
AC 2012-5585: WORK-IN-PROGRESS: LINKING A GEOGRAPHICALLY DISTRIBUTED REU PROGRAM WITH NETWORKING AND COLLABORATION TOOLS

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WIP: Linking a Geographically Distributed REU Program with Networking and Collaboration Tools

Abstract

The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) coordinates a geographically distributed Research Experience for Undergraduates (REU) program with up to 30 students placed at five to eight research sites each summer. With only two to four students at each site, creating a sense of cohort among these 30 geographically distributed students can be difficult. One challenge is providing opportunities for all of the students to interact in ways that support each other's research experience. In an attempt to maximize student learning and personal growth, the program coordinators have leveraged NEEShub, the cyberinfrastructure that interconnects the 14 NEES research sites, to engage students in professional development activities and peer-to-peer interaction. The REU program uses a combination of face-to-face and technology mediated interactions. Cyberinfrastructure tools to support interaction between cohorts at the different sites include a course management system (Moodle embedded in NEEShub), WebEx video conferencing, and a 3D virtual world called QuakeQuest. For the online interaction to be most effective, students 1) need to understand why they are using the tools, and 2) be coached in how to critique each other's work and contribute to threaded discussions.

Introduction

The George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) network consists of 14 large-scale earthquake engineering laboratories, housed at universities across the US. These laboratories provide research hubs for large-scale earthquake engineering research in the areas of structures, soils, and tsunamis and are linked together with a sophisticated cyberinfrastructure. Each site houses large-scale testing equipment, sensors, and support staff; researchers from around the US go to the sites to conduct their work, thus creating a network of shared use laboratories. NEES allows for the concentration of large and expensive equipment and experienced researchers and has served as a model for other earthquake engineering "collaboratories" in Japan, Europe, Taiwan, and New Zealand^[1].

The NEES research experience for undergraduates (REU) program leverages this concentration of special equipment and researchers to create a unique research experience for participants. Since 2006 the NEES REU program has hosted more than 140 students, distributed to as many as seven different NEES sites during a summer. On average, the program hosts 20 students at five different sites each summer. The program has five primary goals:

1. Increase students' enthusiasm for research that turns into a desire to pursue postgraduate education.
2. Develop a high level perspective of the issues and opportunities of earthquake engineering in a global society.
3. Attract exceptional undergraduates, particularly underrepresented students (women, minorities, and persons with disabilities) into STEM careers, primarily the field of earthquake engineering.

4. Cultivate students' professional selves, including networking skills, presentation skills, communication skills, and global sense of the profession.
5. Develop a dynamic social and academic cohort (network) among students to support and enhance the other four goals.

We address these goals with several programmatic methods, some traditional to REU programs and other methods novel to the geographic distribution of student scholars.

NEES REU Program

The NEES REU experience requires a 10 week commitment by the students. Two face-to-face meetings are used to establish and reinforce the development of a cohesive cohort. The first is the two-day orientation event, and the second is the Young Researchers Symposium (YRS) at which they present their research results. At both face-to-face events, students attend earthquake engineering related field trips that engage students in active learning about relevant technical topics and provide opportunities to share a common experience and build or strengthen relationships with their peers. Between orientation and the YRS students spend eight weeks at the research site working with graduate students and mentors on a research project. Through technology-mediated experiences the REU students can continue their networking and collaborations established at orientation. Collectively, both the face-to-face and online events are critical to establishing and maintaining a network of professional peers. We describe some of the details necessary to support the development of network of cohesive REU students.

When possible the REU orientation event, is scheduled to coincide with the NEES annual meeting. The annual meeting gives students a firsthand look at the expectations of performance at a professional conference. The orientation also provides students a chance to start establishing a program-wide cohort, and it allows the program coordinators to develop a rapport with students while providing specific guidance and training about the REU program. Targeted sessions are used to prepare students for the various activities they will engage in during their summer research including performing a literature search, designing experiments, collaborating with peers, and writing and presenting results. Social events are designed as icebreakers and to help students learn more about each other's interests and talents. The goal is for students to be familiar enough with each other to know who might be working on similar projects and comfortable enough to follow up with requests for help by the end of the orientation.

