concerns about the assessment of mental workload that these resources can cause in their users. The assessment of these factors becomes essential to develop new directions for technological productions using these resources.

The analysis of the perceived mental workload from a given task is complex and personal, because it includes both specific characteristics of the task and the effort required for its development, which also has a direct relationship with the individual's personal factors such as motivation, skills [3].

From the application of the NASA TLX instrument after an educational intervention using a VLO, we present the discussion of our results, starting with the sample characterization, followed by an analysis of individual assessment rates of the 6 dimensions of the instrument and the overload of students and specialists.

During the analysis of the students' sociodemographic characteristics, it was found that although UFSC provides free Wi-Fi networks for students, students report that they most frequently access the Internet at their own homes 63% (70/111). This finding can be explained by the fact that the students are more focused on actual classes at the university, using other spaces to complement their online learning.

The fact that 7% (8/111) of the students access the Internet regularly during commuting also drew attention, confirming the global trend of mobility of individuals made possible by the use of mobile devices. Currently, technologies are very popular, especially for providing easy access to information, regardless of time or space [25].

Regarding rates, the 6 dimensions were similarly assessed by both students and specialists, with the dimensions "Performance" and "Mental Demand" standing out, as these had the highest assessment means.

The dimension “Performance” aimed at measuring how satisfied participants felt with their own level of performance for the assessment of pain using the m-OVADor. It had the highest rate of assessment, both among students (58.47 ± 24.19) and specialists (73 ± 28.85).

The assessment indicates a positive contribution of technology to learning acute pain assessment using mobile devices, suggesting it as a viable process to be used in the teaching-learning process in nursing, comparable to results of previous studies [7-9].

By contrast, “Mental Demand” had the second highest rate, both among students (57.20 ± 22.27) and specialists (51 ± 29.45), indicating that the educational intervention through m-OVADor demanded a greater mental workload, especially regarding the amount of mental activity for execution (think, decide, remember, look, and search).

This may be associated with the fact that the simulation of pain assessment in clinical scenarios requires constant involvement and judgment by the individuals, and may also be due to accessing content from mobile devices.

By contrast, “Physical Demand,” defined as the amount of physical activity that the online educational intervention demands from the individual, was indicated by students (29.27 ± 27.91) and specialists (10 ± 8.66) as the dimension that contributed least to the mental workload, just as reported in a previous nursing study [18].

For some authors [26], this result is justified by the low physical demand required for the handling of small mobile devices, which are very popular nowadays. The result is justified by both the familiarity of these individuals with access to the Internet, and the use of their own mobile devices in their academic and personal daily life, which would facilitate interaction with them. In addition, there is the project presentation, which sought to simplify the presentation layout of m-OVADor, thereby facilitating navigation through clinical scenarios.

The presence of 2 outliers (S47 and S67), which were distanced from the mean of most participants, with high levels of overload from the online educational intervention, can be explained by the individual perception of these individuals at the time of data collection, occurring at the end of the school year, when all students had examinations and term papers.

It must be considered that the assessment of mental workload is considered a complex and personal function, which also involves the specific characteristics of the task, the effort for its performance, and the direct relationship between motivation, emotional state, skills, among others [7].

Still, workload can be influenced by the nature of the task, especially when considering that the educational intervention with m-OVADor included access to 3 different clinical scenarios, in which there were a diversity of resources (animation, short texts with definitions and/or descriptions, assessment exercises, and also the clinical judgment to determine nursing diagnoses and interventions), required for the assessment of each presented context.

One should also consider that mental workload generated from VLOs can relate to factors such as the complexity of the individual, resources used for the development of the activity, and factors unrelated to content, such as the multimedia resources used [27-29].

In this sense, one should also reflect on increasing access to mobile devices with Internet access, and the potential of these technologies when applied in the teaching-learning process in nursing.

Arguably these technologies have become popular, especially for the flexibility that allows users to quickly access information at any place or time, to expand their potential to transform individuals’ attitudes and behaviors [30,31].

Specifically in the context of this study, an assessment of mental workload has indicated that the use of these technologies is feasible in higher education in nursing, and can influence the way students build their knowledge, establishing an innovative process for teaching/learning.

Conclusions

The NASA TLX instrument demonstrated applicability for the assessment of mental workload from the use of m-OVADor. The results enabled analysis of the sources related to students’ and specialists’ mental workload from the use of a VLO accessed from small mobile devices. The analysis revealed that the dimension “Mental demand” obtained a greater weight both from the students’ and specialists’ perceptions, which is expected from technologies for online learning, due to the level of attention that they require. Although the study achieved the proposed aim, in no way did it intend to exhaust the possible approaches to the theme. The development of other studies to explore the theme from other perspectives is recommended, to deepen our understanding of the effects of mental workload on learning outcomes and even when planning new strategies for mobile learning in nursing education as well as for validation of the instrument in Brazil.

Acknowledgments

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Nasa Task Load Index Form.

[PNG File, 70KB - mededu_v1i2e15_app1.png]

Multimedia Appendix 2

m-OVADor cover page.

[PNG File, 279KB - mededu_v1i2e15_app2.png]

Multimedia Appendix 3

Clinical scenarios selection by m-OVADor.

[PNG File, 285KB - mededu_v1i2e15_app3.png]

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Abbreviations

ANOVA: analysis of variance
ICTs: information and communications technologies
m-OVADor: Mobile Virtual Learning Object for the Assessment of Acute Pain
NASA TLX: NASA Task Load Index
VLO: virtual learning object
UFSC: Universidade Federal de Santa Catarina

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Original Paper

Semantic Indexing of Medical Learning Objects: Medical Students' Usage of a Semantic Network

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Abstract

Background: The Semantically Annotated Media (SAM) project aims to provide a flexible platform for searching, browsing, and indexing medical learning objects (MLOs) based on a semantic network derived from established classification systems. Primarily, SAM supports the Aachen emedia skills lab, but SAM is ready for indexing distributed content and the Simple Knowledge Organizing System standard provides a means for easily upgrading or even exchanging SAM's semantic network. There is a lack of research addressing the usability of MLO indexes or search portals like SAM and the user behavior with such platforms.

Objective: The purpose of this study was to assess the usability of SAM by investigating characteristic user behavior of medical students accessing MLOs via SAM.

Methods: In this study, we chose a mixed-methods approach. Lean usability testing was combined with usability inspection by having the participants complete four typical usage scenarios before filling out a questionnaire. The questionnaire was based on the IsoMetrics usability inventory. Direct user interaction with SAM (mouse clicks and pages accessed) was logged.

Results: The study analyzed the typical usage patterns and habits of students using a semantic network for accessing MLOs. Four scenarios capturing characteristics of typical tasks to be solved by using SAM yielded high ratings of usability items and showed good results concerning the consistency of indexing by different users. Long-tail phenomena emerge as they are typical for a collaborative Web 2.0 platform. Suitable but nonetheless rarely used keywords were assigned to MLOs by some users.

Conclusions: It is possible to develop a Web-based tool with high usability and acceptance for indexing and retrieval of MLOs. SAM can be applied to indexing multicentered repositories of MLOs collaboratively.

(JMIR Medical Education 2015;1(2):e16) doi:10.2196/mededu.4479

KEYWORDS

semantic net; usability evaluation; semantic indexing; learning objects; medical education

Introduction

Medical learning objects (MLOs), classical sources (eg, textbooks), and digital media support medical teaching and learning [1]. Maloney et al [2] showed that health professional learners regard Web-based repositories as the preferred learning source. To improve the integration and reuse of existing MLOs in the course of medical education, they need to be systematically collected and organized [1,3]. Semantic indexing of MLOs is a prerequisite of useful repositories of MLOs, and semantic networks (SNs) provide a sound basis for consistent semantic indexing [4]. While SNs have worked their way into medical classification systems and e-learning, the usability of those networks has been sparsely investigated [5,6].

Project Context

Multimedia Learning Objects of the Aachen Emedia Skills Lab

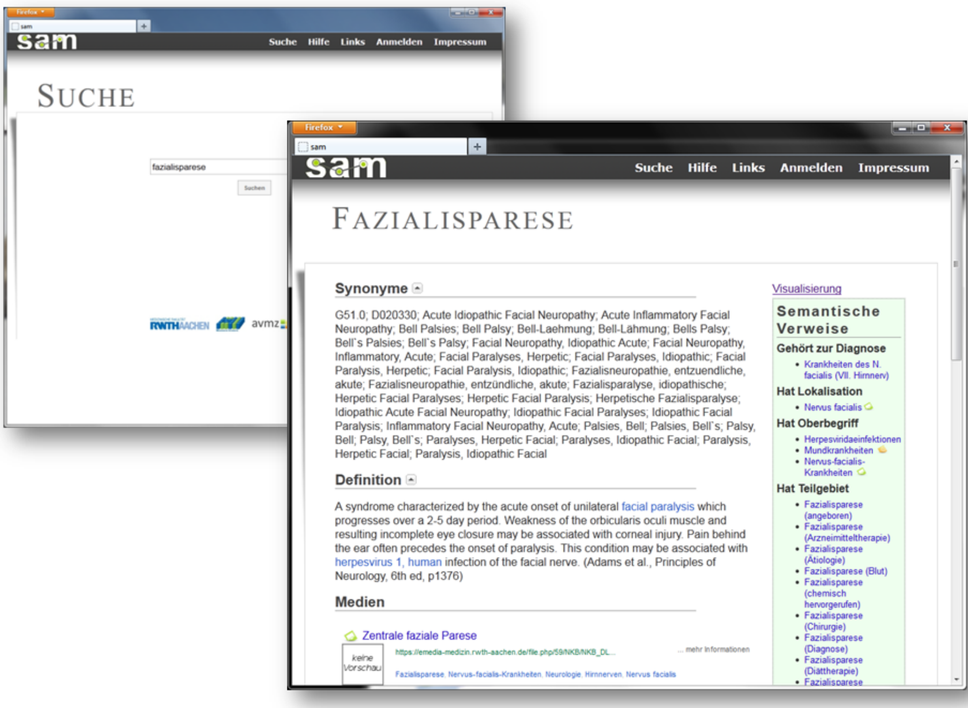
Over the last few years, the Center of Audiovisual Media of the Aachen Medical School has implemented and maintained the emedia skills lab as an interdisciplinary repository of MLOs. The MLOs of the emedia skills lab spread from traditional media (text files, pictures, etc) to modern digital media (videos, podcasts, complete online classes, etc). The MLOs support blended learning and self-studies in addition to the regular classes and thus increase learning flexibility [3]. Additionally, some of the MLOs are integrated in compulsory modules of the local curriculum and are therefore used regularly by learners and medical teachers.

Semantically Annotated Media Project

SAM is a Web app based on an SN (see section on Semantic Indexing), which supports MLO retrieval, connects learning resources of similar content, and presents them together [7]. At present, SAM is used for indexing the MLOs of the emedia skills lab. Nonetheless, SAM provides Web services, which enable linking of MLOs organized in different repositories. SAM implements the structure of a Simple Knowledge Organization System (SKOS) [8]. The system was designed as platform that is "opportunistic" towards the terminological knowledge base (the SN used by the system); that is, SAM's SN can be further developed or completely exchanged. SAM is currently under consideration by other German medical schools.

As an entry point, SAM provides a simple search form equipped with autocomplete functionality. Additionally, an extended search interface allows an easy use of Boolean combinations of search terms and the definition of simple filters. Based on an initial request by the user, SAM generates result pages that show MLOs fitting the query, but more importantly present a part of the SN relevant to the query. Thus, users may explore MLOs directly or switch to the network and explore the space of related concepts, the (synonym) terms associated with a given concept, the semantic links between the concepts, and different MLOs indexed by the SAM concepts, respectively. If the user selects an MLO, SAM presents the link to the MLO in the repository (emedia skills lab) but also gives a short description of the MLO, the set of keywords indexing it, and a list of media with a similar keyword profile. Users may collect the MLOs of their interest following a "cart" metaphor known from online shops. The user's set of selected MLO items can then be used for retrieving similar MLOs, where the similarity is dynamically calculated from the combination of selected items. Due to the app context, the main language of SAM is German, but SAM also includes English definitions for the MeSH concepts included. See Figure 1 for screenshots of SAM.

Figure 1. Screenshots of SAM: Search interface and result page contain the SN links (green box).



SAM Semantic Network

SAM is based on existing and established classifications, namely the Medical Subject Headings (MeSH) and the International Classification of Diseases (ICD). The concepts of both classification systems were merged while preserving the taxonomic structure. In addition to generic associations, cross references between the concepts were established based on semantic relations of the Unified Medical Language System (UMLS). At present, SAM covers more than 2,810,000 links between more than 180,000 main concepts. The concepts include subconcepts derived from MeSH terms combined with MeSH qualifiers (eg, “Heart – abnormalities” as a subconcept of “Heart”).

Background

Semantic Indexing of Medical Learning Objects

Assigning textual descriptors to MLOs characterizing their content is challenging with respect to using characteristic descriptors uniformly and consistently. Using a controlled vocabulary (ie, a standardized collection of keywords) supports consistent indexing. Tools like MetaMap [9] or the Medical Text Indexer [10] were implemented to identify suitable keywords to content starting from a given text by adopting language processing and terminological knowledge. Pure keyword indexing lacks associations between objects assigned to different but semantically related keywords (a learner searching media assigned to “appendicitis” clearly may be interested in a video linked to “appendectomy”). As a step forward, SNs (ie, collections of concepts interlinked by meaningful relations) are means for indexing and linking information objects and can support orientation in large information spaces. Cimino et al already saw the potential of SN for reducing cognitive overload of medical hypertexts as early as 1992 [11]. Semantic indexing of medical content is used in different fields of application, for example, in health-related Web resources [12,13]. SNs in e-learning enable a fast and precise search of MLOs as well as organizing and personalizing an e-learning environment [5].

Usability

The International Organization for Standardization (ISO) standard ISO 9241-11 defines usability as “The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” [14]. The IsoMetrics usability inventory, a usability inspection method, is a questionnaire based on ISO 9241-10, Part 10 [15]. IsoMetrics was designed according to seven dialogue principles [16]: (1) suitability for the task, (2) self-descriptiveness, (3) controllability, (4) conformity with user expectations, (5) error tolerance, (6) suitability for individualization, and (7) suitability for learning. There is a set of questions for each of those principles with five answers for each question and an option for “no answer”.

Another method to evaluate usability is usability testing. The main aspect of usability testing is the involvement of the target users and the observation of their interactions [17,18]. The users walk through a typical usage scenario of the software, and they are observed by experts on different aspects such as the time they take to complete the task and the number and types of errors they make [19]. Also the users can be monitored, for example by thinking aloud combined with video observance [20]. Usability testing is more costly and time-consuming than usability inspection methods.

Nielsen considered both methods, usability inspection methods and usability testing, as highly appropriate for software usability evaluation [21]. They are the most frequently used procedures according to Hollingsed and Novik [22].

Sandars showed that while usability testing is well established in other disciplines, it has not found its way into medical e-learning [23]. Sandars and Lafferty also pointed out that the usability testing of an e-learning tool should be carried out under the conditions that it is typically used in [24].

Long Tail

Long tail is a phenomenon that appeared through Web techniques. Anderson coined the term “long tail” in economics [25], where selling large numbers of very specific products—each in relatively small quantities—could lead to significant profit. O’Reilly stated that a long-tail effect is typical for collaborative Web apps (Web 2.0) [26], which support both the few commonly shared interests (blockbusters) and additionally the huge amount of very specific ones (the long tail). The effect is illustrated, for example, by the power-law shaped popularity rates in social networks [27]. Being a genuine Web-based approach, crowd-based semantic indexing of digital content illustrates characteristics of a long-tail phenomenon. When many users propose index terms for given content, a long tail of keywords used by only a few persons may arise by erroneous choice, but could also be due to aspects relevant for comprehensive indexing, but noticed by only a few users. As a characteristic aspect of user behavior, we explored this issue for the SAM app.

Statement of Purpose

This study aimed at assessing the usability of SAM when used as a tool for accessing and indexing MLOs. Clearly, the usability of SAM has two aspects: (1) The usability of SAM’s user interface (which can be adopted by any MLO repository providing deep HTML-links, and which can operate on any SKOS-conform SN), and (2) the suitability of the currently used SN for accessing and indexing MLOs.

Based on typical tasks (scenarios), the study should uncover typical usage patterns of students using SAM for browsing, searching, and indexing MLOs. From those results, we intend to derive recommendations for apps improving access to MLOs by semantic indices.

Rationale for the Approach to the Problem

We decided to use a scenario-based approach in order to evaluate SAM. The participants were students of the Evidence-Based Medicine (EBM) class in their second year of medical school-target users for SAM.

Methods

Study Design

For this study, we chose a mixed-methods approach. Lean usability testing was combined with usability inspection by having the participants complete four typical usage scenarios before filling out a questionnaire. The questionnaire was based on the IsoMetrics usability inventory because of its widespread use and also because it is advised for a large group of participants to ensure accurate analysis [15]. Here, only the questions from the areas of “suitability for the task” and “suitability for learning” were used. Some extra questions regarding the use of SAM were added, which yielded a total of

19 usability questions. At the end of the survey, there were three open questions for positive and negative feedback as well as improvement suggestions for SAM as a basis for qualitative analysis.

The EBM course is a mandatory module of the curriculum (attended by the first and the second half of each student cohort in the 4th and 5th semester, respectively). Information retrieval including a scenario-based introduction to SAM is a permanent part of the EBM course introduced 2 years before this study was conducted and has continued ever since. Participation in the study was voluntary (see section on Ethical Issues).

Figure 2 shows the course of the study. A pilot study (n=24) took place in October 2012. As a consequence of the pilot study, one more usability question regarding SAM was added and the four scenarios were established. The medical students assigned to take the EBM class in their 4th semester in May 2013 (N=101) were informed about the study and asked to participate. Of these, 95 participants consented and completed the questionnaires. According to the log files, only 90 students accomplished all four search queries given by the scenarios. All participants used computers provided by the university, and logging was based on the computer's IP addresses.

First, participants were asked to give a short self-profile including their gender, semester, and previous knowledge of SAM and semantic tagging in general. Additionally, the participants were asked about their Internet usage habits for studying and private use.

The study comprised two parts. After a short introduction to SAM, the students were given four scenarios to explore their handling of SAM. Table 1 gives an overview on the scenarios covering the typical areas of application. The first two scenarios were given by two pictures to which the participants had to find keywords. This is a typical usage scenario for emedia skills lab staff when uploading new MLOs. The first scenario derived from the Nervous System Class, which is in the 4th semester curriculum, and therefore the topic was known to the participants at the time of study. In contrast, the second scenario derived from the Skin Class, which belongs to the 6th semester curriculum, and therefore the students were not familiar with the topic. In the third and fourth scenarios, there was a change of perspective. The students were supposed to search for available MLOs associated with a given lecture topic via SAM.

Table 1. Structure of the four scenarios.

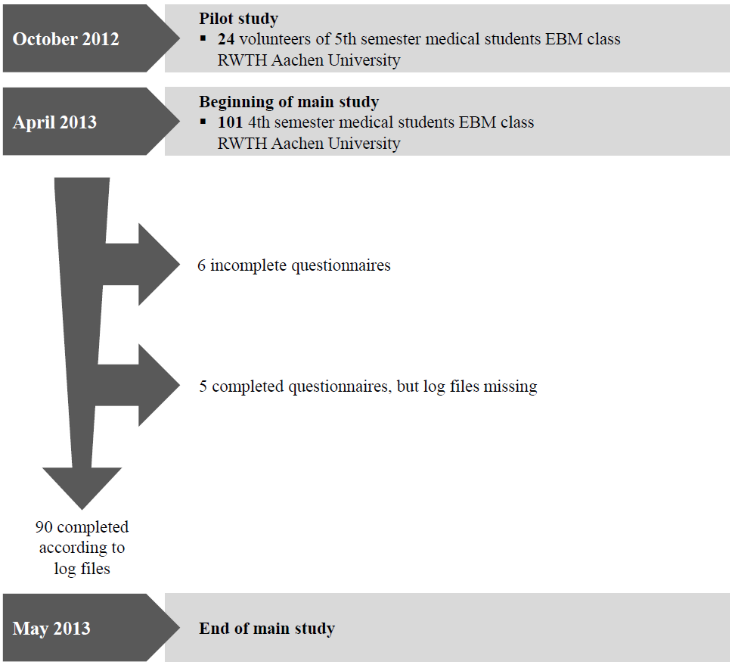
Scenario	Content	User role	Text size
1	MRI image of a glioblastoma	Staff	81
2	Picture of an erythema chronicum migrans	Staff	124
3	Lecture topic “polyneuropathies”	Student	73
4	Lecture topic “patient with cough”	Student	79

The participants had to name keywords they would have used to describe the pictures for Scenarios 1 and 2 or keywords they would have clicked on in order to find linked media for Scenarios 3 and 4. Afterwards, 19 usability questions regarding the use of SAM and three free-text items for suggestions concerning the future improvement of SAM could be answered. The usability questions were Likert-scaled items with an option for “no answer” as well.

Data Elicitation

SAM generated log files based on the static Internet protocol (IP) addresses used in the computer lab adopted for the study. Anonymity was ensured as it was not possible to infer the individual participant from the IP addresses of the semi-public computer lab. The completeness of a survey result was defined by a minimum of four search queries including all four given keywords of the scenarios. All clicks and search queries performed during the introduction of SAM, before the starting keyword (“glioblastoma”) for Scenario 1 was entered, counted as not assigned to a scenario. This analysis focused on the main interest: the top 10 keywords mentioned by the participants. But there is also a long-tail interest, which we covered in our analysis by showing random keyword examples occurring only once.

Figure 2. Course of study.



Data Analysis

Data analysis by descriptive statistics relied on summary statistics and data visualization (scatter plots, bar charts, box plots). Due to the exploratory character of the study, visual inspection of data plots had to play an important part, while these plots provide more information regarding the nature of the relationship compared to the investigation of summary statistics only (eg, correlation coefficients). A scatter plot was used to investigate the relationship between the mean number of clicks per query and the number of queries submitted. A tag cloud was adopted as a means for assessing the occurrence of the top 10 keywords in a semi-quantitative way.

Qualitative analysis was carried out as follows. The open-questions feedback was analyzed by bottom-up qualitative text coding [28]. Two people read the users' statements separately and assigned individual codes to the statements while reading the text for the first time. Afterwards, they ordered the codes and indexed the statements for a second time using the complete code set now. Afterwards, the two persons compared their code sets and agreed on a common set sometimes unifying synonymous terms then used to produce a consensus assignment of codes to statements. This step produced a semantically adjusted rate of conformance between the raters (semantically equivalent codes assigned vs not assigned to the same statements). Interrater reliability was measured by Cohen's kappa. A synoptic rearrangement of statements assigned to the same (previously consented) code then provided the basis of a qualitative interpretation and summary of the feedback.

Ethical Issues

There were no medical data collected nor any risk or disadvantage implied. All data were acquired anonymously at any time of the study. The participation in the study was strictly voluntary. The course participants were informed they could simply skip the study-related parts of the e-learning module of the EBM course with no effect on their learning achievement or course marks. Study participants received comprehensive information on the objectives and methodology of the study. The consent of the RWTH Aachen Faculty of Medicine system block coordinators was obtained in advance of the study.

Software Tools

The study was executed through LimeSurvey 1.85+ [29], an online survey app that contained the scenario descriptions and the instructions on the tasks as well as the usability questions at the end. The data were entered via the Web interface of LimeSurvey and later exported for analysis. Descriptive statistics and box plots were produced by the program R 3.1.0 [30]. Bar charts and the randomization of the bottom 10 keywords were produced by Microsoft Excel 2010. For flowcharts, we used Microsoft PowerPoint 2010. The tag cloud was produced with the worditout website [31].

Results

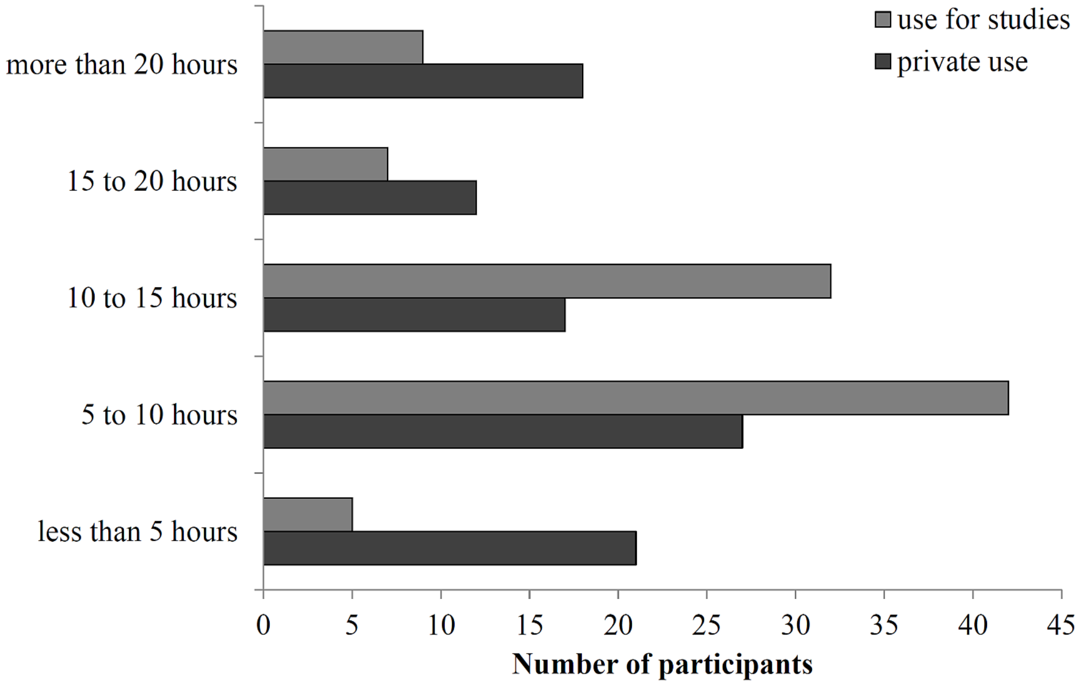
Profile of Participants

To investigate the semantic indexing of MLOs, we first analyzed the profile of participants and their Internet behavior. Table 2 and Figure 3 present the characteristics. We found a noticeable difference between Internet use for studies and private Internet use. The majority of the participants use the Internet 5-15 hours weekly for studying whereas for private use the hours vary between less than 5 hours and more than 20 hours weekly.

Table 2. Profile of all participants.

Characteristics	n
Gender (N=95)	
Male	31
Female	64
Survey questions (N=95)	
I know about the emedia skills lab (yes)	87
I have used the emedia skills lab before (yes)	75
I know about tagging (yes)	17
I have used tagging myself (yes)	8
Completeness of the survey as given by LimeSurvey (N=101)	
Complete	95
Incomplete	6
Completeness of survey after analyzing the log files (N=101)	
Complete	90
Incomplete	11

Figure 3. Internet usage habits of the participants (hours per week).



Main Results

After the short self-profiling, the students were given four typical scenarios to explore their usage of SAM. We also monitored the time the students needed to complete all four scenarios in order to see whether or not they had enough patience to engage in the study and if they showed interest in SAM or not. The participants needed a total of 10.55 minutes on average (Figure 4). We analyzed the number of the students' mouse clicks during the introduction and per scenario (Figure 5). Many students skipped the introduction (median 0) and started directly with the scenario, whereas few intensively familiarized themselves with SAM by using the introduction. For all four scenarios, the median number of clicks per scenario was two. Thus, there were no marked differences between the scenarios with respect to the total number of clicks, while for each scenario there was a wide spread in the number of clicks.

In addition to the total number of clicks per scenario, we investigated the relationship between the numbers of clicks per query and the number of queries. There could have been a linear or non-linear relationship (eg, well-oriented users could have used few queries, each accomplished by a few clicks, whereas disoriented users could have asked many unfocused queries, each accomplished by many exploratory clicks). Inspection of the scatter plot (Figure 6) of the mean number of clicks per query versus the number of queries yielded no marked relationship. The Pearson correlation coefficient was 0.06 indicating a lack of linear correlation. The empty circles represent the participants who did not complete all four scenarios, whereas the filled circles represent the participants that completed all of them.

Figure 4. Observed frequency of duration to complete all four scenarios.

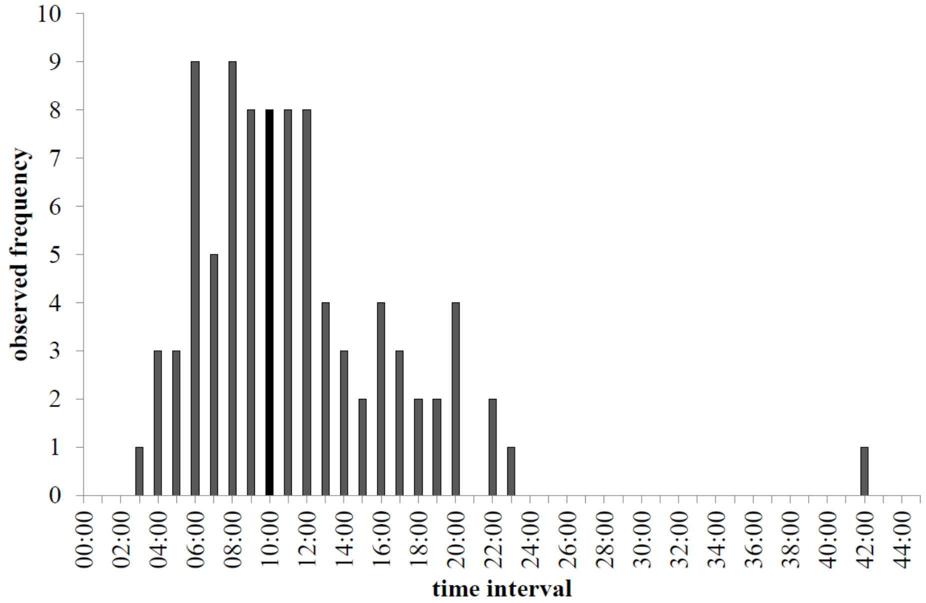


Figure 5. Number of clicks per scenario (x-axis: scenario; y-axis: number of clicks).

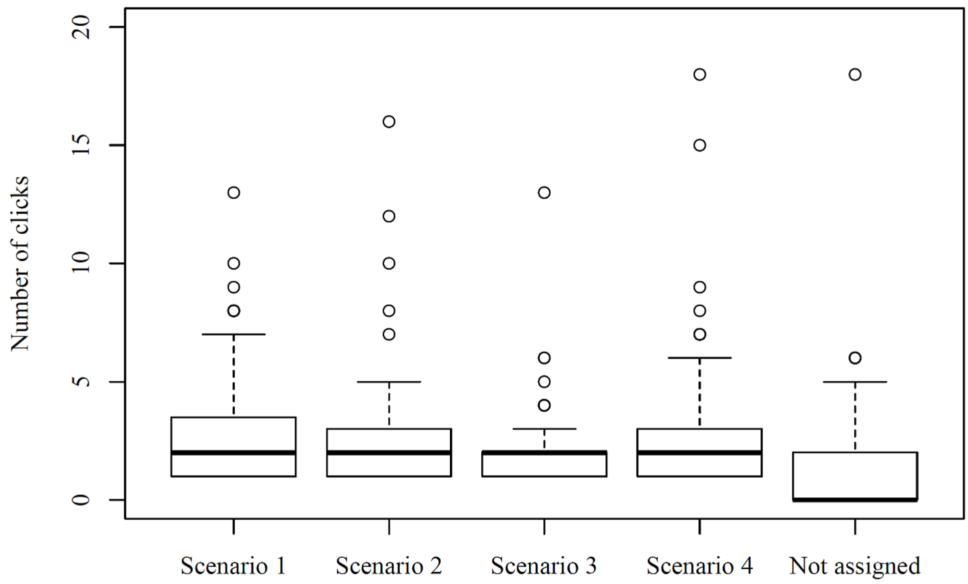
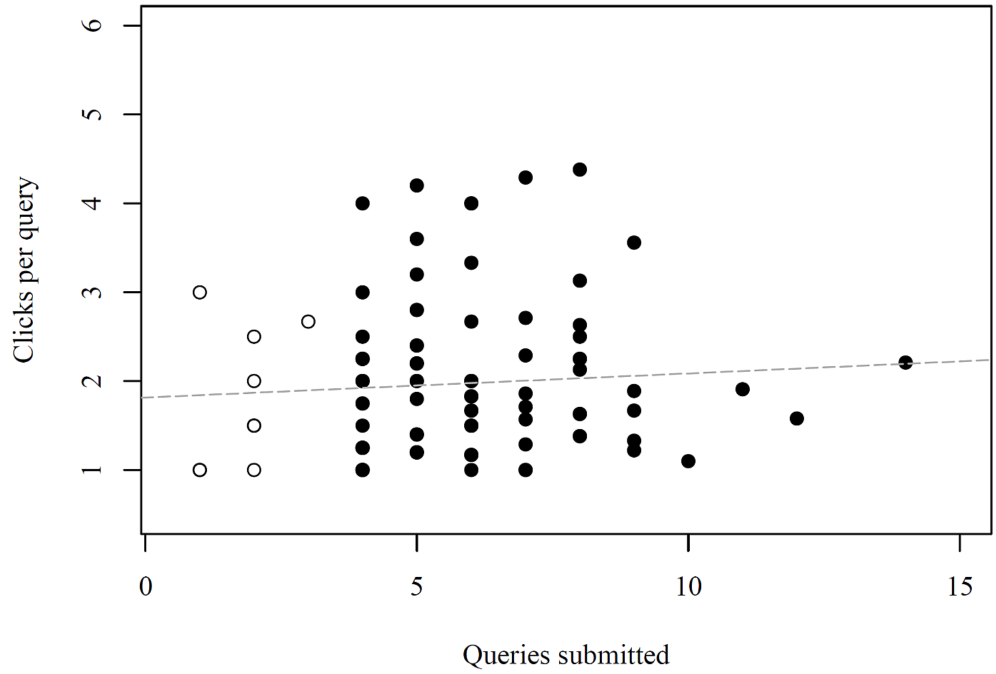


Figure 6. Correlation of clicks per query to queries submitted (empty circles: incomplete, filled circles: complete).



Keywords Given

Table 3 shows the total number of keywords entered for each scenario as well as the number of different keywords entered. For this report, we had to translate some of the German keywords into English. Since some participants entered the English synonym of the keywords up front, there is no distinction left between English and German keywords. Thus, we combined them in Table 3.

Figure 7 shows an exemplary tag cloud visualizing the top 10 answers for Scenario 1. The larger the keyword is written, the more often it was mentioned by the participants for each scenario.

For Scenarios 1 and 2, 2 individual raters went through all keywords and rated them as either correct or incorrect according to the pictures given (Table 4). The data show a very high interrater reliability (Cohen's kappa was .907 and 1 for Scenarios 1 and 2 respectively). Among the top 11 keywords mentioned for Scenario 1, there were 10 correct keywords and one incorrect. Among the top 11 keywords mentioned for Scenario 2, there were three correct and eight incorrect keywords.

Tables 5 and 6 give the 10 and 11 most frequently selected keywords, respectively, for the four scenarios. If two keywords occurred equally often, they share a rank. If the tenth place was tied, 11 keywords were listed. Also, 10 random examples of the long-tail keywords with only one nomination were listed.

Table 3. Keywords entered in each scenario.

	Total number of keywords entered	Number of different keywords entered
Scenario 1	346	74
Scenario 2	427	76
Scenario 3	394	102
Scenario 4	372	61

Table 4. Rating of Scenarios 1 and 2.

