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# Virtual Peer Teams: Connecting Students with the Online Work Environment

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# Virtual Peer Teams: Connecting Students with the Online Work Environment

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## Abstract

This study examined the potential of online collaboration tools to develop team cohesiveness and research skills of undergraduates participating in Virtual Peer Teams (VPTs) in a geographically distributed research experience for undergraduates (REU). The VPTs mimic geographically dispersed virtual teams that are now common in industry. VPTs consisted of four to six students from multiple REU sites around the United States who were asked to experiment with various collaboration and social network technologies to complete specified research-based and social tasks. Surveys were used to collect formative and summative feedback. Students agreed their VPT experiences were significant in their professional development and broadened their network of colleagues. Further, VPTs increased their ability to comfortably provide feedback to their peers, learn about research projects at other sites, and develop a network of colleagues beyond their local research facility. VPT assignments were motivated by earlier assessments of REU cohorts, which indicated that students had gained competencies with social media for connecting with friends and family, but needed more practice with IT tools that they will use in the rapidly evolving work environment. Students indicated that they have continued to use online collaboration tools and skills learned through the VPTs when they returned to their home universities after completion of the summer REU program. While further development of the VPT concept is warranted to address specific student learning outcomes, results imply that students' experiences had a positive impact on their use of these tools and their confidence to use them in future professional interactions involving virtual collaboration.


## Virtual Teams

Engineering graduates entering today's workforce can expect to participate in virtual teams whose members collaborate through a variety of powerful Information Technology (IT) tools. Lipnack and Stamps call virtual teams "the peopleware for the 21st century"[1, p. 2]. In response to globalization and the need to be flexible and competitive, industry increasingly relies on virtual teams to bring together resources and expertise that are geographically distributed[2]. It is estimated that 30 million US workers were engaged in virtual teams in 2000[3]; today the number is even higher. A 2012 survey by the Society for Human Resource Management indicated that 46 percent of organizations use virtual teams[4]. This significant professional trend provided the context for experimenting with virtual teams in a geographically distributed research experience for undergraduates (REU) program. The introduction of virtual teams (called Virtual Peer Teams in this program) was also motivated by a desire to better address two of the REU program goals:

- Cultivate students' professional selves including networking skills, presentation skills, communication skills, and global sense of the profession.
- Develop a dynamic social and academic cohort (network) among students to support and enhance students' learning about the issues and opportunities in earthquake engineering, the quality of their research products, and their enthusiasm for joining the research community starting with a desire to pursue graduate study.

## NEES and the REU

From 2006 to 2014 the REU program, sponsored by the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) engaged 239 students in earthquake engineering research. Because VPTs only were introduced in 2013, a subset totaling 66 students are included in this study. NEES, which operated from October 2004 to September 2014, was an NSF-funded distributed research center with unique large-scale testing facilities at 14 universities, linked together with a sophisticated cyberinfrastructure[5, 6, 7]. Each summer a cohort of 20 to 35 students collaborated with faculty, graduate students, research staff, and other REU students at five to seven of the NEES facilities[8]. Hosting the REU program at multiple geographically distributed sites had the advantage of matching the diverse pool of students with exciting projects that met both their interests and academic schedules (e.g. semester versus quarter). On the other hand, the distributed nature of student placement posed challenges in developing the entire group, or cohort, as a cohesive community both socially and intellectually. The REU program is a richer, more productive and more satisfying learning experience when students get to know each other well and share their work with each other.

With students geographically dispersed across the country, creative approaches were used to encourage student interaction and cohort development[8]. Multiple methods were employed throughout the 10-week summer experience for connecting the community of students and engaging them in intellectual activities including multi-day face-to-face meetings, field trips, webinars, peer interaction through a forum in a learning management system, a virtual world, and online communication[8]. Based on observations and participant feedback about cohort development over several years of NEES REU programs, Virtual Peers Teams (VPTs) were introduced to the program in 2013. The VPTs were modeled on industry virtual teams and peer teams used in education. These teams were organized around goals to develop students':

- Professional identity as researchers and practitioners (specifically in earthquake engineering)
- Collaborative and technological skills associated with working productively in geographically distributed teams
- REU community network to support students' summer research projects
- Professional networks to support long-term professional growth

The professional development of the participants in this program focused on their ability to produce quality research products and feel a part of a research community. To become productive researchers, students need the skills to perform literature reviews, conduct experiments, and effectively communicate results in both oral and written forms. These skills develop through their active engagement in their projects and are assessed through their research products and presentations at the end of the summer. As part of their professional identity they must develop a sense of belonging to the research community. This identity emerges through their successful production of these research products and the acceptance of their peers in the research community. The VPTs provided students with multiple opportunities to have their work critically reviewed by their peers. The VPTs should be a safe environment where peers become familiar enough with each other that they develop trust and the desire to help each other achieve their professional goals. By utilizing VPTs the REU program increased the potential of achieving these desired outcomes.

