Findings and Recommendations

North American Network of Science Labs Online (NANSLO)

Consortium for Healthcare Education Online

Education and Employment Research Center

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SMLR was originally established by an act of the New Jersey legislature in 1947 as the Institute of Management and Labor Relations (IMLR). Like its counterparts that were created in the other large industrial states at the same time, the Institute was chartered to promote new forms of labor-management cooperation following the industrial unrest at the end of World War II. It officially became a school at the flagship campus of the State University of New Jersey in New Brunswick/Piscataway in 1994. For more information, visit smlr.rutgers.edu.

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Rutgers' Education and Employment Research Center (EERC) is housed within the School of Management and Labor Relations. EERC conducts research and evaluations on education and workforce development programs and policies. EERC research expertise includes community colleges, state and federal workforce developmental systems, skills development, college completion, and innovative and technology-based programs.

INTRODUCTION

The Consortium for Healthcare Education Online (CHEO) is a United States Department of Labor (USDOL) Trade Adjustment Assistance Community College and Career Training (TAACCCT) funded grant project intended to develop new or redesigned online and hybrid courses leading to credentials in health care fields in high demand across the West and Midwest. CHEO is an interstate consortium consisting of eight colleges across Colorado, Wyoming, South Dakota, Montana, and Alaska. The consortium includes: Pueblo Community College (PCC), Otero Junior College (OJC), Red Rocks Community College (RRCC), Laramie County Community College (LCCC), Lake Area Technical College (LATI), Great Falls College Montana State University (GFC MSU), Flathead Valley Community College (FVCC), and Kodiak College (KoC).

Each of the eight colleges is required to integrate the following components into its program/course design/redesign: 1) Open Education Resources (OER), 2) use of the North American Network of Science Labs Online (NANSLO), 3) a CHEO-funded career coach, and 4) use of the CHEO PlanYourHealthCareer Hub. This report focuses on the use of the NANSLO labs in CHEO.

NANSLO is a network of laboratories at colleges in the United States and Canada that offer remote science activities to students through the use of robotics and a web interface. The network consists of three nodes; each node is a laboratory equipped with science equipment (the exact equipment varies from site to site) that can be operated over the Internet through a web interface. NANSLO joined the CHEO consortium in order to offer remote science labs to CHEO students as part of the CHEO grants' goal of expanding and enhancing online and hybrid courses to allied health students and to "gatekeeper" basic science courses. The CHEO grant specified that 1) CHEO partners would collaborate to develop twelve lab exercises to be used in allied health and science-related courses and 2) faculty in the designed/redesigned CHEO programs would incorporate NANSLO labs into courses using one of the available nodes. The grant also specified that a third node would be developed and added to the NANSLO network allowing NANSLO to serve more chemistry, biology, physics and health care students.

This report examines the development, expansion, and implementation of NANSLO use under the CHEO grant, including the experiences of the project team members and participating staff, faculty, and students.

EXECUTIVE SUMMARY

This report looks at the evolution and use of NANSLO in the CHEO grant. It begins with a brief history of NANSLO and a summary of NANSLO's activities under the CHEO grant. It then moves to a discussion of implementation efforts relative to NANSLO adoption across the CHEO consortium, including successes, challenges, promising practices, and innovative strategies in the use of NANSLO. Finally, it presents a comparative summary of NANSLO student outcomes to date, key conclusions based on EERC's research and external research, and recommendations for the continued use and expansion of NANSLO relative to CHEO.

This report outlines five key findings to date about NANSLO expansion and use under the CHEO grant to date:

1. **Faculty and student buy-in matters for the success of NANSLO lab activity implementation. Faculty and students who already have positive feelings about online education will be more likely to benefit from NANSLO lab activities.**

Faculty buy-in. Faculty members who are already convinced of the benefits of online education are, in general, more likely to have positive feelings about NANSLO's potential. Faculty members who are proponents of online education as an effective teaching tool are also open to the benefits of NANSLO as a supplement or replacement for face-to-face or kit lab activities in science courses. These faculty members are also more willing to engage with NANSLO, including preparing for and encouraging students to prepare for and engage with the lab activities. This leads to a more positive experience for both faculty and students.

This finding is supported by existing research which shows that, regardless of a general shift in recent years to online education, many faculty members, especially those in the hard sciences, are reticent to embrace online methods as an effective way to teach science. Some scholars state that this is "terribly unfortunate," since multiple objective studies have found that "effective science-laboratory experiences are definitely achievable by fully online students, and students who acquire undergraduate lab science credits online have no problem progressing into graduate-level science careers" (Jeschofnig & Jeschofnig, 2011, p. 5). In fact, a growing body of research has found that online instruction in general is a very effective medium for delivering education (Fredrickson, Reed & Clifford, 2005; Shachar & Neumann, 2010; Jang et al., 2005; Means et al., 2009; Mentzer, Cryan & Teclehaimanot, 2007). A study by the United States Department of Labor in 2009 actually found that "on average, students in online learning conditions performed better than those receiving face-to-face instruction" (Means et al., 2009).

Student buy-in. EERC team members found that many students participating in focus groups were taking face-to-face and online courses at the same time, or were taking online courses but still coming to campus for orientations, special events, or to meet with other online students.

Additionally, in CHEO, students who see the benefits of online learning are more likely to see the benefits of NANSLO, and do not seem as likely to question whether or not it is "as good as" a kit or face-to-face lab activity. A quantitative analysis (presented below) of students taking BIO 101 online through CCCOnline found that those students who participated in NANSLO lab activities increased their final grade percentage by 10 points. These students had already opted into an online delivery modality for their education; they had self-selected for online learning and were thus more likely to embrace the fully online science lab than, perhaps, a student who preferred face to face learning.

Likewise, research shows that students who already see the benefits of online education are more likely to embrace the concept of learning science online. The demand for online education is primarily student-driven (Jeschofnig & Jeschofnig, 2011). Previous studies show that preferences for online education include flexibility, freedom, economic necessity, self-motivation, and the ability to self-pace. As online education becomes more prevalent, two types of students are emerging who prefer online instruction: non-traditional, part-time students with work and family responsibilities, and traditional, full-time, campus-based students who prefer the technology to traditional classrooms. This younger generation, raised on technology, "is comfortable with asynchronistic methods of communication and with interacting in online and telecommunication formats" (Jeschofnig & Jeschofnig, 2011, p. 15). Students who are comfortable with the technology and online format often return to online learning, whether they are on a traditional campus or fully remote.

2. The program's delivery modality matters for the success of NANSLO lab activity implementation.

Online programs/courses. NANSLO was explicitly designed to serve distance students who are not able to access traditional laboratories. As a result, NANSLO lab activities are a great fit for programs which are completely online. At colleges with totally remote programs, where students do not have the option of attending a face-to-face lab, fewer concerns about the value-add from NANSLO adoption are voiced. This is true, for instance, at KoC, where faculty have been very pleased with the new opportunities that NANSLO gives their students. KoC students never come to a campus to do lab activities.

Traditional programs/courses. This is not to say that NANSLO cannot be used in a traditional face-to-face science course. EERC team members found this element among some students taking NANSLO lab activities as part of their face-to-face course. These students found the interaction with students in other states to be an exciting addition to learning science.

Research indicates that online learning better accommodates different social and learning styles and better fits the way some students learn (Jeschofnig & Jeschofnig, 2011, p. 5). Additionally, "Even if remote labs are not as effective as hands-on [face-to-face] labs, the experience of working with geographically separated colleagues and specialized equipment may be educationally important enough to compensate for any shortcomings in the technology" (Ma &

Nickerson, 2006). Using NANSLO as a supplement to face-to-face learning can be highly beneficial. Pape (2004) found that "adding online education to a student's face-to-face experience can enable students to become part of a global community of learners" (p.10). Adding elements of online learning to a traditional course allows students to "gain 21st century skills through online collaboration, online team activities and group projects, and to participate in learning communities with students beyond their bricks and mortar communities of learning" (p. 11).