	Total	Correct	Incorrect	Inconsistent	Cohen's kappa	*P* value
Scenario 1	74	49 (66.2%)	22 (29.7%)	3 (4.1%)	.907	5×10^{-15}
Scenario 2	76	31 (40.8%)	45 (59.2%)	0 (0%)	1	0

Table 5. Top keywords used per scenario (Scenarios 1 and 2) and correctness of the keywords as assessed by 2 independent raters.

Rank	Keywords	Correctness	Occurrence
Scenario 1			
1.	Glioblastoma	Correct	63
2.	Astrocytoma	Correct	52
3.	Gliosarkoma	Correct	28
4.	Retinoblastoma	Incorrect	26
5.	Giant cell glioblastomas	Correct	15
6.	Glioblastoma (diagnosis)	Correct	12
7.	Glioblastoma multiforme	Correct	11
8.	Glioblastoma (classification)	Correct	9
9.	Glioblastom (radiotherapy)	Correct	8
10.	Glioblastoma (pathology)	Correct	6
	Contrast medium	Correct	6
Bottom ten (random examples)			
	Magnetic resonance imaging	Correct	1
	Benign and malignant central nervous system neoplasms derived from glial cells	Incorrect	1
	Glioblastoma with sarcomatous component	Correct	1
	Glioblastoma (ethnology)	Incorrect	1
	Complications	Incorrect	1
	Glioblastoma (metabolism)	Incorrect	1
	Malignant form of astrocytoma	Correct	1
	Diagnosis	Incorrect	1
	Glioblastoma (ultrastructure)	Correct	1
	Grade IV astrocytomas	Correct	1
Scenario 2			
1.	Erythema chronicum migrans	Correct	55
2.	Larva migrans visceralis	Incorrect	33
3.	Erythema infectiosum	Incorrect	25
4.	Erythema	Correct	23
5.	Larva migrans	Incorrect	22
6.	Thrombophlebitis migrans	Incorrect	22
7.	Lyme disease	Correct	22
8.	Erythema induratum	Incorrect	19
9.	Erythema nodosum	Incorrect	19
10.	Erythema ab igne	Incorrect	17
	Benign migratory glossitis	Incorrect	17
Bottom ten (random examples)			
	Skin disease, eczematous	Incorrect	1
	Erythema with elsewhere classified diseases	Incorrect	1
	Gyrate erythema	Incorrect	1
	Diagnosis	Incorrect	1
	Bullseye	Correct	1

Rank	Keywords	Correctness	Occurrence
	Erythema chronicum migrans (epidemiology)	Correct	1
	Bacterial lyme disease	Correct	1
	Chemically evoked	Incorrect	1
	Genetics	Incorrect	1
	Skin	Incorrect	1

Figure 7. Tag cloud visualizing the top answers for Scenario 1.

Scenarios 1 and 4 show a power curve as expected in a long-tail figure, whereas Scenarios 2 and 3 still show a long tail at the end but a more bulky shape at the beginning (Figure 8).

Figure 8. Distribution of keyword occurrence for the scenarios (x-axis: number of keywords given by students, y-axis: occurrence of one keyword).

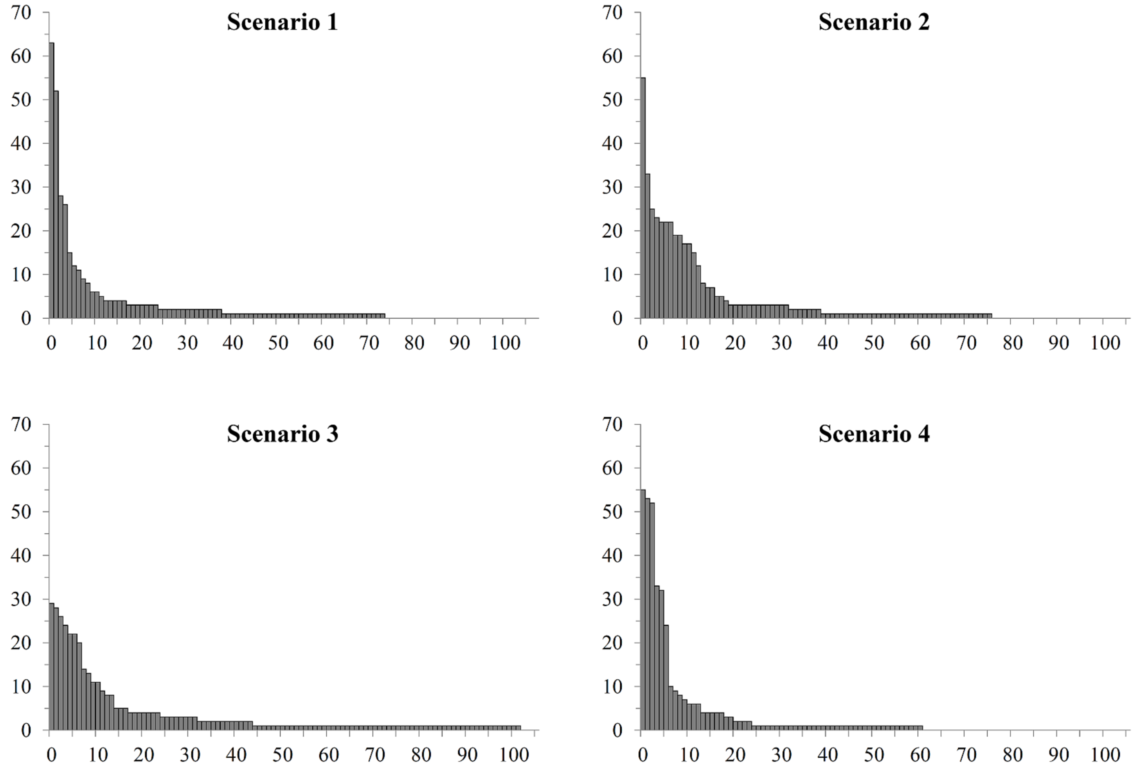


Table 6. Top keywords used per scenario (Scenarios 3 and 4).

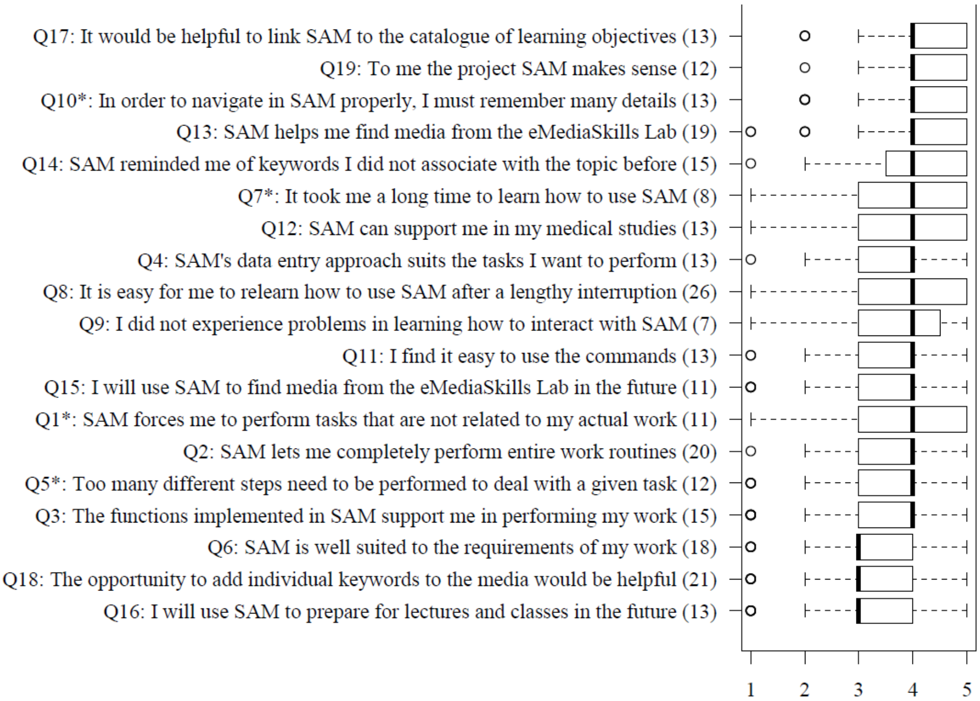
Rank	Keywords	Occurrence
Scenario 3		
1.	polyneuropathies (PNP)	29
2.	polyneuropathies (PNP), cause	28
3.	polyneuropathies (PNP), diagnostics	26
4.	subtypes of polyneuropathies (PNP)	24
5.	other polyneuropathies	23
6.	other specified polyneuropathies	22
7.	polyneuropathies	20
8.	peripheral nervous system, diseases	14
9.	polyneuropathies (etiology)	13
10.	peripheral nervous system	11
	polyneuropathies, (diagnosis)	11
Bottom ten (random examples)		
	polyneuropathies critical illness	1
	peripheral nervous system, diseases, hereditary	1
	degeneration of the axon, myelin or both	1
	polyneuropathies (rehabilitation)	1
	diagnosis	1
	inherited polyneuropathy	1
	immunology	1
	symmetrical, bilateral distal motor and sensory impairment	1
	distribution of nerve injury	1
	disease of mulitneuronal nervs	1
Scenario 4		
1.	symptoms, respiratory	55
2.	breathing deficiency	53
3.	cough	52
4.	symptoms, that affect the circulatory and respiratory system	33
5.	ambroxol	32
6.	cardiac syncope	24
7.	cough (etiology)	10
8.	cough (therapy)	9
9.	cough (diagnoses)	8
10.	respiratory system	7
Bottom ten (random examples)		
	hemoptysis	1
	other polyneuropathies	1
	influenza	1
	dyspnea	1
	mortality	1
	diseases of the respiratory system	1

Rank	Keywords	Occurrence
	parasitology	1
	polyneuropathies (PNP), causes	1
	cough (mikrobiology)	1
	glottis	1

Results of Usability Questions

Figure 9 shows the results of the usability questionnaire. Overall, the participants rated the usability of SAM positively (median 4 for nearly all questions). They clearly marked the advantages of finding new keywords and the search feature for the emedia skills lab. The students stated that the easy handling and fast learnability of SAM were positive features. However, at this stage of SAM, with only a few media linked to it, most participants were indifferent about their future use of SAM for preparing for lectures and classes. They were also indifferent about the possibility of adding individual keywords to SAM (median 3). A few questions seemed to be hard to answer for the students as more than 20% of the participants chose “no answer” as an option. These questions dealt with repeated uses of SAM and the possibility of adding individual keywords to the media. At the time of the study, the students did not have any routine for using SAM.

Figure 9. Usability questions in order of approval on a Likert Scale of 1-5 (5 best, 1 worst). The number of “no answers” is denoted in parentheses. Items yielding negative implications for the rating of the systems (marked by *) are given in the original wording, while the scale was inverted in the figure (thus, a high rating represents a positive appraisal).



Free-Text Items

Two raters who evaluated the free-text items assigned 81 codes to the statements given. The sets of the 2 raters conformed on a large scale: Cohen’s kappa was .857 (z=34, *P*=0) for their independent rating. For the variations, they found a consent code together (eg, “user-friendliness” vs “usability” consented as “usability”).

Most positive feedback was given about the clarity of SAM (Table 7). Usability and simplicity also had strong support. These keywords refer to the general user interface of SAM. Other frequently addressed attributes are synonyms and new associations, which refer more to the semantic content of SAM.

Table 7. “What did you like best?” positive feedback free-text items (codes: given by raters, frequency: of appearance, representative statement: selected typical statement).

Codes	Support	Representative statement
Clarity	9	The clarity
Usability	7	User-friendly interface
Simplicity	7	Easy principle, self-explanatory
Synonyms	6	The big group of linked keywords
Associations, new	5	Keywords come up that I have not associated with the search term before
Search feature	3	Fast search for distributed media
Media	2	The pictures
Knowledge structure	1	Organization and structure of knowledge
Information access, easy	1	Good idea to link information to have an easier access. Thanks

Negative feedback was given about unclear associations where participants were not able to understand associations given by SAM (Table 8). This might also be related to the complaints about missing definitions of keywords and complicated navigation. Another negative aspect mentioned often was the missing media in many categories. Two participants pointed out that the search feature is not very advanced since one can search only for keywords included in SAM. SAM is mainly in German, especially the MeSH keywords. Only the definitions and synonyms are in English. However, 2 participants were irritated by the English language.

Table 8. “What did you disapprove of?” negative feedback free-text item (codes: given by raters, frequency: of appearance, representative statement: selected typical statement).

Codes	Support	Representative statement
Associations, unclear	5	In some keywords I did not see the association with the search term
Media, missing	5	Nonexistent media so many categories were useless
Previous knowledge	2	The keywords are only usable with advanced knowledge
No German	2	SAM is in English although it is for German students. Why is the standard language not German combined with an international offer?
Navigation, complicated	2	Navigation is a bit complicated
Definitions, missing	2	The definition of the keywords is insufficient
Search feature	2	No possibility of searching for individual keywords
Introduction not sufficient	1	The introduction could not sufficiently show SAM’s potential. It is rather confusing
Presentation of results	1	The way of presenting the search results
Time-consuming	1	The constant redirecting is time-consuming
SAM unknown to user	1	I did not know SAM until today
No advantage	1	It is not distinct from other search engines, so I am not sure if I will use SAM in the future
Associations, missing	1	Missing link to differential diagnoses and diagnostic options of diseases

The top suggestion is to add further media to SAM that relate to the negative feedback about missing media (Table 9). Other participants suggested general further development of SAM that might include the missing media or search functionality mentioned above in the negative feedback.

Table 9. "What suggestions do you have?" suggestion feedback free-text item (codes: given by raters, frequency: of appearance, representative statement: selected typical statement).

Codes	Support	Representative statement
Media, enhancement	4	Links to more media
Further development	3	Further development of the project
Definition of keywords	1	Short definitions behind keywords
Link to curriculum	1	Link to curriculum and information about relevance ranking according to your level of education
German language	1	Articles in German
Promote SAM	1	More promotion of SAM, I have not heard of it before
Connect e-learning platforms	1	Connection to other e-learning platforms with help of keywords, ie L2P
Better introduction	1	Better exercises to get to know SAM
Navigation	1	Navigation bar

Discussion

The study aimed to explore typical usage patterns of students who use SAM for browsing, searching, and indexing MLOs and to assess the usability of SAM focusing on (1) the user interface and (2) the suitability of the currently used SN for accessing and indexing MLOs. As stated in the introduction, there is a lack of usability assessment in medical e-learning [23].

Profile of Participants

A total of 95 participants completed the survey, while (according to the log files) only 90 participants completed all four scenarios. We surmise that participants might have copied the keywords from their neighbors or just made up some keywords, and we cannot completely exclude that some participants might have finished the survey later when their activities were no longer recorded.

Main Results

The average time for completing the study and the respective spread showed satisfactory commitment (enough time on average for adequately addressing the task) and a broad variation of user behavior. However, there was 1 participant who took 42 minutes to complete the study, which could be explained by extraordinary thoroughness or a long time needed to familiarize with SAM. Alternatively, he might have been distracted in between and returned later to finish the survey. As shown by the respective numbers of clicks not assigned to scenarios, a relatively small number of students took time to familiarize themselves with SAM. Based on the similar median, the scenarios can be assumed to be equally interesting and equally hard to work on. Moreover, the analysis of duration and click rates shows that, on average, the students worked quickly without browsing through a lot of other keywords. However, there is a wide spread, so there were also a few students that followed a browsing approach instead of a more focused keyword access. The analysis shows that there is no marked relationship between the mean number of clicks per query and the number of queries, which simply illustrates the broad variability of search behavior not being obviously determined by single factors.

Keywords Given

In Scenario 1, some students might not have been familiar with the topic, although it had already been part of their curriculum. Also, some participants might have entered random keywords because they wanted to finish the tasks quickly. This could explain the 22 incorrect keywords. According to the curriculum, the students had not come across the Scenario 2 topic at the time of the study, which explains the number of wrong keywords. Most of the top 11 keywords mentioned for Scenario 2 show up in the associated keywords list of SAM after the search in SAM for "erythema chronicum migrans". Nonetheless, the scenario is realistic in some sense. Usually student assistants working for the emedia skills lab are responsible for uploading and indexing the media. Our results underline the need for a profound knowledge of SAM's SN as well as the content of the media when adding new MLOs to the emedia skills lab and indexing it. The quality of indexing the uploaded media could be improved by hiring students from higher semesters and giving them a detailed introduction and training of SAM before they start their jobs as student assistants for the emedia skills lab. Also, it is not clear if medical teaching staff were better at indexing MLOS since their familiarity with the content of the media might not compensate for their being unfamiliar with SAM's SN.

For Scenarios 3 and 4, the keywords were not classified as correct or incorrect since the students were free to enter keywords of their choice to find additional media. Therefore, the long tail for Scenarios 3 and 4 could indicate a broad interest in different topics as well as different previous knowledge of the individual participants. Scenario 3, in particular, shows a broad interest (102 keywords for one single scenario). Nevertheless, some students might have entered random keywords to finish the assignment quickly. Given the structure and purpose of SAM, no gold standard outcome for Scenarios 3 and 4 could be specified. A scenario in which students would have to find a certain MLO would not represent a realistic use of SAM. Nonetheless, the definition of usability does not necessarily imply the existence of a unique solution to a given problem—otherwise no device for exploring or managing an information space given an individual perspective or interest could be assessed with respect to its usability. Nonetheless, maintaining a focused search and avoiding disorientation while using a complex information space can be considered "achieve[ing] specified goals with effectiveness, efficiency, and satisfaction" (see the earlier definition of usability [14]), and our results at least indicate that the majority of students succeeded here. Additionally, the usability questions adapted from IsoMetrics were adjusted to these circumstances.

In all four scenarios, we observed that besides the top 10 keywords, there are many related keywords that rarely occur directly in connection with the starting keyword. We interpret the less frequently named keywords as long-tail interest. SAM supports linking top keywords to long-tail keywords, which the students may not have associated with a given topic while using regular learning strategies.

Usability Questions

This study was based on the IsoMetrics usability inventory. Hamborg et al showed that IsoMetrics is a reliable technique for software evaluation in the field of hospital information systems [32]. While hospital information systems often use tools for indexing medical diagnoses with keywords, this result motivates the use of IsoMetrics in the context of our study. Also the results of Hamborg yielded a better outcome when he compared the IsoMetrics usability inventory to usability testing methods [33]. Nevertheless, many questions of the IsoMetrics questionnaire could not be adapted to SAM or were not in the focus of this study, which is not a mere software evaluation but rather a study to investigate the acceptance, use, and usability of an SN in medical e-learning.

Free-Text Items

Some of the improvement suggestions go along with the negative feedback. Missing media were often mentioned. New media are continuously added to the emedia skills lab, so the situation can be expected to improve in the future.

One suggestion was to promote SAM in lectures. Obviously, the more faculties know about SAM and provide new media, the more the teachers will talk about SAM in their lectures and classes. Another suggestion was to link SAM's keywords with the curriculum and level of education. A connection between SAM and the catalogue of learning objectives is already planned for the future. One remark was about the lack of German definitions of the MeSH terms. At present, only the MeSH terms are officially translated into German by the Deutsches Institut für medizinische Dokumentation und Information (DIMDI), but not the annotations, cross references, and definitions included in the English MeSH version [34]. Therefore, the definitions were taken from the English version of MeSH.

Comparison With Prior Work

Willett et al identified the need for a standardized taxonomy for medical education and created a taxonomy called TIME-Indexing (Topics for Indexing Medical Education) [35] that can be used for indexing MLOs as well as for curricular mapping. So far, the usability of TIME-Indexing has not been investigated. However, Willet highlights the need for research on ontology use in medical education [36].

Blaum et al performed a systematic review of 14 different structured vocabularies for characterization of MLOs to be organized in an SN [37]. According to the authors, none of those proved to be a good content description of medical curricula and learning resources in the German-speaking world. Neither work systematically investigated the usage of the taxonomy or vocabulary, nor did the authors address usability aspects of the respective computer applications.

SAM visualizes the concept space and helps in navigating it. Cimino introduced a network of concepts called "concept space" [11]. The approach was used, for example, by Karlsson et al to develop a medical decision support system using a controlled medical terminology [38]. Later on, Berners-Lee developed the idea of the Semantic Web [39]. The Semantic Web focuses on automatic interpretation of the World Wide Web and not on the reduction of cognitive overload. SAM focuses on an easier navigation and also the reduction of cognitive overload.

In other areas of application, ontologies and semantic Webs are visualized in different ways. For example, Le Grand and Soto discussed different visualization ideas of topic maps, including graphical three-dimensional representations based on virtual reality concepts like computer-generated landscapes and virtual cities [40]. In comparison to that, SAM so far presents only a list of concepts. In the future, a more sophisticated graphical representation of SAM might be helpful for the users, especially since some participants disapproved of the complicated navigation and unclear associations in the free-text items. Katifori et al gave an overview on different ontology visualization methods and tools [41]. These tools are not only intended to navigate ontologies but also to model and administer them.

New MLOs of the emedia skills lab are indexed manually with SAM. There is also some research on semi-automatic indexing. Gay et al developed an extension of an existing tool, the Medical Text Indexer, to semi-automatically tag biomedical articles [10]. Lacoste et al developed an intermedia medical image indexing and retrieval system [42]. Semi-automatic indexing will be hard if not impossible for videos and other interactive MLOs that are uploaded to the emedia skills lab.

Limitations

While the study focuses on usability aspects, it does not establish a comparative design addressing the way the participants work with, versus without, SAM and their respective effort or efficiency to retrieve learning media. The effects of SAM on the learning outcome of the students were not investigated, while the design of the study does not allow the overall benefit of SAM to be measured. Few incomplete answers had to be excluded from the results in our study.

The interpretation of the long-tail results was complicated by similar keywords being entered leading to a larger number of keywords. The top 11 answers in Scenario 1, for instance, include many keywords containing the word "glioblastoma". Some were enhanced by MeSH qualifiers, while others are more specific, for example, "glioblastoma" versus "glioblastoma multiforme". A similar pattern can be seen in Scenario 2. One keyword among the top 11 is "erythema chronicum migrans";

the other one is just "erythema". Therefore, not all of the different keywords entered in each scenario are semantically independent.

Conclusions

Our study demonstrated that it is possible to develop a Web-based tool for indexing and retrieval of MLOs that yields to high rates of user satisfaction and user commitment representing important aspects of usability. For the first time, we analyzed the typical usage pattern and habits of using an SN for indexing and accessing MLOs. Introducing a controlled vocabulary or classification system generally homogenizes the indexing but requires preliminary training of the indexers. SAM succeeded in a similar homogenization but also yielded a spectrum of individual associations in the long tail as it is typically found when applying Web 2.0 structures. A long-tail interest in random topics can be supported by SAM. We found SAM to be a tool with high acceptance and usability that can be used as a tool for many MLO repositories in different locations.

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Conflicts of Interest

None declared.

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Abbreviations

DIMDI: Deutsches Institiut für medizinische Dokumentation und Information (German Institute for Medical Documentation and Information)
EBM: evidence-based medicine
ICD: International Classification of Diseases
ISO: International Organization for Standardization

IP: Internet protocol
MeSH: Medical Subject Headings
MLOs: medical learning objects
SAM: Semantically Annotated Media
SKOS: Simple Knowledge Organization System
SN: semantic network
TIME-Indexing: Topics for Indexing Medical Education
UMLS: Unified Medical Language System

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Original Paper

Formation of a New Entity to Support Effective Use of Technology in Medical Education: The Student Technology Committee

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Abstract

Background: As technology in medical education expands from teaching tool to crucial component of curricular programming, new demands arise to innovate and optimize educational technology. While the expectations of today's digital native students are significant, their experience and unique insights breed new opportunities to involve them as stakeholders in tackling educational technology challenges.

Objective: The objective of this paper is to present our experience with a novel medical student-led and faculty-supported technology committee that was developed at Vanderbilt University School of Medicine to harness students' valuable input in a comprehensive fashion. Key lessons learned through the initial successes and challenges of implementing our model are also discussed.

Methods: A committee was established with cooperation of school administration, a faculty advisor with experience launching educational technologies, and a group of students passionate about this domain. Committee membership is sustained through annual selective recruitment of interested students.

Results: The committee serves 4 key functions: acting as liaisons between students and administration; advising development of institutional educational technologies; developing, piloting, and assessing new student-led educational technologies; and promoting biomedical and educational informatics within the school community. Participating students develop personally and professionally, contribute to program implementation, and extend the field's understanding by pursuing research initiatives. The institution benefits from rapid improvements to educational technologies that meet students' needs and enhance learning opportunities. Students and the institution also gain from fostering a campus culture of awareness and innovation in informatics and medical education. The committee's success hinges on member composition, school leadership buy-in, active involvement in institutional activities, and support for committee initiatives.

Conclusions: Students should have an integral role in advancing medical education technology to improve training for 21st-century physicians. The student technology committee model provides a framework for this integration, can be readily implemented at other institutions, and creates immediate value for students, faculty, information technology staff, and the school community.

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KEYWORDS

committee membership; educational technology; medical education; medical students; organizational innovation; organizational models

Introduction

Background

Over the last 15 years, technology has become pervasive in medical education training at both the undergraduate and graduate levels [1,2]. The excitement to adopt this technology is often attributed to the unique and evolving needs and capabilities of today's digital native learners [3,4]. Indeed, medical students and residents are eager to integrate digital resources into their training [5-7]. Technology is no longer only a teaching tool, but also a crucial component of curricular programming. Many studies have offered goals for new instructional technologies [4,8], describing the need to "transform learning into a more collaborative, personalized, and empowering experience that can inspire a new generation of learners." [1] With the explosion of new information, new instructional modalities, and the accelerating pace of technological evolution, there has never been a more opportune time to innovate in medical education technology. There are significant challenges, however, for educators and information technology (IT) professionals as they pursue this agenda, including the rapid evolution of technologies [2], highly heterogeneous learners [9,10], diverse educational pedagogies [1], limited funding [11], and varying levels of institutional support [11-13].

Success in overcoming these barriers depends on a systematic approach to project development, including the critical need for learner involvement throughout the process [9,11,14]. Medical students can shape technology development and integration efforts because they better understand student culture and goals, are often more comfortable with IT than faculty, and can offer creative ideas outside of traditional approaches [15-17]. Despite these calls for student involvement, only 21% of United States and Canadian medical schools surveyed sought student input on new applications and services, and even fewer engaged students in student-led contributions to educational technologies [13]. More commonly, student input is solicited only after technology implementation via satisfaction surveys [2,8]. Review of the academic and lay literature identified no reports of formalized or longitudinal student involvement in medical education technology.

The few reports that describe student input in integrating educational technology confirm the vital role students play in this work and their ability to advance the field by novel research projects. Students have worked with faculty in developing a Web-based student resource portal [15], in revising Web-based teaching modules for their peers [17], and in supporting iPad integration into the preclinical curriculum [18]. Other students have worked independently of institutional support to build and pilot novel collaborative studying tools [19], and to test mobile resources for the clinical learner [20-22].

Objective

The rising tide of interest in and opportunities for medical education technologies, combined with the clear successes of student involvement in the aforementioned examples, prompted us to reconsider how motivated students could become engaged stakeholders who could inform the effective use of these innovations. Determining how to harness students' valuable input in a systemic fashion was integral to our approach. In this paper, we describe the ideation, implementation, and impact of a novel medical student-led technology committee, examine its unique benefits, and discuss keys to success for adopting this model at other institutions.

Methods

Implementing a Student Technology Committee

At our institution in the summer of 2012, student input regarding educational technologies was highly fragmented, leading to student frustration with the state of technology offerings. Born from the opportunity to help shape the future, a student interest group formed organically to focus on driving improvements in educational technologies from the student perspective. Over the 1st year, the group undertook multiple projects, including updates to the learning management system (LMS), a pilot study of iPad use in the gross anatomy laboratory, and a clinical podcast series. Strong relationships between senior group members and key faculty were essential to early work. These contacts provided insight into institutional priorities, made connections with relevant faculty and IT staff, and supported group initiatives financially and intellectually. Faculty and staff were appreciative of the high-quality input provided by the group and the efforts of its members and applauded the group's educational technology research endeavors.

At the end of the 1st year, the group's efforts were formalized as the "student technology committee" (STC). The Assistant Dean of Educational Informatics and Technology was selected as faculty advisor to provide close collaboration between the STC and institutional leadership. STC presidents and the faculty advisor enumerated core competencies and operating principles for the committee (Table 1), which were modeled after student-led curriculum committees [23,24].

Table 1. Summary of the student technology committee bylaws.

Bylaws article	Details
Goals and purpose	• Four core goals spanning medical school curriculum (see Areas 1-4 in the "Results" section)
Composition	• Two to three student representatives per class year
	• Faculty advisor is specified (eg, Assistant Dean of Educational Informatics and Technology)
Membership term	• Members serve throughout their 4 years of medical school
	• Membership may be surrendered voluntarily or revoked for failure of responsibilities or conduct
	• Affiliate member status granted to students on temporary leave from medical school (eg, research year, second degree)
Elections	• First-year students apply via written application with secondary interviews
	• New members selected based on holistic review
	• Elections in other class years held as needed if fewer than 2 representatives for a given year or a member leaves the committee
Leadership	• President or Co-Presidents (2) serve 1-year terms (re-election allowed)
	• President(s) elected by popular vote of committee members
	• Serve as liaisons between committee and school leadership, faculty, staff, and other student committees
Meetings	• Held 2 times/month on alternating weeks, additional meetings as needed
	• All meeting minutes recorded and archived
	• First meeting: includes faculty advisor; open to all faculty and staff seeking student technology committee input; focus on project updates as well as administrative and faculty priorities
	• Second meeting: closed; focus on brainstorming new project ideas, addressing current challenges in project execution
Budget	• Annual budget prepared by committee president(s) with approval by committee and faculty advisor
	• Funds secured from institutional student group grants and the Office of Educational Informatics and Technology

Student Membership and Project Operations

Given the unique educational environment of each class year, the STC includes representatives from across the student body. Members serve on the committee throughout their medical school experience to promote continuity and commitment, especially in consideration of the many longitudinal projects the committee undertakes. The committee president(s) is elected annually. Senior (3rd- or 4th-year) students typically will be selected for this position on the basis of availability and flexibility in their schedules as well as experience working with the committee.

New members are selected from the 1st-year class via an application process soon after matriculation. Applicants respond to questions concerning interest in the committee, prior experience with technology, ideas for new technology in the medical school, and thoughts about the future of medical technology. These questions assess applicants' motivation for involvement, relevant experience and knowledge, and ability to think creatively about problems the committee may address. Top candidates, identified based on written applications, are interviewed to evaluate for personal characteristics we have identified to be present in our most successful members (Table 2). Final selections are made based on a holistic review, including consideration as to how applicants' skills may complement those of existing and new members.

The committee operates on a dynamic project management model wherein a single member is appointed the lead for a given project and may flexibly recruit and release additional members to support that project as needed. When serving as project leads, junior members are frequently mentored by senior members in areas including project management, research methods, and administrative and staff contacts. Accountability for project deliverables is reinforced through monthly goal setting and project review, which occur as part of the committee's twice-monthly meetings (Table 1).

Table 2. Qualities of successful student technology committee members.

Quality	How it supports success
Passionate	• Ensures baseline understanding and interest in medical education pedagogy, educational technology, and/or medical practice technology • Drives personal investment in committee work despite multiple demands on available time
Creative	• Supports flexible problem solving in projects with high complexity and multiple resource constraints • Enables out-of-the-box thinking, creating opportunity for true innovation
Problem solver	• Identifies limits of personal knowledge and when to seek help • Improves self-sufficiency on personal projects • In tandem with creativity, enhances committee efforts to address challenging projects
Self-starting	• Minimizes required project oversight • Improves efficiency of project execution
Strong communication	• Enables effective relationships spanning students, staff, and faculty • Aids in team understanding of individual's goals, methods, challenges, and results
Cooperative	• Fosters personal connections with other members • Supports work of all members to advance committee goals • Promotes positive committee culture to improve morale and member effectiveness
Technical understanding	• Familiarity with major consumer technologies (eg, Web services, mobile phones, tablets, wearables) and core technical topics (eg, servers, Wi-Fi)

Results

Delivering on Our Core Work Areas

Area 1: Serve as Liaisons Between Students and Administration, IT Staff, and Course Directors With Regard to All Technologies Related to the Curriculum

Committee members' close proximity to the student body's day-to-day challenges yields an ideal communication channel between students, faculty, and staff. The committee regularly solicits student feedback regarding institutional technologies, while also receiving unsolicited feedback in person, by email, or via anonymous online forms. Issues are communicated directly to the most relevant point person, thereby supporting efficient resolution of student concerns and minimizing communication hurdles between IT staff and students. The committee also works to share the value of new technologies with the student body and to keep them apprised of improvements that are the direct result of their input, closing the feedback loop.

Following the launch of our institution's new LMS, the STC helped to facilitate rapid-cycle development to eliminate software bugs and address essential student needs. Building on first-hand experience using the LMS daily, committee members collected data from in-person discussion with peers and through an online survey. In just 2 weeks, the committee generated reports from end-user feedback that directly informed administrative planning for short- and long-term platform improvements.

Area 2: Serve as a Student Advisory Panel for Continuous Development and Improvement of Technology Involved in the Curriculum

The STC provides faculty and staff with easy, direct access to a mixed cohort of students for soliciting input at any phase of the development process. To date, the student committee has provided input on more than a dozen initiatives and projects, including the LMS, the online learning portfolio, student Web dashboards, a mobile real-time feedback tool [25], the School of Medicine website, iPads and TVs in the gross anatomy laboratory, and wireless printing in the computer laboratory. Faculties have consistently found the STC input on various projects to be extremely useful, lending new insights to guide future directions.

Area 3: Develop, Pilot, and Assess New Uses of Educational Technology or Instruction Related to Technology

As curriculum consumers, students are poised to identify numerous opportunities for novel use of instructional technology. The STC seeks to foster a research and development environment in which members, with suitable mentorship from senior student peers and faculty, can explore novel uses of educational technology. The school supports this mission by providing financial support for pilot projects and dissemination of lessons learned through journal publications and conference presentations. Academic informatics and/or computer science departments can also play an important role in supporting committee research endeavors.

A student-led pilot study and subsequent class-wide integration of iPads into our institution's gross anatomy laboratory exemplifies the extent to which the STC model can impact a school's education ecology. Building on the experiences of other institutions [18,26], committee members rapidly implemented a low-cost pilot study to test iPads loaded with two-dimensional and three-dimensional anatomy atlases with 60 students over a 2-month period. Poststudy surveys revealed that students found it to be a positive addition to their dissection experience with distinct educational value; however, they also identified key shortcomings to address. Working with school leadership, the STC used this information to advocate successfully for deployment of iPads at all tables in the anatomy laboratory. Since then, the STC conducts ongoing analysis to help administrators tailor the hardware and software to student needs.

Area 4: Promote Informatics, Consumer Technology, and Workplace Technology, and Their Applications in Medicine and Education at Our Institution and Abroad

The STC aims to prepare medical students to work in the rapidly evolving health care system under the heavy influence of technological advances. Explicit training in this area at our institution has been scarce. The committee has identified unique opportunities to provide and facilitate instruction concerning effective use of educational technology and to inform student understanding and dialogue about the technologies shaping 21st-century health care. Committee members created online resource guides to aid students in getting the most out of their laptops and mobile devices as learning and clinical tools. The STC developed a “Tech Talks” series of lunch-hour faculty lectures to engage students and the medical center community in thinking critically about popular, clinically relevant topics in biomedical informatics and medical technologies. In addition, efforts are underway to develop elective seminar courses teaching medical students about the changing dynamics of the patient-physician relationship as altered by consumer and medical technologies.