This paper summarizes the key features of effective VPTs that produce quality results and the learning experiences and technologies used to address the challenges of a geographically distributed cohort of students in the NEES REU program. The paper begins with a review of virtual teams in industry as a framework for addressing common challenges faced by geographically distributed teams. Then it describes the NEES REU program, which blended this framework with learning experiences involving peer collaboration, or teaming, emerging in many engineering educational settings to achieve its goals. Specifically the study explores how technology was used in the program to support the development of the REU community, how it facilitated VPT work flow and developed students' confidence to use these technologies. Next the paper presents results from several measures in the study, and ends with a discussion of lessons learned and recommendations for other programs.

**Virtual Teams in Industry**

While many definitions of virtual teams exist, they converge on some common elements: team members interact primarily through technology to work across space, time, and organizational boundaries[1, 2, 3, 4, 9]. In fact, the Internet and advancements in communication technology are at the heart of the emergence of virtual teams as a widespread business practice[2, 9]. Businesses have embraced virtual teams for a variety of reasons. Virtual teams allow companies to bring together the best talent by drawing from multiple geographic locations[4, 9] and respond to change rapidly by forming and dissolving teams as needed[2]. They tend to be more diverse than conventional place-based teams, and that diversity promotes creativity[9]. Virtual teams minimize relocation costs, travel costs, and time away from the office[4, 9]. Among other advantages, virtual teams are highly productive, resulting in shorter development time and reduced time to market[2].

Virtual teams tend to be managed differently than conventional in-person teams with more delegation of leadership to the members and less monitoring and oversight by management[2]. Because team members may be from different divisions or even different companies, they often report to different supervisors[2]. Frequently, up to half of team members are from outside the home country[10] creating a variety of communication challenges including time zone differences[2, 4, 9], contrasting cultural communication styles (e.g. direct versus indirect)[9, 10], and differing interpretations of words and phrases[11]. The issue of time zones is one of the greatest challenges for virtual teams, with 52% of respondents to a survey raising concerns about working around the clock[11]. In addition to cultural issues, because the visual and auditory cues found in oral communication are missing in written communication, virtual teams have a high potential for misunderstanding and communication breakdown, leading to conflict[2, 9, 11]. Thus virtual teams need a more structured approach with well-defined goals and objectives, tasks, roles, and formal processes[2].

Perhaps the most pronounced distinction from conventional place-based teams is that virtual teams operate primarily through technology; many teams never meet in person[10]. This raises a number of challenges, and survey results indicate just one in-person meeting significantly improves all areas of interaction especially in the areas of relationship building, team set up, and conflict resolution[11]. Teams use a mixture of synchronous and nonsynchronous technologies to communicate such as email, phone, instant messaging, and a variety of online meeting platforms

that use web cams and voice over IP (VOIP)[10]. The technology, including its complexity and compatibility, can have enormous impact on the effectiveness of the team[2]. Training in both the use of technologies and strategies for communicating in a virtual environment improve team cohesiveness and satisfaction, yet a 2012 survey found only 16 percent of respondents had received any training for working on a virtual team[10]. With this as a context, the NEES REU program seemed like an excellent place to provide some of this training to help students prepare for their future professional careers.

**Virtual Peer Teams in NEES REU Program**

Virtual Peer Teams blended the benefits of virtual teams in industry with those of collaborative learning with peers used in engineering education. The teams were set up to increase interaction among students across the network while mastering online collaboration tools prevalent in industry. The term *Virtual Peer Team* underscored the fact that the teams were peer driven and formed solely of peers without any graduate students or program staff. In a learning setting like the REU program VPT members are peers each working on independent research products, but they share the goals of producing a quality product and developing their professional identity. Therefore, the primary goals of each VPT were to improve each other's research products (elevator pitch, poster presentation, and final report) and support professional growth through exploring conference opportunities and critiquing LinkedIn profiles and graduate school statements.

