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Special Section
Learning Without Frontiers 2011: Mobile Research Strand





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Distance Learning in the Cloud: Using 3G Enabled Mobile Computing to Support Rural Medical Education

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Abstract

Distance learning technology provides essential support for rural medical education. Special care must be taken to create distance learning systems that do not exacerbate feelings of isolation inherent to distance learning and rural medicine. The most common distance learning technology utilized by medical schools for rural placements is expensive, location specific, and impersonal. New web-based, mobile technology is now available that can efficiently deliver curriculum content to remote students at lower cost and with minimal technical support. This paper describes a pilot implementation of an integrated online clerkship curriculum that offers both synchronous and asynchronous distance learning experiences. Ease of access is emphasized by utilizing inexpensive, widely available mobile technologies and 3G internet connectivity to support streaming video and live video chatting to achieve course specific goals in a social constructivist educational framework.

Keywords

Distance Learning; Mobile Computing; Mobile Broadband; Netbooks; Social Constructivism; Medical Education; Rural Medicine; 3G

Background

The Oregon Rural Scholars Program (ORSP), a training program for medical students pursuing rural medicine at Oregon Health & Science University (OHSU), was developed in response to the declining interest in rural medical practice among US medical students. This decline has been noted nationally for several decades (Jefte, Whelan, & Andriole, 2010). Commonly cited reasons for declining interest to rural medical practice include professional isolation and inability to access current technology (Somers, Young, & Strasser, 2001). ORSP students are selected for their motivation and independence, and complete a minimum of 1/3 of their clinical training in frontier and remote settings, supervised by community-based physicians. Until recently, rural students have had limited contact with peers and on-campus faculty. Recent improvements in communications connectivity in rural areas have created increased opportunity to connect rural students and physicians to peers as well as urban-based medical resources, creating the potential to remove some barriers to rural practice (Geisler, 2010).

Accreditation standards require that rurally located students receive an equivalent, though not necessarily identical, curriculum experience as their campus-based peers. This includes completion of required group activities and interaction with campus-based faculty. A robust, distance delivery system is necessary to meet the educational needs of the ORSP students and faculty, as well as meet accreditation standards.

Distance education has been on the rise in higher education (Pascarella & Terenzini, 2005). While it has been slower to take hold in medical education, there is evidence that e-learning produces similar levels of satisfaction and knowledge attainment in medical students as it does in non-medical students (Pascarella & Terenzini, 2005; Ruiz, Mintzer, & Leipzig, 2006). A downside to distance education is the potential to increase a sense of isolation among students who spend significant time separated from peers and faculty. Dickey (2004) finds that distance learners “may sporadically or continually feel disenfranchised or marginalized by the use of technology” (p. 280). This is especially concerning when coupled with the personal and professional isolation that are common in the rural medical experience. Therefore, specific planning must be employed to effectively use technology to create a sense of community among students and faculty in distance education in order to reduce, rather than increase, isolation among spatially dispersed learners. According to Dickey (2004) “there are methods and strategies to be employed in the design of web-based learning environments that help bridge learners and reduce feelings of alienation” (p. 290). Thus, the ORSP learning platform was designed to reduce the isolation and disconnection inherent in both distance learning and rural medicine.

In designing a cost effective, accessible and functional educational platform for the ORSP, a mobile distance learning system was the most viable option. Many rural US locations still do not have widely available access to high speed broadband Internet connections. Where broadband Internet does exist in rural areas, it is often limited to wired connections at specific locations. Previous attempts to connect students to the resources of the OHSU main campus required expensive fixed location technology that required students to disrupt their educational and clinical experiences to travel to the closest fixed site. ORSP students are community-based learners who need instant access to videoconferencing, voice over internet protocol (VOIP), and Internet from multiple locations. They need access to instant, point-of-service clinical information as well as to faculty. Therefore, ORSP students must bring their classroom with them via highly portable devices and 3G Internet connectivity.

While the use of portable devices in medical education is not new (Cahoon, 2002; Galt et al., 2002; Rothschild, 2002; Smørddal & Gregory, 2003), the use of 3G technology to deliver a consistent high-speed internet connection capable of videoconferencing and VOIP on mobile devices is novel. In previous studies, portable devices were often used for simple data capture, such as patient demographic and clinical data, on the device without the need for immediate Internet connectivity. In cases where the Internet was accessed, it was done through local Wi-Fi connections rather than pervasive 3G Internet connectivity. In contrast, all activities in the ORSP project were accessed via 3G connections, which allow true portability and choice of device, including netbooks and laptop computers. This case study serves as an important example of how situated learning enabled by mobile devices can now take place in a wide variety of locations, including rural and frontier US locations through the use of 3G connectivity.