Benefitting Students and the Institution

Formalizing student involvement in educational technology using the STC model offers clear benefits to the school as well as committee members. Numerous advancements to the educational ecology, including existing and new technologies, are possible (as outlined in the previous section), benefitting all students in the institution through potential for greater personalization of learning as well as improved satisfaction and performance. Working toward a shared goal of improving the academic experience for medical students, the committee, together with faculty and staff, develops a collaborative and constructive relationship that enhances the work of all parties. The IT staff are readily able to engage in rapid-cycle feedback and development without significant time and energy investment, increasing the likelihood of project success. Core curricular faculty and administration gain direct insight into student priorities, wants, and needs, which may differ substantially from thoughts and plans developed without such input. They also learn to break down traditional assumptions about the limited roles medical students should play in institutional initiatives [16]. In some cases, the STC may also assume significant responsibility for development and/or testing of new technologies, reducing the expenditure of resources by the institution on those efforts.

Student members of the STC grow personally and professionally through their experiences. As project leaders, they develop core leadership skills, including team communication, delegation, intuition, and the ability to inspire others. They learn how to problem solve creatively and then translate their ideas and opinions into convincing arguments that gain stakeholder support. Students may also advance their personal technical skills such as computer programming or graphic design, which are increasingly in demand across the medical community.

As peer representatives, student members learn how to solicit and assimilate diverse perspectives and advocate on behalf of a group. Working closely with faculty offers them unique insight into the structure and politics of a large educational organization, which may inform their future work as teachers, leaders, and scholars in academia. Students also receive hands-on training and gain experience in conducting research in medical education, and may have opportunities to develop skills in scientific communication in written or oral formats. Most importantly, their experience may stimulate future learning and self-improvement around any of a number of topics in leadership, education, and technology.

Discussion

A Successful Model for Students as Stakeholders

Motivated by demonstrative examples of the benefits of integrated student involvement in advancing medical education technologies, we developed a new student-led technology committee model to inform effective use of these innovations. Thoughtful engagement of motivated students as stakeholders in the process of educational technology development and deployment was essential to our approach. Further, our STC model provided a basis for unifying efforts and goals of students and school leadership. Our experiences with the STC model have borne out that students, coupled with institutional drive, can help schools to realize technology-focused advancements in their educational ecology. Many opportunities are enabled by this model to generate immediate and long-term value for committee members, the student body, faculty, staff, and the school community.

We have gained the following key lessons, including mechanisms to address potential limitations of our approach, through the initial successes and challenges of implementing our model.

Composing the Committee for Harmony

We learned the importance of the student composition of the committee to ensure alignment of interests and complementary skillsets. Whereas many student committees employ election processes based on popularity or first-come interest [23,24], such processes would likely be unreliable in selecting the best students for the STC model. Through a careful application and interview process, a select group of students is chosen to bring a mix of education and technology interests as well as technical and leadership skillsets (Table 2). Despite the technology-focused work of the committee, not all members need be technological experts. Recruiting such ideal students for the STC model may be challenging in the early days of a new committee. Student interest should be solicited by founding members and/or faculty advisors with recognition that students excited by education and/or informatics often do not know where to apply their interests without invitation.

Fostering Student and Faculty Collaboration

We are fortunate at our institution to have an Assistant Dean for Educational Informatics and Technology to serve as faculty advisor and interface between the STC and the school leadership. Although more institutions are creating similar positions, schools without such dedicated roles should identify faculty advisors with experience in educational technology who are also strong communicators with constituents. As noted by others [23,24], we also found that it is essential for faculty and staff to have an open attitude toward student involvement and to affirm students' contributions to institutional projects. As a 2-way street, there should also be clear support for STC initiatives from school leadership, offering connections to key faculty and staff, financial resources for appropriate projects, and an open door to provide feedback and guidance. Together, these practices empower students as change agents.

While involved faculty advisors and school leadership must make a significant commitment to fully support the STC model, we realized that they can benefit markedly from their participation. These individuals develop a keen appreciation for student input while also receiving gratification in knowing that they are advancing committee members' and the student body's experiences. They may also become co-authors on research publications led by the STC, helping to advance their own careers and contribute to the field of education.

Identifying Appropriate Goals and Project Scope

In this paper, we have presented our framework of 4 core missions that guide committee initiatives. In addition, school leadership and committee members should regularly identify shared goals that can inform specific project targets. We also found that it is essential that salaried work (eg, technical support for students) be reserved only for faculty and staff.

The faculty advisor and committee leadership should collaborate to keep project scopes concise and focused, while simultaneously allowing members to dream big and wonder "What if...?". There is potential concern that students do not have time to be involved in this level of work and may be distracted from their primary commitment as medical students. We have found that group accountability, shared project responsibilities, and input from the faculty advisor can help to keep members balanced and reduce such risks to students' academic focus.

Applying Our Lessons

Moving forward, the STC will need to develop measures of effectiveness to assess contributions to the school's educational ecology. Although informal feedback can provide some guidance, routine surveys and objective metrics may elucidate opportunities to improve both the processes and outcomes of the STC model. These data may also enable the STC to secure additional funding for project development and pilots.

Conclusion

As technology develops into an increasingly more essential component of medical education, students need to play a central role as stakeholders in the creation and refinement of medical education technologies. Through our novel student-led technology committee, active mentorship, and formalized, administrative commitment, we forged a collaborative vision and effort to effect positive change across 4 core missions. Students have demonstrated meaningful contributions to our institution's education ecology while generating substantial benefits for committee members and faculty. Our experiences may serve as a model for other institutions to spark advancement of medical education technologies to improve training for 21st-century physicians.

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Conflicts of Interest

None declared.

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Abbreviations

IT: information technology
LMS: learning management system
STC: student technology committee

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Original Paper

Design of Mobile Augmented Reality in Health Care Education: A Theory-Driven Framework

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Abstract

Background: Augmented reality (AR) is increasingly used across a range of subject areas in health care education as health care settings partner to bridge the gap between knowledge and practice. As the first contact with patients, general practitioners (GPs) are important in the battle against a global health threat, the spread of antibiotic resistance. AR has potential as a practical tool for GPs to combine learning and practice in the rational use of antibiotics.

Objective: This paper was driven by learning theory to develop a mobile augmented reality education (MARE) design framework. The primary goal of the framework is to guide the development of AR educational apps. This study focuses on (1) identifying suitable learning theories for guiding the design of AR education apps, (2) integrating learning outcomes and learning theories to support health care education through AR, and (3) applying the design framework in the context of improving GPs' rational use of antibiotics.

Methods: The design framework was first constructed with the conceptual framework analysis method. Data were collected from multidisciplinary publications and reference materials and were analyzed with directed content analysis to identify key concepts and their relationships. Then the design framework was applied to a health care educational challenge.

Results: The proposed MARE framework consists of three hierarchical layers: the foundation, function, and outcome layers. Three learning theories—situated, experiential, and transformative learning—provide foundational support based on differing views of the relationships among learning, practice, and the environment. The function layer depends upon the learners' personal paradigms and indicates how health care learning could be achieved with MARE. The outcome layer analyzes different learning abilities, from knowledge to the practice level, to clarify learning objectives and expectations and to avoid teaching pitched at the wrong level. Suggestions for learning activities and the requirements of the learning environment form the foundation for AR to fill the gap between learning outcomes and medical learners' personal paradigms. With the design framework, the expected rational use of antibiotics by GPs is described and is easy to execute and evaluate. The comparison of specific expected abilities with the GP personal paradigm helps solidify the GP practical learning objectives and helps design the learning environment and activities. The learning environment and activities were supported by learning theories.

Conclusions: This paper describes a framework for guiding the design, development, and application of mobile AR for medical education in the health care setting. The framework is theory driven with an understanding of the characteristics of AR and specific medical disciplines toward helping medical education improve professional development from knowledge to practice. Future research will use the framework as a guide for developing AR apps in practice to validate and improve the design framework.

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KEYWORDS

augmented reality; health care education; antibiotics; general practitioners; learning environment; learning theory; mobile technology

Introduction

Augmented reality (AR) is a leading topic in media consumption, education, health care, commerce, security and a range of areas involving the development of mobile technologies, such as wearable devices, cloud computing, mobile phones, and tablets. AR was coined to describe a worker-training app in which a computer-produced diagram is superimposed and stabilized in a specific position on a real-world object [1]. AR is defined as a real-time direct or indirect view of a physical real-world environment that is enhanced or augmented by adding virtual computer-generated information to it [2]; Carmigniani and Furht's work focused on AR that is interactive and registered in 3D. The International Organization for Standardization (ISO), an international organization that develops and publishes international standards for audio and video coding, defines AR as a live view of a real-world environment whose elements are augmented by computer-generated content, such as sound or graphics [3]. This definition refers to any computer-generated content that can be used to enhance the real physical environment.

Education frequently intersects with the AR evolution because AR has the following characteristics:

1. AR provides users with an authentic and situated experience, when connected with the surrounding real-world environment.
2. AR enhances the physical environment around users with virtual information that becomes interactive and digital.
3. AR shows users an indirect view of their surroundings and enhances users' senses through virtual information.

When companies were developing early versions of AR, an important focus area was workplace training.

Within health care education, AR has been used across a range of subject areas. In our preintegrative review of papers published before November 2012 [4], we identified 2529 research papers in the Education Resources Information Center (ERIC), the Cumulative Index to Nursing and Allied Health Literature (CINAHL), MEDLINE, Web of Science, PubMed, and SpringerLink through computerized searching with two groups of words: *augmented reality* and its synonyms, and *medical education* and its synonyms. A total of 439 full papers were checked and 77 matched the content criteria. We analyzed 25 of the papers that clearly described a research question and/or aim, research results, data collection, and analysis processes. The results showed that AR is useful for health care learning, and that learners accepted AR as a learning technology. The acceptance of AR was verified by our preliminary interviews with two managers and three physicians in two community hospitals in China.

In our preintegrative review, most papers claimed that AR is beneficial for health care learning. Specific benefits included the following: reducing the amount of practice needed, reducing failure rate, improving performance accuracy, accelerating learning speed and shortening learning curves, capturing learners' attention, improving one's understanding of spatial relationships, providing experiences with new types of authentic science inquiry, and improving the assessment of trainees. However, few papers mentioned using learning theory to guide the design or application of AR for health care education. Instead, the traditional learning strategy, "see one, do one, and teach one," was used to apply the new technology.

A design framework connects concepts with applied problems in order to provide a comprehensive understanding of a phenomenon and to guide practice [5]. An instructional-design framework that supports goals, values, and systematic methods has been shown to overcome the shortcomings of a technology-driven approach, which traditionally has been used to design technology-enhanced training programs [6]. However, in our comprehensive literature search, we did not find a published design framework that guides the design and development of AR in health care education.

The spread of antibiotic resistance has become a major threat to global public health [7]. A health systems perspective was suggested to solve the dangers and ethical dilemmas of current use, misuse, and overuse of antibiotics [8]. General practitioners (GPs) are an essential part of medical care throughout the world, and their education in rational antibiotic use should enhance care in higher-income and lower-income settings [9]. Evidence shows that the effects of GP training in appropriate antibiotic use varies [10]. Well-designed medical education has been shown to improve targeted antibiotic prescribing outcomes [11]. However, evidence also shows that educational outreach often fails in more experimental settings due to insufficient workability where the education does not "fit" with the work environment [12]. In addition, drug-centered pharmacology teaching or disease-centered diagnostic clinical training has been weak in transforming pharmacological knowledge into clinical practice [13]. To address this health care education challenge, our study examined the use of augmented reality as a powerful partner to bridge the gap between knowledge and practice.

Mobile technology, which is portable and can be easily immersed in different environments, is developing rapidly. According to a report by Morgan Stanley, by 2020 the use of mobile Internet computing is projected to surpass desktop Internet usage by over 10 times [14]. There are currently more than 100,000 health care apps available [15], and current mobile tools—tablets, mobile phones, and other wearable devices—include features that rival existing AR tools (eg, built-in video cameras, global positioning systems [GPS], wireless receivers, and sensors) [16]. This integration of embedded devices can facilitate the ability to track learners in their natural environment and objects that enhance learning [17]. In health education, app-based mobile devices have been shown to support individual and social aspects of learning [18].

The benefit of mobile phone use in health care has also been shown for evaluating interventions with antibiotic treatment [19].

In short, AR with mobile technology has the potential to transform health education, yet lacks an effective framework for guiding the design, development, and application of such tools. AR can change the effects of GP training in the appropriate use of antibiotics, in an effort to reduce threats from existing global health epidemics.

This study aimed to develop a mobile augmented reality education (MARE) design framework that would guide the development of AR educational apps for health care settings. We used the rational use of antibiotics as a context for piloting MARE. This study addresses the following research questions:

1. What learning theories are suitable for guiding the design of an AR education app?
2. What factors should be involved in designing the MARE framework to support effective health care education through AR?
3. How can the developed design framework be applied in the context of a health educational challenge, such as improved prescribing of antibiotics?

Methods

Overview

Translating new information into clinical practice depends on six types of systems, each with its own purpose and agenda [20]. These systems include the health care environment, the physician him/herself, relevant clinical information, continuing medical education, implementation of a clinical strategy, and clinical regulatory oversight. The multidisciplinary views provided by such systems could be useful in designing, developing, and applying AR in health care education.

Development of the Mobile Augmented Reality Education Design Framework

The design framework for MARE was built using a conceptual framework analysis method (CFAM) [5]. CFAMs, based on grounded theory qualitative methods, are multidisciplinary research approaches aimed at invoking critical thinking during the iterative processes of the research [21]. CFAMs are used to generate conceptual frameworks from multidisciplinary publications and reference materials. These frameworks connect the problems identified with the concepts to be applied in order to provide understanding of a phenomenon [5]. CFAMs have been applied in designing conceptual frameworks that illustrate social considerations for information technology in health care, education, and work/practice research [21-23]. The CFAM's multidisciplinary approach makes this analysis method particularly suitable for designing a MARE framework, since learning is a complex process.

Jabareen suggested that a CFAM is composed of eight steps:

> *...a) mapping selected data sources; b) reviewing the literature and categorizing the selected data; c) identifying and naming the concepts; d) deconstructing and categorizing the concepts; e) integrating the concepts; f) synthesis, re-synthesis, and making it all make sense; g) validating the conceptual framework; and h) rethinking the conceptual framework. [24]*

To design the framework, we collected data from research papers, government reports, conference papers, and websites, as well as documentation of instructional experiences across areas such as medicine, public health, education, instructional design, information technology, and management. Directed content analysis was used to analyze the collected data. This analysis was guided by a structured process and was particularly useful for conceptually developing a theoretical framework [25]. The initial coding of categories starts with instructional system design theory, which involves following the principle of instructional design to promote effective, efficient, and engaging instruction by asking what, how, and why [26]. The study's lead author (EZ) used direct content analysis to identify key concepts and determine how they might be related within a framework. The concepts were then discussed with the study's principal investigator (NZ). EZ created the framework, as well as the supporting figures to aid future instructional designers in use of the framework, and piloted the framework in collaboration with members of the research team. The framework and supporting figures were then discussed among the authors and resynthesized to support the aims of the study and to improve future usability of the framework by readers.

Application of the Mobile Augmented Reality Education Design Framework to an Educational Challenge

The MARE design framework was applied in designing AR for GPs' rational use of antibiotics education. This application of MARE and a subsequent AR program could help solve a major health care educational challenge. The framework was also a step toward the validation of MARE through its application.

First, following our development of the MARE design framework, a systemic architecture, which was provided by the main framework, helped handle the main factors of the application of MARE to GPs' rational use of antibiotics. Second, the data—specific to education on rational use of antibiotics by GPs—were acquired and analyzed. We collected learner abilities and the rational therapeutic process from report authorities such as the World Health Organization and Public Health England, and then examined the results of rational use within medical and health education. Next we used expected learner abilities to describe the learning outcomes and analyzed the GP learners' personal paradigm with the rational therapeutic process. Last, we compared the learning outcomes and the GP personal paradigm, and used the MARE function structure to define learning environments and design learning activities that would be useful for GPs to improve their ability and develop their own paradigm for the rational use of antibiotics. The learning environment and learning activity design were guided by the learning theories.

Results

The Mobile Augmented Reality Education Design Framework

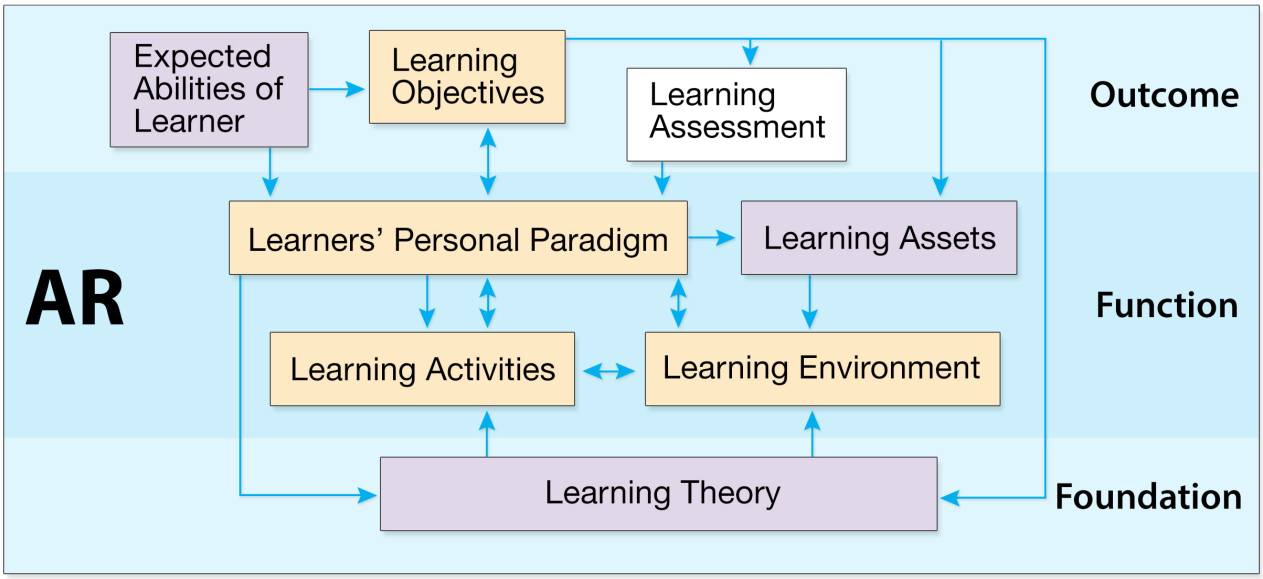
Overview

The relationships among the key concepts we identified using the CFAM informed the following framework shown in Figure 1. The learner is central to the instructional design guided by this MARE framework. These concepts include learning theories, objectives, assessment, activities, environment, materials, and the personal paradigm. They have been mapped to three main layers of MARE—foundation, outcomes, and function.

The three main layers of the framework provide the hierarchical structure for the content objects. The design order started with defining learning objectives in the outcome layer. We then developed the foundation through examining theories that support the MARE framework and its associated AR characteristics. Finally, we focused on designing the function level, which was guided by the learning theories, in an effort to achieve the outcomes.

The relationships between the layers and concepts are illustrated in the following figure through the use of arrows and colors. As the framework design was an iterative process, the AR function layer is the design object, while the foundation and outcome layers provide support to achieve the design aim. The factors within a layer (colored orange and purple) should be considered while designing each layer. The four key elements shown in orange are highlighted in the framework. The purple factors help to support each layer, as needed. One-way arrows pointing to a concept are influenced by their starting ideas. The two-way arrows align with the concepts, as both the source and the target of relationships.

Figure 1. The main elements of the MARE design framework.



Foundation Layer

The foundation provides the reasons why MARE is useful for health care education and considers our first question regarding which learning theories are suitable. Different learning theories provide different views on learning. Learning theory is the foundation for devising learning activities, organizing study content and materials, and establishing learning environments. Guided by suitable learning theory, AR can perform optimally in health care education [27].

Function Layer

Function tells us how health care learning could be achieved with MARE. The function depends upon the learners' personal paradigms, which we will define and discuss more deeply below, and provides support for the outcome and foundation levels. Learning requires suitable material and activities in an appropriate environment. These learning materials and activities should be selected and developed by considering the learning objectives and the learners' paradigm, along with the AR learning environment. The choice of activities and environments should be grounded in learning theory from the foundation level and the characteristics of AR.

Outcome Layer

The outcome helps us understand which abilities health care learners may achieve through MARE and informs how to design the functional level of MARE. Professional certification requirements and the learner's paradigm include preknowledge and influence the learning objectives. Meanwhile, the learning assessment standards, as part of the outcome level, should be ascertained according to the specific learning objectives.

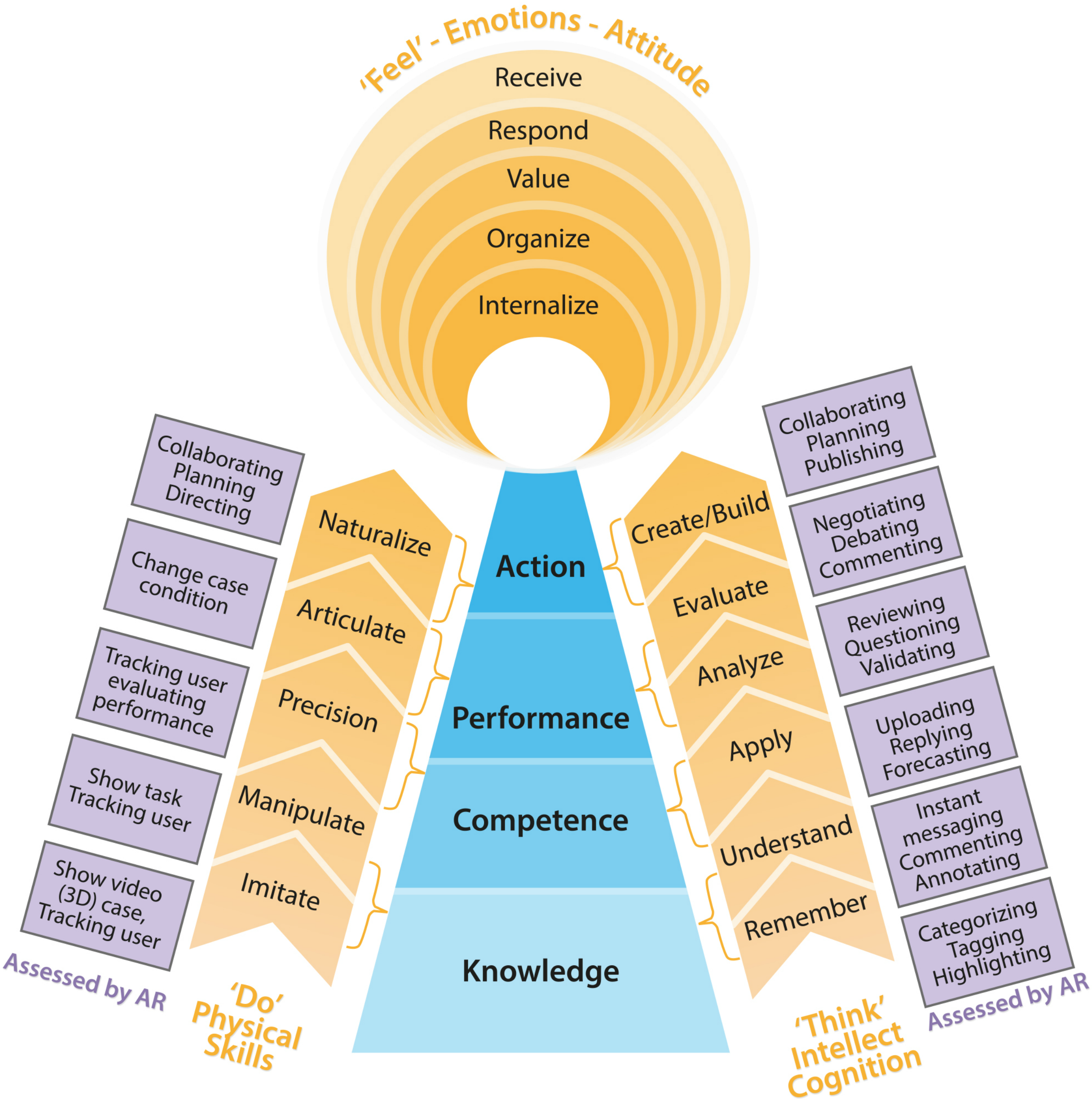
The Outcome Layer Combined With Miller's Pyramid and Bloom's Taxonomy

Overview

First, we consider the outcomes for MARE, which are concerned with the learner's abilities. We combined certification criteria with learning objectives and assessment measures based upon well-established educational frameworks. Miller's pyramid of clinical assessment provides understanding of transforming knowledge to action in medical education [28]. However, most of this research focuses on action verbs adapted from Miller's pyramid [29]. Simply using action verbs on behalf of low cognition levels as the entire ability on Bloom's taxonomy leads to "teaching pitched at the wrong level" [30].

Bloom's taxonomy and its development have been used for planning, designing, assessing, and evaluating training and learning effectiveness around the world. Three domains—the cognitive domain, the psychomotor domain, and the affective domain—have each been ordered by the degree of difficulty. The three domains, also known as cognition, skill, and attitude, are independent but influence one another. Figure 2 shows the integrated hierarchy of an ability model and how to evaluate MARE outcomes, from knowledge to action. Anderson's adapting cognitive domain, Bloom's affective domain, and Dave's psychomotor domain were adapted for MARE [31-33]. As we move from knowledge to action, we see different ability levels form different cognitive and physical skills. Only the affective domain did not map directly to ability level, but affected ability achievement.

Figure 2. Ability frames from knowledge to action: how to evaluate MARE outcomes.



Knowledge Level

Knowledge is about knowing facts, information, descriptions, or skills. Knowledge includes procedural knowledge and declarative knowledge. Procedural knowledge, which is the skill within the knowledge level (KS), can be evaluated by imitating or manipulating. Declarative knowledge, which is the cognition within the knowledge level (KC), can be tested by remembering or understanding. Although attitude is not part of knowledge, attitude affects health care student learning knowledge. Knowledge can be assessed by tracking the students' behaviors during the health care learning process in MARE.

Competence Level

Competence is the ability to apply knowledge or a precise behavior in the practical context. Competence is about knowing and doing something the right way. Emotions and values not only affect the application of knowledge, but are also a foundation upon which to build competence according to physicians' professional competence definitions [34]. The cognition within the competency level (CC) can be evaluated by reliably solving problems, and the skill within the competency level (CS) can track and test physicians operating in real circumstances or simulated practice.

Performance Level

Performance is the quality needed to accomplish work, acts, and achievements in real clinical practice. Performance is based on competence, but is influenced by government, organizations, patients, and individual physician factors [35]. Performance requires higher cognitive ability, such as analyzing and evaluating. A real case from the physician clinical setting is provided for the physicians to analyze and evaluate in MARE. Thus, physicians will analyze and evaluate their cognition within the performance level (PC). Higher performance is articulated in the skills demonstrated. The skill within the performance level (PS) can be tracked and evaluated. Since personal performance is affected by many other factors, improving performance cannot be separated from organizing attitudes or values, which requires comparing and synthesizing different values to resolve conflicts.

Action Level

Action is the ability to run a series of events for a given set of processes in health care to optimize patient outcomes. The results of action come from one's individual performance as well as collaboration with other colleagues and shared decision making with patients, caregivers, or advocates where appropriate. At the action level, the skill is naturalizing behaviors, and the core of cognition is focused upon creating new meaning or structure. The skill within the action level (AS) and the cognition within the action level (AC) can be evaluated through patient outcomes and the impact on other physicians.

By applying this ability frame from knowledge to action, the expected abilities of GPs' rational use of antibiotics are specifically described, as shown in Tables 1-4. Every item that is a component of the expected abilities uses the verbs from Bloom's taxonomy to make the item easy to execute and evaluate. We can use the related assessed ways in Figure 2 to design how to evaluate them in MARE.

Table 1. Expected general practitioner knowledge of rational use of antibiotics.[a]

Domain	Expected knowledge
Cognition	1. Stating public health antibiotics national guidelines 2. Recognizing trade and generic names, and the class of prescribed antimicrobial 3. Understanding the nature and classification of pathogenic microorganisms 4. Understanding the principles of prevention, treatment, and control of infection 5. Understanding the modes of action of antibiotics: broad versus narrow spectrum 6. Understanding the mechanisms of antimicrobial resistance 7. Understanding local microbial-/antimicrobial-susceptibility patterns 8. Understanding of common side effects, including allergy, drug/food interactions, and contraindications of the main classes of antimicrobials 9. Interpreting basic microbiological investigations 10. Interpreting clinical and laboratory biological markers
Skills	1. Obtaining microbiological cultures or other relevant tests before commencing treatment as necessary 2. Implementing microbiological and other investigations to diagnose and monitor the response to treatment of infections and their complications 3. Choosing in case of prior use of antibiotics when selecting an antibiotic for empiric therapy
Attitude	1. Understanding the importance of taking microbiological samples for culture before starting antibiotic therapy 2. Understanding the importance of monitoring for common side effects, including allergy, drug/food interactions, and contraindications of the main classes of antimicrobials 3. Responding to the importance of selection advantages

[a]The table content was developed using various sources [36-38].

Table 2. Expected general practitioner competencies for rational use of antibiotics.[a]

Domain	Expected competencies
Cognition	1. Selecting and prescribing antibiotic therapy according to national/local practice guidelines 2. Using local microbial-/antimicrobial-susceptibility patterns when conducting empiric treatments 3. Using antimicrobial agents for prophylaxis appropriately 4. Constructing the prescription for an antimicrobial with its pharmacokinetics and knowing how this affects the choice of dosage regimen
Skills	1. Choosing and calculating the dose, route, and interval of administration 2. Monitoring the therapeutic drug and adjusting doses to ensure adequate drug levels 3. Using the antibiotics toolkit
Attitude	1. Not initiating antibiotic treatment in the absence of bacterial infection 2. Avoiding the unnecessary use of broad-spectrum antimicrobials 3. Using only single doses of antimicrobials for surgical and other procedures for which prophylaxis has been shown to be effective unless published national recommendations suggest otherwise

[a]The table content was developed using various sources [36-38].

Table 3. Expected general practitioner performances with rational use of antibiotics.[a]

Domain	Expected performances
Cognition	1. Applying best bacteriological guess for empiric therapy 2. Estimating the shortest possible adequate duration 3. Assessing when not to prescribe antimicrobials, and use of alternatives 4. Reassessing the antibiotic prescription around day 3
Skills	1. Switching to the correct antimicrobial based on microbiological results and cost effectiveness 2. Mastering delayed antimicrobial prescription and negotiation with the patient 3. Inputting documentation in the prescription chart and/or in patients' clinical records
Attitude	1. Working within ethical code of conduct 2. Applying legal and ethical frameworks affecting antibiotic-prescribing practice

[a]The table content was developed using various sources [36-38].

Table 4. Expected general practitioner actions with rational use of antibiotics.[a]

Domain	Expected actions
Cognition	1. Engaging the views of others and cooperating with others with more expertise in antimicrobial treatment policy decisions 2. Educating patients and their caregivers, nurses, and other supporting clinical staff 3. Engaging regularly in team-based measurement of the quality and quantity of antimicrobial use 4. Sharing with prescribers, as well as informing antimicrobial surveillance/infection prevention and control measures
Skills	1. Using the results of adverse-event monitoring, laboratory susceptibility reports, antimicrobial prescribing audits, and antimicrobial usage data 2. Producing sustained improvements in the quality of patient care 3. Using locally agreed-upon process measures of quality, outcome, and balancing measures
Attitude	1. Adapting consultations and prescribing to meet patient diversity 2. Ensuring that confidence and competence to prescribe are maintained 3. Maintaining patient confidentiality, dignity, and respect in line with best practice, regulatory standards, and contractual requirements

[a]The table content was developed using various sources [36-38].

The Learning Theories Supporting the Foundation Layer

Understanding learning theories and their interpretations can boost the use of effective teaching and learning strategies for medical education practice [27]. However, as we emphasized, few AR programs in health care education use learning theory to guide the design, development, and application. AR has the potential to provide powerful contextual situated learning experiences and to aid in exploring the connected nature of information in the real world. According to the requirement for transforming health care education and these characteristics of AR, we selected three learning theories guiding MARE design: situated learning, experiential learning, and transformative learning. Table 5 shows the main characteristics of these learning theories and how they can inform MARE design.

The reasons we chose these three learning theories are as follows:

1. From the view of social practice, situated learning theory provides a holistic perspective on the interpretation of learning by exploring the situated characteristics of the learners, environment, and practice [39].
2. Experiential learning theory emphasizes the dynamic state between the learner and the environment [40]. This theory differs from situated learning theory by focusing more on the experiences of an individual learner to create knowledge.
3. Transformative learning focuses on discovering evidence that education facilitates changes in the learner's frames of reference or schema by which the learner identifies his or her life world [41].

These three learning theories provide different views of learning and enhance different characteristics of learning environments, which AR could provide. In addition, the learning activities suggested by these theories could be applied in MARE. Each learning theory can inform decisions for the learning environment, activities, and how to apply AR.

Learning environments that encompass the physical, social, and psychological context of learning are of significant importance and require the attention of medical and other health sciences educators when they teach or design a course [44]. The medical learning environment could be in medical school, an academic health center, or a clinical environment. Different learning settings are supported by different types of learning environments.

Table 5. Comparison of situated learning, experiential learning, and transformative learning.[a]

Characteristics	Situated learning	Experiential learning	Transformative learning
Learning assumption	A dimension of social practice	A holistic process of adapting to the world	Critically aware of the personal paradigm
Learning perspective	Concerns the whole person acting in the world	Combines experience, perception, cognition, and behavior	Implicates transformation in meaning perspective that encompasses cognitive, conative, and affective components
Definition	Learning is participation in communities of practice, which produces knowledgeable identities and the community itself	Learning is the processing of transformative experiences, which includes concrete experience and abstract conceptualization	Learning is changing problematic frames of reference, which comprise habits of mind, points of views, and mind-sets
Environmental conditions	Real-life situation where the learning occurred	Create learning environments for feeling and thinking, reflecting, and acting	Safe environment, authentic settings
Learning activities	Sustained participation via observation, collaboration, and communication	Reflective observation and active experimentation	Critical reflection and dialectical discourse to validate beliefs, intentions, values, and feelings
Implications for MARE[b]	Thinking holistically about learning activities, real practical tasks, real environments, and MARE functions Understanding and using the social situation, especially the real-life environment Design activities to sustain participation with MARE (or AR[c])	Design virtual learning environment for feeling, thinking, watching, and doing Utilize Kolb's spiral model from concrete experience or knowledge to action [40]	Design the learning activities to reflect upon and change problematic frames of reference

[a]The table content was developed using various sources [39-43].

[b]Mobile augmented reality education (MARE).

[c]Augmented reality (AR).

The Functional Level Design

Overview

MARE provides a prompt, portable tool for medical student learning within the clinical setting in order to transform knowledge into practice. The flexible personal paradigm, which is "more inclusive, discriminating, open, reflective, and emotionally able to change," is more appropriate for guiding action [43]. The most important function of AR is mixing aspects of the real environment with virtual objects to create different learning environments. As backed by the learning theories previously discussed, these mixed environments will be useful for the medical student to form a flexible personal paradigm.

We propose the following function structure shown in Figure 3 for developing MARE. The personal paradigm is the starting point of design learning and must transform to become flexible. A physician's personal paradigm includes his or her personal style of diagnosis, treatment, prescription, and drugs (P-diagnosis, P-treatment, P-prescription and P-drugs, which are four related processes) [13]. The physician's personal paradigm could be analyzed through observation and deep interviews.