The Young Researchers Symposium (YRS) at the end of the summer provides students the opportunity to present their work in a professional setting. The YRS includes a keynote presentation by a NEES researcher along with a series of poster sessions where students present their research results (Figure 1). The poster presentations allow students to practice answering questions and sharing their results in a concise manner. They also foster engagement among the members of the cohort as students view and comments on one another's project presentations.

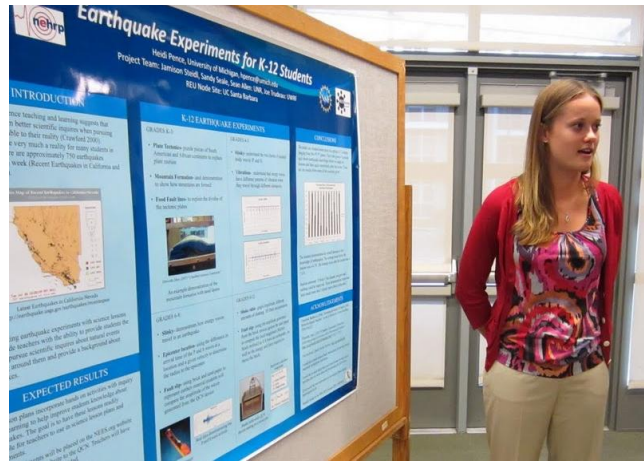


Figure 1: Student presenting research at Young Researchers Symposium

A key element of a successful REU program is establishing and maintaining a cohort among students. A successful cohort means the students interrelate socially and academically. The issue of creating a social and academic cohort is not unique to the REU program. It has been studied for some time in relation to online instruction^[2,3]. In a good social cohort, students relate well with one another and stay in contact with each other over time. Students in a strong academic cohort, collaborate together on learning and academic problems that meet their shared personal and professional objectives. While social and academic cohorts can be separate, we attempt to develop them simultaneously with our REU students. In the near term a strong academic cohort provides peer-to-peer teaching and learning opportunities, which is difficult with students who are geographically distributed. For example, a conversation which starts with a questions about designing a MATLAB model and evolves into an in-depth tutorial, is very difficult when one student is in Oregon and the other in New York. In the long term the social and academic cohort will foster professional connections. The goal behind fostering the social and academic cohort is to nurture professional connections that last.

While the geographically distributed NEES program offers many benefits, cohort among the students tends to suffer because only the students at a particular site have day-to-day interactions. Providing interactions among students based at different sites proves more challenging than co-located cohorts. To counteract this challenge the NEES REU program attempts to develop cohort through both in-person activities and a variety of cyber-interactions during the eight weeks students are at their research sites. Throughout the summer the NEES REU program includes a strong on-line component, including an on-line class and a virtual world, which are described in more detail later. These provide on-going interaction between the cohort and the staff.

NEES Cyberinfrastructure

The NEES cyberinfrastructure, called NEEShub, links the Network's 14 experimental research sites. NEEShub is built on the HUBzeroTM platform that was first used to support another geographically distributed research community, the Network for Computational Nanotechnology (NCN)^[4,5,6]. NEEShub supports the NEES research community through news and announcements; an event calendar; a data repository; access to high performance tools for simulation, collaboration, analysis, and visualization. NEEShub collaboration tools include

groups, wikis, blogs, discussions, and a drop box for sharing files. The site also has a dedicated education, outreach, and training portal called the NEESacademy^[7]. Through the NEESacademy and the NEEShub's dedicated collaboration tools, the NEES REU students have multiple mechanisms to support their individual learning and peer-to-peer interactions. This paper describes the potential of these tools, then explores methods we have established to leverage these tools to support collaboration and research productivity of NEES REU scholars.

NEESacademy, the NEEShub portal for education, outreach, and training (EOT), aims to support the NEES vision of playing a significant role in educating and training the next generation of earthquake-engineering researchers and practitioners. As such, NEESacademy is an advanced learning cyberinfrastructure capable of engaging learners in activities related to earthquake engineering and science that can achieve a range of standard learning objectives sought by K-16 educators. It includes a collection of learning experiences to engage students in earth science, physical science, and engineering design through the context of earthquake engineering. Learning resources include presentations (lectures and conference), research posters, research publications, videos, simulations, software for download, classroom lesson plans, and recorded webinars. In addition, several online classes are available for students at the undergraduate or graduate level^[7].