Focus

This paper describes the practical application of existing web-based technologies to the creation of a system capable of delivering a remote Family Medicine clerkship curriculum to ORSP students in isolated rural locations. The system was designed to be simple, low cost, and highly portable due to the rural nature of the program and modest initial funding of the ORSP program. Our system utilizes inexpensive Asus EEE netbook computers with Verizon-enabled 3G data mobile broadband modems, as access to reliable Internet connectivity varies in many remote locations. These modems have been successfully used in all of our rural locations for passive learning activities (such as accessing the course management system and viewing pre-recorded lectures via streaming media) as well as active learning activities (such as live video-chatting, screen sharing, and file sharing in an Adobe Connect virtual meeting room). Finally, this system has been designed with scalability in mind and can be readily expanded to include more learners, thus better meeting our state’s rural medical education needs.

The combination of mobile device and pedagogical approach used in the ORSP program correlates well with Koole's (2009) FRAME model of mobile learning. All aspects of the FRAME model (Device, Learner and Social) are sufficiently met, as identified in Figure 1. First, netbook computers work well within FRAME's device aspect (D). Netbooks are highly portable computing devices, comfortably fitting into a backpack or purse. They are essentially stripped down laptop computers that provide all the input, output, and processor needs of a larger desktop device. Further, the netbooks use either the Windows XP or Windows 7 operating systems, and include the popular Microsoft Office productivity suite of applications. Most learners are already familiar with the interface of the operating system and software of these devices, requiring no additional training or instruction. The social constructivist pedagogical focus of the Student Clinical Round (SCR) activity that is core to the ORSP program (described in detail later in this article) correlates with the learner aspect (L) of the FRAME model. In describing the learner aspect, Koole (2009) states, "actively selecting or designing learning activities rooted in authentic situations as well as encouraging learners to discover laws within physical and cultural environments are powerful pedagogical techniques" (p. 31). The SCR proves an ideal example of this type of learning activity. Finally, the conversation and collaboration used in the SCR activity using mobile devices meets Koole's (2009) social (S) aspect of the FRAME model. Logistical modifications were made to recreate the collaborative, in person SCR activity in a mobile, virtual environment, thus enabling the implementation of the traditional classroom-based family medicine curriculum in a virtual space. These modifications for mobile learners satisfy accreditation requirements, as well as the D, L and S aspects of the FRAME model of mobile learning, thus providing a rich mobile learning experience for the remote ORSP students.

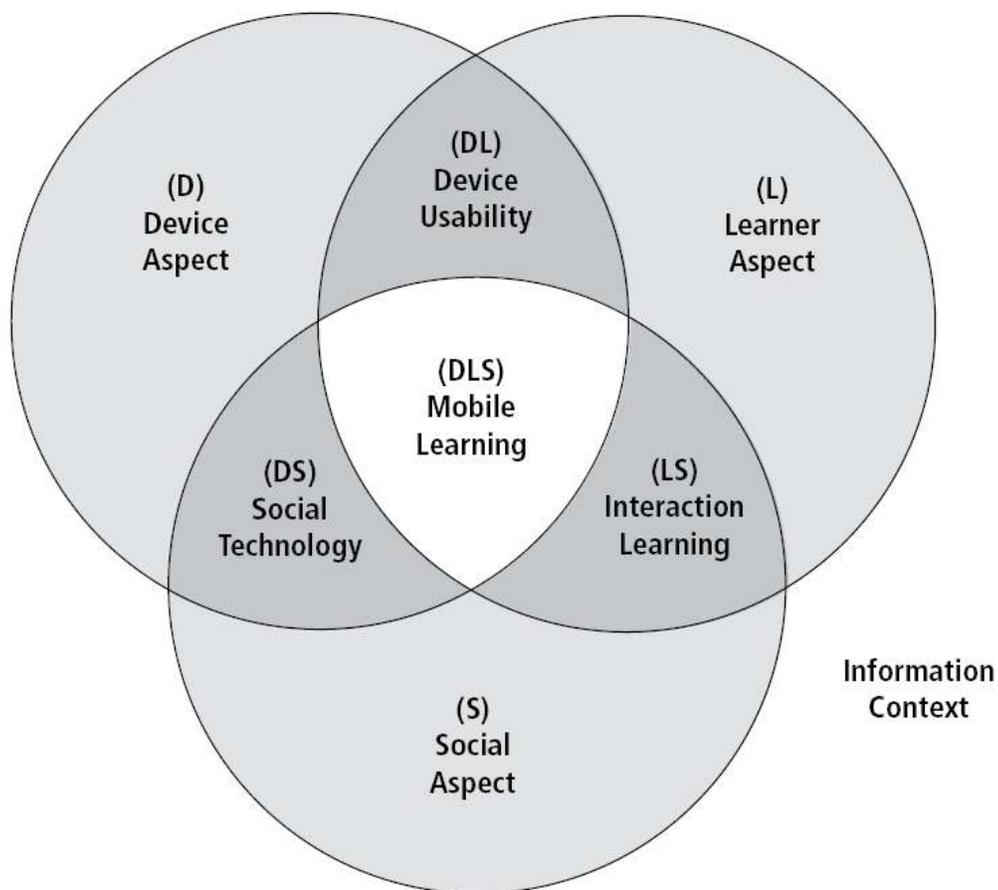


Figure 1: Koole's FRAME Model of Mobile Learning (from Koole, 2009, p. 27. Used with permission)