Second, by comparing the learners' personal paradigms with professional expectations, we can describe the learning objectives and check their problematic reference. The learning activities cycle, which focuses on improving one's personal paradigm from feeling, watching, and thinking to doing, will help learners reflect on their practice and change the problematic frames of reference.

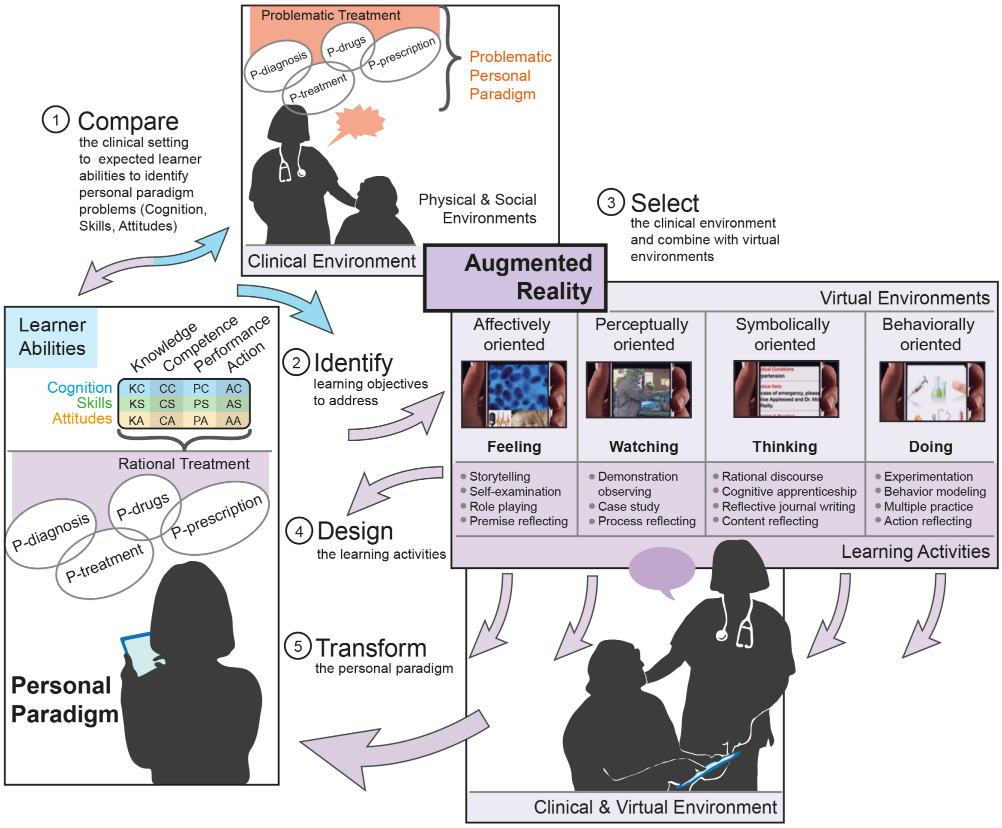
After identifying the learning objectives, an AR environment of MARE framework should be designed. Four oriented learning environments, which can add different virtual objects to the real clinical environment, create multiple sensory channels for learning [45]. Affective-oriented environments affect health care learners' feelings. Perception-oriented environments are beneficial for observation. Symbol-oriented environments are particularly useful for thinking, and behavior-oriented environments are beneficial for doing [42].

The real clinical environments are the immediate context in which a connection is needed between learning and practice. The real clinical environment is the anchor and scaffold upon which learners are encouraged to learn. The real clinical environment includes physical environments and social environments. The content in physical environments, such as patients and their disease, microbiological samples, documentation and clinical notes, medical equipment, drugs, and consequences of bacterial resistance, can be the anchor to trigger a learning activity, which then aims to fulfill a learning outcome within the appropriate therapeutic stage. The social environment (ie, local culture and customs, organizational norms, and policy) shapes the content and forms of learning, which should be more instrumental or communicative.

Virtual environments, which are simulated with computers, extend the real-world environment with an assurance of safety and enable or increase opportunities for engagement. Although it may be necessary or attractive for medical learners to learn in the clinical context, observing a real-world context could be dangerous, expensive, or even impossible [46]. Computer-generated content, such as sound, graphics, 3D, video, or text, shows learners an indirect view of surroundings and enhances learners' different senses to achieve the learning objectives.

In these environments, learning activities are added, which will help medical learners to recognize and build their personal paradigm as they develop skills, gain insights, and determine the dispositions that are essential for translating what they learn into action. Each mixed environment in MARE has its own focus on different learning activities, and the environments should complement and reinforce one another.

Figure 3. MARE function structure.



Personal Paradigm

The personal paradigm is compiled from the frames of reference that shape learners' beliefs regarding guiding action in transformative learning theory. The personal paradigm combines the individual's mind-sets, habits, and meaning perspectives, and encompasses cognitive, conative, and affective components. This paradigm is affected by sociolinguistics, moral and ethical values, learning styles, religious beliefs, psychological heath, and aesthetic preferences [43], and is developed through the learners' learning and/or practice experience. Problematic frames of reference can be caused by poor teaching, disjointed practice, bad example by colleagues, patient pressure, and salesmanship [47].

Learning Environment, Assets, and Activities

The learning environment provides the conditions and external stimuli that facilitate learning and transform the learners' paradigms. Learning assets provide the content for learning [48]. Learning assets are composed of different media forms, such as text, sound, and video; various media can be used in MARE to create different learning environments and realize the valuable functions of different media [49]. MARE mixes real clinical environments and virtual environments in a learning environment within which learners feel, think, watch, and act. Real clinical environments are an immediate context in which learners connect with the learning and practice. These environments include physical environments and social environments. As expected by situation learning theory [39], the clinical environments provide the anchor and scaffold in which learning is encouraged. The virtual environment is useful for learners who learn in different ways and transforms the problematic frames of reference in their personal paradigms. These types of environments conform to create safe environments, in which learners experience learning theories including transformative learning theory [42]. Learning activities are the approach by which learners obtain meaning from learning material, context, and other people in the learning environment. The three learning theories suggest various learning activities, as seen in Table 1. Although an individual's learning style preferences may be inclined toward specific activities, using diverse learning activities is effective for all learning styles [42].

Application of Mobile Augmented Reality Education to a Health Care Challenge

In recent years, one of the global health threats has been the spread of antibiotic resistance. Encouraging rational antibiotic use is of paramount concern to authorities worldwide in order to minimize the development of resistance [50]. Multifaceted national and international strategies have been recommended [51]. Education is an important strategy for the rational use of antibiotics. We used the MARE framework to design GP training for the rational use of antibiotics.

Implementing the MARE framework involves several steps: (1) defining the educational outcomes (based on the outcome layer), (2) defining the GP's personal paradigm, (3) characterizing the learning environment, and (4) designing the learning activities.

The Outcome Layer of General Practitioners' Rational Use of Antibiotics

Overview

The different abilities for rational use of antibiotics were adapted from Public Health England and a number of authors [36-38]. In Tables 1-4, we show how cognition, skill, and attitude can be identified across the spectrum of abilities from knowledge to action. Emotions or attitudes affect the abilities acquired, but do not have a corresponding relationship to specific cognitive and physical skills. We include every affective level in the tables for easy understanding. Attitudes within each level will be surveyed through an attitude questionnaire instrument.

Knowledge Level

Knowledge-level expectations for GPs regarding the rational use of antibiotics are shown in Table 1. When GPs use MARE as a tool for evaluating knowledge, they can scan or take a photo of the object in their workplace, task, or virtual case, and the real object will be integrated in MARE. GP behavior can be tracked and their skill within the knowledge level tested. For example, KS1 involves obtaining microbiological cultures or other relevant tests before starting treatment as necessary. A patient who has bacterial pneumonia or viral pneumonia will be shown to a GP treating in MARE. The GP will either select laboratory tests and interpret results or not. We will know whether the GP achieves KS1 or not. The KC of GPs can also be evaluated in MARE. GPs can write instant messages, comment, and annotate that they understand the rational use of antibiotics. GPs can also categorize, tag, or highlight the information that they think is correct. For example, KC2 is recognizing trade and generic names, and the class of prescribed antimicrobials. GPs can categorize the class of prescribed antimicrobials when using MARE to scan trade or generic names.

Competence Level

The competence level expected of GPs regarding rational use of antibiotics is described in Table 2. Emotions and values not only affect the application of knowledge but are also a foundation for building GP competence according to physicians' professional competence definitions [34]. When we use MARE to evaluate GPs' competence levels, the cases could be conducted in mixed real environments (eg, the real person and the symptom described coexist on the GP's mobile phone in his or her workplace). The procedure for forecasting, executing, or replying can be uploaded to evaluate the GP's CC and CS. For example, CC4 is constructing a prescription for an antimicrobial with its pharmacokinetics and knowing how this affects the choice of dosage regimen. The case condition will change when different antimicrobials are used with their pharmacokinetics. The result for the forecasting of antibiotics by the GP and the dosage regimen will be evaluated.

Performance Level

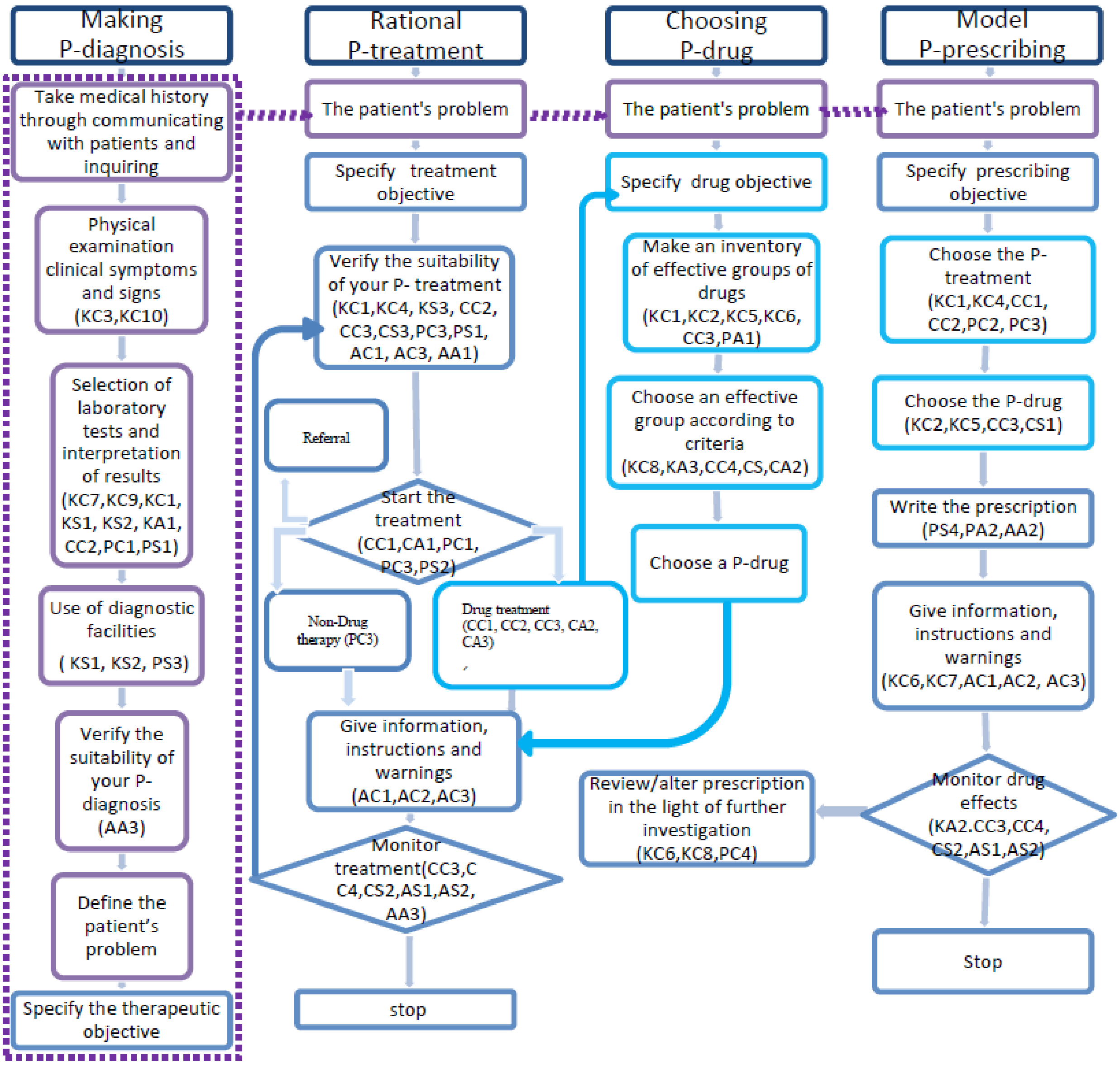
The performance level expected of GPs regarding the rational use of antibiotics is shown in Table 3. To aid GPs in assessing their workplace performance using the MARE framework, we should build a network for physicians in which they can share their work experiences; then the GPs can review, question, and validate their work performances with each other. Further, the GPs can negotiate, debate, and comment on real cases, and their performance in skills, such as PC and PS, can be tracked and estimated. For example, PS2 is mastering when to use a delayed antimicrobial prescription and how to negotiate this with the patient. One way is to evaluate the GP's response with the patient case shared on MARE with other GPs meeting at a real clinic. Another way is through creating a story case in which GPs often meet at their workplace to check how the GP deals with delaying antimicrobial prescriptions and negotiating.

Action Level

The action level involving the rational use of antibiotics is explained in Table 4. It is hard to evaluate GPs' real actions, but MARE could be a platform for GPs collaborating, planning, and publishing their views or directing others. As an initiator for action, GPs' internalized values can regulate the GPs' pervasive and consistent behavior.

First, we use the expected abilities in Tables 1-4 to analyze the GP's personal paradigm with the rational therapeutic process (see Figure 4). For example, a GP needs items KC3 and KC10 for physical examination clinical symptoms and signs. Items KC7, KC9, KC10, KS1, and KS2 are the GPs' abilities when they select laboratory tests and interpret the results, and so on. Each ability item in Figure 4 can be compared with the GP's current personal paradigm. GPs' problematic frames of reference for using antibiotics were identified with comparisons. Problematic frames of reference could be caused by a lack of ability or the wrong habit and mind-set. Finding the problem areas will help establish specific learning objectives. Meanwhile, an evaluation tool was developed to assess these specific GP learning outcomes. Content for Figure 4 was developed using various sources [13,52,53].

Figure 4. The process of revising the personal paradigm for a rational therapeutic process. The figure content was developed using various sources [13,52,53].



General Practitioners' Personal Paradigms About Rational Use of Antibiotics

The GP's personal paradigm is the means by which he or she sets his or her prescribing behavior for antibiotics. Figure 4 displays the process of revising the personal paradigm for a rational therapeutic process. The components of the GPs' paradigms with rational use of antibiotics have been described as different abilities in Tables 1-4. The problem of a GP's paradigm in the real clinical setting could be checked within Figure 4 and Tables 1-4. GPs require different abilities in each phase of the therapeutic process to build their own paradigm with rational treatment as the ultimate aim. Although the P-diagnosis initiates the therapeutic process, each phase in the paradigm could be adapted independently or considered as a whole during the learning process. When a phase is isolated in the independent paradigm for training models, the other relative phases in the paradigms are assumed to be perfect.

In comparison to the expected abilities and the ideal paradigms for a GP’s rational use of antibiotics, GPs will need different abilities in each phase of the therapeutic process. As in Figure 4, we added the expected ability in each stage. For example, GPs need only some KC in a few stages of each phase, and these abilities are the basis of later stages and phases. The ability to combine cognition and skill is needed in most stages, and is shown by being able to progress from knowledge to the performance or action level. Emotions and attitudes are as important to achieving learning objectives as are cognition and skill. As we mentioned before, emotions and attitudes do not map directly to ability level, but rather to the GP paradigm in each stage.

Aside from the abilities that help construct the GP’s personal paradigm, many other factors affect a GP’s paradigm. MARE should help GPs build more accurate personal paradigms or transform problematic frames of reference. In Figure 4, the GP’s existing personal paradigm, the situation, and the characteristics of each stage in the therapeutic process are analyzed. The flow and visualization of relationships can help inform the design of learning activities and learning environments with MARE.

Learning Environment Design for General Practitioners' Rational Use of Antibiotics

After the learning objectives and the GP’s personal paradigm for the rational use of antibiotics are compared, the learning environment could be designed for GP rational use of antibiotics as follows:

1. In affective-oriented environments, visuals or voice simulations are overlaid in the physical environments to affect the attitudes of GPs in specific settings. GPs are encouraged to share their values and feelings from their concrete experiences.
2. In perception-oriented environments, GPs observe the process simulations of infecting and treating with the real object to reflect and change their habit of misusing of antibiotics. GPs will examine the problem-solving strategies that they used in clinical practice.
3. In symbol-oriented environments, the tasks, guidelines, and alarms are integrated in the therapeutic process to show “the revealed and the concealed” aspects of a complex professional activity. GPs create personal knowledge and develop abilities through discovering, building, and testing hypotheses, and through changing variables and observing the results.
4. In behavior-oriented environments, GPs interact with the virtual object in combination with the real clinical environment to practice what they learn and reflect upon what they do. GPs make their own choices and become more critically reflective to adapt to uncertainty and variable conditions through the decision to act upon a transformed insight.

Learning Activities Design for General Practitioners' Rational Use of Antibiotics

The learning activities are designed as design strategies for GPs to focus on personal experience during the entire therapeutic process, and to promote reflection on their own personal paradigm in the rational use of antibiotics. The personal paradigm includes four related processes, and correlation and difference functions (as shown in Figure 4), which affect the rational use of antibiotics. In different learning environments, the four types of reflection—premise, process, content, and action—help interpret and give meaning to the GP’s own experience. Within different learning environments, GPs use different learning activities to achieve the learning outcomes for each stage. Table 6 suggests how to apply learning strategies in the four learning environments.

One specific example of the use of MARE as a software app involves examining the effect of AR on emotions and the emotional and cognitive development of physicians within community-based hospitals. Using MARE, we can develop a mobile phone-based software app to be used on the physician’s own mobile phone. GPs who work in community hospitals would be included in the study after they have given informed consent to participate in the trial. During the learning process, the physician participants would take turns role-playing as physicians and patients. As a physician, a GP could see, through his or her mobile phone, the virtual pneumonia infecting a patient via a bacterium or virus. When a GP chooses an antibiotic to treat viral pneumonia or the dose is wrong in the MARE app, the pathogen and commensal change in the patient’s body will appear on the GP’s mobile phone.

Table 6. General practitioners' learning activities and application examples in learning environments[a].

Learning environment	Learning activities	Examples of use in antibiotic education
Affective oriented		
	Role-playing of GPs[b] as patients could arouse GPs' empathy.	GPs can role-play as patients for one another and use MARE[c] tracking to experience how patients may feel or change during the treatment process.
	Storytelling could be used to share GPs' experiences to become aware of their own problems.	GPs will be encouraged to tell stories related to the situation being addressed by MARE or add as new cases within MARE.
	Self-examination or discussion with peers could raise consciousness about the rational use of antibiotics.	After learning with MARE, GPs examine or discuss with peers how they feel about the learning experience.
	Premise reflecting may lead to transforming the GPs' belief systems in the use of antibiotics.	GPs assess assumptions about what determines or guides prescribing antibiotics within their value systems. Disorienting dilemmas should be designed to define problem processes that provide an opportunity for GPs to reflect on MARE.
Perception oriented		
	Demonstration observing could provide GPs the right therapeutic skills and transformed insights regarding infectious diseases.	GPs can observe antimicrobial therapy dynamic change processes, which simulate a demonstration of the complex interrelationship between patient, microorganisms, and antimicrobial drugs through MARE.
	Case studies could improve the GPs with the ability to analyze and resolve problems.	GPs can analyze well-designed case descriptions of misused antibiotics on MARE and offer solutions and recommendations related to a concrete situation or problem they might meet in the real clinical environment.
	Process reflecting questions the etiology and factors of actions that might change GPs' problem-solving strategies during the therapeutic process.	GPs compare their own problem-solving process with expert modeling or others in MARE to examine their strategies for appropriate use of antibiotics.
Symbol oriented		
	Cognitive apprenticeship, which makes thinking visible, could iteratively build the GPs' intellectual skills in rational use of antibiotics.	GPs follows the guidelines, posters, or cue cards for the rational use of antibiotics in MARE to build their cognitive ability, as described in Tables 1-4.
	Rational discourse could offer GPs accurate and complete information with which to get objective and rational consensus on the rational use of antibiotics.	GPs have an equal opportunity to participate in a rational discourse with a challenging incident or controversial statement about the use of antibiotics, which was designed in MARE.
	Reflective journal writing could help GPs externalize and articulate what they are learning.	GPs write a blog with MARE to record their ideas, thoughts, and feelings about the events they have observed, in order to learn and gain experience.
	Content reflecting involves GPs thinking back to what was done in past experiences, which might transform their meaning scheme for the use of antibiotics.	GPs examine past experiences of their personal paradigms with the use of antibiotics and compare them to the content of guidelines for the rational use of antibiotics and/or engage in comparative discourse with others through MARE.
Behavior oriented		
	Experimenting through scientific-based inquiry methods for problem solving could help GPs develop critical thinking and adapt to changing contexts and new challenges.	GPs use MARE in the experimentation mode, which illustrates phenomena and variables of typical cases involving the use of antibiotics, in order to test their ideas, gather data, and distill the results.
	Behavior modeling could engage GPs in practicing their skills for the desired behavior of the rational use of antibiotics.	GPs participate in interactions with the model, which simulates the desired behavior for the rational use of antibiotics on MARE to help GPs practice and master their skills.
	Multiple practices could enhance a GP's rational use of antibiotics behavior.	GPs participate in planned exercises that use scaffolds and combine different real conditions to practice what the GPs learn in MARE.
	Action reflecting could help GPs apply their current experiences of solving problems in clinical practice to future problems.	GPs think about the problem and the solutions involving the use of antibiotics when they meet in practice. This reflection-in-action or reflection-on-action could be reinforced with MARE.

[a]The table content was developed using various sources [54-56].

[b]General practioners (GPs).

[c]Mobile augmented reality education (MARE).

Discussion

Principal Findings

AR, as well as many other information technologies, is expected to help the reform of health professional learning. AR is a promising technology that can amend curricula rigidity, traditional pedagogy, and adaptation to local contexts in health education [57]. AR has shown its potential as a learning technology in health care education, but most AR systems are still used in traditional pedagogies [4], just like online learning did when it was first introduced.

Effective application of technology in education practice requires profound understanding of the potential of technologies and the specific disciplines, as well as appropriate learning theory support [58]. The MARE framework through a CFAM considers the characteristics of AR and the learning theory supporting it, as well as the objective identification to guide design. This full view of MARE is helpful for medical education to improve professional development from knowledge to practice. The three learning theories provide foundational support from the different views of the relationship among learning, practice, and environment. The outcome layer, which analyzes different ability levels from knowledge to practice, can possibly avoid "teaching pitched at the wrong level" [30], and it can also fill the gap between teaching and clinical practice needs. Moreover, AR is a potential tool to help health care educators fill the gap between teaching and clinical practice, especially through guidance by theories to achieve the aim. The MARE framework meets clinical teaching goals listed in the Association for Medical Education in Europe (AMEE) Guides that apply relevant educational theories to guide clinical teaching in the hospital setting [29].

Limitations

This is the first AR framework based on learning theory with clear objectives for guiding the design, development, and application of mobile AR in medical education. To date, there is no standard methodology for designing an AR framework. MARE uses a CFAM, which is based on a theory that provides systematic understanding of the multidisciplinary, complex relationship from knowledge to practice in medical education. However, this MARE framework created through a CFAM from multidisciplinary publications and reference materials must be tested in practice.

Validation of the framework was suggested by Jabareen [24], but he did not give a method for how to validate it. We checked the internal validity by involving authors from different disciplines and perspectives to reduce the bias. We also used this framework for analysis of, and application in, GPs' rational use of antibiotics. However, since this is a general framework for guiding the design, development, and application of AR in medical education, external validity, which is transferable in qualitative research, must be further tested with users and with the next step to develop an AR app. In addition, a number of experts such as instructional designers, AR developers, GPs, medical educators, visual designers, information and communications technology (ICT) specialists, and interaction designers are needed to further design, improve, and test the framework.

Comparison With Prior Work

The MARE framework is a general instructional design framework that addresses functional conceptualism by explaining and predicting theory with a multidisciplinary perspective [6,59]. Similarly, the general instructional design framework has been used to design e-learning and simulation training frameworks. Situation learning theory was used to guide the design of the learning environment and learning activities for an instructional design model, and transformative learning theory was used to build an e-learning framework [54]. Identifying the learning aim is important for a framework that uses the design process in electrical engineering as a model [60]. Edelson developed a framework with principles and learning activities from the inquiry-based cycle [61]. Distinct from these frameworks, the MARE framework tries to meet all components of functional conceptualism: goal, values, functions, and situations. Learning theories are the foundation of the MARE supporting values. Their selection corresponds to the characteristics of AR and GP learning outcomes. Clarifying the learning goal is the important first step in MARE instructional design. Learning activities are manipulable variables within learning environments. Activities are suggested from learning theories to achieve learning outcomes. Learning activities are described along with the situations for guiding when and how to apply them in the MARE framework.

Implications and Future Work

The proposed MARE design framework addresses the lack of theory for guiding the design, development, and application of AR to improve GPs' rational use of antibiotics. Understanding the theory behind this framework could benefit instructional designers, AR developers, and GP professionals when they apply the recommendations and could ultimately lead to further development of this framework and its practical use.

The first implication of MARE for AR designers is how to apply learning theories and learning outcomes to guide AR instructional design. Situated learning theory, experiential learning theory, and transformative learning theory share some views, but each has unique emphases. The learning activities from which the learning theories are based are effective substitutes for traditional medical instruction in AR environments. The fundamental change in pedagogical philosophy is better than the tinkering with "interactivity" levels by instructional designers to support deeper, richer levels of learning [54]. The learning outcome framework (Figure 2), which combines Miller's pyramid of clinical assessment and Bloom's taxonomy of learning aims, avoids assessment that rests on low ability. AR designers may use the learning outcomes, which are explained in Tables 1-4, to analyze a GP's personal paradigm and to design their AR program. The effectiveness of the strategies and the appropriateness of the goals require further evaluation and refinement.

The second implication of MARE for an AR developer is the function framework. It may help developers understand how to create mixed environments for learning, not just for technology-driven infotainment. Different environments offer different learning functions. AR developers may use the list of teaching activities shown with the MARE framework as guidance when they consider how to develop AR functions. In terms of the learning objective, learning environment, learning activities, GP personal paradigm, and therapeutic process, AR developers may think about how to build interactive models and interactive levels between MARE and GPs in different environments. The learning materials in different environments must be designed and developed.

Another implication of MARE for GP educators and researchers is the new technology and learning activity supported by learning theory, which corresponds to technology characters. GP educators and researchers may integrate it in their instructional practice. They can use the list of broader opportunities of MARE outcomes to compare with their students' learning needs to design an app. The framework could be used to guide other drug or therapeutic intervention education.

Conclusions

Due to the traditional teaching focus on recalling facts, health care professionals face the challenge of transforming knowledge into practice in health care settings. AR could provide a means to resolve this challenge, but it lacked a theory-guided design. Most AR apps still use traditional learning activities—see one, do one, teach one—in medical education, which hinders its educational function.

This paper has described a framework for guiding the design, development, and application of MARE to health care education. This includes consideration of a foundation, a function, and a series of outcomes. The foundation based upon three learning theories enhances the relationship between practice and learning. The function constituted by suggested learning activities and the requirements of the learning environment from the foundation and AR characteristics can amend the gap in the learning outcomes and medical learners' personal paradigms. The learning outcome, which combines Miller's pyramid and Bloom's taxonomy, can clarify the objectives and expectations and avoid teaching pitched at the wrong level [29].

Furthermore, we used a global health challenge—antibiotic resistance—as an application example and chose one important aspect that is the general practitioners' rational use of antibiotics, to which to apply the MARE framework. With this framework, the expected abilities of GPs' rational use of antibiotics are described specifically and may easily be executed and evaluated. The abilities were compared with the GP personal paradigm to solidify GP practical learning objectives and to help design learning environments and activities. Future work will focus on the implementation of the proposed framework by developing a mobile phone-based AR app for GP training and for conducting evaluations in China.

Conflicts of Interest

None declared.

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Abbreviations

AC: cognition within the action level
AMEE: Association for Medical Education in Europe
AR: augmented reality
AS: skill within the action level
CC: cognition within the competency level
CFAM: conceptual framework analysis method
CINAHL: Cumulative Index to Nursing and Allied Health Literature
CS: skill within the competency level
ERIC: Education Resources Information Center
GP: general practitioner
GPS: global positioning system
ICT: information and communications technology
ISO: International Organization for Standardization
KC: cognition within the knowledge level
KS: skill within the knowledge level
MARE: mobile augmented reality education
P-diagnosis: personal style of diagnosis
P-drugs: personal style of drugs
P-prescription: personal style of prescription
P-treatment: personal style of treatment
PC: cognition within the performance level
PS: skill within the performance level

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Original Paper

Maintaining a Twitter Feed to Advance an Internal Medicine Residency Program's Educational Mission

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Abstract

Background: Residency programs face many challenges in educating learners. The millennial generation's learning preferences also force us to reconsider how to reach physicians in training. Social media is emerging as a viable tool for advancing curricula in graduate medical education.

Objective: The authors sought to understand how social media enhances a residency program's educational mission.

Methods: While chief residents in the 2013-2014 academic year, two of the authors (PB, AN) maintained a Twitter feed for their academic internal medicine residency program. Participants included the chief residents and categorical internal medicine house staff.

Results: At the year's end, the authors surveyed residents about uses and attitudes toward this initiative. Residents generally found the chief residents' tweets informative, and most residents (42/61, 69%) agreed that Twitter enhanced their overall education in residency.

Conclusions: Data from this single-site intervention corroborate that Twitter can strengthen a residency program's educational mission. The program's robust following on Twitter outside of the home program also suggests a need for wider adoption of social media in graduate medical education. Improved use of data analytics and dissemination of these practices to other programs would lend additional insight into social media's role in improving residents' educational experiences.

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KEYWORDS

social media; medical education; Twitter messaging; Internet/ethics

Introduction

The current learning environment for internal medicine residency contains potential obstacles to learning: duty hour restrictions, training at multiple sites, increasingly complex patients, and pressures for clinical productivity and timely discharge. Moreover, our trainees have evolved; the so-called millennial generation may require more interactive learning experiences and may favor technology-driven learning platforms [1]. The vast majority of millennials use social media personally and professionally, often accessing sites multiple times daily [2]. As residents face increasing competition for their attention, residency programs need to reconsider how they deliver educational offerings and reach trainees. Social media offers a novel approach to keep contemporary residents informed, to disseminate teaching materials, and to interact with learners.

We tested the use of a novel social media initiative—specifically, a Twitter feed—to enhance the education of our residents and the mission of our internal medicine residency program. A recent systematic review explored the role of social media in medical education; results of social media initiatives were largely mixed [3]. These initiatives resulted in increased feedback to learners and more learner satisfaction, but had equivocal effects on knowledge promotion [3]. The majority of these studies examined medical students; thus, few compelling data exist on the use of social media as a teaching tool in residency education, making this area ripe for testing and evaluation.

To our knowledge, no residency program has reported on its experience or outcomes in using social media to advance the program's educational mission. Herein we describe our implementation strategy for using Twitter and report on its reception among residents. We specifically sought to understand Twitter's value as an extension of our teaching conferences and as a more general educational resource for residents.

Methods

Overview

We conducted our educational intervention in a single internal medicine residency program at an academic medical center over one academic year. The intervention was led by the chief residents, and residents voluntarily participated on Twitter at their convenience.

Our program includes 95 categorical residents. During the intervention, our residents rotated through three hospitals on two campuses. This project represents a pilot curricular innovation. Regarding ethical approval, we have obtained Institutional Review Board (IRB) exemption for this study.

Logistics

We selected Twitter for our platform based on its efficiency, propensity for publicity, its rapid growth, and its novelty. First, a well-curated Twitter feed can offer succinct, timely educational material for busy residents, including program-specific announcements, educational materials, and discussion points on the latest medical headlines. Next, because websites are static and require active maintenance, they do not promote learner engagement or the interactivity that Twitter offers. Finally, a Twitter feed improves the visibility of a program's academic activities, including publicly highlighting the quality and diversity of teaching conferences. We could also promote residents' publications, research posters, teaching awards, and community service work. This publicity may also represent a powerful recruitment tool. Table 1 shows a brief glossary of Twitter terminology.

We launched our @Medchiefs Twitter account in July 2013 while two of the authors (PB, AN) served as chief residents and the third author (VA) served as associate program director for the University of Chicago Internal Medicine Residency Program. Only the chief residents had the account's password. We linked our Twitter account to Facebook, and thus all of our tweets were also simultaneously broadcasted to our followers' Facebook feeds. We also embedded the Twitter feed directly into our chief residents' website [4]. Because our website hosts our conference calendar, resident team schedules, vital administrative policies, and service rules, most residents access the site at least daily.

Table 1. Brief glossary of Twitter terminology.

Term	Meaning
@Username	Designation of a Twitter user; usernames always preceded by an @ sign
Tweet	*Noun:* A message consisting of 140 characters that is publicly displayed on the user's timeline *Verb:* To post a brief message on one's own timeline
Retweet	*Verb:* To repost another user's message verbatim to one's own timeline
Timeline	The running feed of messages posted or retweeted
Followers	The group of other users who has voluntary elected to follow one's own timeline
Hashtag	Designation of an indexed keyword; a searchable term or topic on Twitter

Time Invested in Twitter

We estimate that the chief residents dedicated 30 to 60 minutes daily to actively maintaining our feed. This time included reviewing other users' posts, messaging followers, and queueing up tweets for later dissemination. Additionally, we often tweeted in real time during conferences, such as weekly Department of Medicine Grand Rounds.

Establishing or Using Hashtags

By searching specific "hashtags," Twitter users can quickly find tweets or users within specific areas of interest. When possible, we applied hashtags to conference tweets such as #grandrounds. After reaching out to other programs on Twitter and reviewing hashtag trends, we settled on the nascent #AMReport to designate tweets from our internal medicine morning report. We also created a program-specific hashtag, #UCIMR, to encourage our residents to reference our program online.

Types of Tweets and Their Purposes

We loosely adhered to our own "rule of thirds" when tweeting; a balanced number of tweets pertained to resident education, recognition of our program's academic activities, and outward promotion.

Tweets about our morning report constituted the greatest number of indexed tweets; a total of 31% of our tweets related to the morning report conference. Tweets were used to broadcast teaching points from our morning report and summarize key features of the case.

In addition, tweets from teaching conferences linked to relevant medical literature discussed, and occasionally shared, educational radiographs, computerized tomography (CT) scans, or pathology slides from interesting cases. Any patient-related materials that were shared were stripped of all identifiers to avoid Health Insurance Portability and Accountability Act (HIPAA) violations.

Because resident-prepared morning report cases were reviewed by chief residents in advance, “tweetable” teaching points were prescheduled for broadcasting during the conference via Hootsuite, a third-party social media application. Using this approach prevented chief residents from being distracted during the conference and also offered the opportunity to reflect on the most valuable teaching points for each case.

We also tweeted relevant news for our residents by discriminating which medical headlines would apply most to our residents. In addition, we highlighted institution-specific accomplishments and examples of our faculty physicians being recognized in national and global forums.