Students are likely to prefer one learning type over another, and cognitive style can impact a preference for remote vs. face-to-face learning (Khachadorian et al., 2009). Therefore, "instructional materials presented in a variety of formats that are aligned to student preferences are more likely to engage and maintain student attention and be conducive to learning" (Khachadorian et al., 2009). Research indicates that a mix of learning environments is highly beneficial to students; therefore, offering remote lab activities in conjunction with traditional activities could be beneficial to students. Courses that mix modes of learning are likely to appeal to a variety of learning types. NANSLO can be used effectively as a supplement to face-to-face learning, as long as faculty members prepare to circumvent campus firewalls prior to NANSLO sessions (see below for a discussion on campus firewall and technical challenges).

There are concerns among some faculty, in CHEO and in general, that remote access will be used as substitute for face-to-face, practical engagement, and will ultimately reduce student interaction and learning. But research finds that "remote labs can offer some valuable education advantages which are not possible with traditional labs" (Hanson, et al., 2009, p. 331) and can "reinforce learning" (p. 332), indicating that it can be used as a supplement to, not necessarily a replacement for, traditional face-to-face lab activities. In addition, remote science labs are desirable for promoting certain kinds of learning outcomes, even over traditional lab activities (Ma & Nickerson, 2006). Specifically, remote lab activities are especially good at promoting conceptual and professional skills, while face-to-face lab activities tend to be better at teaching design skills (Ma & Nickerson, 2006). Therefore, NANSLO lab activities should be considered for certain types of learning objectives, not necessarily as a replacement for all learning objectives.

Hybrid programs/courses. Similar to its usefulness as an alternative learning tool in traditional courses, NANSLO can be used in hybrid courses as a supplement to face-to-face or kit labs, a replacement for face-to-face or kit labs, or in conjunction with specialized labs, such as allied health labs that may include elements NANSLO cannot do—such as wet mount slides. For example, LATI faculty members use NANSLO for some activities they lack the equipment for on campus, but still require students to come to campus for other lab activities in person.

3. **The type of course NANSLO is utilized in matters for the successful deployment of NANSLO activities overall.**

NANSLO lab activities are seen among many CHEO faculty members as better suited for basic science prerequisite courses than for many of the more specialized allied health courses. NANSLO lab activities are not seen as a good fit for all courses or all programs based on the subject matter. There is ongoing confusion among CHEO consortium members about what disciplines NANSLO should be serving; initially, it was believed that NANSLO lab activities would support prerequisite science courses, but many CHEO programs have limited foundational science courses required. Conceptualization of lab activities always included allied health courses, but the intent was to create lab activities that had the most demand and best impact across multiple institutions. One theme noticed by EERC team members, in speaking to CHEO faculty and NANSLO staff members, is that faculty members seem inclined to "plug and play" full lab activities rather than pulling out elements of NANSLO activities that might better suit their specific needs. If a full lab does not fit into their course plans, they tend to avoid using NANSLO altogether. According to NANSLO staff, however, some slides and parts of activities are perfectly suitable for allied health courses, even if the full lab is not. LATI faculty members in its MLT program regularly use individual NANSLO slides to emphasize specific points, for instance. NANSLO lab activities were designed to be used in science prerequisite courses; therefore, full lab plans are better suited to "plug and play" with basic science courses. Some individual elements, however, are readily suitable for all types of science courses, including allied health.

4. **Preparation makes a difference for the successful deployment of NANSLO. Faculty and student preparation before lab activities increases student outcomes and decreases technical issues.**

Faculty preparation. Within CHEO, EERC team members notice two teaching styles relative to NANSLO: one in which the faculty member was positive about NANSLO, fully engaged in the NANSLO experience, preparing for the lab activity and encouraging—or even requiring—students to prepare, and one in which the faculty member was less positive, was disengaged from the lab activity, and did not prepare for or require students to prepare for it. Not surprisingly, EERC team members found that those students in the first group enjoyed their lab activity more, felt they learned more, and were better prepared for the activity than the second group. Some faculty members felt letting students fail was part of the learning experience, and required students to take a NANSLO lab more than once. In these cases, the second time those students took the NANSLO lab they were better prepared, and thus had a more positive experience.

Research indicates that engaged faculty tend to create more engaged learning in their students, and those faculty members who engage in reflective teaching practices, honing their strategies according to what works best for their students, tend to produce more actively engaged and

collaborative learning environments (Hanson, et al., 2009). Likewise, basic preparation prior to taking a remote science lab (equivalent to preparation for a face-to-face lab activity) has been found to increase student outcomes (Khachadorian, et al., 2009; Ogot et al., 2003). Proper preparation was discussed as one of the factors that impact learning outcomes in remote and simulation laboratories at an educational and media conference in 2008, but most proponents of remote lab activities feel that no more time goes into this preparation than would go into preparing for a face to face lab activity: "A significant portion of time and attention in traditional laboratories must be devoted to understanding the procedures to be followed and to setting up and taking down equipment" (Bright, et al., 2008). Remote laboratories contain all the same characteristics of a face-to-face learning environment, and thus should be treated the same in terms of student preparation. Ogot, et al. (2003) found significant differences in the outcomes of a group of students completing a remote science lab who had an hour to complete a pre-lab activity versus a group that did not. Likewise, one of their key findings was the importance of faculty producing explanatory notes and instructional documents—discussed in class or the equivalent—ahead of time. Keislon, et al. (1999) found that without proper preparation, students are likely to become distracted by technical issues or impatient with the computer and will disengage from the lab activity.

EERC's research has found the same trends relative to preparation among CHEO faculty. Faculty members who are better prepared, require their students to prepare, and who properly test the lab interface before running the activity in their course have better overall success with students completing the NANSLO lab activity. As will be discussed below, accessing a NANSLO lab from campus can create technical challenges because of firewalls used at the college. Proper testing before using a lab activity from campus makes it possible to avoid this. Also, faculty members who develop notes and pre-lab procedures for students to complete prior to attempting the lab activity report positive student experiences and learning outcomes; these faculty members also seem more positive about and engaged with NANSLO in general.

Student preparation. Closely linked to the above discussion regarding faculty preparation is the concept of student preparation prior to attempting a remote lab activity. As noted above, research has shown that students who complete pre-lab preparation tend to have better learning outcomes than students who do not. EERC found that CHEO students who had difficulty navigating the remote lab process had not read the pre-lab material or watched the instructional demonstration video and nearly all students interviewed felt their difficulty was a result of lack of preparation. This will be discussed in detail below.

5. **Technical challenges associated with NANSLO under CHEO have primarily been the result of using the technology from behind campus firewalls. This challenge can be avoided by planning ahead and coordinating with campus technology departments, or by accessing the lab activities from off campus.**

NANSLO's technology was developed for remote, online access and therefore was not originally intended to be used on campus. Attempting to access the technology behind campus

firewalls (designed to protect the integrity of student data from unauthorized access) can cause technical challenges, delays, and freezing of the interface. There is a fix for the problem, but it requires preparation on the part of the faculty member or student; lab managers at the NANSLO node need to be aware of possible concerns ahead of time so they can troubleshoot the issue and work around the firewall. Accessing NANSLO from off campus eliminates the problem completely. EERC team members found that most CHEO students were unaware of this and many were attempting to access their lab activity from campus computer labs or common spaces, thus running into technical issues that were ultimately avoidable. This will be discussed in more detail below.

METHODOLOGY/DATA SOURCES

The qualitative methodology for this report includes content analysis of consortium goals and activities to date, relevant proposals, and project- and college-specific statements of work, quarterly reports, and technical survey information collected by NANSLO. EERC team members have also conducted extensive phone and in-person interviews with the NANSLO Discipline Panel participants, CHEO project leads, staff, and faculty, NANSLO lab personnel, and participating students. Most interviews were taped and transcribed; non-taped interviews involved extensive note taking. These transcriptions and notes, as well as the documents cited above, have been coded through the use of NVivo qualitative data management software and analyzed by EERC team members.