Engagement Through a Course Management System

To offer online courses and certification without needing to implement an entire secure content management system (CMS) from scratch, NEEShub developers integrated the free open source Moodle CMS software into NEESacademy. Moodle provides tools that are typical of commercially available content management systems such as a calendar, forums, chats, quizzes, assignments, lessons, surveys, groups, rubrics, and grading. The Moodle CMS can support a standalone online course or a blended learning environment of online and in-person interactions. Figure 2 shows the landing page for the Moodle customized for the REU program, which has been named the REU Network. The page includes a week-by-week set of assignments to guide the students through self introductions to peers, research ethics, a literature review, a project summary and project update, poster development, and application to graduate school. In addition, the CMS contains archived presentations, mentor training materials, guidelines for deliverables such as the end of summer poster and paper, and a place for participants to post photos. The integration of Moodle into the NEEShub provides a single access point for the students. One login provides access to all of the tools in NEEShub and to their unique REU Network sections designed for the NEES REU program.



Figure 2: Landing page of NEES REU Network, the content management system customized to support the NEES REU program.

Using the NEES REU Network to support the geographically distributed REU students has several advantages. First since the CMS is not tied to one university, enrolling students is straightforward. Typically, commercially available CMSs are licensed to a particular university so students must be enrolled at that university to use the system. Any student can use the REU Network; he or she only needs to register for an account on NEEShub. Second, all REU program staff as well as each of the REU site coordinators are designated as teachers in the system, allowing them to add content and to view students' submissions. Again this would be cumbersome with a commercial CMS tied to a particular university because the NEES REU site coordinators are employed at 6 to 8 different universities.

An important goal of the REU program is to develop students' research and professional skills. If the students were collocated, then their skills would be developed through a series of short lectures reinforced by active learning in small groups. This format is used during the orientation at the beginning of the program. After orientation, when students return to their sites they are in different time zones and they all have different weekly research schedules, making synchronous interaction challenging. To address this challenge, most of the interaction is asynchronous. Each week students access online resources in the REU Network and complete follow-up written assignments of varying length and complexity. Deliverables include a PowerPoint for an elevator speech summarizing their research project, a project preview, a literature review, a project update memo and Gantt chart, a graduate school statement of purpose, a draft poster, and a draft final report. The assignments serve two purposes: developing skills such as how to create a poster or write a literature review, and keeping the projects on schedule so that all students are fully prepared to present at the Young Researchers Symposium.

After deliverables are posted, students are required to review and comment on the work of at least two of their peers that are not based at their research site. The CMS provides a threaded discussion linked to each deliverable. All students can browse each other's work and leave questions and comments to their peers. Feedback ranges from informational questions such as "when will you be testing" to critical evaluation such as "the statement of purpose conveyed mixed feelings about deciding to pursue graduate school." Research on learning, particularly online learning, confirms that requiring students to comment on other's work increases the impact of each assignment by providing context, models, opportunity for reflection, practice, and feedback^[8, 9].

The first online assignment that students complete is a self-introduction. Students and staff are asked to upload a photo to their profile so that everyone knows what they look like. This process of creating a social presence (or electronic personality) is an important part of creating connectedness in an online group^[10]. Then they are asked to respond to a series of questions about who they are, where they grew up, where they go to school, their NEES research site, and their goals for the summer. Then to initiate dialog among the students they are asked to talk about their favorite and least favorite classes, where they want to be in 10 years, and their "best adventure." The best adventure question tends to really open up the students to talk about themselves. Groups form in the "real world" as well as online on the basis of identifying commonalities and shared interests^[10]. As with other online assignments, students are asked to read and comment on the introductions of at least two other students. REU staff also read and comment on posts to become more familiar with all the students and initiate a conversation and to welcome the members into the group. It is important to comment on all student introductions or students can feel ignored and thus disengage from the online group^[10].

This online self-introduction assignment has been used as a seed for the face-to-face icebreaker at the orientation. A staff member compiled a list of one unusual attribute for each student from the self-introduction they shared on-line. At the orientation participants were given the list and then spent about 40 minutes matching their peers with the attributes on the list by engaging in face-to-face conversations. They could not ask "which one of these are you?" Instead they were required to converse about relevant subjects until it became obvious which attribute matched. This first peer-to-peer introduction proved to be a very effective way to help students find common ground and become more familiar with each other. Links between students were independent of which site they were going to attend, so we believe this helped to establish the desired network-wide cohort of students.