Advancing House Officer Recruitment

We recognized that our Twitter feed might also buttress our recruitment efforts. By having applicants follow us during the recruitment season, we could continually highlight our robust academic activities and dedication to resident education. As such, during the 2013-2014 interview season, we distributed flyers promoting our Twitter feed to all applicants on their interview day.

Survey of Residents

At the end of the 2013-2014 academic year, we conducted a brief 14-item survey on our residents’ use patterns with our Twitter account. Our survey asked residents how frequently they viewed the Twitter feed, how informative they found tweets, and how valuable they found the intervention. Our IRB determined this survey-based study to be exempt.

Online Audience

Both Twitter and third-party companies Hootsuite and Simply Measured provide a number of metrics on followers and online activities. These metrics include online influence of followers, approximate locations of followers, and popularity of individual tweets. This online data was retrieved on July 23, 2014, approximately one year after the inception of our account.

Results

In our first year, we amassed a following of more than 1000 Twitter users; we grew our global following by 3 users per day. At the end of the 2013-2014 academic year, we identified at least 27.1% (35/129) of our current residents, preliminary interns, and chief residents among our Twitter followers. We also published over 1000 tweets, or about 3 tweets per day. Our messages generated a total of 782 retweets.

The largest segment of our followers consists of health professionals as evidenced by the four most common keywords in our followers’ profiles: *medicine*, *medical*, *health*, and *physician*. Only 35% of our 1091 followers access Twitter from our program’s time zone; this data suggests that most our followers have no formal connection to our home institution.

Our survey on attitudes and use of the Twitter feed was completed by 61 of 95 of our categorical medicine residents (64% response rate). Of 61 responding residents, 33 (54%) residents reported having a Twitter account. However, the majority of our residents (36/61, 59%) reported using Facebook or our website as their preferred way of accessing our Twitter feed. Most residents (47/58, 81%) reported reading our tweets at least once per week, but only 11% (7/61) of our residents accessed the feed daily. The majority of our respondents (42/61, 69%) agreed that our Twitter feed enhanced their education in residency.

Tweets about our morning report were well received with 84% (51/61) of our residents reporting morning report tweets as occasionally or often informative. Most residents (43/61, 70%) agreed that our morning tweets captured the major teaching points. Interestingly, our tweets about medical news and the latest literature garnered greater interest, with 87% (53/61) of our residents finding these tweets informative.

Additional survey data on our intervention is found in Table 2.

Table 2. Survey of categorical medicine residents regarding Twitter use and its roles in advancing the educational mission (n=61).

Survey item	n (%)
Reported having personal Twitter account (number of respondents)	33 (54)
Twitter feed's contribution to educational mission	
Role of Twitter (number in agreement)	
Helps residents remember teaching points from the morning report	39 (64)
Captures the major teaching points from the morning report	43 (70)
Makes residents feel less removed from the residency program during external rotations (off-campus hospital, emergency ward, etc)	38 (62)
Enhances overall education in residency	42 (69)
Category of tweets (number that rated tweets as informative)	
Morning report	51 (84)
General medical information	53 (87)
Grand rounds	44 (72)
Residents' accomplishments, social events, and other institution-specific information	49 (80)

Discussion

Principal Findings

Maintaining a residency-run Twitter feed appears to have educational value both internally and externally. Our survey data demonstrates that Twitter was a frequently accessed and appreciated educational resource for residents. Moreover, our robust following outside of our home institution suggests a greater need for resident-directed educational resources in social media.

Though maintaining a Twitter feed requires an additional investment of a chief resident's time, we believe social media's strengths in reaching learners justify the effort. Although the educational cornerstone of our residency program has been live teaching conferences, residents have competing priorities that limit attendance. For example, in 2013-2014, our average resident was present for only 48% of conferences they were eligible to attend (excluding post-call days, clinic days, and days off). Giving residents an alternate means of receiving educational material thus represents an important service.

We opted for voluntary participation in our intervention for at least two practical reasons. Most importantly, we wanted to respect residents' limited time. Additionally, we wanted to use Twitter as an adjunct to—and not a substitute for—our more traditional educational offerings. We felt that compulsory participation could potentially detract from participation in other valuable and mandatory curricula including live conferences and Web-based learning modules.

Our work has some important limitations. Most notably, this intervention occurred at a single site in a single residency program; thus, our results may not be generalizable to all types of medical education settings. Additionally, we did not directly compare Twitter to other educational interventions and thus cannot comment on social media's relative value in supporting our program's curricula. Our survey data also relies on self-report of frequency of use rather than actual quantification of use. Finally, we did not directly examine Twitter's ability to promote knowledge acquisition and retention.

Professionalism and Legal Concerns

Concerns about professional boundaries and patient privacy might deter residency programs from engaging in social media. Fortunately, guidelines on professional use of social media can be found in a position paper by the American College of Physicians and the Federation of the American Colleges [5], and other tools for understanding professionalism issues are available in the Association of American Medical Colleges' (AAMC) digital literacy toolkit [6]. Many institutions also have their own social media policy. Generally, such guidelines emphasize the sanctity of patient privacy. Experts recommend a "pause before posting" approach when using social media; a brief reflection on a message's appropriateness often serves as an adequate checkpoint. These general rules of engagement provide an excellent framework for managing a residency program feed.

As program leaders, chief residents are well positioned to role model the use of social media and understand the responsibility and care required to manage a medium prone to misconduct. For example, while we occasionally posted interesting images from case conferences or teaching services, all images were completely deidentified and posted asynchronously to the patient's hospitalization. Likewise, when tweeting educational materials and original articles from journals, we maintained compliance with fair use by sharing only small parts of published works.

Future Work

To develop a better understanding of the impact of our program's Twitter account, we would like to expand the use of data analytics in the coming academic years. Tools embedded in Twitter or offered by third parties allow for meaningful data extraction including the times of day that followers interface with our account and the popularity of specific tweets. These data may better inform future programs on how to best use social media to reach residents.

Analysis of tweets by hashtags would provide additional insight on the content and potential uses of Twitter in resident education. Hashtags likely represent the easiest way to standardize tweets across residency programs. Though other authors have recently analyzed the use of academic conference-specific hashtags on Twitter [7,8], we are not aware of any analysis of hashtags used for regular resident teaching conferences such as the internal medicine #AMReport. Widespread adoption of specific hashtags like #AMReport would create a standardized tweet format and would facilitate large-scale data collection across multiple programs.

Conclusions

Although recent systematic reviews have relied on low-level outcomes to assess social media's role in medical education and higher education [9], we believe this medium represents a major frontier in education. We encourage other residency programs to invest the time to maintain a Twitter feed. As our data show, a program-run Twitter account can serve as a meaningful educational tool for the millennial resident.

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Conflicts of Interest

None declared.

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Abbreviations

AAMC: Association of American Medical Colleges
CT: computerized tomography
HIPAA: Health Insurance Portability and Accountability Act
IRB: Institutional Review Board

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Original Paper

Go Where the Students Are: A Comparison of the Use of Social Networking Sites Between Medical Students and Medical Educators

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Abstract

Background: Medical education has grown beyond the boundaries of the classroom, and social media is seen as the bridge between informal and formal learning as it keeps students highly engaged with educational content outside the classroom.

Objective: The purpose of this study is to explore the perceptions of medical educators and medical students regarding the use of social media for educational purposes.

Methods: Both groups (medical educators and students) were invited to take a survey. The surveys consisted of 29 questions, including Likert-style, multiple choice, yes/no, ranking, and short answer questions. The survey forms and statistics were built using Google Drive analytics with the free Spanning Stats module. To compare between professors and students, results were exported to a Microsoft Office Excel spreadsheet (Microsoft Corp, Redmond, WA). The study protocol was approved by The Ottawa Health Science Network Research Ethics Board (OHSN-REB:20140680-01H).

Results: The overall response rate to the survey was 40.9% (63/154) for students, and 36% (72/200) for medical educators. The majority of educators (79%, 57/72) and students (100.0%, 63/63) had presence on social networking sites (SNSs). Only (33% 19/57) of educators used SNSs with their students, the most used sites were Facebook (52%, 10/19) and Twitter (47%, 9/19), followed by LinkedIn (21%, 4/19), Google+ (16%, 3/19),YouTube (11%, 2/19), and blogs (11%, 2/19). Facebook (100%, 63/63), YouTube (43%, 27/63), Twitter (31%, 20/63), and Instagram (30%, 19/63) were the sites most commonly used by students. The educators used SNSs mainly to post opinions (86%, 49/57), share videos (81%, 46/57), chat (71%, 41/57), engage in medical education (68%, 40/57), take surveys (24%, 14/57), and play games (5%, 3/57). On the other hand, students used SNSs mainly to chat with friends (94%, 59/63), for medical education purposes (67%, 42/63), to share videos (62%, 39/63), to post opinions (49%, 31/63), to take surveys (11%, 7/63), and to play games (6%, 4/63). Most educators (67%, 38/57) do not use social media in their education Although most of the educators (89%, 17/19) and students (73%, 46/63) found the use of social media time-effective, that it offered an inviting atmosphere (89%, 17/19 and 70%, 44/63), and that it enhanced the learning experience (95%, 18/19 and 70%, 44/63), both groups stated that they had colleagues who refused to use social media. The detractors' concerns included privacy issues (47%, 18/38), time-wasting (34%, 13/38), distraction (21%, 8/38), and that these media might not be suitable for education (11%, 4/38). When it came to using SNSs with the students, the educators most often used SNSs to post articles (42%, 8/19), explanatory comments (31%, 6/19), and videos (27%, 5/19).While students preferred the following posts : Quizzes (87% 55/63), revision files (82% 52/63) and explanatory comments (29% 21/63).

Conclusions: Although social media continue to grow, some educators find that they do not offer suitable modes of learning. However, it is important to acknowledge that there are persistent differences in technology adoption and use along gender, racial, and socioeconomic lines; this is often referred to as the "digital divide". The current study shows that students prefer certain posts like quizzes and revision files, while educators are focused on posting videos, articles, and explanatory comments. Medical educators are encouraged to focus on the students in a way to minimize the gap between learners and educators. It will remain our responsibility as educators to focuson the student, use SNSs at their fullest, and integrate them into traditional Web-based management systems and into existingcurricula to best benefit the students.

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KEYWORDS

social media; e-learning; innovations in medical education

Introduction

Information and communication technologies (ICTs) have evolved tremendously over the last few decades, bringing with them a new perspective on methods of teaching and learning. Currently, social networks are used by millions of users, most commonly adolescents, for a variety of purposes, such as chatting, socializing, posting, and most interestingly, learning [1,2]. Medical learning has grown beyond the boundaries of the classroom and now social media is seen as the bridge between informal and formal learning as it keeps the students highly engaged with educational content when not in the classroom [3].

In recent years, new Web-based social media have been portrayed as placing the learner at the centre of knowledge networks by providing expertise that can potentially lead to new forms of learning despite the fact that these media make no educational promises. Educators have advocated integrating Facebook, Ning, and other sites into kindergarten to grade 12 (K-12) academic life [4]. Advocates have also promoted social media use as part of a connectivist learning theory. This recent move elevates social and communicative connections to the level of an epistemic category central to learning processes. In other words, social media learning empowers students [5,6]. This type of learning is characterized not only by greater autonomy for the learner but also by changing roles for the teacher; indeed, a collapse of the distinction between teacher and student altogether is indicative of connectivist learning [6].

Many teachers have adopted an everyday practice of incorporating digital technologies in the classroom and extending learning beyond the traditional boundaries of the institution. The rapid advance of technology is driving educators to implement tools they may have only recently learned. Most college age students, otherwise known as digital natives, Generation Y (Gen Y), Net Generation (Net Gen), and Millennials [7] are far ahead of teachers in technology usage and they are demanding that technology be used within the classroom. This younger generation of students has spent their entire lives surrounded by and using computers, video games, digital music players, video cameras, mobile phones, and all the other toys and tools of the digital age [8].

Incorporating digital technology into everyday study has changed not just the teacher's role but also the way students learn [9]. Now students can assume more responsibility for their own learning, access a vast pool of knowledge, and learn anywhere at their own pace. As well, they can share knowledge and experiences, communicate with their peers and teachers, and enhance their learning experiences.

Experts in any field are more accessible than ever before, thanks to social media. They share their ideas and experiences in videos, articles, and so on. Thus, even before first encountering students, teachers can provide an insight into the professional world and prepare students for their studies. Students get the chance to "meet" their professors and their classmates even before arriving on campus.

One of the major advantages of social media tools is the creation of community. Social media fosters communication, engagement, and collaboration [10-12]. A community can be created locally for a particular class, university, or it can extend beyond a single campus using a virtual world, such as Second Life [12]. This way of communication is well-suited for the lives of college-age students, Millennials who were born in the technology age and who are very technology savvy, despite the debate that using technology does not necessarily mean that the user understands technology [13].

However, with the growing amount of time that youth are spending on social networking sites (SNSs), do educators consider these sites to be of educational value? The purpose of this study is to compare the use of social media as an educational tool by medical students versus medical educators.

Methods

Overview

The infrastructure of the Faculty of Medicine at the University of Ottawa is designed to allow free WiFi Internet access for all employees and students anywhere on the campus. At the University of Ottawa, online support for courses includes teaching materials that are available through a learning management system. The study protocol was approved by The Ottawa Health Science Network Research Ethics Board (OHSN-REB: 20140680-01H).

Recruitment

Professors of different medical specialties (N=200) and second year medical students (N=154) were surveyed regarding their use of SNSs as an extracurricular way of enhancing the learning experience. Survey questions were based on the current literature [14-17] and optimized with input from faculty and medical student focus groups.

Study Structure and Statistical Analysis

The surveys consisted of 29 questions including Likert-style, multiple choice, yes/no, ranking, and short answer questions. The survey forms and statistics were built using Google Drive analytics with the free Spanning Stats module.

The survey questions were divided into the following sections, each of which approached a concern about professors’ and students’ use of social media (1) social media presence, (2) purpose of social media use, (3) frequency of social media access, (4) the devices used for social media access, and (5) perceptions of social media use in education.

The frequency of social media use was the number of times the user accessed SNSs in a given hour, day, week, or month. With respect to the medium of social media access, laptop, desktop, mobile phone, and tablet were the devices listed. Medical educators and students were asked about their reasons for using social media in general and for educational purposes in particular. Respondents’ opinion about using social media in education were tested by asking them to rate on a Likert scale, ranging from strongly disagree to strongly agree (Textbox 1).

In addition, participants were asked about their concerns with using social media in education. To compare professors and students, results were exported to a Microsoft Office Excel spreadsheet (Microsoft Corp, Redmond, WA).

Textbox 1. Statements rated on a Likert scale.

Statement

1. Social media can be used as a suitable learning environment.
2. Social media sites are more accessible than other ways of communication.
3. I am aware of privacy settings that limit access to personal information.
4. Social media provide an inviting atmosphere that encourages me to participate.

Results

The overall response rate to the survey was 40.9% (63/154) for students and 36.0% (72/200) for medical educators.

Medical Educators

Of the medical educators who participated, most were clinicians (52%, 37/72), full-time professors (26%, 19/72), part-time professors (13%, 9/72), and others (10%, 7/72) (eg, teaching assistants and sessional lecturers), and the majority dedicated more than 100 hours per year to their teaching (55%, 40/72). Some participants (21%, 15/72) did not have a presence on any SNSs; among those who did, the most frequently used sites were Facebook (61%, 35/57), LinkedIn (47%, 27/57), Twitter (46%, 26/57), Google+ (30%, 17/57), and YouTube (22%, 12/57), followed by other sites including Pinterest, Instagram, and Tumblr (Table 1).

Table 1. Students and medical educators social networking sites (SNSs) use by type of media.

SNSs	Users, n (%)	
	Medical students (n=63)	Medical educators (n=57)
Facebook	63 (100%)	35 (61%)
YouTube	27 (43%)	12 (22%)
Twitter	20 (31%)	26 (46%)
LinkedIn	13 (21%)	27 (47%)
Instagram	19 (30%)	5 (8%)
Pinterest	11 (18%)	10 (18%)
Google+	8 (13%)	17 (30%)
Reddit	5 (8%)	1 (2%)
Tumblr	4 (6%)	1 (2%)

The educators used SNSs mainly to post opinions (86%, 49/57), share videos (81%, 46/57), chat (71%, 41/57), engage in medical education (68%, 40/57), take surveys (24%, 14/57), and play games (5%, 3/57) (Table 2). Most educators (67%, 38/57) did not use social media in their education. They expressed concerns such as privacy issues (47%, 18/38), time-wasting (34%, 13/38), distraction (21%, 8/38), and that these media might not be suitable for education (11%, 4/38). Some educators even mentioned that they were unaware of social media use in education (29%, 11/38).

Table 2. Students' and medical educators' use of social networking sites (SNSs).

Uses of SNS	Users, n (%)	
	Medical students (n=63)	Medical educators (n=57)
Medical education	42 (67%)	13 (23%)
Play games	4 (6%)	3 (5%)
Chat	59 (94%)	45 (71%)
Share videos	39 (62%)	40 (70%)
Post opinions	31 (49%)	54 (95%)
Take a survey	7 (11%)	15 (26 %)

Of the educators who used SNSs with their students, the most used sites were Facebook (52%, 10/19) and Twitter (47%, 9/19), followed by LinkedIn (21%, 4/19), Google+ (16%, 3/19), YouTube (11%, 2/19), and blogs (11%, 2/19). About 32% (6/19) of educators logged into their accounts daily, 21% (4/19) logged in a few times per week, 5% (1/19) logged in weekly, and another 5% (1/19) logged in a few times per month. Finally, 21% (4/19) logged in only once per month and 16% (3/19) rarely logged into their accounts (Table 3).

When it came to using SNSs with the students, the educators most often used SNSs to post articles (42%, 8/19), explanatory comments (31%, 6/19), and videos (27%, 5/19). Others used SNSs to post lecture comments (31%, 6/19), book recommendations (31%, 6/19), revision files (21%, 4/19), quizzes (8%, 3/19), and course related humor (16%, 3/19). Most participants (95%, 18/19) would recommend SNSs to their colleagues, and 80% (15/19) found social media to be more accessible than other ways of communication. Strong majorities also considered social media to be time effective (89%, 17/19), inviting (89%, 17/19), and an improvement in the learning experience (95%, 18/19). In addition, 79% (15/19) of participants stated that they had colleagues who refuse to use social media for educational purposes.

Table 3. Students and medical educators' frequency of logging into social networking sites (SNSs).

Frequency of logging into SNSs	Users, n (%)	
	Medical students (n=63)	Medical educators (n=19)
Lost count	21 (33%)	
Few times a day	32 (51%)	
Every hour	5 (8%)	
Few times per hour	5 (8%)	
Daily		6 (32%)
Few times per week		4 (21%)
Once per month		4 (21%)
Few times per month		1 (5%)
Rarely		3 (16%)

Medical Students

All of the students (100%, 63/63) had presence on SNSs. The most common used sites were Facebook (100%, 63/63), YouTube (43%, 27/63), Twitter (31%, 20/63), and Instagram (30%, 19/63). Other social networking sites followed, as shown in Table 1.

The students used SNSs mainly to chat with friends (94%, 59/63), for medical education purposes (67%, 42/63), to share videos (62%, 39/63), to post opinions (49%, 31/63), to take surveys (11%, 7/63), and to play games (6%, 4/63) (Table 2).

The devices that students used to access their accounts were laptops (94%, 59/63), followed by mobile phones (70%, 44/63), tablets (33%, 21/63), and desktops (11%, 7/63). With respect to the frequency of social media access, 51% (32/63) of students logged into their accounts a few times per day and 33% (21/63) stated that they received push notifications, as the account is always running on their mobile devices. Another 8% (5/63) logged into their accounts daily and 8% (5/63) a few times a day (Table 3).

The types of educational posts that students preferred are shown in Table 4. Most students (77%, 50/63) would recommend SNSs to their peers and 62% (39/63) stated that they have friends who refuse to use these sites mainly because of distractions; privacy issues were not the main concern as 88% (55/63) of the students stated that they knew how to adjust privacy settings. Most students (73%, 46/63) found social media to be a time-effective way of communication and 70% (44/63) found it an inviting atmosphere that improved their learning experience. However, 68% (43/63) of students stated that no other professor used social media as a way of communication with their students.

Table 4. Students' preferred types of educational posts (n=63).

Type of post	n (%)
Quizzes	55 (87%)
Revision files	52 (82%)
Explanatory comments	21 (29%)
Post-lecture questions	14 (22%)
Course-related humor	14 (22%)
Book/article recommendations	14 (22%)
Videos	9 (14%)

Discussion

Principal Findings

According to Coates:

> *Blended learning, integrating a variety of media to deliver teaching material to students is used by universities all over the world. It is associated with the use of Web tools such as email, podcasts, blogs, discussion boards, and a university learning management system. [18]*

These systems provide a Web presence for course instructors to manage the course material [18]. They also have the advantages of being student-centered, focused on the course material, no distractors, and no privacy issues. “No matter how those systems are developed to manage processes such as exams, assignments, course descriptions, and basic course material, they are not well-suited to some other activities such as problem-based learning” [19]. In addition, they lack the element of social connectivity which today’s students are familiar with [20].

The emergence of SNSs has raised questions about whether we should confine ourselves to course-integrated learning management systems or whether we should go where the students are. Educators do not want to integrate these tools into their curriculum just for the sake of technology [21]. However, today’s college-age students are the first generation to grow up with the Internet; they do not remember a time when it did not exist. They are technologically savvy and dependent upon the Internet. Therefore, educators must reach out and engage these students with social media and even join their communities or create similar ones [22,23].

The current study shows that there is a controversy about whether to use SNSs in general and in education. While 100% (63/63) of students had a presence on SNSs, only 79% (57/72) of medical educators were members of those sites and only 33% (19/57) used them with their students. These results are in accordance with the results of a survey conducted by the Babson Survey Research Group in collaboration with New Marketing Labs and the education-consulting group Pearson Learning Solutions. The survey was drawn from almost 1000 college and university faculty nationwide and found that more than 80% of professors used social media in some capacity. The survey noted that 30% of educators used social networks to communicate with students and more than 52% used online videos, podcasts, blogs, and Wikis during class time. It was also found that older faculty used social media at almost the same level as their younger peers [24] which contradicts our result that 67% (38/57) of medical educators who did not use SNSs in their teaching were in the older age group (age >50). Rank also subsumes age differences that exist among faculty; older people normally occupy the rank of associate or full professors. O’Shea [25] argues that the distinctions for adopting technologies are blurring the traditional dichotomies which now are best characterized as 5 groups of innovators, early adopters, early majority, late majority, and laggards. Indeed, one study found that age was a poor predictor of social media usage within a research context [26].

The use of social media is, however, increasing rapidly in the classroom [27]. Our study shows that Facebook, LinkedIn, and Twitter are the most popular sites for medical educators while for students, Facebook, YouTube and Twitter were the top 3 sites (Table 1). Educators used those sites mainly to post opinions, share videos, chat, and for medical education purposes, and students mainly used them to chat, for medical education purposes, to share videos, post an opinion, take a survey, or to play games (Table 2). For the 33% (19/57) of medical educators who used social media with their students, Facebook, LinkedIn, and Twitter were again the top 3 sites and they were mainly used to post articles, videos, and explanatory comments. Students, however, preferred the quizzes and the revision files.

There are several reasons that educators at the University of Ottawa were in favor of using SNSs with their students including (1) the ease of accessibility and connectivity with students, (2) the ease of disseminating information and accessing different audiences, (3) time flexibility and virtuality, (4) interactivity, (5) students’ reliable use of these sites, and (6) the ability to use the same material repeatedly.

The reasons students favor SNSs included (1) interactions with colleagues (asking/answering questions), (2) sharing resources, (3) accessibility, (4) post-lecture questions, (5) the ability to review quizzes before exams, and (6) the ease of tracking information.

Although most of the participants (medical educators and students) would recommend social media to their colleagues, the majority had colleagues who refuse to use SNSs for educational purposes. These colleagues were mainly concerned about privacy issues, distractions, and wasting time. Interestingly, some of the educators stated that they did not even know about social media use for educational purposes. Cheston et al [28] stated that social media tools can be used safely in medical education settings and that their use may have a positive impact on learner outcomes.

The results of the present study are in agreement with the results of Chen et al [29] who found that the use of social media in teaching is relatively scarce. Despite the limited use of social media in the academic world, research has supported the connectivism theory and found benefits of using social media if the technology is adapted for teaching [30,31]. Most faculties agree that the interactive nature of social media technologies create better learning environments and increase the communication with peers and students. However, concerns remain about distraction and privacy issues.

Our results contradict the results of Moran et al [32], who found that 90% of faculties used social media in courses they taught. Nearly two-thirds of all faculties in the Moran study used social media during a class session and 30% had posted content for students to view or read outside of class. Over 40% of faculty required students to read or view social media as part of a course assignment and 20% had assigned students to comment on or post to social media sites.

These findings demonstrate that SNSs are growing and are here to stay. However, it is important to acknowledge that there are persistent differences in social media use along gender, racial, and socioeconomic lines; the so-called digital divide [33], and those parameters need to be further explored.

Conclusions

Today's students grew up with the Internet and they don’t remember a time where it did not exist. They are communicating, learning, and adapting to the world via this relatively new way of communication. Although social media continue to grow, some educators find that they do not offer a suitable mode of learning. However, the current study shows that students prefer certain posts like quizzes and revision files, while educators are focused on posting videos, articles, and explanatory comments. Medical educators are encouraged to triage the students at the beginning of the semester and find out what their preferences are and focus on them in a way to minimize the gap between learners and educators.

Despite all the criticism, social media have the potential to build interactivity, engagement, and collaboration. It will remain our responsibility as educators to focus on the student, use SNSs at their fullest, and integrate them into traditional Web-based management systems and into existing curricula to best benefit the students.

Conflicts of Interest

None declared.

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Abbreviations

ICT: information and communication technology
SNS: social networking site

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Original Paper

Virtual Patients in a Behavioral Medicine Massive Open Online Course (MOOC): A Case-Based Analysis of Technical Capacity and User Navigation Pathways

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Abstract

Background: Massive open online courses (MOOCs) have been criticized for focusing on presentation of short video clip lectures and asking theoretical multiple-choice questions. A potential way of vitalizing these educational activities in the health sciences is to introduce virtual patients. Experiences from such extensions in MOOCs have not previously been reported in the literature.

Objective: This study analyzes technical challenges and solutions for offering virtual patients in health-related MOOCs and describes patterns of virtual patient use in one such course. Our aims are to reduce the technical uncertainty related to these extensions, point to aspects that could be optimized for a better learner experience, and raise prospective research questions by describing indicators of virtual patient use on a massive scale.

Methods: The Behavioral Medicine MOOC was offered by Karolinska Institutet, a medical university, on the EdX platform in the autumn of 2014. Course content was enhanced by two virtual patient scenarios presented in the OpenLabyrinth system and hosted on the VPH-Share cloud infrastructure. We analyzed web server and session logs and a participant satisfaction survey. Navigation pathways were summarized using a visual analytics tool developed for the purpose of this study.

Results: The number of course enrollments reached 19,236. At the official closing date, 2317 participants (12.1% of total enrollment) had declared completing the first virtual patient assignment and 1640 (8.5%) participants confirmed completion of the second virtual patient assignment. Peak activity involved 359 user sessions per day. The OpenLabyrinth system, deployed on four virtual servers, coped well with the workload. Participant survey respondents (n=479) regarded the activity as a helpful exercise in the course (83.1%). Technical challenges reported involved poor or restricted access to videos in certain areas of the world and occasional problems with lost sessions. The visual analyses of user pathways display the parts of virtual patient scenarios that elicited less interest and may have been perceived as nonchallenging options. Analyzing the user navigation pathways allowed us to detect indications of both surface and deep approaches to the content material among the MOOC participants.

Conclusions: This study reported on first inclusion of virtual patients in a MOOC. It adds to the body of knowledge by demonstrating how a biomedical cloud provider service can ensure technical capacity and flexible design of a virtual patient platform on a massive scale. The study also presents a new way of analyzing the use of branched virtual patients by visualization of user navigation pathways. Suggestions are offered on improvements to the design of virtual patients in MOOCs.

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KEYWORDS

computer-assisted instruction; education, medical; medical informatics applications

Introduction

Background

The rise of interest in massive open online courses (MOOC) is remarkable. What started as an experiment in connectivist learning theory turned, in just a few years, into a phenomenon involving several million participants and the most prestigious universities [1,2]. Even though the trend has met with criticism [3] and there are already signs of fading enthusiasm [4,5], the changes witnessed in terms of the openness of education to massive participation are unlikely to be reversed.

Health sciences, traditionally slower in adaptation of new trends in education, are inspired by these changes as well [6,7]. A recent systematic review identified nearly 100 health-related MOOCs conducted in 2013 [8]. The motivations of medical universities for participating in such initiatives varies but may involve reaching out to appropriate but less privileged learner groups, possibly to bridge the language gap between patients and their health care providers or to increase the impact and visibility of the university in a particular field [6-8]. MOOCs are also seen as a tool in the "flipped classroom" curriculum reform, which requires students to engage in self-directed online preparations prior to face-to-face learning activities. This frees up time for hands-on training, group work, and individual consultation with teachers on the campus [7,9].

The currently predominant type of massive open online courses, called xMOOCs, has been criticized for building on bite-sized video lecture clips, textbooks, and multiple-choice questions—regarded as a rather outdated form of learning [3]. This development can be partly explained by the decontextualized technical confines offered in generic-purpose MOOC environments. However, there are several discipline-specific information technology tools which could vitalize the learning activities without requiring much attention from the instructors. One of these tools, available for health training, is virtual patients [10].

Virtual patients have shown a positive effect on learning [11,12] and are increasingly used at medical faculties [13,14]. Although definitions vary, virtual patients are most commonly understood as interactive computer simulations of real-life clinical scenarios for medical training, education, or assessment [15]. Several types of virtual patients can be constructed, depending on the applied technology and target competency; these include virtual patient games, high fidelity software simulations, and virtual standardized patients [16,17]. To teach clinical reasoning and decision-making, the most common type involves interactive patient scenarios that employ simple Web-based technologies [17].

We began with a prior theoretical analysis of the idea of embedding virtual patients in MOOCs, from an educational point of view [18] and continued with a discussion of technical mechanisms for the integration [19]. We regarded the extension of platform functionality beyond the standard tools as a major risk considering the sheer numbers of students. Preparation for a MOOC thus requires recruiting a support team to clear pedagogical and technical hurdles [9]. From a different perspective, the great quantity of participants could also offer an opportunity to identify patterns in virtual patient use, which normally remains largely unnoticeable due to the small sample size of students in the traditional classroom. A recent systematic review of literature in the field of MOOCs has concluded that "while there is research into the learner perspective neither the creator/facilitator perspective nor the technological aspects are being widely researched" [20]. We aim to address these needs by reporting on our technical experience in organizing what to our knowledge is the very first health-related MOOC including virtual patients.

Objectives

The primary objective of this paper is to present an in-depth analysis of the technical preparations required to include virtual patients in a MOOC. This will inform the parameters for future preparatory tests and suggest solutions for dealing with the intensive usage of information technology infrastructure resources while offering a server-side educational component for a massive audience. The second objective is to identify ways of highlighting the different navigation pathways of virtual patient interactive use. We hope that this study will reduce the technical uncertainty related to such extensions, indicate aspects that could be optimized for a better learner experience, and also raise prospective research questions by describing indicators of virtual patient use on a massive scale.

In particular, we are interested in answering the following two research questions: (1) What are the information technology challenges and technical solutions for offering virtual patients in a MOOC? (2) How can user navigation pathways be presented for virtual patients integrated within a MOOC?

Methods

Setting

This report is a case study carried out at Karolinska Institutet (KI), a Swedish medical university, in the second half of 2014. KI was the first Scandinavian university to join the edX consortium launched by Massachusetts Institute of Technology and Harvard to create and disseminate MOOCs [21]. Once the agreement with edX was concluded in the summer of 2013, an internal call led to the selection of two courses for the first wave of KI MOOCs. One of them was "KIBEHMEDx: Behavioral

Medicine—a Key to Better Health," presenting the science of changing behavior to improve health and quality of life [22]. This course was selected as a target for introducing virtual patients due to its clinical, case-based character.

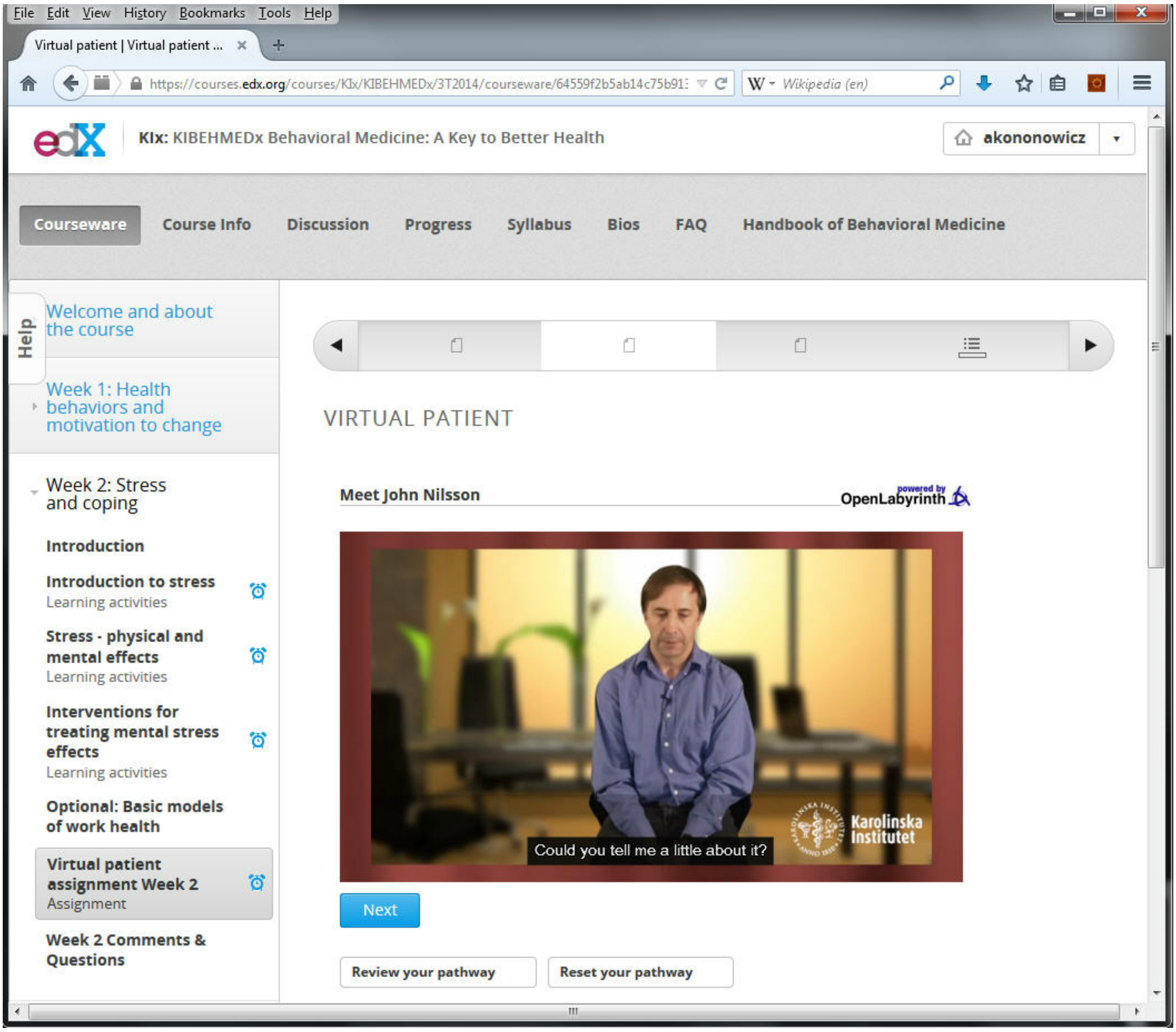
Being part of the edX consortium required using the edX MOOC platform to host the course [23]. The platform supports presenting videos, multiple-choice questions, and facilitation of online discussion; however, it has no direct support for presenting interactive patient scenarios. Our prior research has shown that this integration challenge can be resolved by using an IMS LTI-interface [19]. For the virtual patient platform we selected an open-source solution: OpenLabyrinth [24]. This platform is the most advanced, freely available interactive patient scenario system with a long history of use in educational activities and research projects [25-28]. The platform supports the branching paths navigation model, meaning that learners are presented with a clinical case in which they can select from a number of alternative options that lead to individual learning trajectories [29]. Version 3.1 was selected following a recommendation by the developer as the most stable release at the time the course was prepared. The standard graphical layout of the system was altered to fit the edX design using the built-in skin mechanism.