For the quantitative analysis to research the impact NANSLO labs have on students, data from within the Colorado Community College Online System (CCCOnline) was used. CCCOnline, as part of the Colorado Community College System (CCCS), has been utilizing NANSLO since its inception in the Next Generation Learning Challenges (NGLC) grant. CCCOnline accepts students whose home institution is one of the 13 CCCS schools and provides online instruction. Because NANSLO is a new initiative and is still being implemented in CHEO-specific colleges, not enough quantitative data was available for analysis of CHEO schools only. For this reason, CCCOnline data was used, as the available population size is much larger. Data was derived from four introductory science courses for which NANSLO labs have been developed, e.g. Biology 111 (BIO 111), Chemistry 111 (CHEM 111), Physics 111 (PHYS 111) and Physics 211 (PHYS 211). These courses were confirmed by the system to have utilized NANSLO labs during the treatment period. Once the program participants were identified, the EERC obtained "grade book" information from CCCOnline, which includes the grade as a point and as a percentage of the total points available for the course assignments.

HISTORY

BCcampus, a consortium of 25 institutions in British Columbia, and North Island College (NIC) launched the concept of remote web-based laboratories (RWSL). The idea was originated by two NIC staff members to provide students with access to a remote telescope for experiments.

NANSLO was established in 2011 under the NGLC grant funded by the Bill and Melinda Gates Foundation and the William and Flora Hewlett Foundation to replicate and scale up the NIC node at colleges in the U.S. The goal of the NANSLO project "was to integrate remote web-based laboratories (RWSLs) into online community college science courses in physics, chemistry, and biology" as part of the NGLC's greater focus on the promotion of "innovative educational technologies" (Stokes & Helms, 2012, p. 2). Concretely, this meant the creation of a node in Denver, Colorado (CCCS) and the development of new and expanded lab activities.

The NGLC grant was evaluated by Inverness Research to determine the feasibility and potential of remote labs to enhance student science learning. Prior to this grant, students taking entirely remote science courses generally had to use science kits to complete their lab activities, or were required to come to campus to complete activities in face to face labs as part of hybrid courses. The goal of the NGLC grant was to add NANSLO as a lab option for these students. The grant evaluation identified key challenges and successes.

The greatest challenge identified through the NGLC evaluation was the failure of remote labs to "provide students with a reliably user-friendly and satisfying learning experience" (Ibid, p. 5). Over 40 percent of students were prevented from completing the lab they attempted, and those that did complete their lab still experienced significant technical issues. Greater bandwidth was required than had initially been expected, and no Mac OS interface was originally available due to the limitations of the LabVIEW software. As a result of these issues, students preferred kit-based labs, and rated them as having a greater educational value. Reported student learning experiences did vary across subject matter areas, however—physics students had more positive learning experiences than biology and chemistry students. Despite technical concerns, all groups involved with NANSLO during the NGLC project agreed that RSWLs "should have a lasting place in online science courses" (Ibid, p. 9).

The CCCS node was designed under the NGLC grant to duplicate the success of the NIC effort. During the 15 month NGLC grant project, NANSLO developed and installed sophisticated equipment in Denver, Colorado, provided the requisite software to control it remotely, and designed five new lab experiments across three disciplines. The high level of complexity and collaboration involved in the process of NANSLO's initial development was a significant hurdle which the project overcame within a limited time span. The NANSLO project succeeded as a proof of concept for remote labs as an addition to online courses; "it began to move a few skeptics toward somewhat greater acceptance that remote labs can strengthen the science learning experiences of college students" (Ibid, p. 11).

NANSLO IN CHEO

Expansion

Under the CHEO grant, the NANSLO network was expected to expand and improve the capacity of the NIC and CCCS nodes, to develop a new node located in Montana, and to develop 12 new experiments. The network of three nodes was intended to expand access for students to science labs online, and to increase the variety of lab activities that could be integrated into courses. Under CHEO to date, NANSLO labs have been developed for use in chemistry, biology, and health care courses. They are used in hybrid and entirely online courses; they are also used as a replacement for existing lab activities and as a supplement or additional learning experience. NANSLO also offers physics labs, which CCCOnline courses are using.[1] The CHEO consortium colleges have not used physics labs in their CHEO programs because physics courses are not generally prerequisites for health care programs.

The CHEO grant allowed for expansion and innovation in the NANSLO node network. The original node at NIC received equipment upgrades through the CHEO grant and was able to expand the number of lab activities it offers. New equipment was purchased, including Nikon microscopes, spectrometers, air tracks, an electron charge/mass apparatus, and robots.

The CCCS node was also able to upgrade and expand. At the start of the grant, the node moved from its original location at the CCCCS office into a larger facility leased at RRCC's Arvada campus. The customized space gained from this move allowed the node to increase the amount of equipment and number of students that could be served. CHEO funds allowed the node to replace its older microscopes with newer microscopes that have higher picture quality, and which can use a robotic slide loader. As of the writing of this report, the lab offered 27 labs—23 of which were developed under the CHEO grant.

GFC MSU houses the newest of the three NANSLO nodes, built under the CHEO grant and completed in the summer of 2014. The college served on the advisory board of the original NGLC grant and some faculty members assisted with the creation of lab experiments through that process. The CHEO grant offered them the opportunity to house a node on campus. Although the lab has been set up physically at the college since early summer 2014, the remote capabilities of the lab were not operable until August 2014. As a result, the lab was being used within the college, but was not able to be operated remotely. Due to the delay, FVCC, the other Montana CHEO college, was not initially able to use the node. Although FVCC prefers to use the Montana node, they are able to use any of the three nodes. FVCC used the CCCS node until the GFC MSU node became available in the fall of 2014.

[1] CCConline is run by the Colorado Community College system and offers fully accredited Associate of Arts degrees, Associate of Applied Science degrees, and certificates in various disciplines through the Colorado Community College system colleges.

Lab Activity Development

Once the expansion of the nodes and purchase of new equipment had been completed, NANSLO's next step under CHEO was to create new lab activities in order to expand the number of courses in which the remote labs could be used. Faculty discipline panels were tasked with creating new lab activities which could be used to replace or supplement existing science labs offered in courses.[2] Discipline panels were formed by faculty members at CHEO consortium colleges who volunteered to participate in the lab development process. Three panels represented biology/allied health, chemistry/allied health, and physics disciplines across all eight colleges. Managers from the three nodes gathered ideas from the discipline panels and other faculty involved in the CHEO project for lab concepts that could be delivered remotely, meet learning objectives for the intended course(s), and be completed cost effectively. Input was solicited through emails, teleconferences, online meetings, wikis, and two face to face workshops in Boulder, Colorado. These workshops were coordinated by the Western Interstate Commission for Higher Education (WICHE).

The initial workshop, held in June 2013, served as an informational introduction to online and hybrid education and NANSLO orientation for instructional designers and for faculty. Here faculty identified 17 NANSLO web-based lab activities they would like to have developed, with the idea that faculty would have the opportunity to contribute ideas and best practices for teaching these remote web-based lab experiments. However, faculty involvement at this point was considered minimal. NANSLO laboratory managers have commented that, at first, the discipline panels were not overly effective in generating usable labs. The biggest limiting factor in the creation of lab activities was a lack of concrete learning goals; faculty provided many ideas for possible activities, but few measurable learning goals that could be used to build actual lab activities. Subject matter experts (SMEs) in biology, chemistry, and allied health were contracted to redesign the four existing lab activities created under the NGLC grant and to fully develop eight additional lab activities. After the SMEs designed the activities, the activities were posted to the CHEO Wiki, whereby faculty had the opportunity to review and provide feedback for each activity. While involvement by CHEO faculty did not greatly increase, the end process produced quality lab opportunities for students.