Virtual Peer Teams were composed of students from multiple sites and ranged from four to six members, as illustrated in Figure 1. Typically an experimental facility would host two to five students in any given summer, which would form a local cohort. Therefore, the REU program would support five to seven local cohorts that fed into five to six VPTs. Virtual Peer Teams participated in regularly scheduled research meetings to share progress and challenges, identify solutions to concerns, critique each other's work, and explore professional development opportunities. Members were initially assigned to teams by the REU leadership, but the students were responsible for organizing the VPT meeting schedule, selecting collaboration tools, leading the meetings, and producing deliverables.

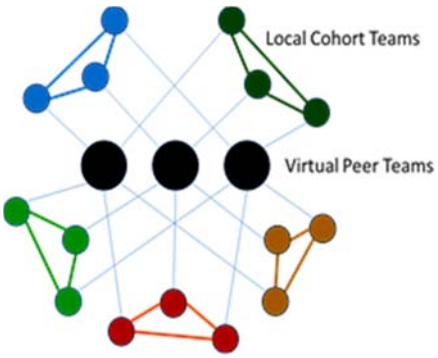

**Figure 1: Network of peers draws from local site cohorts to form VPTs**

When the REU leadership formed the teams they took into consideration the types of research projects students were working on, geographic location, gender, ethnicity, and beginning and end dates for participating in the program (which was driven by whether the student came from a university on the semester or quarter system). Since an important goal of VPTs was to encourage REU participants to establish bonds with students beyond their local cohort, team assignments minimized the number of students from the same local cohort. After the first implementation of the VPTs in 2013, students expressed the same concerns about time zones as virtual teams in industry. The NEES research facilities were spread throughout the U.S., with a maximum three-hour time difference. Students indicated that the three hour time difference posed challenges for scheduling meetings. While in industry peer

teams deal with time challenges by meeting very early in the morning or late in the evening, in many cases this was not an option for the REU students, because they could only use the facilities when staff were available, essentially 8 AM to 5 PM. VPTs needed to work around project schedules and facility schedules at multiple sites. To address this issue, in 2014 teams were composed to limit the time difference if possible, and the orientation forewarned the student about the time challenge and suggested some coping strategies.

A strength of the VPT interactions was consistent feedback that team members provided to one another on their professional development and research products. REU participants generated drafts of an elevator talk explaining their projects, sections of their final reports, their final posters, and graduate school personal statements. Students also completed a LinkedIn profile and prepared a proposal to attend a professional conference during the academic year following the REU program. Each of these assignments was reviewed by members of the student's virtual peer team. Through this repeated interaction the members of the team could gain familiarity with the research projects and with one another, which improved the quality of the feedback. VPTs provide a stable cohort of peers with whom team members develop a rapport over time. The REU leadership believe this is critical to team members developing accountability, familiarity, and trust with each other. This cohesiveness can foster a safe environment where peers feel comfortable sharing their earlier work products and are willing to accept feedback to improve these products.

> I also liked that we got to know the people that peer reviewed our work later in the program. I think peer reviews mean more if you can get a feel for the person that is doing the review.
>
> *Former REU student*

Prior to inclusion of VPTs in the program, REU participants were asked to select two or three of their peers to review for each work assignment. This created several challenges: 1) each student had a different set of reviewers for each assignment, 2) reviewers only gained superficial knowledge about any single research project, limiting their ability to see how all the pieces fit together, and 3) some projects would receive reviews from many students, and others would receive only one or two. The feedback tended to be superficial and only provided general words of encouragement. The virtual peer teams, the accompanying tasks and rubrics, and associated training were designed to improve the quality of the feedback.

**Supporting VPT Workflow: Online and Collaboration Tools**

The ubiquity and bandwidth of the Internet make virtual connection of teams easy and reliable. Further, a team's workflow can be enhanced with a wide range of tools that support their synchronous and asynchronous sharing and processing of information. Depending on the particular goals of the team and the kinds of activities the members are performing, these tools can be an asset to their communication and information management process. The program explored a number of existing low cost methods for REU students to connect with each other. Although some unique alternative tools were explored, the leadership converged on encouraging students to use "native" technology, that is, technology they might already have some familiarity with. Table 1 represents an organized list of technology used for this project. Other researchers present a more generalized list of tools with more descriptions of their potential for supporting a team's process, workflow, and information management[(2)].