Methods

The components of the Family Medicine rotation include clinical experiences, readings, an essay, a written exam, an Objective Structured Clinical Encounter (OSCE), lectures, and a weekly group presentation activity called Student Clinical Rounds (SCRs). Of these activities, only the latter two required synchronous availability of faculty and students to effectively engage in the activity. Additionally, both lectures and the SCRs could not be replicated individually in a student's rural location. As lectures are primarily passive learning exercises for on-campus learners, a decision was made to record these lectures and make them available to the remote learners asynchronously via streaming video. SCRs, on the other hand, are student-driven problem-based learning assignments. Problem-based learning is a social-constructivist, student-centered pedagogy in which students work together to collaboratively problem solve and reflect on their experiences (Bridges & Hallinger, 1997). In the SCR activity, students present to their peers a case they have observed in clinical practice during the week, guiding them through the clinical reasoning inherent in determining the differential diagnosis for the patient. A faculty instructor is present to provide guidance and feedback both during and after the exercise. The on-campus, in-person SCR activity requires a high level of student participation. Therefore, in order to create a sense of community and combat feelings of isolation among the remote learners, SCRs were recreated in a virtual space as "face-to-face" exercises, replicating as closely as possible the on-campus interactive environment via video chat.

Hardware and Software

An early decision was made to deliver curricular content via the Internet, a.k.a. "the cloud", rather than through a device-centric software and hardware based system. This allowed us to keep the system low cost and highly portable. It also gave our learners the flexibility to access their curriculum and classroom activities on any web-enabled, Adobe Flash-capable device with a broadband Internet connection. Though students were provided with netbook computers and 3G data modems to ensure constant Internet connectivity (as will be described in detail later), they additionally had the freedom to use any device capable of meeting the course needs. In this sense, the classroom traveled with the students and was available anywhere there was an Internet connection.

As planning for the program began, OHSU used a proprietary, hardwired videoconferencing system. While this system had proven effective for conducting site-based departmental meetings, the hardware and subscription costs per site were prohibitive for the modest budget of the ORSP. Additionally, the legacy system's hardware requirements allowed no flexibility for student access at point of need. By using the Internet as the delivery medium instead, students could bring their videoconferencing equipment with them in the form of webcam equipped netbook computers. Asus EEE brand netbooks running Windows XP and, later, Windows 7, were chosen based on strong consumer ratings, battery life, and inexpensive cost. Netbooks were upgraded from 1 GB to 2 GB of RAM for increased performance.

Many of the ORSP sites are categorized as "frontier" by the US Census Bureau (i.e. less than 6 persons per square mile), and in these areas reliable Internet connections capable of handling streaming media, video chat and VOIP could not be guaranteed. Equipping each student with 3G capable Verizon mobile broadband modems was effective in ensuring reliable, portable internet access. Verizon demonstrated the best 3G connectivity in the remote parts of Oregon. Advanced field testing verified that these devices would allow for video chat and streaming lecture videos with a 3-4 bar reception signal. At a cost of \$60 (US) per modem, per month, for unlimited data, this approach proved less expensive and far more flexible than alternative videoconferencing options.

Sound quality was a key consideration in development of our system. An 'echo' effect, caused by the audio from the netbook's speaker being picked up by the netbook's microphone, caused considerable distraction and disrupted the natural flow of interaction. The solution was to provide headphones for each netbook user, eliminating the feedback echo entirely.

Software platforms needed to be as lightweight and intuitive as possible for our users, so all software was made accessible through an Internet browser. This also kept our system highly portable by making it completely cross-platform. For standardization and ease of troubleshooting, we provided equipment to students, but did not limit their ability to access their course to the provided devices only. Rather, students could use their own computer or a clinic computer to access all elements of the system. Additionally, they were free to use their data modems on their own computers.

All course content was housed on OHSU's web-based Sakai learning management system (LMS), which the students already utilized throughout their medical school curriculum. This familiarity with the Sakai system minimized training time for students and faculty and added no additional costs for web hosting or technical support. Students accessed the asynchronous curricular components (lectures and course materials) as well as the synchronous component (Adobe Connect virtual meeting room) via links embedded within the centralized Sakai system.