As the summer progresses, students post deliverables that are more directly associated with activities at their home site. Whereas REU staff comments on the deliverables tend to focus on guiding the student in their research, students are more likely to relate to the post on a more personal level. For example, students were asked to share a short project preview. A staff member commented, "How does this project matter in the grander scheme of seismic risk mitigation?" On the same post a peer wrote, "You said that for a further seismic analysis you will include the foundation, but have you guys thought about including the soil into your analysis as well? The reason I ask because the project I am working on at UCLA is on Soil-Foundation-Structure Interaction (SFSI)." This example also illustrates a common exchange between an REU administrator and a student in an effort to help the student succeed. In some cases if that

staff member is aware of other similar research, then a connection between research projects at multiple REU sites might be made. When projects have common elements, a short face-to-face presentation and follow-on discussion would be ideal; however, it is not feasible given the geographic and time zone constraints. We see a high potential for students to establish site-to-site linkages among research projects through the networking supported by these online conversations. This asynchronous online conversation provides a good alternative for fostering peer-to-peer learning and creating academic cohort.

Professional Development through Web Conferencing

The NEES REU program uses a hybrid of synchronous and asynchronous interactions that go beyond that of a typical online learning community. Every other week the entire cohort and the REU coordinators at each equipment site, meet in a WebEx meeting. The purposes of these meetings are to share program information common to all sites and to engage students in an exchange of ideas and information. The synchronous meeting via WebEx is more efficient for the site coordinators (because they do not have to replicate material) and further strengthens a network-wide cohort of peers. The first WebEx meeting extends the orientation for the students to meeting all REU site coordinators, graduate student mentors, and other REU staff and summarizes expectations for the summer. Subsequent WebEx meetings usually involve guest speakers. Speakers present topics ranging from project management skills and tools, to advanced topics in earthquake engineering. For example, topics have included tsunami damage in the Chile earthquake, and experiments with large scale testing machines and how they are used to advance knowledge of engineered systems. One very important session involves a panel of faculty discussing graduate programs at three or four universities with major earthquake engineering research programs. This WebEx meeting is focused on the REU goal of encouraging students to pursue postgraduate education. In all WebEx meetings students are encouraged to ask questions and engage with the presenters, but typically few take the opportunity. We see this presentation as an important component to recruiting students into STEM graduate careers and we are concerned that by not engaging with the presenter students are missing an opportunity to become more informed. We discuss more about this issue in the section on challenges.

Engagement through a Virtual World

In addition to WebEx, we are experimenting with alternative meeting methods that can increase students' engagement with each other and possibly better emulate the experiences they had at orientation. The online threaded discussions and the WebEx meetings provide a structured and formal method for interacting with peers. However, the protocol for exchanging information can be slow and result in a less energetic interaction with peers. One of the best attributes we observed in the face-to-face activities like those at the orientation is the speed and fluidity of students' interaction with each other. Students can slip in and out of conversations with their peers. We have been experimenting with providing this kind of interaction using a 3D virtual world we call QuakeQuest. In this world, students are represented by avatars that can walk around and talk with their peers using Voice Over Internet Protocol (VOIP).

The ultimate goal for QuakeQuest is to have a place where students can go to share and build knowledge with each other. QuakeQuest builds on a previous project where students meet to develop a conceptual design of an aerospace product (this world was called AeroQuest)^[11].

QuakeQuest is similar to the popular virtual world called Second Life. These types of worlds are designed for participants to interact with each other and with objects in the virtual world. Currently QuakeQuest allows large groups to meet and have small private conversations with each other using VOIP. The main objects they can share with each other are research posters (and other PDF documents). With these basic elements we are able to host virtual poster conferences between students.

A special REU QuakeQuest world was used to help students learn more about the field of earthquake engineering, how to design effective posters, and how to effectively communicate their ideas and results to colleagues. Figure 3 shows several key elements of the world. Once students log into the world they are able to walk to special kiosks where they can browse archives of research posters from past years, or draft posters their peers have developed. Students can select the posters and put them into their virtual briefcase. They can then walk around the world and meet students in private conversation areas. Any avatars that are located in that space can talk with each other. When in a conversation area, students can remove a poster from their briefcases and set them up for public viewing. This is one of the primary methods we have developed for facilitating discussions between peers.