At the May 2014 faculty professional development workshop, faculty were provided with a handbook containing 12 NANSLO lab activities developed to date based on recommendations from the June 2013 professional development. During the May 2014 workshop, 15 new suggestions were made for additional NANSLO lab activities, and seven more were later suggested. As a result of the work by SMEs and faculty feedback, a total of 27 NANSLO lab activities have been developed or redesigned for the CHEO initiative.

[2] More information about lab activities offered through the NANSLO nodes is available at www.wiche.edu/nanslo.

While this process of collaboration was an important one, it did slow the development of labs. Each lab procedure was posted on the wiki for approximately one month; after a month, the lab activity was considered reviewed. NANSLO personnel reported that this stage resulted in very little direct feedback. Once developed, further testing with small groups of students or lab technicians was undertaken to refine the procedure before it was made available to colleges for use.

Once each lab was created and tested at one of the NANSLO nodes, instructions were created for the lab process, and packets were put together and posted on a wiki. For ease of access, these labs, as well as video tutorials on how to use NANSLO's remote control panel, were transitioned to the NANSLO website on pages dedicated to that information. From this website, faculty can browse available labs, select one or more to use in their course(s), and decide whether to include the lab(s) as supplemental activities or as replacements for existing lab activities. Lab activities taking place at the CCCS and GFC MSU nodes are then scheduled through network scheduling software. WICHE is responsible for oversight of the development of the scheduling system and is working with colleges on its implementation and adoption. Lab activities taking place at the NIC node are currently scheduled through NIC. The goal is that eventually, all lab activities will be scheduled and coordinated through the network scheduling software; however, the NIC node is currently still testing the installation of the network scheduling system at its location.

USE OF NANSLO in CHEO

Research indicates that remote labs such as NANSLO, where students actually "manipulate sophisticated science equipment located in professional laboratories," provide online students with "adequately realistic and sophisticated laboratory experiences" (Jeschofnig & Jeschofnig, 2011, p. 4). Remote labs are different from simulated labs, where manipulation of actual equipment by students does not occur. Remote access labs are real-world experiences because they "provide access to fully functioning advanced scientific instrumentation that is actually used…in genuine, real-world science applications and investigations" (p. 54). Despite research that has shown that remote science labs are equivalent to face-to-face labs in terms of student outcomes (Sonnenwald, Whitton, & Maglaughlin, 2003; Scanlon, et al., 2004; Corter, et al., 2004; Sicker, et al., 2005; Carlson & Sullivan, 1999), faculty resistance is not uncommon. Likewise, the adoption of NANSLO labs at CHEO consortium institutions has been slow and uneven.

Use to Date

Despite the slow adoption of NANSLO labs across the consortium, two colleges have used NANSLO a great deal, and have already developed some promising practices that can inform other CHEO colleges during later adoption. As the main users of NANSLO through fall 2014, these colleges' experiences and innovations are highlighted here. GFC MSU and KoC both have embraced NANSLO, and use it in a variety of courses. Interestingly, the emphasis on which types of courses NANSLO has been integrated into is different at each of the colleges; GFC MSU

has focused on utilizing NANSLO in hard science courses that serve as prerequisites, while KoC has integrated NANSLO labs into its allied health curriculum. Since some consortium faculty members feel that NANSLO is not appropriate for health care courses and others feel that it is not appropriate for the hard sciences, the fact that the two high use consortium colleges use NANSLO to serve each of these very different populations, respectively, shows that NANSLO can be used effectively in both course types.

Great Falls College Montana State University (GFC MSU). As mentioned above, GFC MSU houses the newest NANSLO node, and, as a result, there has been high interest in the incorporation of NANSLO labs into coursework at the college. The node manager has been active in promoting the possibilities of NANSLO lab usage to the college community; for example, she set up groups of students in a common area at the college and had them run through some of the lab procedures. This served both to test the equipment and to demonstrate the node's capabilities. Faculty walking past the demonstrations stopped to watch and to talk to the node manager and students. Because faculty members were able to see the labs in action, this sparked interest and excitement, and led to several faculty members integrating NANSLO into their courses. It should be noted that demonstrations within the college, when using the node located at the college, are not affected by firewall issues (firewall issues at colleges outside a node's location will be discussed in greater detail below).

Faculty members at the college are also fully engaged in creating new experiments for their courses using the NANSLO node. For example, one faculty member explained a radiation experiment he was developing in conjunction with the GFC MSU node manager that he planned to use in his class. Faculty members "pop in" to the node to discuss ideas and test possible lab experiments. The node manager regularly engages faculty and staff at the college and encourages new ideas and innovations in online and hybrid learning through NANSLO.

GFC MSU's node manager has also recruited the help of several faculty members and IT staff at the college to develop innovative ways to use the NANSLO equipment to run other teaching tools at the college. For instance, a recently purchased high-tech mannikin has been added to the teaching hospital at the school. The node manager, IT staff, and other staff at the college are planning to integrate the mannikin and NANSLO equipment if possible, so the mannikin may be operated remotely. This will allow students in online programs and students at extension campuses to run simulations with the mannikin without having to come to campus.

In addition to faculty and staff, GFC MSU engages students to work with the equipment in the node and encourages creative thinking in regard to potential lab experiments and the use of the node's robotic equipment. Lab technicians at all the nodes are generally students who use their experience with NANSLO to build skills.

Some research has indicated that the overall success of remote laboratories is at least partly attributable to highly engaged and motivated instructors who are constantly engaging in research and investigation of student learning outcomes, active engagement with designing lab

activities, and active collaboration with other instructors and laboratory staff (Hanson, et al., 2009). Other studies show that, in general, the best instructors "engage in an iterative process of honing their teaching strategies" (Bain, 2004; Darden, 2003). All these elements are present at the GFC MSU node, where highly engaged faculty and staff discuss new ideas, refine teaching strategies, and work with students to ensure high quality remote lab experiences.

Kodiak College (KoC). Given the online nature of KoC's medical office coding program, having a fully remote science lab component is a valuable addition to the program. Faculty buy-in at the college has been high. Three labs were incorporated into regular coursework for its CHEO program: the meiosis and mitosis lab, introduction to microscopy, and a human diseases lab. To improve student outcomes and overcome some of the challenges that students face in the complex online environment of NANSLO labs, faculty members have developed extensive support processes. Faculty have created documents with detailed explanations of the scheduling process, screen shots of the labs, and tips for use during the labs, such as how to focus the microscope, how to gain and release control of the microscope, and how to communicate with lab technicians and other students using the teleconference line.

Research recognizes the development of student preparation tools prior to beginning lab activities (whether they are remote or traditional) as a promising practice:

> Online, just as on campus, the laboratory component of a lab science course should be structured in a way that allows students to gain significant personal familiarity with experimental procedures and processes as well as opportunities to participate in designing experiments. (Jeschofnig & Jeschofnig, 2011, p.8).

A faculty member at KoC points out that non-science majors, such as the medical office coding students, are often wary of science labs in general, a concern that can be compounded by lack of preparation. And because the NANSLO labs are adding another element—remote operation—to the science lab experience, this support and preparation is critical to student success:

> [I] do a synchronous lecture. I say, OK, this is exactly what we're going to do, I take screen shots. This is how you're going to do it. Then after the lab, there's a follow-up. The next week, this is okay, now you're going to turn in your lab reports. Did anybody have any problems getting their pictures? I have a picture gallery as backup, just in case, right. So [I'm] trying to limit their apprehension, because certainly I can tell you at first, that they are very apprehensive.

This faculty member at KoC is engaging in another promising practice by recognizing her students' anxieties about science labs in general and thinking through what information they most need to have, prior to beginning the process, if they are to successfully complete the remote lab activity. Jeschofnig and Jeschofnig (2011) state that "to genuinely be effective, online educators should continuously put themselves in the shoes of their students" (p. 34). Additionally, "they must think about what information their students need, and they must then

provide it in clear, concise, and precise prose and graphics" (p. 34). This faculty member is clearly doing both of these things, and student surveys from her courses report high student engagement with and positivity about their NANSLO activities.