**Table 1: Technology used in NEES REU program**

| Technology | Description | Medium |
|---|---|---|
| **Communication (Asynchronous)** | | |
| Online forum (built into LMS) | Share documents with entire cohort and comment using threaded discussion | Text and images |
| Email* | Share information between VPT members. Feedback provided via comments in body of message or as part of attached documents. Can archive messages | Text body and attachments |
| Texting and instant messaging/chat | Short information sharing: e.g. coordinate meeting times, answer short questions (Rapid response rate of information.) | Text |
| Doodle polls* | Coordinate meeting times with entire program or with VPT (Efficiently use members' time and identify best time to meet.) | Structured text in a timeline format |
| **Verbal Communication (Synchronous)** | | |
| WebEx | Large meetings with entire cohort for orientation and training. VPT meetings to complete VPT activities. | Share multimedia and applications |
| Skype*<br>Google Hangouts* | Meet simultaneously with VPT members. (Easy and efficient method of sharing and integrating ideas through verbal interaction. Shared resources for managing and building knowledge). | Audio<br>Share screen, applications, documents |
| Telephone | Conference calls facilitate verbal communication between two or more members of a team. Link phone with WebEx to increase audio quality | Audio |
| **Collaboration (synchronous)** | | |
| Google Docs*<br>(WebEx, Google Hangouts*) | Verbal communication combined with simultaneous interaction with resources. Sharing resources with simultaneous manipulation of materials. | Share documents and applications |
| **Document Management (asynchronous)** | | |
| Google Docs/Drive*<br>Dropbox*<br>LMS: Moodle) | Share photos from research activities and community events, e.g. field trips.<br>Share and archive team work products, e.g. share and manage information.<br>(Central location for members to access anytime, anywhere.) | Text documents, images, audio, video |
| **Long-term Network Development** | | |
| LinkedIn* | Create a public and professional profile to help students establish a professional network starting with their NEES REU community. VPT members provided feedback on profile description. | Web page, photos, links to work products |
| Facebook* | Connect socially with peers in the NEES REU community to support cohesiveness. Requires maintenance by leadership team. | Web page, photos, video |

*Tools with no cost to student

The Virtual Peer Teams had two major activities, 1) review each other's work and 2) design an executive summary of professional development opportunities (e.g. conferences). Reviewing and critiquing each other's research products (elevator pitch, research report, and poster drafts) requires teams to specify methods to share a draft of each member's work and then for peers to provide comments, questions, and recommendations. Sharing can be accomplished asynchronously through Internet tools such as email (with and without attachments), online forums with document attachment features, and shared Google Drives and Google Docs (i.e. cloud systems). In some situations students published their work publicly to the entire cohort using the Learning Management System's online forum tool, for example when they wrote their self-introductions. This allowed everyone the option to read each other's work. Each VPT had the responsibility of reviewing the work of their team members. Typically students would include general comments in the body of the text of email exchanges. Or a team member might prefer annotating a document file with comments and corrections, and then attaching this to an email, or sharing it in the cloud. The VPTs were encouraged to become proficient with shared drive methods like Google Drive or Dropbox to circulate their documents and to use Google Docs as a way to collaboratively work on a student's work product. Shared documents are the most advantageous because they allowed all team members to see what and how their peers communicated their feedback to the others.

Synchronous communication while simultaneously sharing documents provides an avenue for rapid and efficient exchange of ideas. Further it supports oral communication of ideas. The initial program orientation provided students with some training on use of Google Docs and Google Hangouts. The intent was to leverage the potential of readily-available free tools that support VOIP and document sharing to emulate virtual-meeting experiences the students will have in the future. For example, the final REU activity is presenting a poster session to experts and peers. A draft version of the poster was reviewed in VPT meeting sessions using Google Hangouts or WebEx using real-time sharing of the document with everyone connected to a session. The students did not have the total experience of a face-to-face interaction, but they could practice presenting their ideas and their peers had the opportunity to critically evaluate the work and could ask questions and provide feedback.

The NEES REU leadership team explored multiple options for the second major activity for the VPTs. The intended purpose of the second activity was to engage the teams in a challenge task that required knowledge building together, managing ideas, and making decisions. Ideally VPTs would have completed a design project or research project where the team worked to explore options, critically evaluate alternatives, make a decision, and prepare a development plan. At the same time, the leadership team was concerned with the overall workload of the students, which limited the scope of the projects VPTs could complete. Therefore, the second major activity of the VPTs was to generate a short report recommending potential conferences they or others in the larger cohort might attend. The goal was for them better understand how conferences can support their professional development and to generate and describe the possible opportunities. The intent was for the team to work together to build the team's knowledge about these opportunities and design an innovative approach for sharing the information with the rest of the REU cohort.