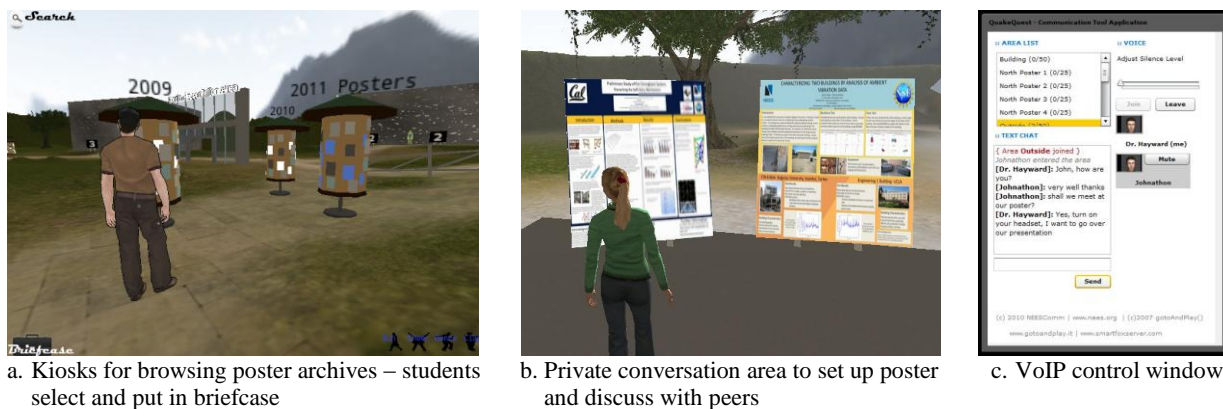


Figure 3 – Basic components of QuakeQuest

The poster sharing sessions in QuakeQuest were used in several ways to meet several objectives. The first activity was designed to familiarize them with prior REU research and to practice using this virtual world. Students were asked to review prior REU posters archived on NEESAcademy (powered by NEEShub) and select several posters based on several criteria. They were to identify a poster they thought was an excellent example and to find posters that related to their research and/or research interest. They were then to meet with a peer inside QuakeQuest at a time they mutually defined. Once in the world they met in a private conversation area and shared their thoughts and ideas about the posters they found from the archive. The second activity required students to generate an initial draft poster summarizing their research project. They submitted their poster to the NEESAcademy, which was automatically linked with a kiosk in QuakeQuest. Students then met in the virtual world on a specified day. Students were assigned to present their poster at a given time and also critically review poster presentations by peers at other NEES sites. If time permitted, they were allowed to walk around the virtual poster conference to learn more about what others are doing. REU leaders had the opportunity to walk around the virtual world and look in on these poster presentations.

This use of QuakeQuest simulated, with great fidelity, a real poster presentation format typically used at professional conferences. This pilot test of a novel form of interaction illustrated its potential for students to practice their presentations and receive valuable feedback from their peers. It also helped peers learn more about what others are doing before the end of the summer. In addition, we invited students from another earthquake engineering REU program hosted by the Pacific Earthquake Engineering Center (PEER). Both the PEER REU students and the NEES REU students were exposed to a broader range of research by combining them in the QuakeQuest virtual poster session. We hoped this activity would increase students' reflection on their own projects and interaction with each other throughout the rest of the summer. Except for small technological difficulties, pilot testing of the experience went well.

This kind of virtual poster session could be replicated in multiple WebEx meetings. However, this would come at an increased expense in terms of cost, time and effort, and reduced opportunities for free choice exploration. The WebEx sessions would be in a linear format (one presentation after another) and would not allow students the flexibility offered in the virtual world of moving around and selecting the posters they are most interested in viewing and interacting with the presenters.

Results

A systematic study has not been completed on the effectiveness of the different networking and collaboration tools that students use throughout their research experience. Ultimately our research methods will resemble a longitudinal study where earlier implementation of our program will be compared to current implementation of the program. One of our primary sources is a student survey about all aspects of the program with several questions that focus on the online component. This survey is completed at the end of the summer during the YRS session. This kind of design experiment method^[12] provides us with formative feedback on our program, which informs the iterative refinement of our program. We are looking for additional instruments to inform other aspects of our program.