Asynchronous System Components

Asynchronous course components were made available as links on an HTML page created within the Sakai LMS (Figure 2). Lectures were recorded digitally, converted to Flash streaming video, and then housed on OHSU internal streaming servers. Special care was taken to make the streaming videos compatible with 3G Internet access speeds by saving all videos at no more than 256 bitrate. Field testing determined anything above this bitrate caused excessive buffering, resulting in frustrating delays on the user end.

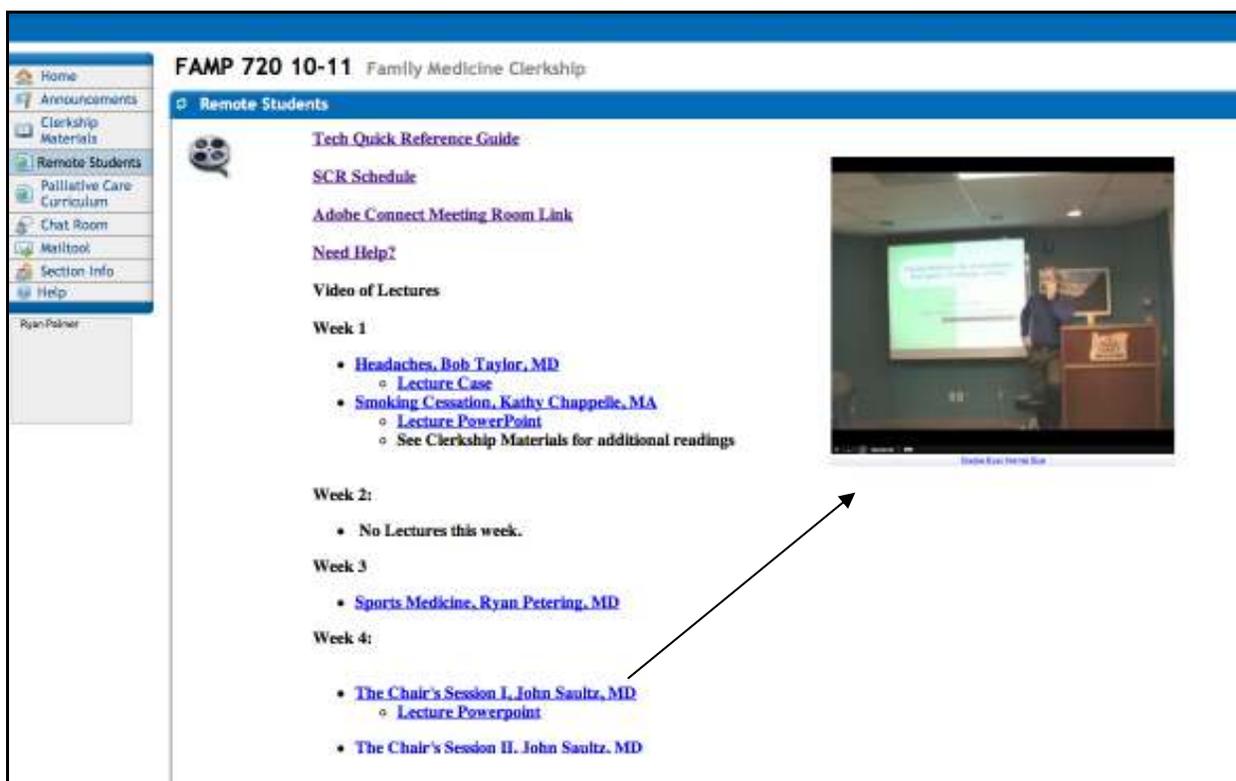


Figure 2: Asynchronous delivery of lecture content and materials via Sakai (Participants pictured have given permission for their images to be used)

Synchronous System Components

Adobe Connect was used as the software for the synchronous SCR sessions. This software was accessible through any Flash-enabled web browser and was available through an existing institutional license. Connect is also highly functional, allowing for multiple video streams, chat, shared notepads, and document sharing. These functionalities helped replicate the on-campus, in person group SCR experience.

SCR Configuration

The ORSP launched in July 2009. Since that time, the synchronous SCR sessions have evolved through three configurations, described below.

SCR configuration 1: Blended on-campus and remote learner mix

Initially, remote students joined their on-campus colleagues for blended, live SCR sessions. The on-campus, physical meeting room was set up with the virtual meeting room participants projected onto a large screen. This was designed to make on-campus students feel as if they were communicating with remote classmates directly, and not 'talking to the screen'. A Connect meeting room operator facilitated the meeting from the side of the room. Figure 3 indicates the blended room technical configuration. Figure 4 indicates how this setup looked from within the Connect meeting room.