The Behavioral Medicine course was designed for a 5-week run. In order to increase active learning opportunities it was decided that weeks 2 and 3 would be illustrated by virtual patients in the form of interactive patient scenarios. The week 2 scenario dealt with treatment of stress-related symptoms; week 3 with treatment of sleep problems. These scenarios were presented as separate cases but both were connected by the story of John Nilsson, a high school teacher suffering from stress and sleeping problems (Figure 1).

The virtual patient scenarios consisted of 80 and 61 screen cards or nodes, respectively, containing text description, decision elements, free-text assignments, multiple-choice questions, and videos (Table 1). The videos were created for the purpose of this course and involved a professional actor, two clinicians, and a film team. Video length varied from 16 seconds to 6 minutes 39 seconds. All videos were hosted on YouTube and embedded in the virtual patient scenarios using an internal frame. Some of the videos from the first week (week 2 of the course) were repeated in the week 3 scenario, forming review nodes. Decision nodes represent screen cards that allow the user to select how to proceed, based on at least two options. The branched navigational structure of virtual patients was designed in the VUE (v3.2.2) editor [30] and then exported to OpenLabyrinth. The possibility of following the same branching option twice was blocked to prevent cycles. The virtual patient activity for each of the two course weeks was planned for approximately one hour. Students were asked to self-report, following the edX honor code, by indicating that they spent at least 30 minutes per week interacting with the virtual patient.

The Behavioral Medicine MOOC started on September 9, 2014, and lasted 5 weeks, until October 14. The week 2 virtual patient was available for the first time on September 16 and the week 3 virtual patient became available on September 23. All services were active for two more weeks (until October 28) for a tapering period.

Figure 1. Virtual patient presented in the edX Behavioral Medicine course.



Technical Infrastructure

The OpenLabyrinth system is successfully used at several medical universities worldwide. However, to the best of our knowledge, it has not been used as part of a large course yet. As a recent systematic review has shown, an average MOOC involves 43,000 enrollments, and there have been reports of courses with over 200,000 registered users [4]. The typical dropout rate is very high with just 6.5% of participants finishing the course on average [4]. It is also known that user activity is not evenly distributed, with large peaks before deadlines for graded homework [2]. Since MOOCs are often characterized by demands for computational power in bursts, we decided to use a cloud infrastructure as a solution that matches the expected requirements well.

Cloud computing is a way of providing computing resources as services that can be created on demand, usually in the form of virtual servers (machines). Clouds have been applied by industry to dynamically scale Web applications to respond to varying peaks in workloads. They have also been successfully used in scientific and healthcare applications, where they allow for obtaining computing resources quickly to compute intensive simulations or data analysis tasks [31,32]. In medical research, a good example is the Virtual Physiological Human (VPH)-Share project, which offers a cloud platform for hosting and sharing computational models of the VPH research community, providing on-demand access to computing services [33,34].

To evaluate the performance and scalability of OpenLabyrinth, we used Gatling (v1.5.5) [35], to carry out stress tests of the system on 8CPU/16GB RAM server using a simple virtual patient test case consisting of 10 nodes and content similar to that expected in the final version of the case. We simulated 50, 100, 150, and 300 users traversing three random paths, changing the nodes with one request per second on average. In the 300-user test, this resulted in 14 requests per second at the highest peak during the stress test time lasting 17 minutes. The number of 300 concurrent users was regarded as sufficient for the maximal load since a previous report from the 6.002x course, which had an enrollment rate of 154,000, indicated that the reported peak of activity per day was 5000 unique certificate earners; divided by 24 time zones this generated an estimate of slightly above 200 active users an hour [2]. To reflect the nonuniform distribution of users in time zones we increased the upper boundary to 300 users.

The stress tests showed a very good response time in all cases (around 100 ms), low RAM (max 460MB) and processor use (max 1.3CPU) but around one percent (0.66%) of requests for 300 concurrent users led to a 404-page error. This was traced to a database deadlock problem. The error rate for 50 users was significantly lower (0.02%). Since it was not feasible for us to find the source of the deadlocks in the given timeframe, we decided to mitigate the risk of this error by reducing the number of concurrent users using cloud technologies. The idea was to have more numerous but less powerful virtual servers to share the user requests in a balanced way and thus decrease the likelihood of database problems.

For the implementation we approached the VPH-Share project, specialized in offering cloud services for biomedical applications [34]. Their cloud management solution—Atmosphere [36]—enables flexible design of virtual server templates (images) and their execution as atomic services in a number of software and hardware configurations (CPU and RAM) [37]. We developed a virtual server template based on the Ubuntu (v13.10) Linux distribution (Apache v2.4.6; MySql v5.5.37; PHP v5.5.3) and with OpenLabyrinth (v3.1) preinstalled (Figure 2). A load balancer (nginx) was instantiated to evenly distribute user requests between template instances. For the start-up we decided to use four micro instances of virtual servers (1CPU; 512MB RAM) in parallel with the possibility of increasing this number in case of a higher than expected workload. The cloud infrastructure was hosted by Academic Computer Centre Cyfronet AGH in Kraków (Poland), running OpenStack cloud software [38] (Figure 3). The use of the VPH-Share platform should not be considered a limiting factor as it has many similarities in functionality with commercial providers like Amazon EC2, and the virtual server templates are in fact fully transferable between the solutions.

As an emergency backup solution in case of unexpected technical problems, we had prepared an alternative virtual server template consisting merely of the Web server with a preinstalled HTML version of the virtual patients, not requiring the database system. This version was designed by writing a script exporting OpenLabyrinth cases to a set of static HTML web pages. Obviously, this version had fewer computational requirements; however, it also had limitations in terms of restricted functionality, as tracing user sessions or recording students' answers was not possible. In the end it turned out to be unnecessary to use this template during the MOOC, but it provided security for the project team.

Figure 2. VPH Share cloud platform with virtual patient system templates prepared for the Behavioral Medicine MOOC and a running instance of one of the templates on a virtual server.

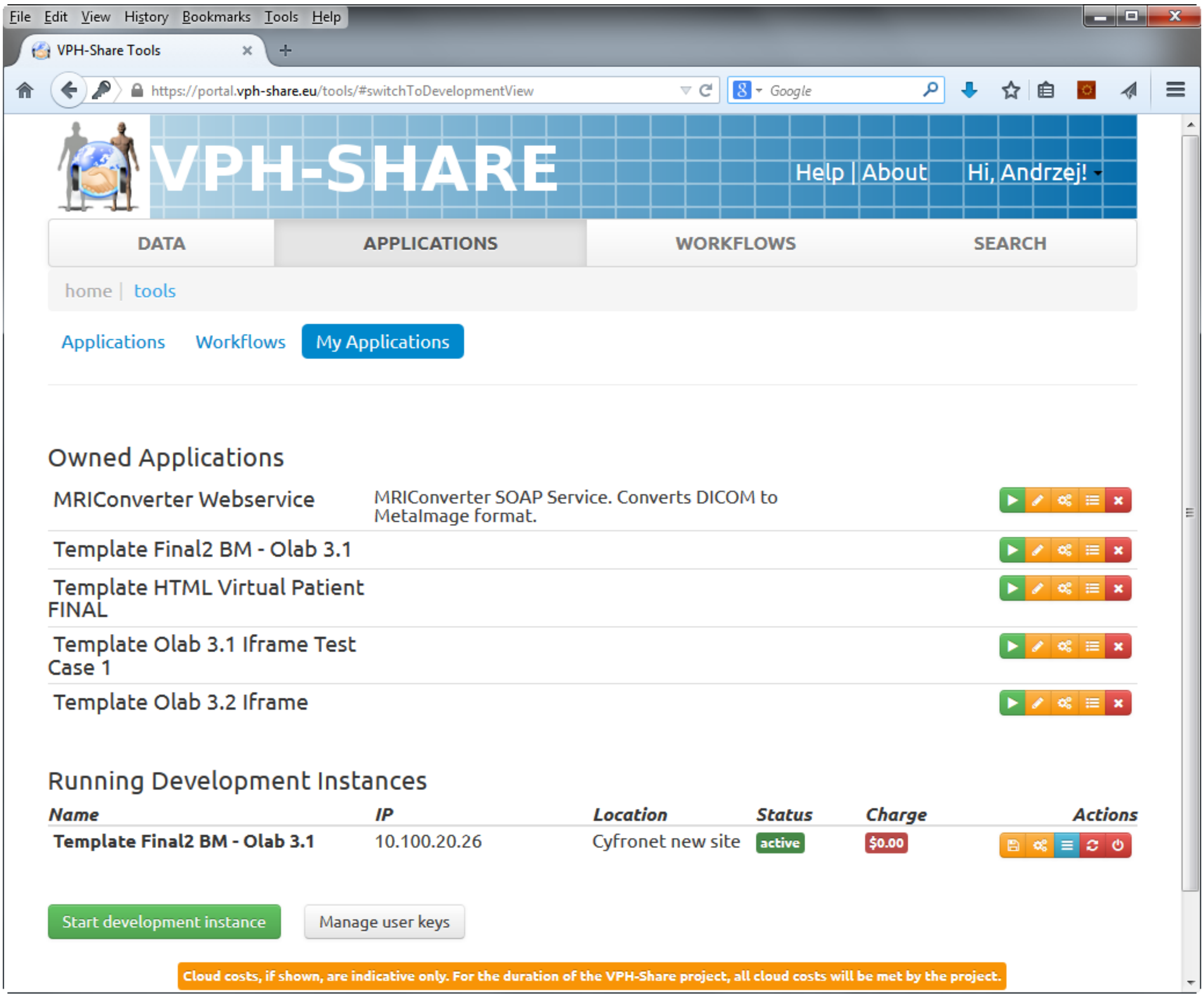
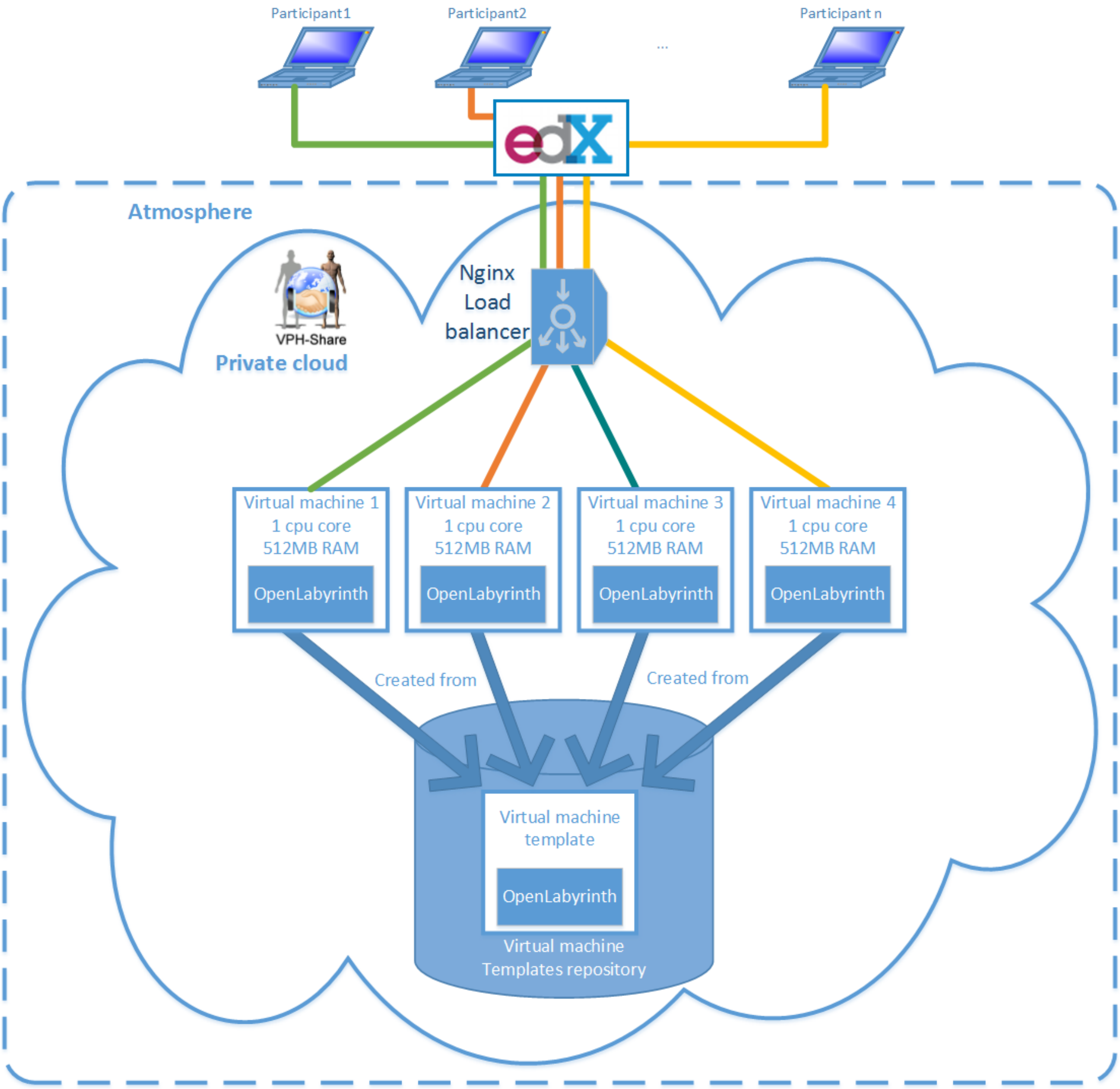


Figure 3. Cloud architecture for the Behavioral Medicine MOOC.



Data Collection and Analysis

Web server and database logs as well as user sessions were recorded in the OpenLabyrinth system. The data were archived and aggregated from the four virtual servers after the tapering period had ended. There was no need to add new parallel servers. The Web server logs were parsed using a simple Java language script and postprocessed in Excel (Microsoft). Spearman correlation coefficients were calculated in Statistica v10 (2010) (Statsoft), using a significance level of 5%.

User pathways were analyzed by an on-purpose project-designed analytic tool developed in Java by one of the authors of this article (AAK). The developed tool visualizes the results by displaying them as numerical and grayscale values in the navigation graph. The structure of the graph is read from VUE files used previously in designing the virtual patients. Next, the XML content from VUE files is copied and modified based on the user session statistics from OpenLabyrinth and once again opened in VUE to display the result. Four different types of visual analyses were generated: (1) number of visitors in each screen card of the virtual patient, (2) pathway exit points: percentage of visitors who ended the session in the given node, (3) time in seconds spent in each screen card on average, (4) percentage of visits selecting individual decision options and branching ability of decision nodes.

In order to evaluate participant satisfaction with the course in general as well as the virtual patient experience and to confirm the quality of technical capacity offered in the MOOC, the participants were surveyed for their opinions on using virtual patients via an anonymous questionnaire to which invitations were distributed immediately after the course. The Likert-scale questions were analyzed using Excel for descriptive statistics. Free-text comments detailing the technical issues encountered by course participants were analyzed qualitatively for recurring themes.

Data on user enrollment and declared completion were acquired from the edX platform statistics (edX insights). In this study, we did not trace the link between sessions and user demographics or learning outcomes and treated user data entirely anonymously. This type of research does not require explicit permission of an ethical review board according to Swedish law (Act 2003:460).

Results

General Statistics

The number of enrollments reached 19,236 but just 4586 (23.84%) logged in during the first week of the course. On the official closing date of the course (October 14), 2317 (12.05% of the total enrollment rate) and 1640 (8.53%) participants had declared their respective completion of the week 2 and week 3 virtual patients. This number kept growing after the course was officially closed in the tapering period. The honor code certificate for the whole course was earned by 740 participants, or 3.85% of the total number of original enrollments. The most frequent participant countries of residence were: United States (27.61%), India (8.97%), and United Kingdom (4.84%). See Multimedia Appendix 1 for a geographic breakdown of participation.

Server Load

Figure 4 presents the number of server requests per day in the course lifetime and tapering period. As planned, the virtual patient service started in the second week of the course. The focus of the course instructors on virtual patients was in week 2 and 3. The peak of activity in the virtual patient system was on September 23—the release date for the second virtual patient scenario—with 7768 page requests per day corresponding to 359 unique user sessions. During that day in the most active hour (17:00-18:00 CET) the service had 875 page requests (24 unique user sessions).

In general, the most active hour of the day was 18:00-18:59 CET with 181 server requests on average. The least active time was 07:00-07:59 CET with 84 server requests on average (Figure 5).

We also analyzed the number of errors reported in the Web server logs. Out of the 131,303 server requests, only 35 could be traced as having been caused by database problems (0.03%).

Figure 4. Virtual patient server requests per day in the Behavioral Medicine MOOC.

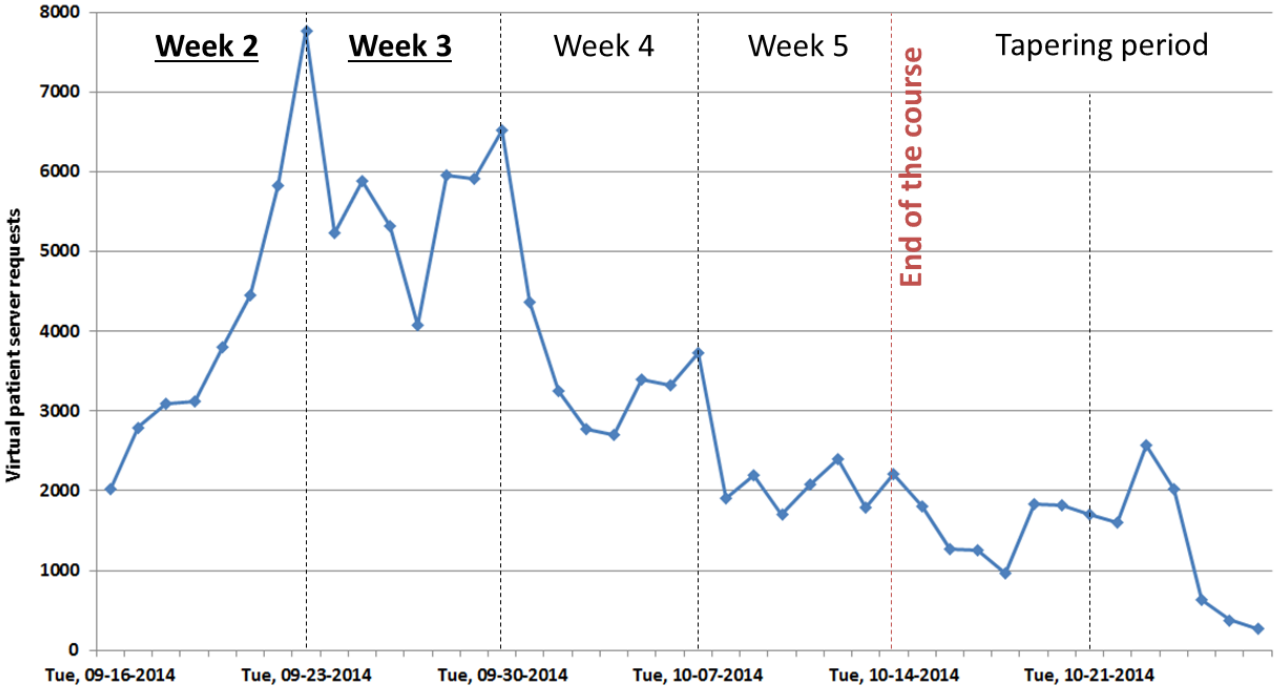
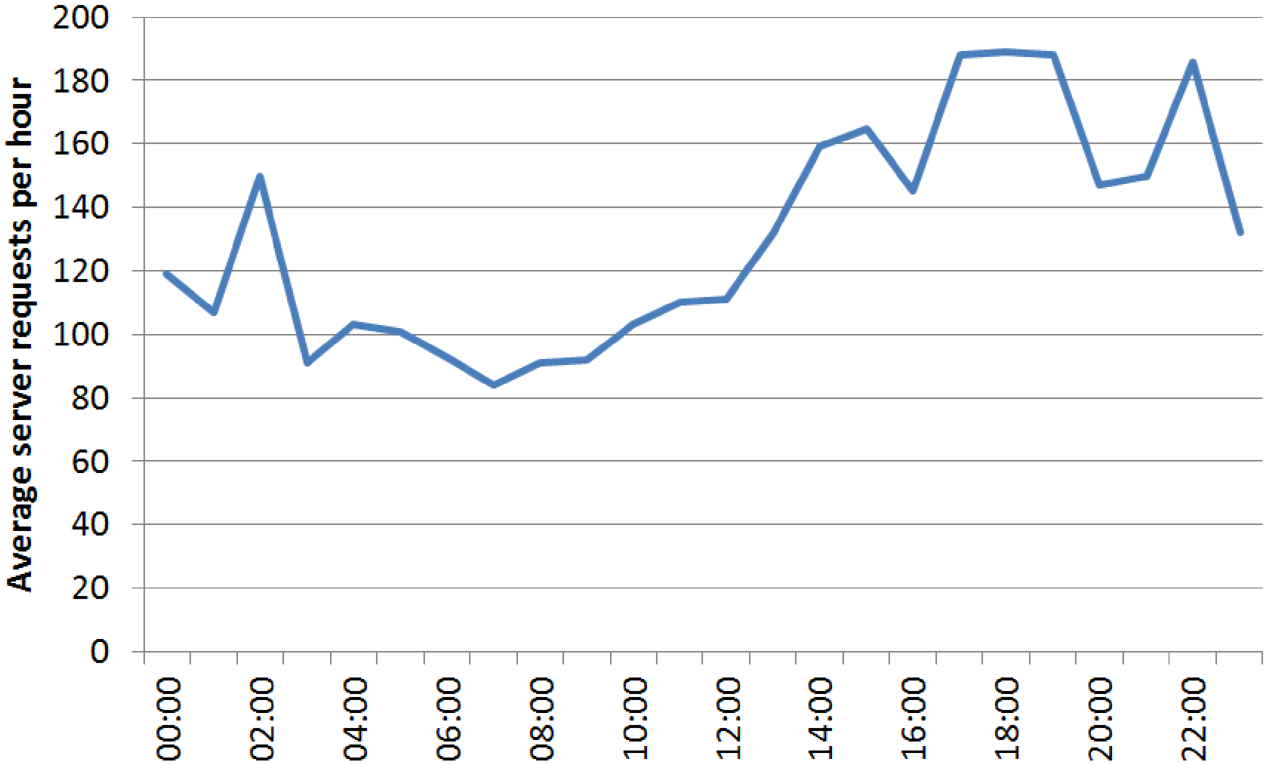


Figure 5. Average virtual patient server requests per hour in the Behavioral Medicine MOOC.



User Pathways

The analysis of the number of visitors to the virtual patient scenarios shows a relatively high number of initiated sessions: 3467 in week 2 and 2201 in week 3 (Figure 6). At the same time the bounce rate (number of users leaving just after opening the start page of virtual patients) is also high: 1994 out of 3467 (57.51%) in week 2 and 1486 out of 2201 (67.51%) in week 3. Around 75% of sessions ended before visiting 10% of the total number of screen cards in both virtual patients. The most popular pathway (and shortest at the same time) through the week 2 scenario is visible by the most intensively shaded line of nodes in the visualization in Figure 6. This pathway was designed by the case authors as containing the best options from a clinical point of view, based on course content. It consists of 30 screen cards. Four hundred twenty participants (n=420) reached the final nodes of the case. In week 3, the shortest and best path was also the most popular one. Three hundred forty-five (n=345) participants reached the final nodes of the week 3 case.

The frequency distribution of the number of visited screen cards in one session had a local peak around the length of the critical path (number of screen cards in the shortest pathway connecting the start and end nodes). The frequency distribution for week 2 had an additional peak around 51 nodes, corresponding to the group of students who selected a branch with 16 nodes for additional explanations. The frequency distribution of user pathways longer than the length of the critical path drops steadily, reaching the zero level at 79% (week 2) and 90% (week 3) of the total number of nodes in the scenarios.

Table 1 shows the time spent by users on average in different screen card types. Participants spent the most time (approximately 2 minutes) on screen cards requiring entry of a free text answer to a question. This occurred despite the fact that each free text question displayed a clarification stating that no individualized feedback would be provided in response to student entries. Interestingly, we observed a moderately strong correlation between the average percentage of viewed video time and shortest distance of the screen card to the start node ($R=0.55$; $P<.001$). The average time spent on video nodes was shorter than the actual length of the video when the node was closer to the start than the end of the interaction with the virtual patient but was longer than the actual length for videos closer to the end node.

Figure 6. Number of visitors in screen cards of week 2 virtual patient.

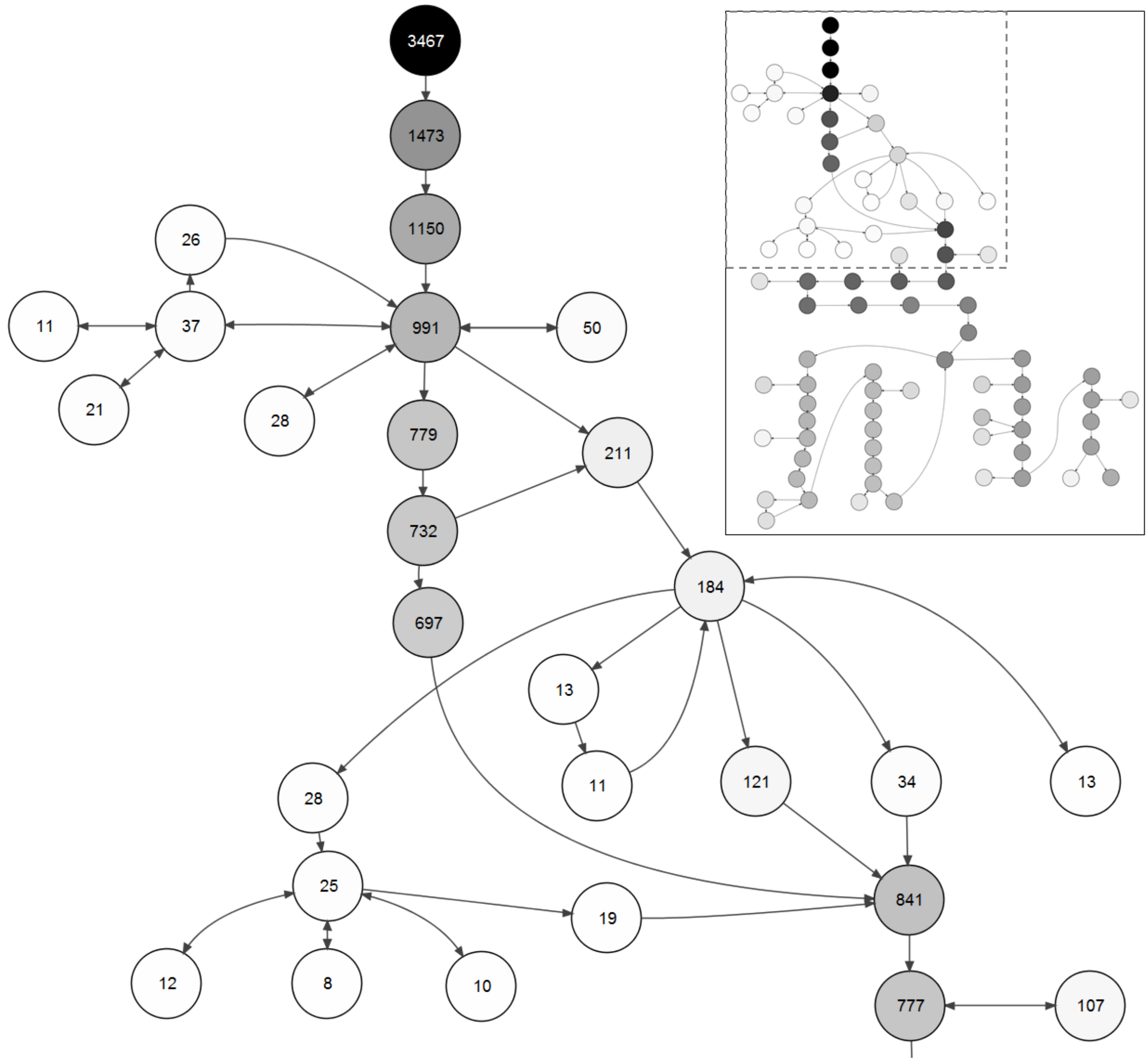


Table 1. Average time spent on screen card types.

	Week 2		Week 3	
Screen card type	Count	Time [s]	Count	Time [s]
Decision node	19	28.6	11	27.2
Free text question	6	120.3	5	131.6
Multiple choice question	1	66.4	2	23.1
Review	0	-	4	124.3
Text	35	17.5	25	20.4
Video	19	98.8	14	73.4

In the week 2 scenario, the shortest possible path from the start to the end node required 37 minutes, but the average session in which the case was completed (containing one of the end nodes) lasted 48 minutes. One hundred twenty-one (n=121) sessions that completed the virtual patient were longer than one hour. For the week 3 scenario, the shortest path consisted of nodes taking 27 minutes on average, where the mean case completion session was 39 minutes long, with 56 sessions longer than one hour.

Figure 7 shows visualization of exit points in the week 2 virtual patient, displaying the percentage of visitors who left the virtual patient after visiting the given screen card. The percentage is relative to the total number of users entering the node. We have highlighted a node with a high dropout rate, possibly due to a challenging task in this screen card. A review of the specific node indicated that it contained a time-consuming free text question, referring to previous videos, which might have discouraged the participants from continuing their work with the virtual patient scenario.

Figure 8 shows a visualization of choices made by the course participants in the week 2 virtual patient. The links (edges) leaving decision nodes are indexed by the percentage of visits following this option relative to the total number of outgoing connections. The decision node is labeled by a heuristic value calculated as information entropy from the percentage of selected options, divided by the maximal information entropy for the given number of branches. We use this value as a benchmark for branching quality as it has its maximum value 1 for perfectly even distributed user selections. The node highlighted by *a* in Figure 8 is an example of poor branching as the alternative option is selected in just 4.6% of visits which may indicate a nonchallenging choice. Correspondingly, the branching value is low (0.27). In contrast the node highlighted by *b* in Figure 8 has a more evenly distributed user count, indicating interesting and not obvious choices (heuristic value 0.79).

Figure 7. Percentage of visitors who left the virtual patient after visiting the particular screen card.

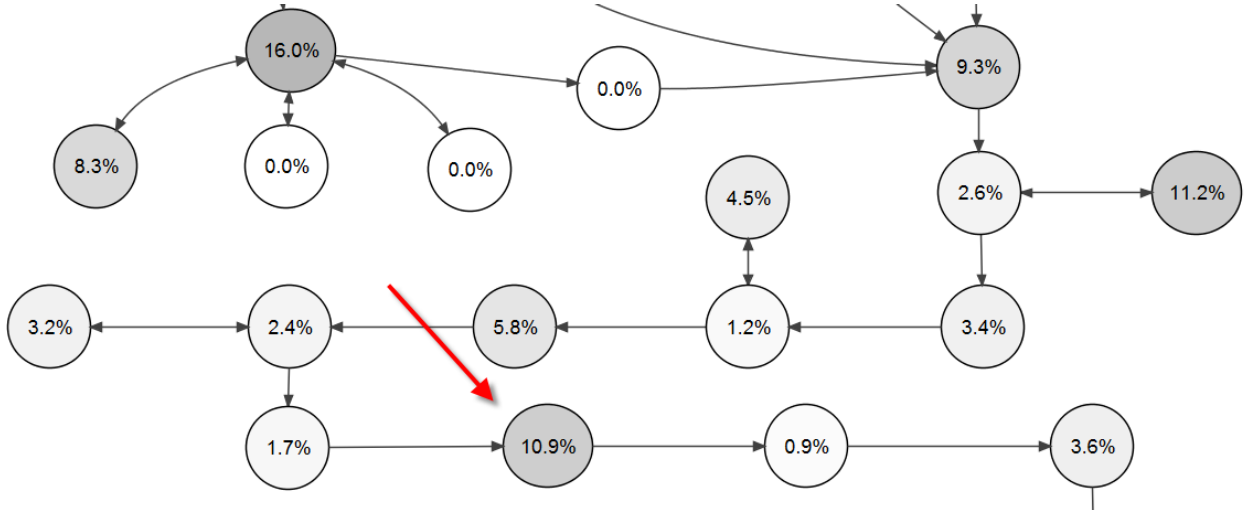
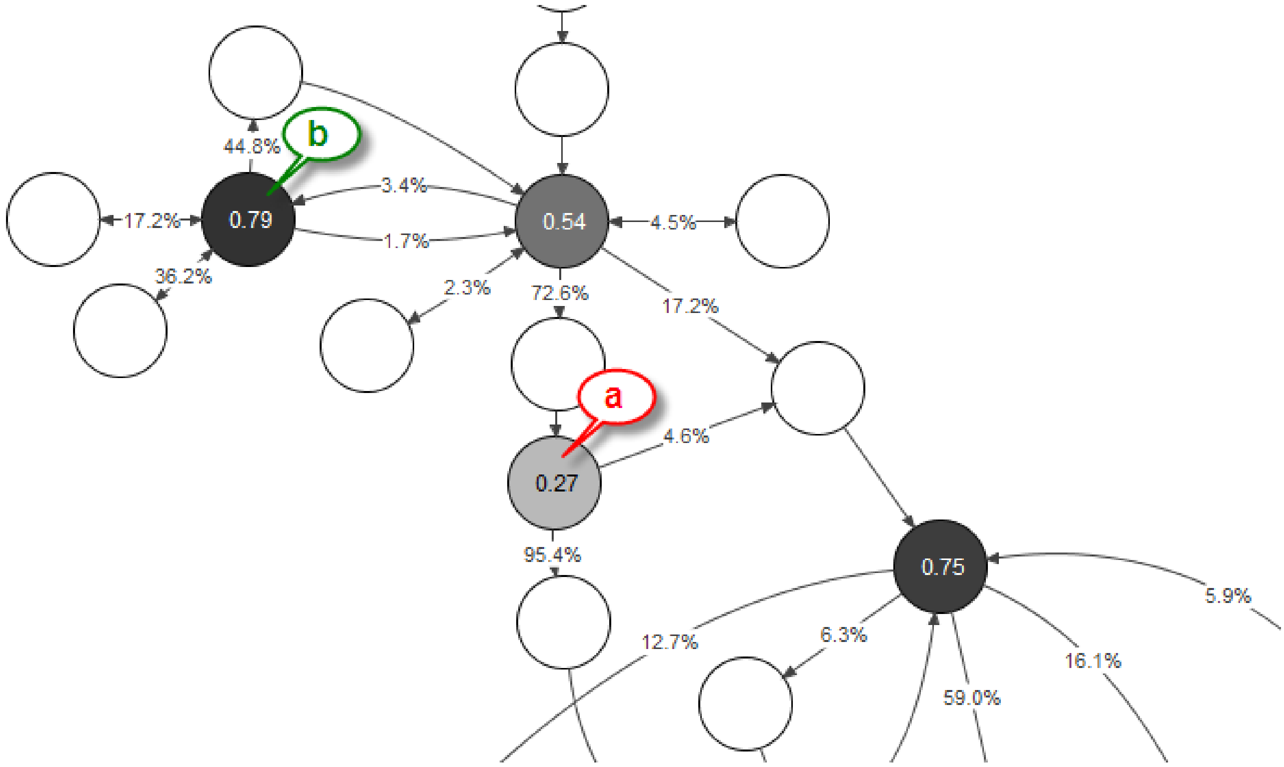


Figure 8. Visualization of learner choices in decision nodes.