Faculty buy-in at both GFC MSU and KoC is high. Faculty members at both colleges have been highly engaged with NANSLO, including assisting with lab activity development, serving on discipline panels, creating pre-lab materials to ensure student preparation, engaging students in active learning with NANSLO, and championing the benefits of NANSLO to students and other faculty as well as other consortium members.

Both GFC MSU and KoC have developed these promising practices relative to NANSLO and both schools' faculty and staff members continue to further develop and refine NANSLO use at their respective colleges. Although they were the two highest use CHEO schools as of the fall of 2014, these colleges are certainly not the only schools using and refining NANSLO in their courses. The table below (Table 1) looks at lab usage and experiments offered to date at CHEO colleges through December 2014; future EERC reports will provide more extensive use information as it is gathered.

Table 1. Lab Usage across Colleges by Lab Activity as of December 2014

	FVCC	GFCMSU	KoC	LATI	LCCC	OJC	PCC	RRCC
	Biology							
Intro to Microscopy	X	X	X					
Mitosis & Meiosis	X	X	X				X	
Diseased vs. Healthy Cell			X					
Cell Types Comparison	X						X	
Histology-Epithelial Tissue	X							
Histology-Connective Tissue							X[3]	
Histology-Muscle Tissue								
Histology-Neuronal Tissue								
Membrane Osmosis				X	X			
Membrane Diffusion					X			
Hematology		X					X[4]	
Parasitology								
Buffer Systems								
Enzyme Activity								
Bacterial Activity								
Photosynthesis					X			
Fungi & Protista								
	Chemistry							
Emission Spectroscopy		X						
Beer-Lambert Law	X	X				X		
Electron Charge/Mass				X				
Gas Chromatography		X						
Acetic Acid Titration				X				
Food Dye for Sports Drinks								
Titration of Citric Acid								
Enzyme Activity								
Buffer Systems								

As of fall 2014, there were 2,089 enrollments in courses with NANSLO lab activities under the CHEO grant at both consortium colleges and through CCCOnline. See Table 2 for details of use.

[3] This was an early version of histology and fits best as "connective tissue," but wasn't the final version of it.

[4] Only two out of eight students even attempted this activity, and only one student completed it.

Table 2. Courses Offering NANSLO Lab Activities by College and Term

College	Term	Couse Subject	Title	Total Enrolled	Pass Rate[5]	Mean of GPA
Great Falls	Fall 2014	Allied Health MA	Phelebotomy	6	67%	1.50
Great Falls	Summer 2014	Biology	Discover Biology/Lab	17	88%	2.01
Great Falls	Fall 2014	Biology	Discover Biology/Lab	39	77%	2.40
Great Falls	Spring 2014	Chemistry	Intro to General Chem w/Lab	64	92%	2.89
Great Falls	Fall 2014	Chemistry	Intro to General Chem w/Lab	94	84%	2.65
FVCC	Fall 2014	Biology	Principles of Living Systems	104	89%	2.75
FVCC	Fall 2014	Human Biology	Basic Human Biology Lab	50	78%	2.53
FVCC	Spring 2014	Chemistry	College Chemistry II	27	85%	2.67
Kodiak	Fall 2013	Human Biology	Human Biology	15	80%	2.67
Kodiak	Fall 2014	Human Biology	Human Biology	21	81%	2.40
Kodiak	Spring 2014	Medical Assisting	Essentials of Human Diseases	20	95%	3.40
LATI	Fall 2014	Chemistry	Inorganic Chemistry Lab	2	50%	2.00
LATI	Fall 2014	Medical Laboratory	Urinalysis and Body Fluids	25	88%	2.24
LCCC	Fall 2014	Biology	General Biology	10	60%	1.44
OJC	Spring 2014	Medical Laboratory	Intro to Clinical Chemistry	2	100%	3.0
PCC	Summer 2014	Biology	Basic Anatomy And Physiology	18	83%	2.29
CCCOnline	Spring 2013 – Fall 2014	Biology	Gen College Biology I/Lab: SC1	818	52%	2.10
CCCOnline	Spring 2013 – Fall 2014	Chemistry	Gen College Chem I/Lab: SC1	356	63%	2.61
CCCOnline	Spring 2013 – Fall 2014	Physics	Physics Alg-Based I/Lab: SC1	233	58%	2.51
CCCOnline	Spring 2013 – Fall 2014	Physics	Physics Calc-Based I/Lab: SC1	151	52%	2.19
Total				**2089**		

[5] The pass rate and mean GPA are for the entire course in which the lab activity was utilized and are not the pass rate of the lab activity itself.

Reception

Faculty Reception. Opinions and use of NANSLO vary across the consortium and among faculty members. As with all innovations, there is a range of acceptance and adoption. There are keen early adopters and fairly staunch resisters. Some faculty members are excited about the opportunity NANSLO offers, while others don't see its value. Interest in and use of NANSLO also varies a lot depending on the campus and the delivery plans for courses and programs. This section looks at the variance in reception to NANSLO and some of the reasons behind that.

Positivity about NANSLO is tied to several perceptions among faculty members. Some noted that the use of remote-controlled microscopes and equipment is increasing in science-based careers; therefore, many faculty members find value in that experience. Others talked about embracing innovative concepts in online education, something that the CHEO project is fundamentally aligned with. As could be expected, faculty members who are already convinced of the benefits of online education in general are more likely to be positive about NANSLO's potential. EERC team members heard many faculty members across the consortium express excitement about innovations in online education in general, and positivity about the potential of NANSLO to bring science labs to remote students in a new and exciting way.

Positive faculty response is aimed largely at the concept and ingenuity of the remote labs and at staff involved with NANSLO—the majority report high satisfaction with the efforts of node managers and the assistance of lab technicians. One faculty member commented on the process of lab development as something exciting and innovative, and felt the node managers excelled at bringing ideas to life:

> I think that they are a fantastic dynamic group of people, and I love the idea that [NANSLO is] like Google: "You [faculty] think outside the box. You think of the labs. We [NANSLO] will make them."

Science faculty members at some CHEO colleges have wholeheartedly embraced the concept and are excited about using NANSLO labs in their courses. Science faculty at GFC MSU, for instance, are extremely involved in creating and using labs and often "pop in" to the node located there to brainstorm and discuss new experiments with the node manager. Science faculty at LCCC are also embracing the concept and using several labs in current and upcoming science prerequisite courses. While NANSLO is generally better equipped to deliver activities suited for science prerequisite courses, allied health faculty are leading the charge in some colleges. At some colleges, allied health faculty members use NANSLO labs more than science faculty do. KoC's allied health faculty use NANSLO labs and are very positive about them, for instance. LATI's allied health faculty members also use NANSLO labs in their medical lab technician courses and have experienced very positive results.

Faculty buy-in is not uniform across disciplines and colleges, however. Interest in and use of NANSLO varies by faculty, discipline, and college, and patterns of use are hard to find. For

example, science faculty members at OJC have not yet been convinced of the feasibility of replacing all or even some of their labs with remote labs, for the most part believing that kit labs—and especially face to face labs—are a better learning experience for students. This reticence was exacerbated after faculty experienced technical issues during demonstrations, some of them caused by college firewalls interfering with the lab interface. Likewise, at FVCC, some science faculty members are not entirely convinced of the utility of fully remote science labs, especially in the hard sciences, such as chemistry. Even beyond the CHEO project, this is not an unusual phenomenon. Although much research has recently focused on the benefits of online education in general and of online science labs in particular, some faculty members remain reluctant to embrace the concept of online science labs as equivalent learning tools to face-to-face labs:

> Many [educators] feels providing distant online students with traditional laboratory experiences is an impossible task and refuse to even consider offering science courses online. They believe valid science experimentation can only be performed on campus. (Jeschofnig & Jeschofnig, 2011, p. 8).