## Alternative Technologies

In addition to native tools, the REU leadership explored the potential of an online tool called InterLACE developed at Tufts University[12] to help with the exchange and organization of ideas. The tool provides a shared workspace where each member of a team can post a sticky note on a whiteboard. Students can do this synchronously or asynchronously. Each space had a specific activity associated with exploring an idea or finding information to resolve questions. Each VPT member could interact in this space by sharing virtual sticky notes containing their thoughts and ideas. Then these sticky notes could be moved, sorted, and linked together as part of a team's approach to finding patterns and organizing the information. The tool was briefly introduced to the students during the face-to-face orientation session in week 3. Students tried the tool but did not rate it favorably as an environment to support VPT activities. In retrospect, the tool did not support their workflow for the two major activities assigned to the VPTs.

Viewing and critiquing other's work was central to the outcomes of the REU program. Classic online meeting tools were used to connect teams and allowed them to take turns presenting their work. As an alternative to this approach the REU leadership also experimented with the use of a 3D virtual world that simulated a poster session at a conference venue. This environment, called QuakeQuest[8], is similar to Second Life[13,14] where avatars representing the participants were free to travel through the virtual space, which was populated with the students' draft posters. The goal of the interaction was to allow students to see other's presentations and meet and talk with them at their own pace. Therefore, like a real poster session, they could seek out peers with similar interests, view their work, and provide critical feedback. The process required less oversight than a series of online meetings and allowed students to take more responsibility for their own learning. It also allowed the REU leadership team the freedom to quickly transition between various sessions and oversee the discussion. The experience was novel and the students appreciated the intent. However, the novelty of the experience and wide range of avatar actions were too distracting. In addition, the variations in computers, microphones, bandwidth, and security firewalls limited the potential of seamlessly engaging all the students in the process. Details of this tool and the research conducted were reported in an earlier paper[8].

## Integration of Online Tools into REU Community and VPTs

Table 1 summarizes a wide range of possible technologies that were tried by the participants in the REU program. Program experiences over the years, combined with consideration of the specific tasks for the VPTs, led to the selection of a core set of technology tools. Table 2 illustrates the final sequence of learning experiences for the REU cohort and the tools used to support the activities. This blend of tools and sequence of activities led the students through progressively more complex interactions and tasks. For example, the early activities were designed to initiate cohesiveness among the members of the cohort by familiarizing one another with their background and interests. The self-introduction activity provided them a simple way to learn the tools while learning more about their peers. Once the VPTs were formed their first assignment was to sign up for a Google+ account and become familiar with Google Hangouts, make a circle for the VPT, and meet in Google Hangouts to check if hardware (computers, cameras, and mics) work. Next VPTs were asked to meet in Google Hangouts or a technology of their choice to practice their elevator talks. It should be noted that the 2014 schedule shown in

Table 2 is slightly different than the 2013 schedule. The first in-person meeting moved around in different summers to accommodate the students attending a national conference. Therefore in 2013 the first in-person meeting occurred in week 2 rather than week 8. In addition, 2013 was a program development year, so numerous changes were made in 2014 to respond to the formative assessments in 2013.

**Table 2: REU Community and Virtual Peer Team Online Interactions and Assignments (2014)**

| Assignment Title | Week | Purpose | Technology |
|---|---|---|---|
| Self-introduction (All) | 1 | cohort development | LMS |
| Webinar - Online orientation (All) | 1 | program administration<br>cohort/professional development | WebEx |
| Create Google+ circle and meet in Google Hangouts (VPT) | 1 | test equipment<br>professional development | Google Hangouts |
| Elevator talk and poster practice (VPT) | 1 | cohort/professional development | VPT choice |
| Elevator talk and poster presentation (All) | 2 | cohort/research skill development | WebEx |
| Peer review - Introduction and literature review sections of report (VPT) | 2 | research skill development | VPT choice, LMS |
| Compile list of professional conferences (VPT) | 3 | professional development | VPT choice, LMS |
| Compose flyer to summarize most desirable conference, finalize list of other conferences for REU community (VPT) | 4 | professional development | VPT choice, LMS |
| Webinar - Graduate programs (All) | 5 | professional development | WebEx |
| Peer review - Graduate school personal statement (VPT) | 6 | professional development | VPT choice, LMS |
| Webinar - LinkedIn/networking (All) | 7 | professional development | WebEx |
| Webinar - Preparation for in-person REU meeting at national conference (All) | 7 | program administration | WebEx |
| Peer review - LinkedIn profile (VPT) | 8 | professional development | VPT choice, LinkedIn |
| Peer review - Draft of research posters (VPT) | 9 | research skill development | VPT choice, LMS |
| Webinar - Preparation for Young Researchers Symposium (All) | 9 | program administration<br>research skill development | WebEx |

As discussed previously, the VPTs were designed around four goals that include both developing the technical and communication skills to work effectively on a virtual team and developing a cohesive network of students to support each other during the summer and beyond. The “REU Network”, the learning management system (LMS), was used as a central location to post all assignments and work products, which facilitated monitoring of progress by the REU leadership. Each VPT was free to select its own tools for team collaboration, but the program encouraged them to use Google Hangouts for in-person meetings. This provided some uniformity in tools that would facilitate REU staff helping students when they got stuck.