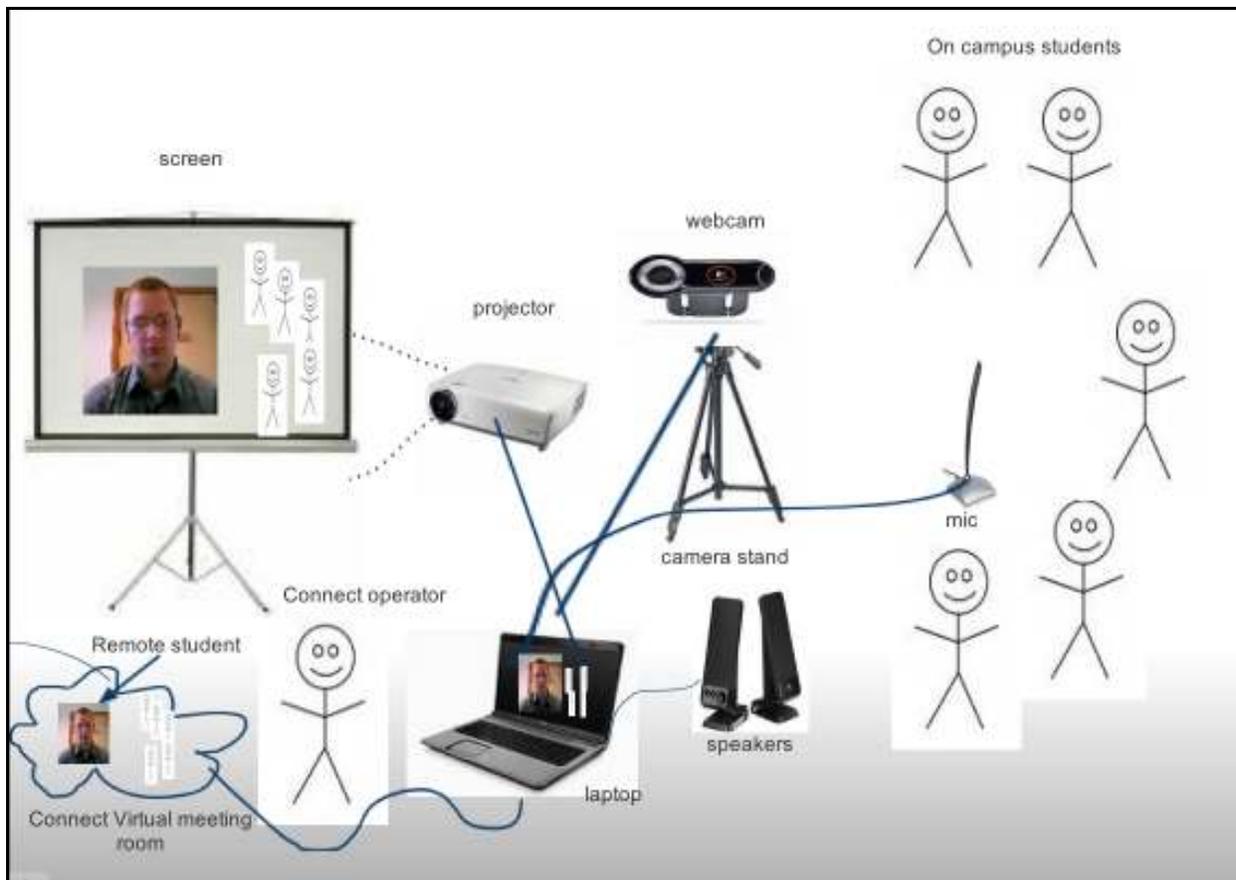


Figure 3: Remote and On-Campus Blended Learning Room Technology Set-Up

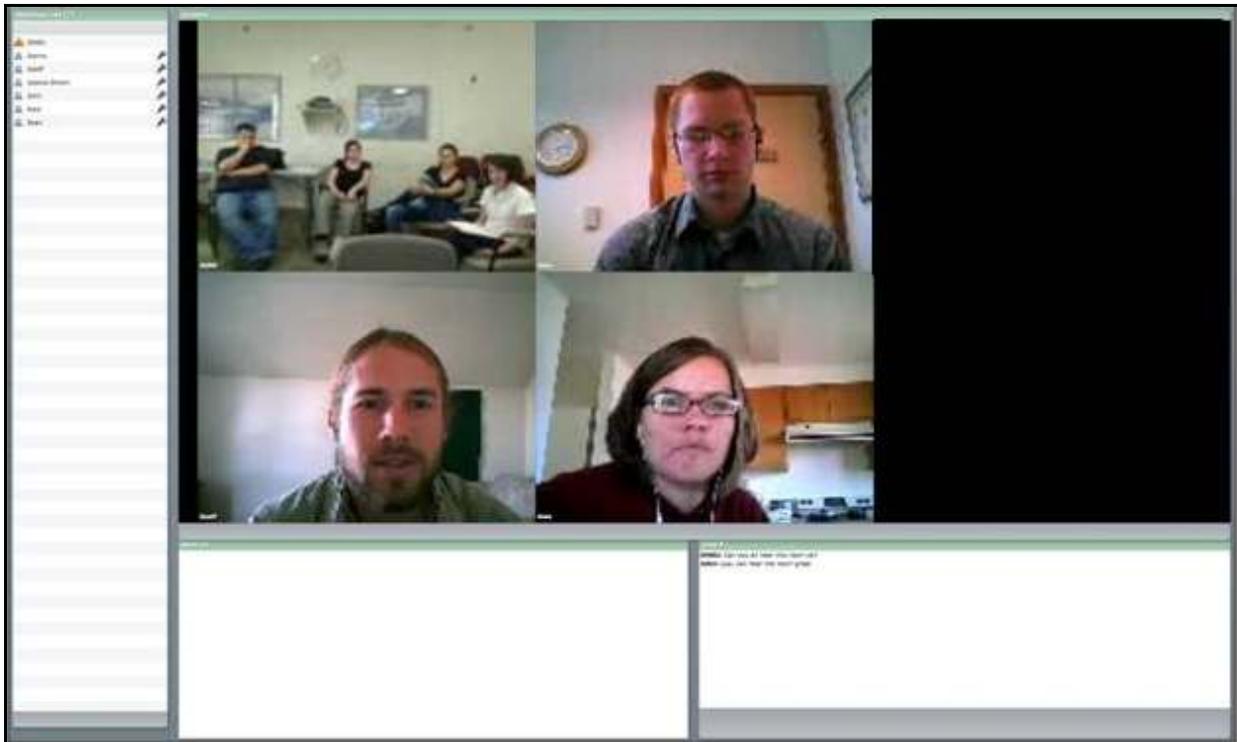


Figure 4: Appearance of Blended Learning Set Up from within Adobe Connect Meeting Room

SCR configurations 2 and 3: Online only (multiple webcam vs. one presenter at a time)

As the number of remote learners increased, a decision was made to turn the remote learners into a separate SCR group, with a faculty leader and Connect facilitator joining the group virtually. This eliminated the need for technical equipment at the on-campus location.

There were two different iterations of the online-only configuration. In the first iteration, pictured in Figure 5, all students and faculty participated with video cameras turned on. In practice, we found that the utilization of multiple video cameras and VOIP overloaded the 3G modems, resulting in transmission delays. While the multiple-camera configuration worked well with 1-3 students, the transmission delay between speakers grew more pronounced as the number of participants grew. This created an awkward situation in which speakers with longer delays were 'talking over' other speakers. We therefore switched to a room configuration in which only one student, who was the SCR presenter, utilized the webcam (see Figure 6). We found that this configuration improved voice transmission speed and better managed delays. Additionally, after checking in at the beginning of the SCR, remote learners turned off their webcam and initiated conversations using a 'raise hand' feature in the Connect meeting room. This helped mitigate the voice time lag, as the participant with a raised hand would know he/she was cleared to speak once he/she received the voice command from the speaker. An additional interactive feature in Connect that was used was the chat pod. The chat pod created a 'back channel' conversation where interesting points were raised for further discussion throughout the session. Further, this chat tool allowed for side coaching by faculty as well as technical troubleshooting during the session. We have found the configuration in Figure 6 to be the most effective of the three configurations at encouraging interaction, and one that can be scaled up to include more remote learners without degrading session quality.