While use in allied health at some schools is common, there are other CHEO colleges where faculty members have not found ways to integrate NANSLO or do not see it as a good fit for their programs. While CHEO faculty and staff across the consortium generally like the concept of remote labs, PCC, OJC, and RRCC all have faculty and staff who feel that there are currently not enough lab choices that fit well with their health care courses and programs. Some faculty members have also talked about the need for in-person lab experiences. Faculty at PCC have talked about how their health care students still need to learn hands-on skills with microscopes, since they will likely be using real microscopes once they are employed.

Some faculty have talked about already having equipment on campus to offer the labs that NANSLO provides and, therefore, not seeing the benefit of offering the labs remotely. One CHEO staff member stated that her college's faculty members are very hesitant to replace face-to-face labs:

> The two reservations that our faculty have are: one, it doesn't take the place of a full lab course… and then, secondly, if we can do the experiment ourselves here on campus, it's not clear why it would be better to do it through NANSLO.

Further, some were skeptical about the "value" added by remote controlled, online labs:

> The … reservation would be, if we can do experiments, if we can have students do experiments in the lab in person with their own hands, why would it be better to do it remotely controlled through NANSLO?

It should be noted that the major focus of the NANSLO project has been to extend science education to entirely online students who would not otherwise be able to do a lab in person at a

college's preexisting laboratory facility. However, research has found that there are many benefits to incorporating online science labs with traditional face-to-face labs. These studies have found the following factors that support the combination of in person and remote lab activities:

1. Remote labs can enrich and reinforce tactile, face-to-face labs (Jeschofnig & Jeschofnig, 2011; Hanson, et al., 2009).
2. Remote labs provide real-world technology experience that face-to-face labs cannot (Jeschofnig & Jeschofnig, 2011).
3. Remote labs allow students to participate in advanced and dangerous lab activities that could not feasibly be done in person due to safety concerns (Jeschofnig & Jeschofnig, 2011; Khachadorian, et al., 2009).
4. Remote labs focus on teaching concepts (conceptual skills) and professional skills, while face-to-face labs focus on teaching design skills and social skills. Together, the two types of labs offer a mix of learning objectives (Ma & Nickerson, 2006).
5. Creating a mix of learning environments is beneficial to students (Ma & Nickerson, 2006).
6. Remote access labs are repeatable, and students also have the flexibility to complete the labs at times convenient to them. Doing both types of labs allows students to experience the benefits of both access modes—the face-to-face access at a set classroom time and the flexible remote access (Hanson, et al., 2009).
7. Instructional materials presented in a variety of formats allow students with different learning styles to engage (Bright, et al., 2008).
8. Remote access allows students to be connected to a broader community of learners and teaches a slightly different type of collaboration than a face-to-face lab does: collaboration across distances. With access to both types of labs, students can experience both types of collaboration (Pape, 2004).

Student Reception. Overall, students have reacted positively to the NANSLO lab experience. Of 359 students who answered the question on the NANSLO technical survey, 92 percent (N=331) believed that it was a valuable lab experience. Likewise, students participating in focus groups believed that their lab experience was valuable:

> The experience was more than satisfying and we [the student and her lab partners] were extremely pleased to be able to do this remote lab activity.
>
> We took turns to do all four exercises by ourselves and it was very challenging and interesting but we did it. We were able to do microscopic examinations, analyze and observe. At the end we photographed the tissues.
>
> We will definitely do it again, what a great experience that was! And so much fun, too!

I thought it was pretty cool.

Some students did report minor negativity relative to their lab experience. For instance, some students reported difficulty finding the specimens on the slide, and, because they were operating the microscope remotely, they did not know how to simply look directly at the slide in order to see it better. Students would have preferred that the microscopes auto-focused. However, learning to focus the microscope is one of the learning objectives of the lab activity. There were also some image quality issues reported; however, these were a result of students' not focusing the microscope properly, and, again, learning how to properly focus a microscope is a major learning objective of the lab activity.

Pre-Lab Preparation

As with all labs in college courses, preparation is essential to success. Many faculty members noted that students who prepare for their labs by reading the lab interface instructions and introduction to NANSLO handout or by watching the NANSLO instructional video will have more positive outcomes. This finding is backed by substantial research, which has found that students who prepare for lab activities generally have better learning outcomes. Pre-recorded videos have been shown to help increase student outcomes in remote lab activities in general:

> The video clips provide uniformity of presentation to all students and allows the students to review the material over and over again. This approach has been shown to be effective in ensuring students have a successful experience when they run the lab. (Ogot et al., 2003, p. 59).

A significant difference in outcomes has been seen between students who had an hour to do pre-lab preparation relative to those who did not (Ogot, et al., 2003).

However, NANSLO is no different from other classroom activities in that not all students prepare even if asked to. This lack of preparedness can lead students to have trouble conducting the activities. Lack of preparedness is evident in the data collected from students who were interviewed or surveyed by EERC team members. The majority of students who were not assigned preparation material for the lab admitted they had not made use of available resources before beginning the exercise.

Lack of preparation is a primary source of challenges for students when completing NANSLO lab activities. The most common issues for unprepared students are technical in nature; these students generally lack an understanding of how to operate the web interface, how to capture slide images, how to control the microscope functions, and how to release control to another user. Students who overcame these technical challenges (usually by heavy reliance on NANSLO lab technicians) did find the labs interesting and helpful. In a focus group at FVCC, none of the students (N=11) had reviewed the pre-lab material before attempting to log on. Several students echoed that the lack of preparation hindered their lab experiences:

> The concept is really good, moving the slides around, but my problem started with not knowing how to log in. I should've been better prepared.
>
> I think the second time, when I know what to do, it will be better.
>
> If you know what to do, you can get on and it's fine.

Success for students seems to hinge on preparation. Some faculty members make preparation a part of their course pre-lab process, and feel that no more preparation goes into NANSLO than goes into any other science lab. One faculty member at FVCC noted that in a face-to-face lab, the instructor has to prepare the students for the lab, or students may hurt themselves or "blow something up." NANSLO, this faculty member stated, requires some preparation, but no more than a face to face lab would. A faculty member at KoC makes lab preparation mandatory; students must pass a pretest to take a NANSLO lab. If a student does not pass the pretest, he or she cannot take the NANSLO lab until he or she does pass it. Students are provided with support at every step as they prepare for and complete NANSLO labs. The instructor feels that the better students understand the process, the more prepared they will be and the more they will participate.

Technical challenges

As illustrated above, some technical challenges can be overcome by sufficient support processes for students prior to taking a lab. However, some technical issues are not related to student preparedness. Common technical issues for students and faculty have been trouble logging in, the user interface freezing or lagging, and an inability to participate. These problems are often linked to the challenge of remote access through university firewalls when students try to complete their labs from computer labs on campus. This problem contributes to slow connections and freezing of the user interface. Accessing the NANSLO labs from home, rather than on campus where firewalls get in the way of connection, resolves many of these problems.

The original goal of NANSLO was to extend access to science lab activities to students who were not able to access a college's campus resources directly. The use of lab activities by students from college campuses was not anticipated initially and, therefore, the interface was not designed to be accessed through college firewalls. As one NANSLO node manager stated, "[the] system is, in a lot of ways, designed predominantly to reach a student in their home environment. There are often firewall issues with actual institutions and colleges."

Another manager echoed this:

> Our system is accessible from anywhere in the world that there's [an] Internet connection. However, if you're on a campus behind a firewall and inside a secure environment with a lot of things locked down, there may be some conflicts with some of

> the computer services we're trying to push through the Internet to your computer that's there on that campus. This is never a problem with a computer in a coffee shop or a person's home.

A third manager at a different node also stated that this problem has been challenging:

> The biggest problem we've actually had is when people are accessing us from institutions and there's firewall problems. So if they have too many rules in place, it will basically ramp our speed down and then the students have a lot of lag.