Training and rubrics were essential to the effectiveness of the VPTs. At the orientation webinar in week 1, staff emphasized why peer feedback is important and gave a tutorial on how to give effective feedback. In this tutorial the staff discussed specific examples of bad and good

feedback from NEES REU programs in previous years. This was followed by a testimonial from a former REU student about the importance of peer feedback. After the first VPT assignment in which students practiced their elevator talks, the VPT was required to summarize their feedback for each presenter in the LMS. Throughout the summer VPTs were given checklists and rubrics to evaluate elevator talks and posters, literature reviews, graduate school personal statements, LinkedIn profiles, and final project posters. Students used these both as guidelines to develop their own products as well as tools to guide their critiques of others' work. Another important benefit of the checklists and rubrics was that the feedback that each student received from multiple reviewers was based on the same criteria and essentially came in the same format.

## Evaluation Methods

This multi-year REU program went through several iterations of continuous improvement. Each year activities were refined and new technologies introduced to enrich the experience. In 2013 a short mid-summer formative assessment was implemented at week 5 to obtain immediate feedback about whether VPT goals were being met and if the team activities were effective. It consisted of two Likert scale questions regarding how effective the VPT was at achieving various goals and short answer questions providing specific feedback. The 2013 final program assessment included two additional formative Likert scale questions, regarding how well VPTs supported learning and cohort development. The 2014 REU program implemented only a summative assessment as part of the final program assessment, which included nine questions related to the VPTs. This assessment included four questions about skill building and knowledge, three questions about collaboration tools, one question about supporting learning and one about supporting cohort development. Data are presented for both 2013 and 2014 to highlight the development process and represent two different phases of the VPT implementation. Caution should be taken when making a direct comparison across the two years. The cohorts for 2013 and 2014 comprised different groups of students and a different set of research sites, with only two students participating in both the 2013 and 2014 REU programs.

## Results

### *2013 Results – Development and First Use of VPTs*

The 2013 data reflect the development of VPTs from a nascent idea to a functional program element. Thirty of the 36 REU participants completed the online formative assessment survey. The first Likert scale question asked students to identify how effective the VPT activities were in helping them complete their REU products (Figure 2). The data show the peer review interactions of the VPT were the most effective activity of the VPT teams while regularly scheduled meetings were somewhat sucessful. Except for the practice elevator talks which were critiqued live in Google Hangouts, and the practice poster session in QuakeQuest, peer reviews were asynchornous with comments recorded in the REU Network.

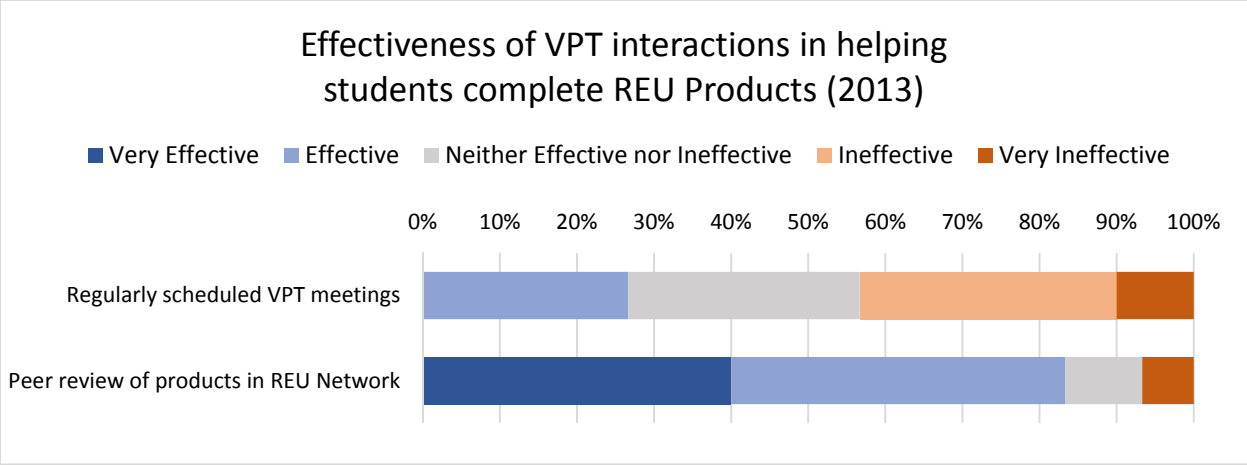


**Figure 2: 2013 students' perceptions of the effectiveness of VPT interactions (online meetings and peer reviews) in supporting completion of their REU products.**