The exit survey consisted of a series of statements related to the REU experience that students rated with Likert scale ranging from very satisfied (1) to not very satisfied (5) and a neutral position (3). The statements targeted various aspects of the REU program including categories of interest in STEM careers, the influence of the REU program on seeking graduate studies, development of research skills, and effectiveness of various learning experiences (e.g. orientation, YRS, WebEx meetings, online lessons, QuakeQuest Poster Session, etc).

Students indicated higher satisfaction with face-to-face events such as the orientation, YRS, and group social activities than they did with the web conferencing and QuakeQuest sessions^[13]. Students expressed some dissatisfaction with the QuakeQuest virtual poster session (average 3.7 in Likert scale with 1 being very satisfied). However the QuakeQuest session experienced some technical difficulties and students likely had not been given adequate opportunity to gain expertise with this unfamiliar environment before the virtual poster session. In several cases students had poor audio equipments which either provided interference affecting everyone's experience or limited their capability to participate in the conversation. These issues are being

address for the 2012 implementation by improving the VOIP interface and providing students with microphones and headsets that have been tested with the system

Students were asked to rate their satisfaction with using the REU Network (Moodle course). The average score was 2.07 indicating an overall satisfaction with the system. However, the standard deviation 0.83 was reflective of about ¼ of the students being very satisfied and ¼ being neutral and the rest being satisfied^[13]. Furthermore when asked about the effectiveness of different experiences in supporting learning about earthquake/tsunami engineering and research, students reported the most value from face-to-face experiences (orientation, YRS, research at the site, field trips) and final deliverables (poster and final report) and the least value from the cyber-activities (WebEx, online assignments, QuakeQuest). These results for QuakeQuest suggest that we may not be providing enough guidance to participants about the benefits of online peer-to-peer interaction and how to best use the cyber-activities to support the student experience. We are working on developing the robustness of the VOIP issues in QuakeQuest. Currently the virtual world is underutilized. We are looking to increase the kinds of interactions and objects students can experience in the world that would increase their professional skills and provide additional opportunities for them to share and compare ideas about earthquake engineering research.

With respect to the goal of creating an effective cohort, students were asked to rate the effectiveness of REU experiences in helping to connect with other students (1 – a great deal to 5 – not at all). Students rated the face-to-face experiences the most effective (site experience (1.50), site field trips (1.81), orientation (1.58), YRS (1.36), YRS poster session (1.71)). They rated the cyber-interactions as less effective (WebEx (3.56), online assignments (3.29), QuakeQuest (3.46)^[13]). The question did not distinguish between connecting socially and connecting academically, so the results leave some questions about specifics on the effectiveness of the cyber-interactions from the students' perspective. However, it is clear that students prefer face-to-face interactions for creating connections.

Finally, students indicated a high satisfaction regarding the relationship with peers at their research sites (average 1.5 on a 5-point Likert scale with 1 being very satisfied). Unfortunately, there were no questions about relationships with students not at their sites. This needs to be added in the future.

Challenges, Issues, and Opportunities

The program is meeting its goals. The REU students continually demonstrate outstanding work on their research projects at the Young Researchers Symposiums. Furthermore, a study of NEES REU alumni indicates that 65% have gone on to earn MS or PhD degrees and 85% feel that the REU program influenced their career path^[14]. Achieving the major goals of a distributed REU program requires overcoming a number of challenges including mentorship, coordinating objectives, establishing shared learning objectives with students, establishing and maintaining a productive learning community of young scholars, and ensuring reliable technology.

The primary challenges for the REU program center on expectations for success and how participation in various activities contributes to success. Also, coordinating the support staff needed to successfully mediate students' experiences at the sites and engaging students in cyber-

enabled learning experiences are critical to maintaining students' productivity. The results from student self reports and observation by the program staff has helped define these issues and identify opportunities for change.

A challenge for many students is project management, and establishing a plan of action early in the summer. A plan is critical to minimizing student stress by keeping them on track toward producing results that can be reported at the YRS. Students tend to overestimate their professional skills associated with managing, executing, and reporting a research project. Therefore, they will underestimate the value of enrichment experiences embedded in the REU program of study. For example, the orientation program and WebEx sessions include lessons in project management and technical writing. Results from a post orientation survey indicated many students believe these sessions are not needed because they have prior experience. However, their performance on drafts of their reports and in many cases the final version indicates the contrary. Our experience over multiple years indicates that students need practice organizing their ideas and learning to communicate using technical writing. Therefore, we will continue to focus on these professional activities and identify ways that help students identify their own need for improvement and develop strategies toward meeting those needs by the end of the program.