The issue does not always occur, however, as students have had success accessing the labs from their dorms on a number of occasions: "We've had students very easily log in from [CCCS] dorms on various [Colorado system] campuses, so it's physically those locations that the universities view as theirs and sit behind the university-level firewall" that are often challenging. These locations seem to include classrooms, computer labs, and student common areas.

One way to alleviate this challenge, according to NANSLO node staff, is to test the system ahead of time, in the room and with the computer(s) that will be used to access the system. Sometimes faculty members skip this step or test the system by logging in from home, which doesn't test the firewall issue:

> We've had people that have logged on and said, oh, everything works fine, and we find out later that they were in their office or they were sitting in the their home living room, and then they go into their actual classroom and it doesn't work because they're dealing with campus firewalls.

NANSLO node managers say that they can work around the problem given enough time. If instructors want to use the labs in their classrooms, or if students need to access computers in the campus computers labs, there is a fix to the problem:

> Even at the level of things that we can't solve [the existing campus firewalls]…if a campus were to plan far enough in advance and we had the chance to then work with their IT department, their IT department could set up a socket specifically for us that would pass through the firewall. So that is a fixable problem. It's just not a solution that you can do in ten minutes, which is why we're always telling people, plan ahead and test everything. If we have enough time and we can work with the right people, we can get through almost anything.

Students taking traditional courses in addition to their online courses, students taking hybrid courses, and students located near campus taking online courses may come to campus to complete their NANSLO lab activity. EERC team members found this was the case at more than one CHEO institution. In fact, the majority of the focus group students at FVCC completed their

NANSLO activities on campus, regardless of their ability to take them elsewhere. Reasons for this included use of the computer lab, use of the campus Wi-Fi, and the desire to meet with lab partners in person to take the lab together. These students were all unaware of the problems that accessing the labs behind campus firewalls could present. According to NANSLO lab managers, with proper preparation these technical issues can be resolved.

In order to better understand and solve technical issues, NANSLO node managers at the CCCS node created a survey, focusing on the technical aspects of NANSLO, for distribution to students immediately after finishing a lab. These surveys are collected by EERC through Qualtrics survey software. Students self-selected themselves to take the survey after completion of a NANSLO lab. Most students participating in the survey were taking their labs through CCCOnline courses. A relatively low percentage of students reported experiencing technical difficulty with the labs. Since most students completing the survey were CCCOnline students, they were less likely to have attempted to access the labs in an area with campus firewalls and more likely to have attempted access at home or in coffee shops, libraries, or dorm rooms. Of the total respondents (N=284), 15 percent (N = 43) reported having difficulty with technical aspects of the lab experience (taking control of the equipment, capturing screen shots or data, releasing control of the equipment, etc.), and 10 percent (N=28) reported general trouble controlling the lab equipment through the remote interface.

Future Plans

Several CHEO colleges currently using NANSLO are planning to integrate more labs into courses that are already using NANSLO, as well as expand to additional courses and/or programs at the college. For instance, some GFC MSU faculty members are planning to expand NANSLO usage into courses that have not previously used the labs, such as anatomy and physiology (A&P) courses and some online health care courses in non-CHEO programs. Additionally, CHEO staff plan to integrate teaching tools in their simulation hospital with the NANSLO equipment at the GFC MSU node, allowing them to be operated remotely.

LCCC, LATI and FVCC faculty members who previously have not used NANSLO in their courses are also planning to integrate it beginning in spring 2015. KoC plans to increase the number of labs used in its medical office coding courses in the near future, and is also considering expanding NANSLO usage to other programs at the college.

Conversely, OJC, PCC, and RRCC have no plans for NANSLO use beyond the CHEO grant period, except for those students who use the labs as part of their CCCOnline courses. All three of these schools feel that although the NANSLO concept is great, the existing labs are just not a fit for the health care courses they offer.

NANSLO OUTCOME COMPARISON

The main question, when considering the incorporation of NANSLO relative to other available remote-lab options (such as science kit labs), is whether or not, and how, student learning outcomes are affected by the use of NANSLO. In other words, does the use of NANSLO, as a replacement of or supplement to other fully remote options increase, decrease, or have no effect on student outcomes? As mentioned above, since CHEO colleges are still in the process of implementing NANSLO, the population size was not large enough for a quantitative analysis and, as a result, CHEO courses were not used for analysis. The population of CCCOnline students utilizing NANSLO activities, however, was large enough for analysis and a comparison group was readily available. Each course used two NANSLO lab activities, replacing two of the eight to ten lab activities provided in each course.

To determine whether student learning outcomes were affected by the use of NANSLO labs in courses, we elected to study student outcomes in four introductory CCCOnline science courses for this report. These courses were selected because they presented a sufficiently experimental situation for meaningful comparison. The courses used were: Biology 111 (BIO 111), Chemistry 111 (CHEM 111), Physics 111 (PHYS 111), and Physics 211 (PHYS 211). These courses were followed through CCCOnline for two semesters: the fall 2013 semester, when NANSLO was not being used and the spring 2014 semester, when the CCCS node became operational again. This allowed for analysis of one group of students who had no access to NANSLO labs (because the node was not operational) compared to another group of students who used NANSLO labs through CCCOnline. Aside from the incorporation of NANSLO labs in the spring semester versions of each course, there were no substantial differences in the course material, schedule, or evaluation methods between the two semesters.[6]

The labs were all followed by a quiz or test that would have covered the material learned from the lab. As informed by the literature,[7] we used these grades, along with the final course grade, as tests for the impact of NANSLO on student learning outcomes (Corter, et al., 2007; Ogot, et al., 2003; Lang, 2010). In order to determine whether the use of NANSLO was the potential cause of any changes in grades (Ogot, et al., 2003; Lange, 2010) we also looked at the impact of several control variables on student grades, e.g. age, gender, GPA, credit hours earned, and student major (Simonds & Brouck, 2014; Zeegers, 2001; Corter, et al., 2007; "Online versus Traditional Learning: A Comparison Study of Colorado Community College Science Classes" 2012; Impey, 2013). No differences were found with any of the control variables between the two cohorts.

[6] A breakdown of students in each course by semester is illustrated in Appendix A.
[7] A full literature review can be found in Appendix A.

RESULTS

An analysis of the average grades achieved by CCCOnline students in related coursework showed little difference between those students in courses with NANSLO lab activities and those in courses without. Table 2 displays average grades for lab-related assignments for students who did not have a NANSLO lab activity (the Comparison, Fall 2013 group) and those students who did use a NANSLO lab activity (the Treatment, Spring 2014) group. The final grade percentages for the chemistry and physics students were statistically similar. However, students in the Biology 111 treatment group had a significant increase in their grades as compared to the fall semester comparison group, indicating that the difference in average grades could potentially be linked to the use of NANSLO (Table 3). It should be noted that the BIO 111 course did not use NANSLO as a replacement for its kit labs in microscopy and meiosis/mitosis. Instead, the NANSLO versions of these labs were presented in addition to the kit versions, requiring students to take each lab topic twice, once with each modality. As such, this repetition of learning may be the reason why the 10 point increase in course grade percentages is seen in the treatment group.

Due to low sample sizes, we cannot say definitively that the following results are representative of the population as a whole, but they do provide an interesting first look at grade stability following the integration of NANSLO lab activities into the CCCOnline curriculum.