The program attempted to provide multiple opportunities for students to learn about the science and engineering associated with earthquakes and tsunamis. Figure 3 illustrates the impact of various REU experiences on their learning about earthquake engineering. As expected, their research (site experience) which consumed about 85% of their time had the most impact on their learning. In this 2013 first implementation of VPTs, 36% of students indicated that working with their virtual peer teams supported learning. Less than 25% indicated that webinars supported learning. This result was expected because aside from the graduate school program webinar, in 2013 the webinars were mainly used to distribute expectations and logistical details.

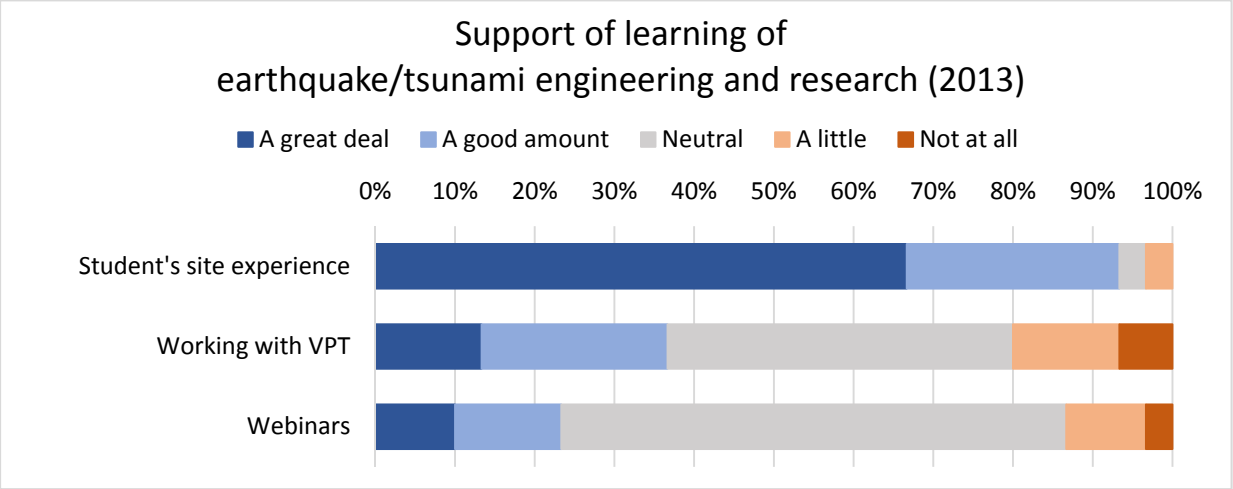


**Figure 3: 2013 students' perceptions of how much the REU interactions supported research and learning of the science and engineering of earthquakes/tsunamis**

The program sought to connect the peers through various co-located face-to-face and virtual experiences. Figure 4 confirms prior findings in the literature[15] that emphasize the positive impact that co-located face-to-face meetings like the REU Orientation and the NEES Annual meeting have on cohort development. More than 90% of the students reported that these events impacted their ability to connect with their REU peers. A positive finding is that 54% of students reported that working with VPTs connected them with other REU students.