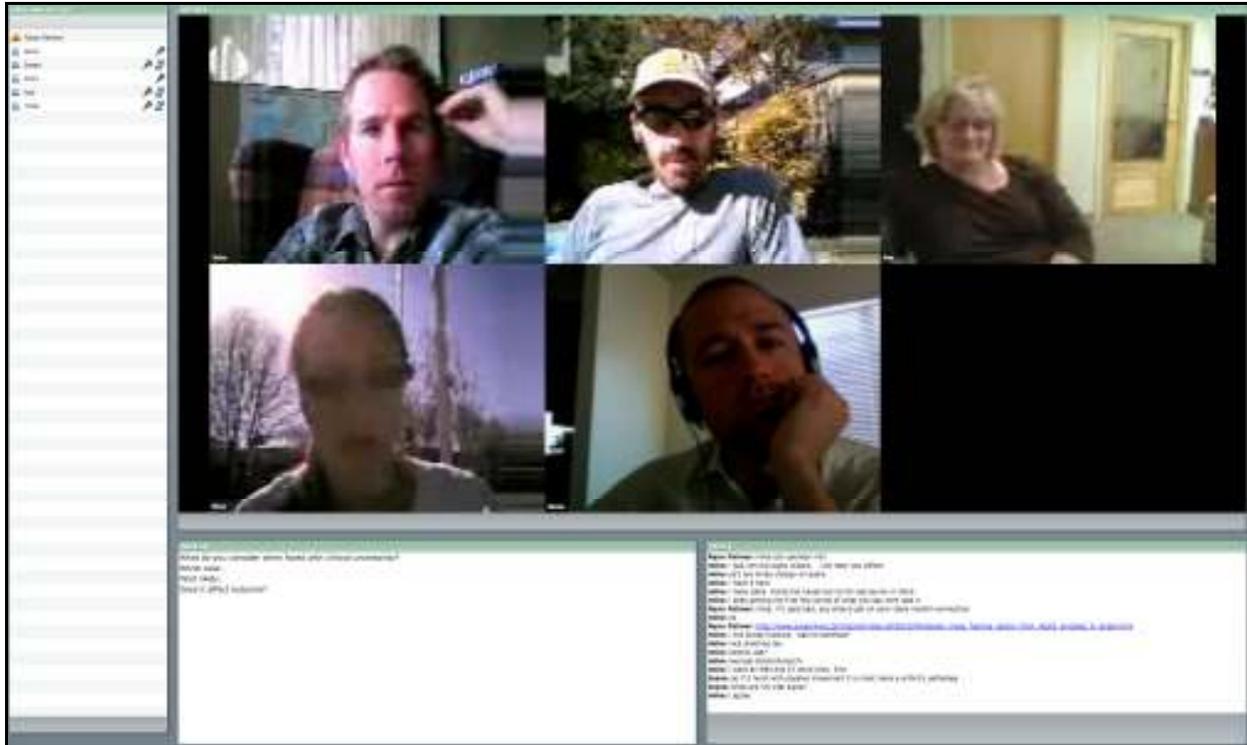


Figure 5: Online Only SCR Group with All Webcams Enabled (Note the diverse locations in which participants are situated)

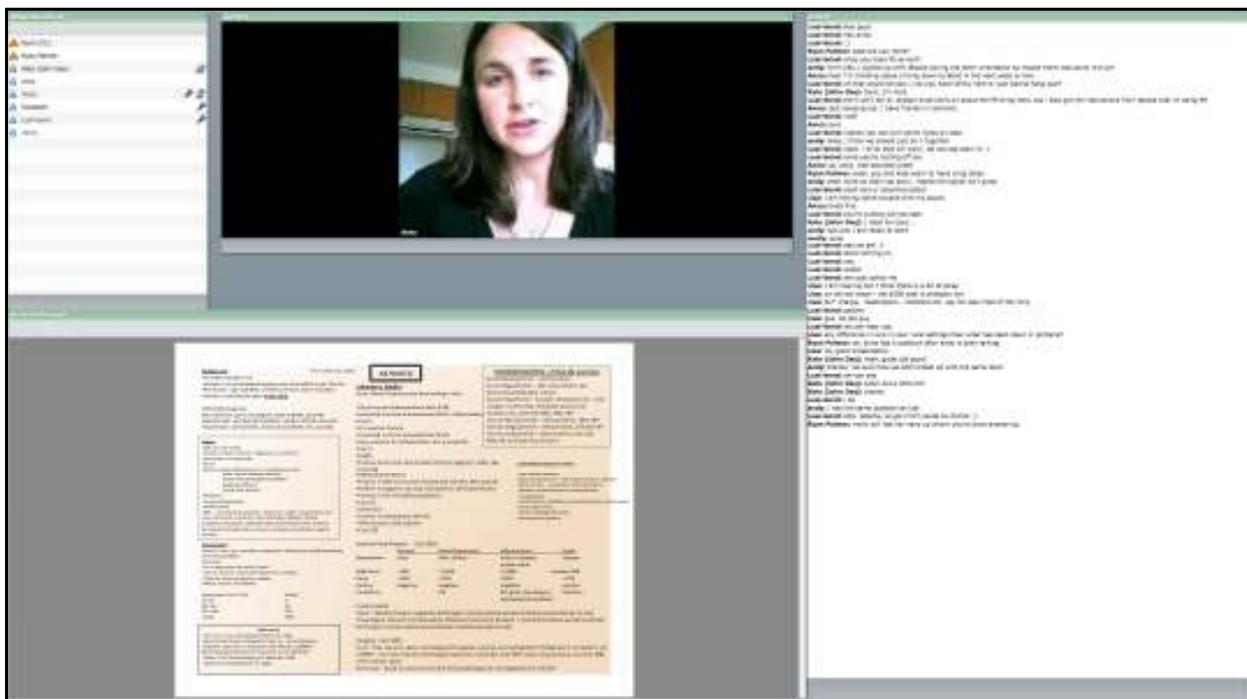


Figure 6: Online Only SCR Group with 'One Presenter at a Time' Configuration

Evaluation

The Oregon Rural Scholars project and mobile platform have been in use since July 2009, with 23 students having completed the experience using our mobile content delivery system. Deploying a mobile curriculum using 3G Internet connectivity in rural locations was largely unprecedented. As such, there were many unknowns during early implementation, requiring constant attention in order to fine-tune the system and resolve technical issues. Some of the more persistent issues were poor sound quality, inconsistent Internet connectivity (often based on students' use of local Wi-Fi routers rather than the 3G data modems), and delay in VOIP during synchronous discussions. We have recently adapted the meeting room configuration as described in Figure 6, and these issues have been significantly reduced. Most students experienced some technology-related issues during their remote experience. Despite these issues, student surveys indicate a largely positive reaction to the program and technology used.