Survey Results

We received 479 responses to the participant survey (2.49% of all enrolled and 20.67% of those who declared they had completed at least one virtual patient). Multimedia Appendix 2 contains a detailed summary of the responses. For the great majority, using a virtual patient was a new experience (87.3% declared they had not used virtual patients before and 11.5%

had used virtual patients prior to the course). A great majority strongly agreed (58.5%) or agreed (24.6%) with the statement that the virtual patient was a helpful exercise in the course. Only 1% of participants disagreed or strongly disagreed. The level of difficulty of the virtual patients was just right for the majority of respondents (neither too easy nor too difficult: 62.8%). It was difficult to very difficult for 21.1% and easy to very easy for 12.1%.

Eighty-one percent (389 out of 479; 81.2%) of surveyed participants did not encounter any technical problems while using virtual patients. Nevertheless, it was surprising that a relatively high percentage (77 out of 479; 16.1%) reported experiencing technical issues. The dominating themes in the free text description of technical issues were (1) problems with videos, (2) Internet connection problems, (3) problems with broken sessions, and (4) unrelated problems. Each of these themes contained around 15 comments. The video problems related to the inability to access YouTube videos in some countries or the inability to download them offline. Sometimes the videos did not seem to start properly, got stuck, or played only the audio track—these problems could be explained by slow Internet connections or compatibility issues with Web browsers on some platforms. The problems explicitly classified as Internet issues referred in general to the inaccessibility of broadband connections in regions of the world such as India or rural Canada. The issues classified as broken sessions were most likely related to the virtual patient platform and manifested by nonsaved user answers, page display errors, unexpected session reset, or (in two reported cases) surprising redirection between nodes. Some of the problems could be explained by session timeout or browser issues but they could just as likely be due to previously identified software problems in the platform. Luckily, these difficulties were not reported often and did not influence the general positive picture of the learning experience. Lastly, the technical complaints also contained issues not directly related to the technical side of virtual patient scenarios, like language issues, difficulties in posting comments on the discussion board, or complaints about videos that were not part of the virtual patient scenarios.

Discussion

Principal Findings

This case study presents experiences collected while organizing what is probably the first MOOC including virtual patients. The scope of the report is on virtual patient usage expressed in terms of required technical capacity and user navigation pathways to inform preparations of further, similar courses. The general impression after introducing virtual patient scenarios into the Behavioral Medicine MOOC was positive. The great majority of participants regarded virtual patients as a helpful exercise in the course, and the declared completion rate of the virtual patients activity (12.05% and 8.53% out of 19,236, weeks 1 and 2, respectively) was relatively high in relation to the total course completion rate (3.85%). We received many free text comments in the discussion forums praising this learning resource (Berman et al, manuscript in preparation). The course organizers will retain this activity for continued runs of this MOOC and have begun using the virtual patients in their traditional campus-based teaching activities.

From the organizers' perspective, the intimidating number of participants at start-up was not as challenging from the technical perspective as expected. One contributing factor is the high dropout rate typical for MOOCs, and the more evenly distributed frequency of requests than expected due to the truly global reach of the learning activity. In the end, the technical infrastructure was loaded, in terms of concurrent users, 20 times less intensively than anticipated as the worst-case scenario. The server capacities of one virtual machine would be most likely have been sufficient to host the course even when considering the database problems noted in the course live run.

Considering the virtual patient statistics obtained, the necessity of using cloud infrastructure might be questioned. However, several benefits to this solution were confirmed in this study. A platform-as-service saves costs, as it was not necessary to purchase any new hardware for the MOOC to guarantee a dedicated server for the virtual patient platform. The possibility of scaling the solution—horizontally (number of CPU and RAM) and vertically (number of instances)—provided us with security in case of higher than expected popularity of the course. The openness of MOOCs suggests the real need of taking such precautions. The solution of preparing different types of virtual server templates was very helpful. This provided flexibility for the course organizers in terms of switching between different services outside the MOOC platform, depending on how the course evolves in real time. It also saved time while reusing the services for other occasions (eg, for on-campus classes with small groups of students). The idea of creating micro-instances of virtual servers to circumvent problems with concurrent access to legacy code is new and has not been discussed in the literature before [39]. The presented integration is likely to be succeeded by more computationally demanding integrations of simulation in virtual patients [40]. For such scenarios the use of cloud services will be indispensable.

The OpenLabyrinth system proved its usefulness in this study as a virtual patient player for a MOOC. The technical problems reported by some students did not seem to overshadow the general positive picture of the activity. The problems we traced as directly related to the OpenLabyrinth environment were not numerous. This would be interpreted differently in the case of commercial courses or high-stake examinations organized on a massive scale. The most often reported problems with low Internet connection for videos or banned YouTube services are not related to the virtual patient software. The course participants were informed by the organizers in the general course rules about restrictions in use of the YouTube service in some countries and offered manual downloads of the video clips outside OpenLabyrinth; however, this solution was not offered explicitly in OpenLabyrinth. This seemed to negatively influence users and suggests other options should be considered for hosting videos. We recommend uploading all videos as separate files to the MOOC platform to be downloaded on demand by participants from countries with blocked access to services such as YouTube. An alternative solution would be to host a video streaming service on a generic cloud infrastructure, but this would considerably raise the technical requirements. We were not able to spot any irregularities which would indicate users of specific web browsers had particular problems using virtual patients in OpenLabyrinth. It is to be acknowledged that we did not optimize the display for mobile devices (tablets, smartphones), a factor which could be an issue for some of the participants. We recommend considering this group in particular in upcoming MOOCs introducing virtual patients.

The course was slightly less frequently visited and completed than an average MOOC. This might be explained by the specificity of the topic and the general trend of larger supply and shrinking interest in MOOCs [4]. The high bouncing rate of virtual patients is not surprising as it includes those who just explored the course's content without intending to interact with the cases. Among those interested enough to move to the second node of virtual patient, 30% to 50% completed the exercise, which took 45 minutes on average. We interpret this as an objective sign of interest in the task.

One worrisome aspect is the discrepancy between the self-reported completion rate of the exercise and the actual session logs. It was not necessary to complete the virtual patient exercise in order to tick off the assignment; users merely had to spend 30 minutes in the scenario and comment on this on the discussion board. The declared completion rate of the week 2 assignment was 2317, but the number of sessions containing the second node of virtual patient was 1473. This raises doubts regarding how seriously participant declarations are to be taken. The observation of digital dishonesty is not new [41]. It is unclear, however, why participants would act dishonestly when no formal recognition is attached to acquiring an honor code certificate. Future studies should examine this kind of behavior in more detail.

One innovative aspect of this study is the use of visual analytics methods to report user activities in virtual patients. Visual analytics is an emerging trend employing human cognitive abilities to recognise visual patterns in analytical tasks [42]. Visual methods have been used in activity dashboards of learning management systems and in observing patterns of interaction on discussion boards [43]. However, the potential of visual analytics in virtual patients has been so far largely unexplored. The visualizations presented in this paper show a map of the virtual patient scenarios with overlaid navigation pathways, thus including several topological dependencies that would not have been easily noticed in traditional visitor statistics presented in tabular form. This function of depicting the flow of virtual patient activity is highly instrumental for quality control of online education. The coincidence of the most popular pathway with the correct one can be interpreted as a sign of a successful learning process. At the same time it has to be remembered that this indication is biased by the limited number of possible pathways through the case. It has also been reported that some students learn by exploring the wrong options on purpose which might further blur the picture [44]. The detected nodes with high dropout or low branching levels led to discussions about possible changes in the virtual patient structure for future editions of the course.

The observation of the number of visited nodes in user pathways and the moderately strong positive correlation of the percentage of viewed videos to the distance from the start node might suggest the existence of two groups of MOOC participants using virtual patients: learners with either surface or deep approaches to the content material. The existence of such groups is predicted by educational theories [45] and has been observed in e-learning environments [46]. The group we identify as possible surface learners in our MOOC leaves the virtual patient soon after opening the cases (as when 75% of sessions end before 10% of the content is viewed) and do not follow through on the assignments completely (as those leaving the video nodes before the video playback time in initial parts of navigation pathways). The more highly motivated group, identified as about 400 probable deep learners, is visible by the peak in frequency distribution of navigation pathway length with approximate equivalence to the length of critical pathway through the cases. An additional indication of deep learning might be the observed higher percentage of carefully carried out exercises closer to the end nodes (as visible on the example of the average time spent on video nodes). The high motivation of a subgroup of users might also be suspected from the time spent on entering answers to the free text questions (high average time for this type of node) even though there was no hope for individualized feedback or credit for such exercises.

Limitations

This study has its limitations. There were just two virtual patient scenarios introduced to the course using OpenLabyrinth. The branching potential of virtual patients has not been used to its full extent because of limited resources for developing alternative versions of videos, fixed recommendations of professional behavior which should not encourage too much experimentation, and the novelty of this form of teaching to the subject matter experts of the course. It was also assumed from the beginning that this study would not link session data to user details. The study evaluates the idea of introducing virtual patients in a MOOC at the first level (participation) of Kirkpatrick's hierarchy [47,48]. We did not evaluate the effects of learning in the MOOC in terms of acquired knowledge, but following the positive outcomes at the first level we plan to conduct evaluations at higher levels and encourage others to do so. As we received 479 responses to the participant surveys (which is 2.49% of the total number of enrolled users), it might pose a high risk for nonresponse bias effect. However, when considering that the evaluation survey was announced as the last step of the whole course and 740 participants earned the certificate, the same number might indicate a high response rate (64.7%) among those who completed the course. The heuristic selected for measuring the branching quality was selected arbitrarily and will be improved in the future, taking into account the baseline level of learner expertise. The time spent by students in individual nodes of the case on actual learning is very difficult to control and should be treated as a rough indicator of the thoroughness of a virtual patient session. Some of the students might have used it for other, unrelated activities. This problem is often encountered while evaluating virtual patients activities [49]. However, as there were no direct incentives for spending more time on particular nodes (the credit was based on an honor code declaration), we assume that this bias is evenly distributed. The impact of any future changes made to improve the quality of virtual patients based on the clues taken from the visual analytics tool will be the subject of studies on future editions of the MOOC.

Future research should focus on observing how participants choose navigation pathways depending on participant-related factors. This could give insight into how experts, expert students, and lay people approach problem solving in a MOOC. It would be interesting to look for correlations between such indicators as branching level and student satisfaction from learning. Technical solutions used in this paper, such as building different variants of virtual patient system templates or using visual analytics methods to improve virtual patient quality are innovative and not yet optimized nor standardized. These could form integral elements of a cloud-based platform dedicated to organizing health-related MOOCs. The introduction of virtual patients to massive audiences, thanks to the large number of participants, opens up new, previously inaccessible venues for experimentation with this learning design with potential for future research on the topic.

Conclusions

This study reported on the probable first introduction of virtual patients to a MOOC. It positively verified the feasibility of using OpenLabyrinth, an open-source, freely available virtual patient system for a large audience setting. The system can now be added with greater confidence to future health care MOOCs. This report delivered concrete technical parameters (like the number of users per hour) to inform preparatory stress tests carried out prior to extension of health care MOOCs by adding nonstandard server-based interactive components. It demonstrated to the medical community how a cloud infrastructure (using the example of VPH-Share, but generalizable to comparable commercial solutions) can be employed in teaching activities on a large scale to deal with problems with errors in legacy code preventing high numbers of concurrent users, limitations in availability of hardware resources, or the need to prepare and store different configurations of the software tool. The paper further recommends adding to the existing branched virtual patient systems additional components graphically visualizing user pathways by demonstrating the spatial relationship between statistics pertaining to particular nodes. This is an added value to the existing tabular forms enabling the presentation of session statistics in learners' areas of interest. Nodes rarely visited or visited for a shorter time than expected based on content, as well as branches seldom taken, can be analyzed in a context of preceding and following nodes and in a general overview of the whole case structure. This can be done to increase the attractiveness of the case or detect problems in understanding the content.

The innovation was warmly welcomed by the majority of course participants responding to the survey. A few challenges remained regarding accessibility and slow transfer of YouTube videos and occasional unexpected technical behavior on the part of the virtual patient system. We hope that this article will contribute to the expansion of future health-related MOOCs with interactive elements such as virtual patients.

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Authors' Contributions

Author AHB wrote the virtual patient scenarios following consultation with guidance from AAK and NS for structuring the scenarios. TB, PN, and MM were part of the team that developed the Atmosphere cloud platform. TB, PN, MM, and AAK designed the architecture and deployment of the virtual patients in the cloud environment. TB, AAK, and NS configured, tested, and monitored the server templates instances. AAK developed the visual analytics tool prototype. CMG and NZ coordinated KI's participation in the edX initiative. AHB was director of the KIBEHMEDx MOOC. AAK, AHB, NZ, and NS planned the analysis and analyzed and interpreted the results. AAK wrote the text of the manuscript with contributions from all authors. All authors have read and approved the final manuscript.

Conflicts of Interest

None declared

Multimedia Appendix 1

Geographic breakdown of participation.

[PDF File (Adobe PDF File), 4KB - mededu_v1i2e8_app1.pdf]

Multimedia Appendix 2

Detailed results of the user survey.

[PDF File (Adobe PDF File), 18KB - mededu_v1i2e8_app2.pdf]

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Abbreviations

KI: Karolinska Institutet
MOOC: massive open online course
VPH: Virtual Physiological Human

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Original Paper

Digital Literacy in the Medical Curriculum: A Course With Social Media Tools and Gamification

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Abstract

Background: The profession of practicing medicine is based on communication, and as social media and other digital technologies play a major role in today's communication, digital literacy must be included in the medical curriculum. The value of social media has been demonstrated several times in medicine and health care, therefore it is time to prepare medical students for the conditions they will have to face when they graduate.

Objective: The aim of our study was to design a new e-learning-based curriculum and test it with medical students.

Method: An elective course was designed to teach students how to use the Internet, with a special emphasis on social media. An e-learning platform was also made available and students could access material about using digital technologies on the online platforms they utilized the most. All students filled in online surveys before and after the course in order to provide feedback about the curriculum.

Results: Over a 3-year period, 932 students completed the course. The course did not increase the number of hours spent online but aimed at making that time more efficient and useful. Based on the responses of students, they found the information provided by the curriculum useful for their studies and future practices.

Conclusions: A well-designed course, improved by constant evaluation-based feedback, can be suitable for preparing students for the massive use of the Internet, social media platforms, and digital technologies. New approaches must be applied in modern medical education in order to teach students new skills. Such curriculums that put emphasis on reaching students on the online channels they use in their studies and everyday lives introduce them to the world of empowered patients and prepare them to deal with the digital world.

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KEYWORDS

medical education; social media; digital literacy

Introduction

In the last couple of years, the Internet has played an increasingly important role in communication and information management in medicine and health care. An information-based society leads to an exponential increase in the amount of information available, the free flow of information, interactivity, real-time communication, and opportunities for collaboration [1].

In 2013, Internet use increased to 85% and 72% in the United States and in the European Union, respectively [2]. Besides using personal computers , the rate of mobile phone, tablet, and laptop users also increased underscoring the importance of "continuous online presence" [3,4].

The use of the Internet to search for health-related information has become a common practice worldwide [5]. As such, the online world is a primary source of medical information. Online searches for health-related information doubled between 2002 and 2012 from 40% to 80% [5,6]. Approximately 80% of Internet users search for medical information using search engines, the third most regular online activity after web browsing and checking emails [7].

Besides basic online activities, social media plays an increasingly important role in medical communication [8,9]. For example, 45% of Norwegian and Swedish hospitals are using LinkedIn, 22% of Norwegian hospitals use Facebook for health communication, and statistics reported Facebook as the fourth most popular source of health information [10,11].

The Internet and medicine connect on numerous bases from telemedicine and mobile applications to online practices and community sites affecting the world of research [12,13]. Therefore, digital literacy and the knowledge and use of digital tools in communication, keeping ourselves up-to-date, dealing with information pollution, using mobile health devices and applications, as well as assessing the quality of medical websites has become a crucially important skill in medical practice [14].

The profession of practicing medicine is based on communication, and as social media and other digital technologies play a major role in today's communication, digital literacy, defined as the ability to effectively and critically navigate, evaluate, and create information using a range of digital technologies, must be included in the medical curriculum [15]. Since the value of social media has been demonstrated several times in medicine and health care, it is time to prepare medical students for the conditions they will have to face when they graduate. In addition to answering traditional medical questions, they will have to be prepared for patients asking questions about the World Wide Web.

Use of social media channels for personal rather than professional purposes, unintentionally revealing details of patients' private information, and the massive social media use by medical students raise awareness about the importance of acquiring skills related to digital technologies from the first year of medical school [16]. While there have been attempts at using social media platforms in education, examples are sporadic and an extended curriculum is very much needed [17-19].

An online physician study (N=5000) showed that 80% of Hungarian physicians used the Internet on a daily basis, mainly for searching relevant literature or for the drug database. Almost half of them believed that he/she had a worse or same level of knowledge of digital technology than the average population. This suggests that around 50% of the surveyed physicians thought that digital literacy should be introduced to the curriculum of medical education [20].

In order to include the teaching of digital literacy skills in the medical curriculum, an elective course was launched at the University of Debrecen, Medical and Health Sciences Center, in 2008, and later moved to Semmelweis University in 2012. As medical students from around the world demanded access to the materials, an online e-learning platform and a Facebook challenge with gamification were launched in 2012 in order to motivate students to improve their digital skills during the course of the semester.

The aim of this study was to test whether such an interactive, on-and offline-based curriculum with innovative methods could help medical students acquire digital literacy skills, as well as to improve their knowledge about the digital world. Here, we demonstrate the methodology, format, and details of the curriculum. We also aimed at analyzing the descriptive feedback of the student participants. The main educational goals included testing the curriculum, format of the course, and design of the online channels made to teach students about digital literacy through digital channels. Our study, however, did not focus on the long-term consequences of the curriculum; these will be analyzed and discussed in further studies.

Methods

Student Demographics

Data of surveys filled in by 932 medical and dentistry students, from over 20 countries, of Semmelweis University in the 2010/2011, 2011/2012, and 2012/2013 semesters were included in this study. Each student who enrolled completed the course modules and filled in the survey.

Procedure

Students (N=932) attended live lectures for 12 weeks where Prezi-formatted presentations were shown [21]. Students were encouraged to use touch screen and laptop devices during the lectures to improve the digital communication between them and the lecturer. They had the opportunity to ask questions on Twitter as well during the lectures.

A Facebook page was established to launch a competition. The first students to correctly answer the questions covering the topics and learning points of the lectures got bonus points. There were 1-3 questions posted every day during the semester.

The e-learning platform was designed to let the students re-watch the presentations, access all materials and references mentioned in the lectures, and do tests. Completing the online course resulted in an opportunity to skip the written exam. Students had a written test at the end of the semester.

Online Surveys

Students filled in online surveys before and after the course using the website SurveyMonkey [22] (Multimedia Appendix 1). The survey included questions that allowed students to self-report changes in their digital skills, as well as questions that objectively measured the change in their attitude. The surveys included questions about demographics, digital habits, Internet use, online study solutions, their knowledge of social media, empowered patients, the devices they have, and feedback about the course.

Statistical analysis was descriptive, focusing on percentages and averages. Anonymous data were visualized by Microsoft Excel 2007.

Hungarian regulations such as Decree No 35/2005 (26th of August, 2005) of the Ministry of Health on the clinical trial of investigational medicinal products for human use and on the application of the good clinical practice, and Decree No 23/2002 (9th of May, 2002) of the Ministry of Health on biomedical research on human subjects (applied to conducting a clinical trials) are not applicable in our research, therefore, ethical approval was not required.

Course Structure

The elective course is an official part of the medical curriculum at Semmelweis University, Budapest, Hungary, both in the Hungarian and English programs. It consists of 10 lectures, each 1.5 hours in length, as well as platforms to openly discussing the content on the course Facebook page, the written exam, and the 2 online surveys.

The lectures were developed based on current global trends of social media use; the first textbook of the area (Social Media in Clinical Practice [23]) and the feedback of global experts such as E-Patient Dave deBronkart, Lucien Engelen, or the Pew Internet Research Project, in order to make sure all the relevant and crucial topics are covered in an extensive but evidence-based manner. The course focuses more on the meaningful use rather than the actual popularity of these channels and methods (Textbox 1).

Textbox 1. Course lecture topics.

Topics

- Introduction to social media and medicine with practical examples: basics of using the Internet, history of online communication, key social media channels and their evolution, ethical aspects of using the Internet for medical purposes.
- Medical search engines and Google applications in medicine: tips and tricks about doing online searches either on regular search engines or medical/scientific ones. The pros and cons of using Google tools in medicine.
- Being up to date with RSS and online resources in education: methods to deal with information pollution, tracking search results, scientific papers, medical information, and news.
- The mysteries of medical blogging: the advantages and potential dangers of writing a medical blog.
- Using Twitter and other microblogging platforms for medical purposes: description of the quickest online channels and its use in medicine and health care.
- Using medical community sites, tools for online collaboration: rules of using social networks such as Facebook as well as medical ones as medical professionals. Tools to collaborate and write manuscripts online.
- Medical mobile phone (smartphone) applications: how to assess the quality of medical mobile phone (smartphone) applications.
- The world of e-patients and social media in health care: how patients and healthcare institutions can and cannot use social media.
- The medical aspects of Wikipedia and wikis: the power of masses, building communities, and assessing the quality of medical information on Wikipedia.
- Virtual environments in medicine: examples when virtual reality environments are used for collaboration and global communication.
- The future of medicine and social media: future technologies and trends that shape the future of medicine with an emphasis on online communication.

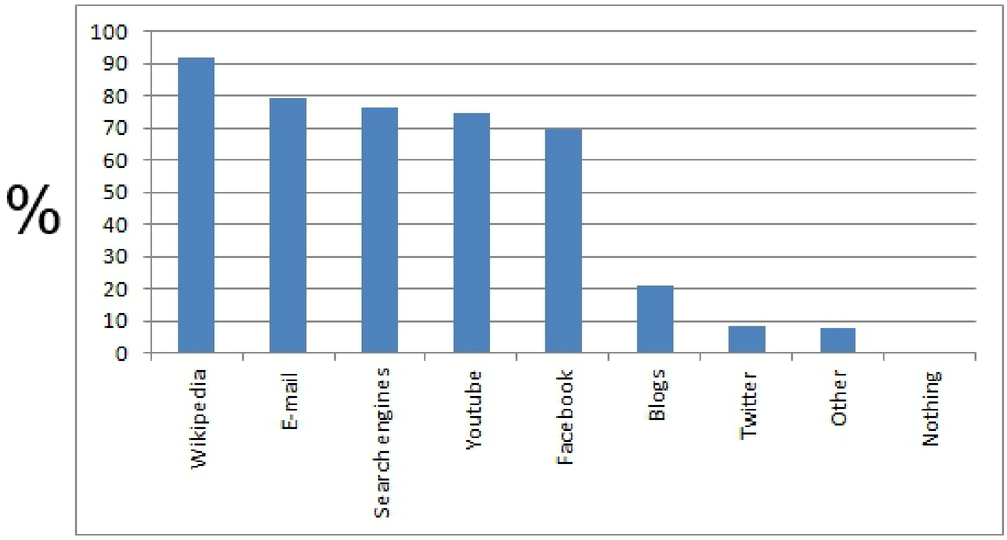
Design of the E-Learning Platform

The e-learning platform [24] was launched in April, 2012, under the name "The Social MEDia Course" (Figure 1). The course consists of 16 extended presentations in Prezi format with handouts, references, a comment section, and a test for each presentation.

In order to use the concept of gamification in motivating students to continue the study process after the lectures, successfully completing the test as well as completing other tasks resulted in the acquisition of a badge that students could share on their social media channels. Badges were also provided with different levels of activities on the site such as leaving meaningful comments on the presentations, asking questions, or submitting new test questions for future students, thus further motivating them to proceed with the e-learning element of the course. Finishing all the tests earned the "Ultimate Expert" badge and a certification of completing the course.

The platform also includes a community feature which lets students crowdsource challenges related to the digital worlds together [25], and another feature allowing students to submit more challenging questions for the online tests [26].

Figure 1. Students enrolled in the course filled in online surveys about the online resources they use in their studies. The y axis represents the percentage of students that chose the particular answer.



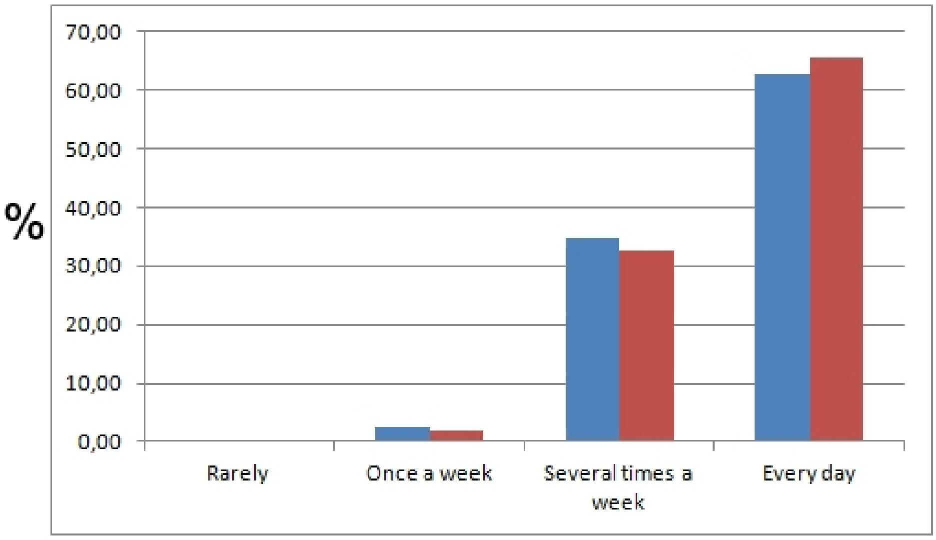
Results

Online Habits

All students had access to the Internet at home or at the university. They used at least one online resource in their studies such as Wikipedia (91.8%, 856/932), email (79.5%, 741/932), search engines (76.3%, 712/932), YouTube (74.4%, 694/932), Facebook (69.5%, 648/932), blogs (21.0%, 196/932), Twitter (8.1%, 76/932), and other (7.7%, 72/932) (Figure 1).

The vast majority of the students used the Internet on a daily basis before (62.6%, 583/932) and after (65.4%, 609/932) the course, and this did not increase due to the course (Figure 2).

Figure 2. Internet usage of the students enrolled in the course. The y axis represents the percentage of students that chose the particular answer. Blue and red bars represent responses acquired before and after the course, respectively.



Acquired Skills

Based on the survey results, students learned how to define social media, medicine 2.0, health 2.0, e-patients, blogs, RSS, and Twitter (Figure 3). The percentage of those responders who did not know how to define social media dropped from 46.7% (435/932) to 8.8% (82/932), and those who could define it perfectly increased from 5.8% (54/932) to 23.2% (216/932) during the course. They learned how to assess the quality of medical websites, how to transform frustrated patients to e-patients who could be equal partners, and what websites they could share with their future patients. Students thought they could meet the needs of e-patients in their professional lives and would meet their expectations (Figure 4).

Figure 3. The number of students that could properly define social media. The y axis represents the percentage of students that chose the particular answer. Blue and red bars represent responses acquired before and after the course, respectively.

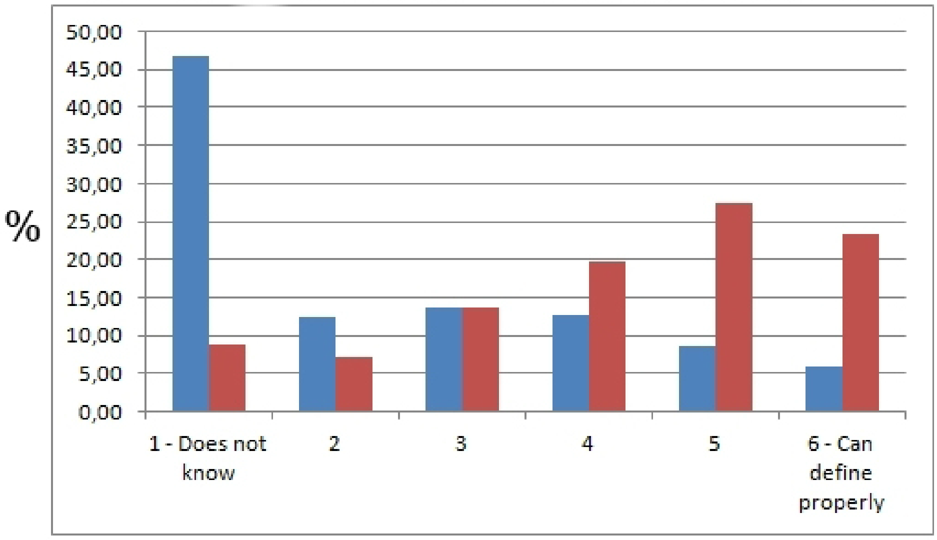
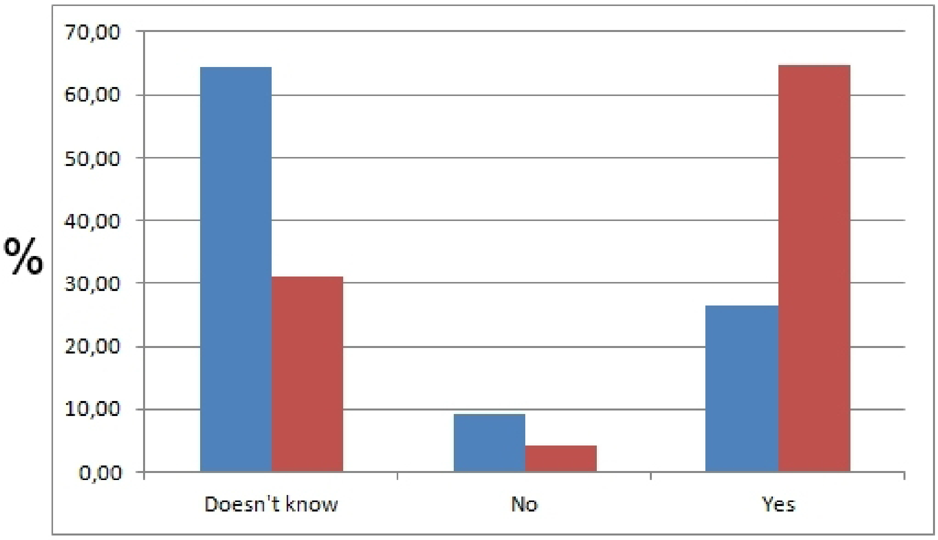


Figure 4. Whether the students believe they will meet the special needs of e-patients. The y axis represents the percentage of students that chose the particular answer. Blue and red bars represent responses acquired before and after the course, respectively.



Feedback

The suggestions provided by the course were valued as highly valuable and quite valuable, and overall, 99.7% (929/932) of students liked the course (Figure 5). Most of the students (74.7%, 696/932) also visited the website and found it useful (Figure 6).

Figure 5. Students enrolled in the course filled in online surveys about how many useful suggestions the course provided them with. The y axis represents the percentage of students that chose the particular answer.

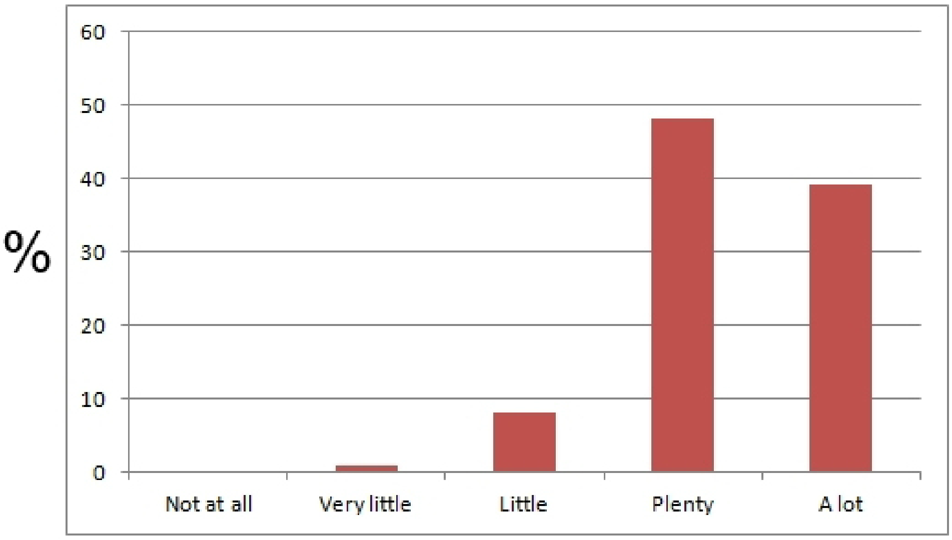
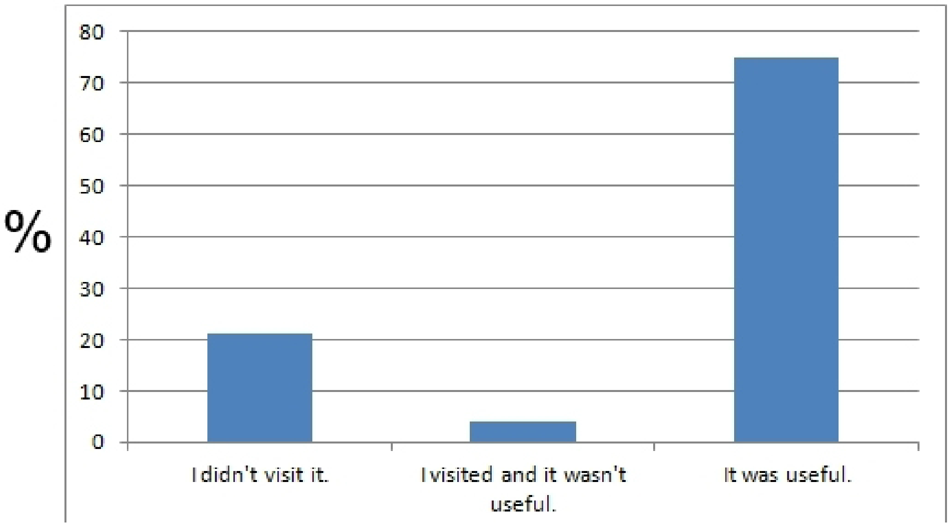


Figure 6. The number of students that visited the course website. The y axis represents the percentage of students that chose the particular answer.



Discussion

Principal Findings

This is the first example demonstrating that digital literacy, with a special emphasis on social media describing how major platforms such as Facebook, blogs, Youtube, Wikipedia, Twitter, and Google, can and should be used in the medical profession, and was successfully added to an official medical curriculum (offline and online).

Several methods including gamification were designed to reach and teach students where they spend their online time. As all the students had Facebook accounts, challenges, tasks about online activities, and questions about the topics covered during the lectures were posted every day during the semester on the course Facebook page [27] and the student with the most bonus points did not have to take the written exam.