Table 3. NANSLO Outcome Comparison

CCCOnline Course	Kit Lab (Fall 2013)	NANSLO Lab (Spring 2014)
BIO 111	**Student Average Grade**	
Unit 1 Test	57	56
Unit 3 Test	49	51
Final Grade Percentage **	43	53
CHEM 111		
Chap 9 Quiz	58	53
Chap 11 Quiz	57	56
Final Grade Percentage	57	66
Lab 6 Assignment	55	43
PHYS 111		
Unit 2 Test	58	52
Final Grade Percentage	47	50
Acceleration/Motion Lab Assignment	48	54
PHYS 111		
Unit 2 Test	51	48
Final Grade Percentage	48	48
Acceleration/Motion Lab Assignment	57	44

$^{*}p < 0.05$ $^{**}p < 0.01$ $^{***}p < 0.001$

To further control for other possible factors, the difference in final course grade outcomes for Biology 111 was modeled to isolate the impact NANSLO had on this change. Only age and GPA were determined to be potentially significant control variables.

Participation in NANSLO lab activities increased the final grade percentages by 10 points, holding all other variables constant. However, this was a weak to moderate relationship. All students, regardless of their ages, benefited from this 10 point increase in scores by being in the treatment group. While a student's incoming GPA increased average scores 17 points for each full point of GPA, e.g., raising a 2.0 to a 3.0, students at every success level received the same benefit from participating in NANSLO. These results show that even while controlling for age and previous academic success, NANSLO appears to be of benefit, regardless of starting position, when looking at BIO 111 final course grade percentages. Overall, this model explains 28 percent of the total variance in final grade percentages (Table 4).

Table 4. Results of an OLS regression of NANSLO usage by age and GPA

		Statistical Significance Information					
	Coefficient	**Standard Error**	**t-statistic**	**p-value**	**Symbol**	**Lower 95% CL**	**Upper 95% CL**
Treatment	9.9924	2.8347	3.5300	0.0000	***	4.4229	15.5618
Age	-0.2251	0.1929	-1.1700	0.2440		-0.6041	0.1538
GPA	17.2908	1.2656	13.6600	0.0000	***	14.8041	19.7774
Constant	5.0621	6.2200	0.8100	0.4160		-7.1587	17.2830
Notes: N=499; F-statistic is 66.44 with 3 *df*; adjusted R^2 is 0.2828.							

These results indicate that NANSLO would be appropriate for all students in producing the same expected results as kit labs. However, each course used only two NANSLO lab activities out of eight to 12 total lab activities provided in the class. Future research should focus on instances in which NANSLO lab activities make up the entirety, or at least a majority, of the lab activities offered in the course to test whether the impact becomes stronger. As was noted previously, low sample sizes prevent these conclusions from being representative.

CONCLUSION

Many CHEO faculty members, staff members, and administrators feel very positive about the NANSLO concept and the innovations in online learning that NANSLO represents. Likewise, most students are generally positive about their NANSLO experience after completing a lab.

Use and adoption of NANSLO has increased over the grant period, although some technical issues remain. While most of these technical issues can be mitigated or fully eliminated by addressing campus firewall issues or by accessing the labs from off-campus, faculty and students at CHEO colleges seem to prefer to use the labs on campus. Although pre-planning can help to address the technical issues that firewalls cause if faculty choose to access the labs

on campus, this planning does not generally occur. EERC team members have found that this issue remains the primary barrier to successful NANSLO usage.

Another barrier to usage is that some faculty members feel that the available NANSLO lab activities are not a good fit for their health care courses. Although NANSLO nodes developed almost twice as many new labs as the CHEO grant had required, many faculty still struggle to find lab activities that fit well with their curriculum. This is partially the result of faculty considering NANSLO lab activities to be "plug and play" activities instead of considering what elements of lab activities may fit best with planned courses and course learning objectives.

Initial results with the limited population of students available suggest that students using NANSLO lab activities receive grades similar to those of students using traditional distance lab options, such as lab kits. This indicates that students taking NANSLO lab activities learn the material just as well as students using kit labs. Further analysis and outcomes reporting on NANSLO will occur in forthcoming CHEO reports by the EERC.

Recommendations

With these key conclusions in mind, there are five recommendations for moving forward with NANSLO through the end of the CHEO grant period:

More education for faculty and program staff is necessary. While education about the benefits of NANSLO and what is offered through the network has been conducted at all colleges, more education is required. For example, technical challenges remain a barrier to student success and a primary source of both student and faculty negativity around the NANSLO labs relative to CHEO. Faculty and student preparation before lab activities decreases technical issues and improves student engagement. Faculty must be properly educated about the amount of preparation necessary and best practices for preparing students to successfully complete labs. Likewise, campus firewalls contribute to technical challenges. CHEO students and many faculty members were unaware of how firewalls can impact their lab experiences. More education about how to avoid these issues is necessary.

Additionally, administrators and project leads may consider further education of faculty members about the benefits of online education, including remote science labs. Since faculty buy-in regarding online education affects the use of and engagement with remote laboratories, the institution or department's environment relative to online learning may impact NANSLO usage and engagement in CHEO. Forcing faculty to use an online tool may create or increase resistance and negativity (Hawkins, Graham, & Barbour, 2012). Thus, educating faculty about the possible benefits of using remote science labs as an additional learning tool may help increase engagement.

Consideration of the type of course delivery modality being used should inform how NANSLO is used. NANSLO lab activities can be used in a variety of ways. How a course is delivered should inform the way in which remote lab activities are used in the course.

If a course is 100 percent online and students are not located near campus, NANSLO offers a great opportunity to add a science lab element where none previously existed. NANSLO lab activities can also be used as a replacement to kit labs, or a supplement to kit labs.

If a course is traditional, with access to hands-on, face-to-face lab activities, NANSLO could be considered as a supplemental lab activity or alternative learning tool. Additionally, NANSLO can be considered as a solution to face-to-face laboratory "bottlenecks" for institutions that cannot afford to expand space or build more laboratories. Remote lab activities are especially suited to the development of conceptual and professional skills, whereas face-to-face labs are better suited to the development of design skills; therefore, using the two lab types in conjunction can be beneficial. Student outcomes from CCCOnline showed a 10 point increase in grade average among those students who used both a lab kit (getting the hands-on element of learning) and the fully remote NANSLO lab activity. A potential reason for this could be the ability of students to take the same lab twice—through different teaching tools. Courses with students accessing NANSLO labs from campus should take into account firewall issues and prepare appropriately.

If a course is hybrid, NANSLO may be considered as a supplemental activity, an alternative learning tool, or in conjunction with some activities that are done face-to-face. Hybrid course instructors should also consider firewall issues and pre-plan accordingly.

Consideration of course type should inform how NANSLO is being used. Since NANSLO was designed to serve science prerequisite courses, it fits best with these types of courses. If NANSLO's full "packaged" labs are not a good fit for a specialty course such as an allied health course, faculty should consider using selections of the lab activities instead of the full lab activity.

Pre-lab preparation should be stressed. Research indicates that students learn better when they are fully prepared for the remote lab activity. Preparation for remote lab activities should be considered equally as important as preparation for face-to-face lab activities. Several promising practices exist among CHEO faculty that indicate this is true among CHEO students as well, and existing material created by these faculty members is licensed OER; faculty do not need to recreate material on their own. However, requiring students to complete the pre-lab material seems the only way to ensure that they actually review it.

Pre-planning to circumvent firewall issues is necessary when lab activities are accessed on campus. Not only should faculty members allow enough time to test the lab activity from the location where they plan to use it, but they should also inform students that accessing the lab from campus computer labs or common areas might be problematic. If students wish to meet in

groups to access NANSLO, they should meet in off campus areas (such as coffee shops, libraries, etc.) that do not have firewalls, and will then likely avoid most technical issues. Faculty members using NANSLO labs in their classrooms may need extra time to test the process in order for NANSLO lab techs and the institution's technology office to work through firewall issues. Preparation and pre-planning reduces the likelihood of encountering technical challenges. Issues caused by firewalls can be avoided by either 1) accessing NANSLO off campus, or 2) pre-planning to work around campus firewalls.

Appendix A

Cohort Participant Count by Course		
Course	**Comparison**	**Treatment**
BIO 111	279	220
CHEM 111	55	36
PHYS 111	23	71
PHYS 211	33	42

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