Students primarily value the research experience because they view it as having the greatest potential for future academic and career success. As a result they do not fully buy into the online assignments and interactions. Their ratings of the REU experience often are influenced by the quality of the research project they are assigned, the level of support they receive to engage in the experimental design, and the amount of time they are given to work on their project. They tend to view the online activities as taking them away from the "real" work of their research projects. In fact, typically the online assignments are aimed at helping them manage their timeline to complete research activities (literature review, abstract, interim and final reports) that are required on all research projects. Furthermore, we likely have not been explicit enough about the value of the online interactions to enhancing their community, and the value of the community to their future careers.

The lack of buy-in to the online activities has several facets. One – overconfidence: many students felt that the Moodle assignments were busy work, though we were trying to help them craft better reports by having them draft sections at a time. They do not fully understand that structure we impose is meant to help their productivity and quality of reporting. Two – lack of comfort/familiarity with virtual interfaces: many of our students were not comfortable using a virtual world to interact. This discomfort leads to reticence in using the technology and limits their ability to adapt it into their workflow. Three – communication: we were not effective in conveying to the students that these activities would be useful and beneficial to them, so students put in minimal effort or required significant prodding to complete the work. Four – ineffective feedback by peers: students need some training in how to give meaningful feedback that effectively helps their peers improve the quality of their research. Students need to learn to critically review research to establish its quality and what is missing from the research. This increases their ability to identify future research questions and their own ability to frame and design a research study. Feedback such as "this looks great" is not very useful. In the future we will work with the students to help them understand that reviewing other's research gives them

additional practice in designing effective research studies that lead to quality results. Therefore, we will work to be even more transparent about our expectations for their learning and the value added it provides each student.

Students' negative feedback on new social network methods for sharing and comparing ideas was a surprise at first. However upon further reflection several issues came into play. First, QuakeQuest is still in the development stage and there were some technical glitches during the virtual poster session. Instead of looking at themselves as Beta testers who could provide valuable feedback to the developer, the students expressed frustration that the technology did not work perfectly. In retrospect, we should have done a better job of helping them to understand what to expect when using a Beta version of software. Second, a common assumption is that students of the digital age all use game like environments. However, the survey suggests that these students have not adopted these media as part of who they are and how they operate. Third, while students are very familiar with interacting through social media such as Facebook, it did not translate to interacting in the virtual world. Students gave their presentations but only a few students were actively asking questions and providing feedback. We witnessed a similar resistance to speaking up in an online interaction during the WebEx sessions. Finally, a common assumption from popular culture is that students of the digital age all use game environments and will enjoy using them as part of their learning. However, the survey suggests that these students have not adopted these media as part of who they are and how they operate. Other studies suggest similar outcomes for undergraduate engineering students. In the 2012 REU, we plan to help students become more adept at speaking up in an online meeting, because this has become a common method of interacting in the increasingly global professional world. We consider this to be a valuable professional skill that we can develop in the REU program.

Students need time to gain trust in one another and in the REU leadership. It takes time to fully understand which REU students have the skills and backgrounds to provide the help other students need. At a lab, researchers might discover they are struggling with the same problem while they talk over lunch. An online environment does not offer the same opportunity for serendipity to emerge. We believe our methods used in face-to-face meetings accelerate the rate at which student become familiar with each other, but we do not observe as much inter-site collaboration and intellectual support. In 2012 we are going to experiment with methods that encourage students to seek expertise from one another (e.g. bulletin boards or knowledge groups).

Summary and Conclusions

Overall the program is meeting its goals. Students overwhelmingly report an increased understanding of, and interest in, research. A longitudinal study indicates that 65% have continued onto graduate programs in STEM fields. Several students have continued on in PhD programs in earthquake engineering and pursued additional undergraduate opportunities in earthquake engineering. End-of-program assessments indicate that students find the report and poster sessions particularly valuable in terms of their growth. While the program creates social and academic cohort, this is the goal that needs the most future attention.