Survey results are available for the first 19 of the first 23 students. The experience was largely positive and was preferable to the alternative of returning to a weekly, campus-based classroom session. Table 1 summarizes the quality of the experience for the synchronous component (SCR) and for asynchronous activities using 3G connectivity. We found that 90% of students found using the technology to be "extremely easy" or "fairly easy". The majority of students (63%) found the ability to connect to classmates "extremely valuable" or "somewhat valuable". One student noted that "it was nice to hear how others' experiences were going and to note that although we were isolated we were not alone." An overwhelming 95% of students preferred continuing use of the technology to the alternative of returning weekly to campus to participate in the classroom-based activities. We conclude that the intermittent technical challenges experienced by most of the respondents did not seem to negatively influence their overall satisfaction with the technology or program, and that the students generally found the mobile learning activities to be of acceptable quality. Further evaluation is needed to determine if the use of cloud-based computing to replace traditional classroom activities results in any difference in knowledge, exam scores, or other academic assessments.

Table 1: Summary of Survey Responses Regarding the Quality of the Technology Experience for Remote Classroom Activities (N=19)

Rating	Student Clinical Rounds (SCR)	All Other Activities
Excellent	3 (15.8%)	6 (31.6%)
Good	9 (47.4%)	9 (47.4%)
Indifferent	5 (26.3%)	2 (10.5%)
Weak	2 (10.5%)	2 (10.5%)
Poor	0	0
Did not answer	4 (21.0%)	4 (21.0%)

Reflection

Initial evaluation and observation indicates acceptance of the program and technology and positive perceptions by most students. Our students are largely of the 'Net Generation', and are generally comfortable, adaptable, and willing to experiment with new technology (Oblinger & Oblinger, 2005). Despite student affinity for technology, it would be incorrect to assume students are 'experts' at problem solving and using new technology (Oblinger & Hawkins, 2006). Robust orientation to the technology as well as providing technical support and troubleshooting throughout the experience improves acceptability and mitigates frustrations with technology issues.

While the surveys indicate a positive reaction to the program, the survey set ($N=19$) is too small to draw wide-ranging conclusions about the program's success. Current students using the system are largely self-selected for an interest in the rural lifestyle and education, so they may be more forgiving of the limitations of the technology than would be a typical student. That said, we have recently achieved a sustainable room configuration for the SCR sessions that is optimized for the 3G data modems, largely eliminating the sound and delay issues encountered previously. We anticipate positive reactions to the system's technology to remain the same, if not grow stronger, as the program progresses and additional features are added.

We have created a simple, effective, and inexpensive way to deploy a mobile Family Medicine curriculum to multiple rural locations throughout the state. The use of 3G Internet connectivity to stream content as well as video conference in rural locations represents a significant and largely unprecedented technological advance over previously available technology in terms of cost, mobility, and flexibility. Most importantly, this program is scalable. Students or content can be added to the system relatively inexpensively with additional netbooks and broadband modem accounts.

In sum, this pilot project was undertaken to determine if a traditional classroom-based curriculum could be cost-effectively adapted for delivery to remote students using readily-available technology and resources. Our preliminary success confirms the feasibility of our current system, but several research questions arise for future study. Study of this system's effectiveness for content delivery compared to traditional classroom methods, as well as further study on optimal delivery methods, should be undertaken. Other important areas of study include determining whether access to better connectivity through Internet-enabled devices and an interactive curriculum will reduce feelings of isolation among rural learners, as well as whether the availability of technology that overcomes professional and personal isolation in a rural setting will increase the likelihood of students choosing to practice there.

Looking to the future, the authors would like to expand the scope of the curriculum to include more student participation in a wider range of interactive exercises, thus creating a truly mobile classroom. We are especially encouraged by the possibilities afforded by the plethora of high-powered tablet computing devices that will soon enter the market (Chen & Hwang, 2010), many with front facing cameras for video chat and Flash viewing capabilities. A 3G enabled, highly portable tablet device could create a 'classroom' in each student's pocket, and every moment of the day could become a learning event. Additionally encouraging is the upcoming introduction of higher speed 4G mobile Internet technologies. Faster wireless connections on ultra-portable, always-on devices will allow for a more connected Rural Scholars experience. Such connectivity would allow more learners to engage in deeper learning experiences, no matter how remote their location. Ultimately, this could equate to better care of our in-need rural populations.

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