Students learned new skills during the lectures which focused on practical examples and real-life situations, and they accessed the content in an e-learning platform where they were motivated with features implementing gamification.

Limitations

A limitation of this methodology might be the lack of access to the Internet in other areas, and the small numbers of cases of e-patients or medical professionals describing the use of social media on a national level as mostly global examples are available. A possible reason behind the observation that 21.3% (199/932) of survey responders did not visit the course website and 3.8% (36/932) of them visited but did not find it helpful might be that students prefer watching videos on e-learning platforms rather than watching presentations, reading studies, and doing tests. Another reason might be that no other course at the medical school uses such innovative methods including the interactive e-learning platform or Facebook challenges in teaching, therefore, time might be required for students to get accustomed to these techniques.

As this is the first study focusing on whether digital literacy skills can be added to a course at a medical school and whether these skills can be improved upon during the course, not being able to compare these results to other studies was also a limitation.

Conclusions

We believe that a well-designed course improved with constant evaluation-based feedback is suitable for preparing students for the massive use of the Internet, including social media platforms and digital technologies, and new approaches must be applied in modern medical education in order to teach students skills required for a world rich in digital technologies and e-patients.

Courses worldwide provide curriculums about medical informatics and information retrieval which have become an important part of training medical students [28-31]. To the best of our knowledge, this is the only course in the official medical curriculum that not only implements social media channels in teaching certain skills but also focuses on the use of the digital world, especially social media platforms, for medical and other professional purposes. This study was meant to raise awareness to the importance of introducing medical students to the use of digital solutions in the settings of medical education and generate a discussion about what other methods could also be used to reach this long-term goal.

The structure of this course appears to be an efficient way of transforming medical students' views about the Internet, show them professional behavior, teach them how to create online profiles for themselves, and how to get to a meaningful use of a huge range of online tools and platforms. Students require specialized training in order to fill health care with technology-savvy professionals.

Acknowledgments

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Authors' Contributions

BM designed the study, performed experiments, and wrote the paper. ZG and JK wrote the paper.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Survey questions.

[PDF File (Adobe PDF File), 194KB - mededu_v1i2e6_app1.pdf]

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Original Paper

A Conceptual Analytics Model for an Outcome-Driven Quality Management Framework as Part of Professional Healthcare Education

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Abstract

Background: Preparing the future health care professional workforce in a changing world is a significant undertaking. Educators and other decision makers look to evidence-based knowledge to improve quality of education. Analytics, the use of data to generate insights and support decisions, have been applied successfully across numerous application domains. Health care professional education is one area where great potential is yet to be realized. Previous research of Academic and Learning analytics has mainly focused on technical issues. The focus of this study relates to its practical implementation in the setting of health care education.

Objective: The aim of this study is to create a conceptual model for a deeper understanding of the synthesizing process, and transforming data into information to support educators' decision making.

Methods: A deductive case study approach was applied to develop the conceptual model.

Results: The analytics loop works both in theory and in practice. The conceptual model encompasses the underlying data, the quality indicators, and decision support for educators.

Conclusions: The model illustrates how a theory can be applied to a traditional data-driven analytics approach, and alongside the context- or need-driven analytics approach.

(JMIR Medical Education 2015;1(2):e11) doi:10.2196/mededu.4789

KEYWORDS

Quality Management; Medical Education; Healthcare, Professional Education; Analytics; Decision Support Model; Computer-assisted Decision Making.

Introduction

Rapid Changes and the Implications for Educators

The quality of services offered by the health care organizations is closely associated with the quality of health care professional education [1]. Schools and educational programs prepare and train future health care professionals to become the next generation of caregivers. New health care professions emerge all the time [2], and new training programs must meet the needs of the evolving workforce. During their training, students are provided with the necessary theoretical knowledge, practical skills, and professional attitude.

Rapid changes within their specific domains cause the professional's knowledge to differ from that of today's students

[3]. Scientific discoveries require new theoretical knowledge, technological development requires new skills, and new working concepts require new professional attitudes (eg, collaboration with multidisciplinary and international groups).

New pedagogical approaches (eg, flipped classroom, gamification, or simulation) that engage learners in their personal development by encouraging lifelong learning and increasing their skill set [4] have been tested, discussed, and evaluated, with promising results [5]. To continually redesign the curriculum is a real challenge for educators and educational developers [6]. The most demanding task is to choose appropriate teaching and learning activities. Therefore, when it comes to decision-making support, the development of novel methods becomes essential, especially when driven by educational purpose.

Analytics has successfully supported decisions in other areas (business, military, intelligence, politics, and economics). Though analytics we can interpret data and predict trends by calculating correlations [7].

Related Work

Educational Informatics is a multidisciplinary research area that uses Information and Communication Technology (ICT) in education. It has many sub-disciplines, a number of which focus on learning or teaching (eg, simulation), and others that focus on administration of educational programs (eg, curriculum mapping and analytics). Within the area of analytics, it is possible to identify work focusing on the technical challenges (eg, educational data mining), the educational challenges (eg, Learning analytics), or the administrative challenges (eg, Academic- and Action analytics) [8].

The Academic- and Learning analytics fields emerged in early 2005. The major factors driving their development are technological, educational, and political. Development of the necessary techniques for data-driven analytics and decision support began in the early 20thcentury. Higher education institutions are collecting more data than ever before. However, most of these data are not used at all, or they are used for purposes other than addressing strategic questions. Educational institutions face bigger challenges than ever before, including increasing requirements for excellence, internationalization, the emergence of new sciences, new markets, and new educational forms. The potential benefits of analytics for applications such as resource optimization and automatization of multiple administrative functions (alerts, reports, and recommendations) have been described in the literature [9,10].

Dimensions and Objectives of Academic- and Learning-Analytics

The field of analytics is multidisciplinary and involves different techniques, methods, and approaches. Some practitioners divide the performed actions into three different dimensions: time, level, and stakeholder. For each of these dimensions, specific analytic approaches may be applied to address specific questions.

In the dimension of time, Descriptive analytics produces reports, summaries, and models to answer: What, how, and why did something happen? Analytics monitors processes and provides real time alerts and recommendations to answer: What is happening now? Predictive analytics evaluates past actions and estimates the potential of future actions to answer: What are the trends, and what is likely to happen? Analytics also simulates the effects of alternative actions and supports decisions. Using analytics, choices are based on evidence rather than myths [11].

The scope of analytics can also be classified into five levels: course, department, institution, region, and national/international [12].

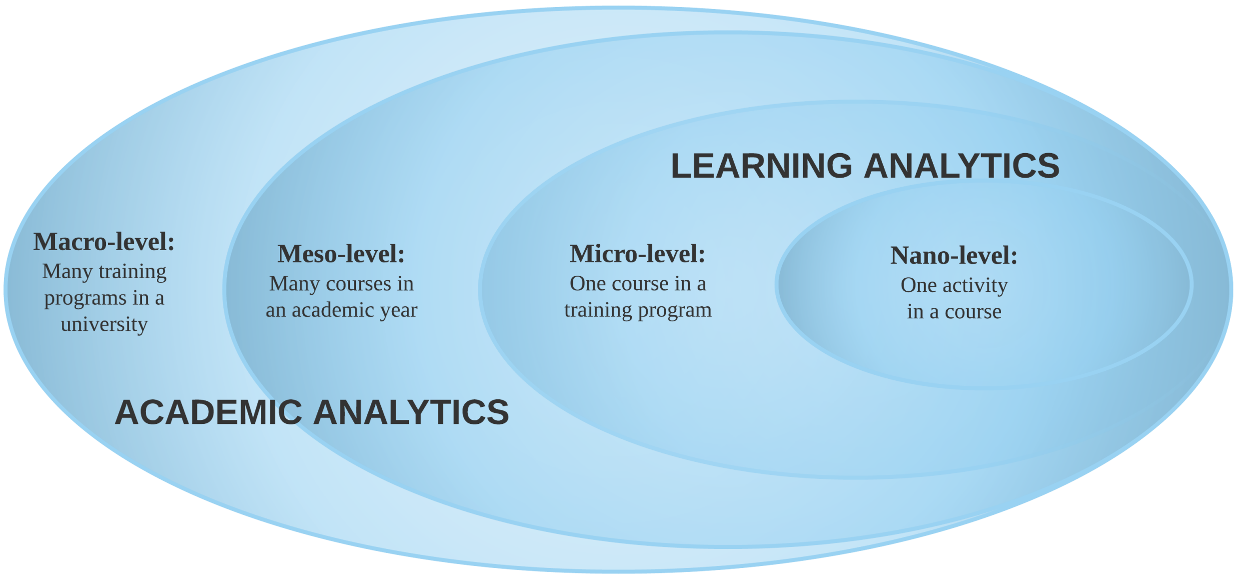
More specific terms have been used. The term “nano level” refers to one activity in a course, “micro level” refers to a course in a training program, “meso level” refers to many courses in an academic year, and “macro level” refers to many training programs in a university [13]. Figure 1 illustrates the relationships between these levels.

The term “Learning analytics” refers to operations at the micro and nano level, when the focus is on decisions concerning achievements of specific learning outcomes. “Academic analytics” applies to the macro and meso levels, when the focus is on decision making regarding procedures, management, and matters of operational nature [14]. Figure 1 illustrates how the different forms of analytics overlap.

The application of analytics can also be oriented toward different stakeholders, including students, teachers, administrators, institutions, and researchers. They may have different objectives, such as: mentoring, monitoring, analysis, prediction, assessment, feedback, personalization, recommendation, and decision support. Analytics can apply different techniques, including visualization, data mining (including classification, clustering, and association), and network analysis within those different tasks.

Chatti et al [15] propose different dimensions: The environment; what data is available? The stakeholders; who is targeted? The objectives; why do the analysis? And the method; how has the analysis been performed [15]?

Figure 1. The curricular levels and overlaps of the different forms of analytics.



Introduction of the Underline Theory and the "Analytics Loop"

Even if the dimensions or the methods and objectives of the approaches described above differ, the fundamental idea of the five steps [16] of the analytics loop is always the same. The five steps of analytics are:

1. Capture: Access to data is the foundation of all analytics. This data can be produced by different systems and stored in multiple databases. One great challenge for analytics projects in this step is that necessary data may be missing, stored in multiple formats, or hidden in shadow systems.

2. Report: This step involves creating an overview to scan. Different tools can be used to create queries, examine information, and identify trends and patterns. Descriptive statistics and dashboards can be used to graphically visualize eventual correlations.

3. Predict: Different tools can be used to apply predictive models. Typically these models are based on statistical regression. Different regression techniques are available and each one has limitations.

4. Act: The goal of any analytics project is to provide information based on predictions and probabilities that support decision making. Analytics can be used to evaluate past actions and estimate the effects of future actions. In that way, analytics can provide alternative actions and simulate the consequences of different actions.

5. Refine: This is the self-improvement process. The monitoring, feedback, and evaluation of the project's impact create new data and evidence that can be used to start the loop again with improved performance [16].

Aim and Objective for This Study

The aim of this study is to investigate how analytics could contribute to the quality management and improvement of health care professional education. We aim to provide a deeper understanding of the process of synthesizing the available educational data to create the necessary information to support decisions. The research question we seek an answer to is: How can the different parts of the analytics loop (Capture, Report, Predict, Act, Refine) after Campbell et al [16] be described in a conceptual model for an analytics-driven quality management framework in health care professional education?

Methods

Study Design

Every research project consists of five key components: goals, theoretical framework, research questions, methods, and validity [17]. A number of other factors can also affect the design and thus make all empirical research unique. Traditional research follows a linear approach. This qualitative study follows an interactive approach [18]. According to this approach, interconnections between the components and the structure are flexible, and the research questions are not the starting point. Instead they are at the center, like a hub, and they connect directly to all of the other components [18].

We expand, one by one, the five key components (goals, theoretical framework, research questions, methods, and validity) [18] in order to clarify the chosen design.

There are three goals in conducting this study: personal, practical, and intellectual. The personal goals which motivated us to do this study include curiosity about the specific theory and a desire to change the existing situation. The practical goals focus on finalizing a conceptual model to describe how the theory works. The intellectual goals are to understand the processes, identify eventual gaps, and provide explanations.

The theoretical framework is based on the fact that analytics has been successfully used in other areas. Academic analytics has been defined as the application of business intelligence in education [19]. The value of analytics for higher education has been described as very positive. Analytics in general could generate insights based on data and improve the decision making process [12]. Learning analytics could support decisions and improve learning, and Academic analytics could make the quality management of educational procedures easier and more effective.

The theory of the analytics loop is well described, but we have yet to see its full potential implemented in an analytics-driven quality management process in the setting of health care professional education. The research question thus focuses on providing deeper understanding, insights, and explanations. The main research question could be divided into three sub-questions: (1) How does the quality improvement work in health care professional education today? (2) How could this process be changed using academic analytics, and (3) What inputs are necessary to get the theory to work in practice.

The overall methodology follows the deductive case-study approach [20] and develops a conceptual model [21]. The design was deduced to test the theory of the analytics loop (capture, report, predict, act, refine; after [19]). The conceptual framework has been used to explain key factors in graphical form.

Strengths and Weaknesses

Case studies can be used to illustrate real problems and needs and help us to identify gaps in processes. A clear limitation is the potential to generate recommendations, solutions, or generalizations recognized as normal in other contexts.

The case study method includes interviews and observations. Responders included five teachers, two course designers, two directors, and two coordinators during a review to improve the quality of a masters' program in health informatics. Analysis of the text generated by the responders has been re-used to create the conceptual model. The case in this study is considered a middle-step to help us understand the needs and illustrate the gaps.

The main focus is on the creation of a conceptual model to test the theory in general. The combination of the methods allows us to close the loop and validate the outcomes.

Validation

The validation and empirical implementation of the study includes three steps: (1) mapping of the actual quality improvement process, (2) development of a case to illustrate eventual benefits of Academic analytics, and (3) creation of a conceptual model to identify the needed data.

The Case Study

A teacher suspects gaps in the curriculum of a course and wants to improve its quality by adding a new type of teaching activity. What is the current practice, and how would this scenario change after using analytics?

Results

The first two sections summarize observations from the responders' interviews, and describe challenges and the current quality improvement processes. The third section summarizes how the different analytics solutions can be used in this particular case. The last section describes how the theory works.

The Challenges and the Request of Constant Improvements

The educational program managers and faculty face two kinds of challenges which require constant curricular changes and improvements.

The first challenge pertains to the course content. The syllabus is influenced by recommendations of the International Medical Informatics Association [22]. However, the field of health informatics is continuously changing and growing; new techniques, aspects, theories, and solutions emerge constantly, and teachers have to renew the teaching material and course curricula annually. During this reform, according to DaRosa & Bell [6], we consider the curriculum to be a product. This improvement is time-consuming but relatively easy. The faculty are familiar with the new knowledge; they have time to prepare the material and the examination type is easy to define. Eventual success or failure is easy to measure.

The second, and greater challenge, is to improve and adapt the methods to provide this content. According to DaRosa & Bell [6] the curriculum is now a process. The focus is to engage the students to be active participants and not passive recipients of prescribed knowledge. The students in this masters' program are already practitioners in their field; either computer engineers or health care professionals. The program instructors use different teaching approaches (case projects, group-work, team-based learning) rooted in different learning theories, like constructivism, experiential-based learning, and connectivism. They constantly try to improve the course, which proves to be demanding work. The achievements or objectives are more generic in nature (problem-solving ability, engagement in personal learning, critical thinking), the examination is sometimes unclear, and there are no pre-defined measurements of success or failure.

The Current Quality Improvement Process in Different Levels

During course development, coordinators have to define, re-define, or improve the course content; choose appropriate teaching activities; and follow policies and recommendations. During this phase, they work in close collaboration with other teachers, instructors, course designers, and program managers, and they have access to other experts from the department. Some instructors are willing to test and implement new pedagogical approaches in their sections, like the flipped classroom approach, gamification, or simulation. They can always share ideas and experiences and get feedback, but they admit that sometimes they rely only on a "gut feeling," especially in the case of new implementations. While the course is in session, the coordinators again have to trust this "gut feeling" in the hope that everything will turn out well.

The students give their feedback through a Web-survey after the course ends. The feedback pertains to the alignment between the course objectives, teaching activities, and supporting learning materials, as well as with other courses in the program, and communication and collaboration with other students and teachers.

The course coordinators compile and send a final report of the survey results to the program management. This report includes the coordinators' own reflection of the results and plans for future changes and improvements.

The program director, students, and teachers convene once a year to conduct a SWOT-analysis (Strengths, Weaknesses, Opportunities, and Threats), which leads to an action plan for the following year. The program director introduces this action plan to the program committee and the board of education.

The board of education closes the loop by sending feedback to the program director and faculty, which the course coordinators consider during course development.

How Analytics Can Change This Scenario

In this scenario, we can identify all the different dimensions described (in section 1.2). Before the course starts and during the preparation stage, the course coordinators can use curriculum mapping tools to identify the gaps precisely. They can get insight into what kind of learning objectives are not properly supported by teaching or learning activities. They need suggestions for new appropriate and motivational teaching activities to add into the schedule. Furthermore, through other analytics tools, they can analyze the class and predict their needs. Examples include student demographics, previous performance, approaches to learning, the blend of technology used, and group dynamics. This kind of data can be processed by a range of algorithms and predictive models to develop the probable characteristics of the class [23].

In the next step, other visualization tools can provide alternative suggestions for designing appropriate activities to fit this particular class and demonstrate the effects of each. The coordinator can monitor the activities and progress during the ongoing course. They can zoom in and out from the entire class to one working group or one student. They can also follow the progress of the generated social networks. They can calculate the general engagement and identify students at risk. In an open platform, they can also compare current analytics from this class with other, anonymized datasets within the same educational program, from other faculty, or even from similar courses in other universities [23].

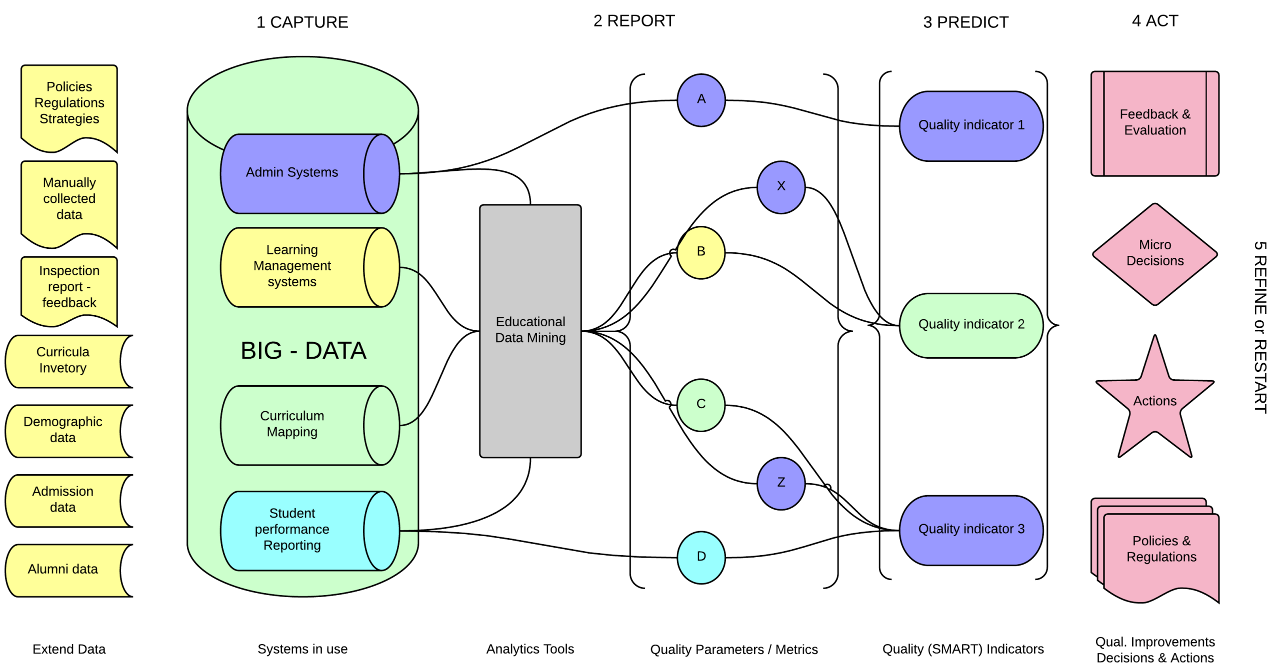
The results and experiences generated by the course can be used to build up the knowledge database with evidence about different pedagogical interventions. This can assist in contextualizing the Policy and Environmental analytics within the organization (department or university) and be a key part of the quality improvement and academic research.

How the Theory Can Work With the Existing Data

Analytics Loop Step 1: Capture

We had access to a collection of large and complex datasets which we will call "big-data". In this context, "big" refers to complexity rather than volume. Examples of big-data include: demographics, admissions, syllabuses, curricula, course evaluations, teacher's reflections, students' performances, and logs (see column 1, Figure 2). The included systems collect and store more data on a daily basis. Examples of systems are course administrative systems, learning management systems, curriculum mapping systems, and student performance reporting systems (see column 2, Figure 2).

Figure 2. Analytics-driven quality management framework.



Analytics Loop Step 2: Report

Different types of data are collected: numeric, text, statistics, structured, metrics, and values. Using different analytics tools [24,25], the data is processed (see column 3, in Figure 2) and transformed into metrics or parameters (eg, Boolean operators: True/False (see column 4, Figure 2)).

Analytics Loop Step 3: Predict

The challenge here is not lack of data, but synthesis and interpretation. Other analytics research projects have focused on data collection and its processes (eg, tracking mobile data and the use of standards [26]), or on data processing techniques (eg, data mining [27], and better reporting or presentation (eg, Visual analytics [28]).

Our focus is on the synthesis and decision support. This synthesis includes three main steps: The creation of SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) quality indicators, transformation of the analyzed data into meaningful information, and presentation of the correlation between the nodes (column 5, in Figure 2).

The creation of quality indicators is the key step in this model. Some indicators are simple (eg, more than 75% of students have done one exercise before the deadline). It's easy to identify the supported data and easy to check. However other indicators are complex (eg, the students are engaged in their studies, the students are developing a professional attitude, or the course is linked to relevant research.)

The next step is identifying the necessary parameters or metrics. The analytics tools (see column 3, Figure 2) process all captured data and all parameters/metrics and eventual correlations between them (see column 4, Figure 2). The challenge is to select the most important of these. The importance or need for specific entities depends on the quality indicator which can change from case to case. The context (eg, the class size or education level) determines whether a metric is relevant.

The last step before making a recommendation can be done by visualizing or highlighting correlations or causalities (or lack thereof) between the chosen metrics.

The most important factor in this data transformation is first to inform and further to support decisions by setting a clear and specific context. Data or metrics, correlations between them, and eventual conclusions and recommendations are relevant or not depending on the context.

Analytics Loop Step 4: Act

The goal of any analytics project is actions based on data-supported decisions. The decision-making process however is sensitive and complex (see column 6, Figure 2). Even if the evidence, analysis, and data are enough to convince and support one decision, the decision makers may act differently. This inconsistency depends on a number of factors, including context, needs, economy, resources, climate, policies, ecosystem, and circumstances.

Analytics Loop Step 5: Refine

Evaluation of the analytics process can provide valuable feedback. This new data and evidence can lead to correction and modification of the analytics loop. Evaluation of the implemented actions and interventions create new data, which can lead to better suggestions and recommendations.

Discussion

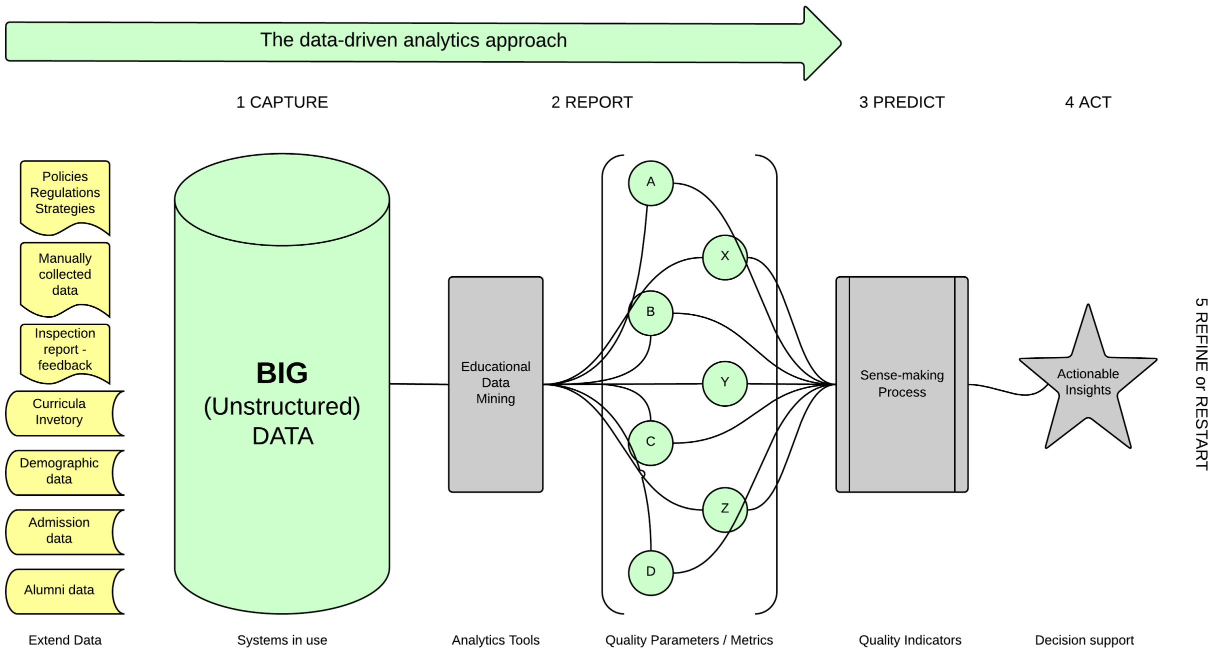
Principal Findings

This study develops a conceptual framework to describe how analytics can support the decision making process and improve the quality of health care professional education. The starting point was to follow the steps of the analytics loop, to examine how it works and illustrate the challenges. We can read this model in both directions.

Data-Driven Analytics Approach

Reading from the left to the right, the framework describes the common and traditional data-driven analytics approach, which is more meaningful to experts in the data-mining area. It starts from the data and ends at the decision. According to this approach, we start the loop capturing as much data as possible and then push it through the steps. The main focus is on the data and the techniques to collect, store, clean, secure, transfer, process, and access the data. In the next step of reporting, a large amount of data is an asset. The more data we put in, the better reports we get out. However, processing such large datasets also presents a challenge, requiring more advanced mining techniques and more powerful computers, tools, and software. To make sense of all this data, calculate all trends, and investigate all possible correlations is a demanding task. Educational data-mining (see column 3, Figure 3) is clear just to experts in the data-mining area, a drawback of the approach. Results from the analytics engine might be accurate, precise, and based on evidence, but still remain just suggestions. Sometimes the decision makers, because of unknown circumstances, don't accept the recommendations and act differently. In this data-driven approach, decision support (see column 6, Figure 3) is like a black box, and the processes within it are unknown. According to the analytics loop, the last step is to start all over again with more data.

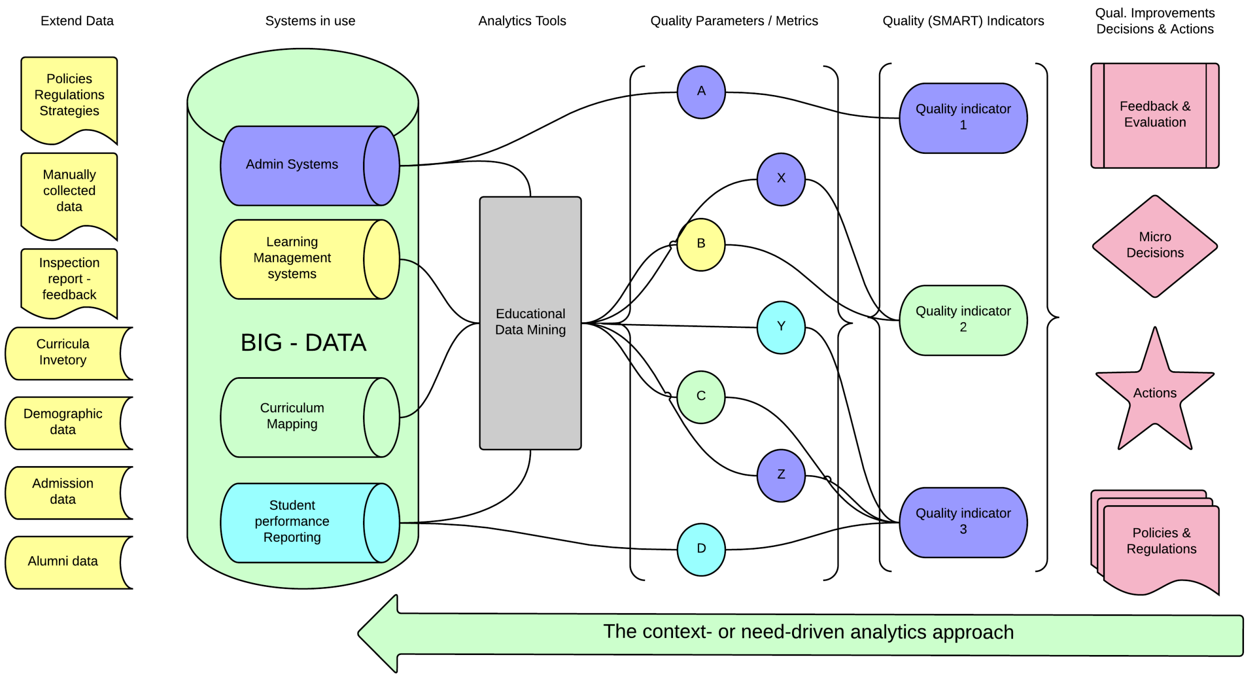
Figure 3. The data-driven analytics approach.



Context- or Need-Driven Analytics Approach

We can also read the model from the right to the left. The framework describes a new analytics approach that we can call context- or need-driven analytics. This approach is more suitable for non-technical oriented educators and decision makers (like faculty in health care professional education). The approach starts from the need for a decision, and goes through analysis of relevant data. Quality improvements, decisions, and actions (see column 6, Figure 4) must be crystal clear. All details are important: the stakeholders, the context, special needs, financial limits, access to resources, organizational climate, existing policies, technological ecosystem, timing, and other circumstances which affect the decisions. The outcomes from this analysis are the request of specific information to support a decision or micro-decisions. This relevant and specific information results from synthesis of carefully selected and specific data. These data are selected, processed, calculated, compared, mined, and operated by analytics tools using specific mining techniques. The analytics engine contains other integrated mechanisms and specialized agents to identify systems producing the data or repositories containing the data. This time we pull the data and processes from educational data mining (see column 3, Figure 4), which is like a black box for this group of users. The last steps of the analytics loop either refine the data to answer the primary question, or generate a more specific question to restart the analytics process.

Figure 4. The Context- or need-driven analytics approach.



Data-Driven Approach Versus Context- or Need-Driven Approach

Big data alone, even lots of it, may become cumbersome and demanding to manipulate, hence weighing down processes intended to achieve beneficial results.

Although effort and time can be conserved at the onset of adopting a context- or need-driven approach (ie, by eliminating options deemed unsuitable based on contextual standpoints), the very nature of this approach demands specifics. This presents the likelihood of missing possible underlying problems overlooked by the user, which surfaced in trends detected from optimized data-driven strategic approaches.

The context- or need-driven approach can serve to identify specific areas of concern, but it cannot function with a dearth of big data. Optimized data-driven strategic approaches can help drive root-cause analysis to identify all possible interactions within the system that could contribute to areas of concern.

Analysing the Use Case From the Context- or Need-Driven Approach

The scenario of the use case is the same as before; a course coordinator identifies a gap in the curriculum and asks for support to choose proper learning activities for this group. The coordinator starts from column 6 in Figure 4 and takes into account all the circumstances (context, special needs, financial limits, available resources, existing policies and organizational climate, technological ecosystem, timing, and all other parameters) that can affect the decisions. After this primary analysis, some suggestions would be excluded to save effort and time (eg, activities for which we don't have money to buy equipment). The creation of clear and concrete quality indicators in the next step (see column 5, Figure 4) is important, especially when some indicators are compound and complex. Quality indicators include: which of the suggested teaching activities engage the students in their studies, and which activities help students to develop a professional attitude.

Column 4 in Figure 4 contains specific and carefully selected metrics or parameters (eg, numeric data or Boolean operators: True/False) that are necessary and directly connected to the quality indicators.

The biggest challenge in this approach is the development of tools, mechanisms, operators, and agents that can recognize, select, pull, and process the relevant data to support the creation of those parameters (see column 3, Figure 4).

Columns 1 and 2 are the same as before, but indexing, structuring, and standardizing all data before storing it could facilitate the process.

Knowledge Transfer From Other Areas

Supporting decisions by data and evidence has been used in other application domains in the past. Some Clinical Decision Support Systems (CDSS) use these principles (ie, comparing specific selected parameters from one individual patient against standards). Medical doctors and other health care professionals use this kind of (CDSS) systems to determine a diagnosis or choose a treatment.

Using the same metaphor as the previous use case, teachers and course designers can check the qualitative health of a course, identify problems, suggest appropriate treatment, and monitor the progress. We can observe some characteristics of the CDSS and learn some lessons.

These systems are extremely precise but also highly specific and specialized for just one or a limited number of purpose(s). Universally applicable systems which can diagnose all possible diseases do not exist.

Such systems access and process only specific data sets, leaving out redundant ones.

The essential power of these systems is to clarify incomprehensible data sets, and in this way, support decisions.

The Scientific Value and the Practical Use of This Study

One challenge when trying to connect analytics and education is to communicate issues and theories concerning one area to specialists and experts from the other. Case studies and conceptual models have been used successfully for this purpose. In general, a case allows us to apply an idea or theory to a particular context and to test it from different points of view.

The case we have used illustrates a real problem. A clear limitation of using the case studies as a method is the ability to make generalizations. The challenges and process are specific only for the involved personnel. Any recommendations and solutions for the particular case do not apply in other contexts. We used the case to understand the practical use of analytics and illustrate the communication problems between experts from the areas of analytics and education.

The conceptual model demonstrates how the theory of the analytics loop can be applied to both the data-driven analytics approach and the context- or need-driven analytics approach with respect to each groups' terms and conditions. The model also identifies the challenges. A different approach might result in different recommendations.

Conclusions

All parts of the analytics loop [19] can be conceptualized both in theory and practice. Decisions that improve the quality of education can be driven by synthesizing existing data rather than acquiring more data. Data can be transformed to information when it has been contextualized. Analytics projects do not always have to follow the traditional linear data-driven approach. The context has high impact on the decision making process. The context- or need-driven analytics approach emphasizes inclusion of all necessary details and is more suitable for non-technically oriented users.

Beyond recognizing the promise and potential of new technologies, mapping how ICT (analytics) and ICT-based learning (education) fit in the design and implementation of health care professional's education remains a vital task which, as seen from Figure 2, lies within the middle columns, away from the extremities.

Hence, in the best interests of both the students and the organization, these two approaches should ideally co-exist and function in tandem. Instead of dichotomizing our choices, we should explore the middle ground.

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Conflicts of Interest

None declared

Authors' Contributions

Vasilis Hervatis is the main author, Alan Loe wrote sections in the results and discussion, Linda Barman composed parts of the background and methods, John O'Donoghue wrote parts of the background and results, and Nabil Zary composed parts into the discussion and conclusions.

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