REU students can optimize their learning in a summer by interacting frequently with their peers. Students local to the same research site can meet daily to discuss their work, collaborate to

overcome small problems, and can expand their experience by learning about each other's projects. The NEES REU program has the opportunity to amplify this experience five-fold because it typically hosts five to seven REU sites across the country and NEES has a cyberinfrastructure capable of supporting their interactions. The challenge is identifying methods to encourage an information exchange and form a catalyst that increases the chances students will turn to their peers for assistance. However, undergraduate students may have a parochial view of their personal learning goals and what it means to succeed during their summer experience. Building on theories of teaming and methods for how to develop cohesiveness between students, the NEES REU program continues to develop learning experiences that maximize students' abilities to conduct research, learn about the breadth of earthquake engineering, and learn to be productive with team members.

The current program has developed a number of effective practices that encourage students to work together. Self report surveys indicate face-to-face meetings early in the summer are critical to increasing their familiarity with each other and initiating a social cohesiveness. This social cohesiveness can increase their comfort level with each other, which could increase the sharing of ideas and overall team productivity. When students move to their research sites they have multiple ways to continue learning from each other using technology. Cyber-enabled technologies have been used for formal learning activities that encourage students to share their thoughts with their peers and provide constructive feedback. However, we have little evidence that students spontaneously look to their peers to help them solve problems or access additional information beyond their local site.

In the 2012 implementation of the NEES REU program there will be additional learning experiences designed to increase the development of a network-wide cohort of students that is both socially and academically coherent. The objective is to increase the amount of interaction and support from peers during their summer research experience. The orientation session will provide additional mechanisms to learn more about the talents of their peers and encourage students to turn to their peers when they need assistance. In addition, we will utilize technologies that will lower barriers for students to turn to each other for assistance on a daily basis. Currently we are exploring the use of tools like instant messaging^[15] and video conferencing (e.g. Skype), or other video based tools, that provide students a mechanism for text messaging for short answers or supporting a multiple student interaction to learn how to use tools like MATLAB. The goal is to create a culture where students turn to peers as well as research mentors to work through challenges. As part of orientation students will gain familiarity with these tools and will be encouraged to use them once they are at their local sites.

Regular meetings with the full cohort of students are an important mechanism for reorienting students to what is happening beyond their local sites. Further it is an efficient mechanism for providing information common to all of them. Previously this time has been used to have guest speakers share information about graduate programs or research. In addition to these sessions we will use the time for students to learn from each other. Therefore, we will use the public forum to encourage students to solicit help on problems they are experiencing or share something new they have learned or about things happening in the field. Based on prior experience we know students are often reticent to talk or share in these larger forums. Possible reasons could be a lack of cohesiveness between peers, a perception that they have nothing to offer, or lack of

comfort with online meetings. New activities designed to share problems and new information will be explored during WebEx meetings.

Threaded discussion and on-line forums around shared topics in a community can be very effective ways of soliciting help from a community. For example, communities of user groups around computer operating systems are filled with questions and problems people are experiencing. In a vibrant community, these are often answered within a day by other community members who have an answer or possible solution. What makes these communities work is the energy provided by those willing to go online regularly and answer these questions. A small community like the REU may have the expertise in the pool that could provide solutions to questions, but may lack the discipline or incentive to review the forum on a regular basis. We will explore mechanisms to encourage students to request help from the community and encourage people to respond. The first challenge will be to get people in the practice of posting questions; the second will be getting people to take time to review. The initial method will be to establish forums as a place for students to ask questions and to assign people to take turns being moderators of a discussion. This does not mean they need to answer questions, but to review the questions and try to broker help for them. This kind of stewardship model for participating in the REU community will require students to value this as an important part of their developing research experience and their responsibility to a research community.

Finally, QuakeQuest and the shared group space on NEEShub provide excellent environments for students to meet and learn from each other. Successful interaction in these worlds requires robust methods for communicating and interesting things to have conversations about. Currently the world only has posters as something to investigate together. We are working to integrate additional objects and artifacts of interest to the students in which they can interact with, co-design and have conversations about. Our plan is to increase the number of experiences students will participate in during the ten weeks. QuakeQuest was developed and beta tested in year 1 of the NEES REU, and in year 2 a more functional world was presented to students. Through experience (evaluation) with the virtual world we have learned that students need more time to experience the world before using it to present posters.

Finally, we need to make a more deliberate effort to help students understand the value of both the social and academic cohort. During orientation and throughout the summer, we will provide that rationale behind activities so that students fully understand how the REU activities contribute to outcomes beyond the completion of their research projects.

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