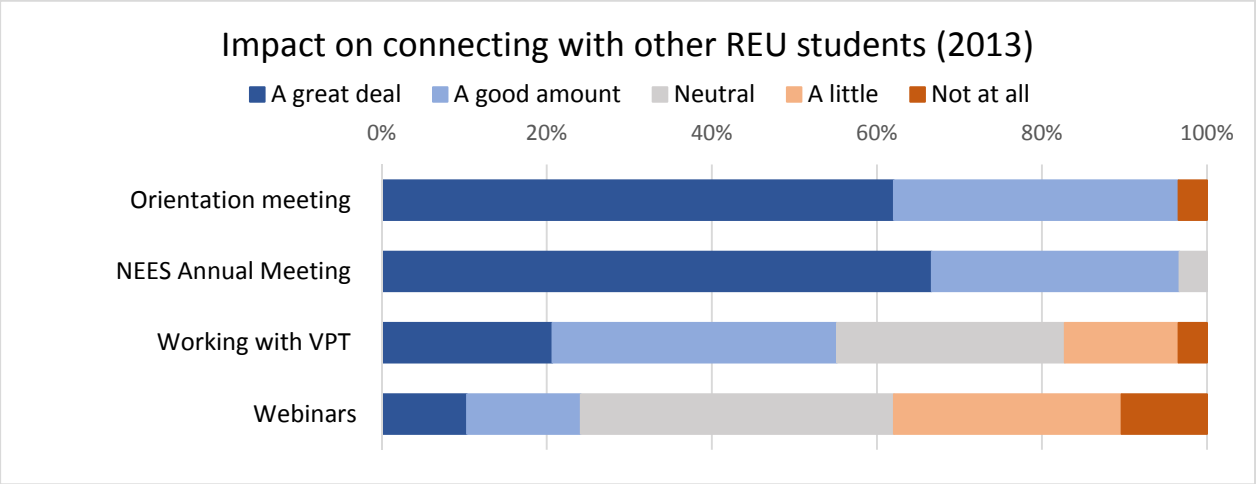


**Figure 4: 2013 students' perceptions of the impact of REU activities on connecting with peers**

Figure 5 and Table 3 show the technology that 2013 students opted to use for connecting with their VPTs. These data indicate that the students had higher rates of use of email and Google Docs and lower use of the advanced capabilities of Google Hangouts. These data combined with the negative response to InterLACE indicated that students preferred familiar "native" technology to support their workflow for VPT activities. Some anecdotal evidence suggested that better training in Google Hangouts might also increase adoption of the technology. Therefore, in the second year this became part of the orientation.

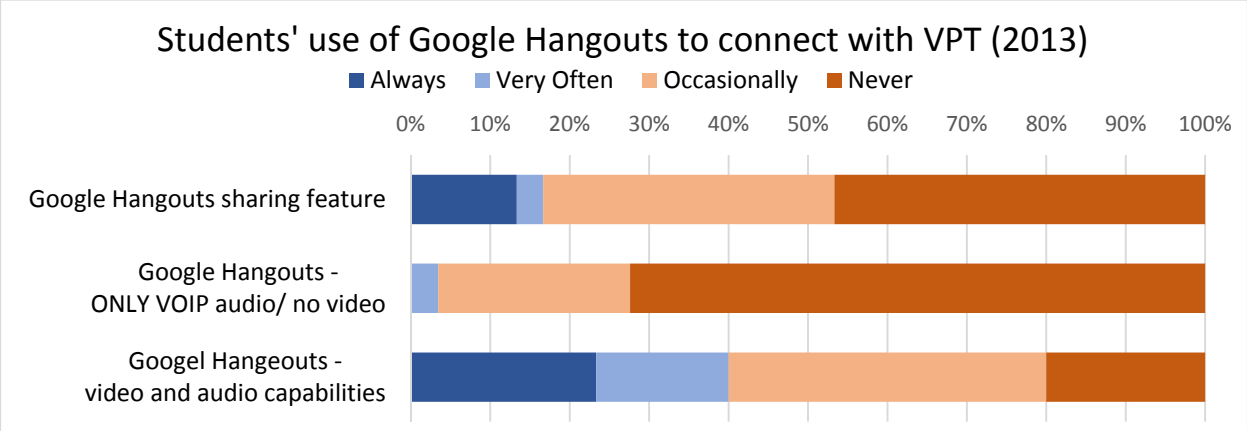


**Figure 5: Use of Google Hangouts by 2013 virtual peer teams**

**Table 3: Other technologies used to connect with VPTs**

| Technology | Students using |
|---|---|
| Email | 7 |
| Google Docs | 7 |
| Google Drive | 5 |
| Text | 2 |
| Dropbox | 1 |
| Skype | 1 |

*2014 Results – Second Implementation of VPTs*

In 2014 modifications were made to the VPT experience. As was described in detail earlier, these included augmentations to orientation, a detailed timeline for VPT interactions and products, more rubrics, and fewer online platforms to master. Therefore, several questions were added to the survey to better focus on these new dimensions. Figure 6 illustrates a very positive reaction to the VPT experience associated with the development of their collaboration skills and networking. More than 80% of respondents indicated that VPTs increased their networking with students at other sites, made it easier for them to connect in person the first time they met, and taught them new techniques for collaborating over a distance. Further, 75% indicated that the VPTs improved their collaborations skills.

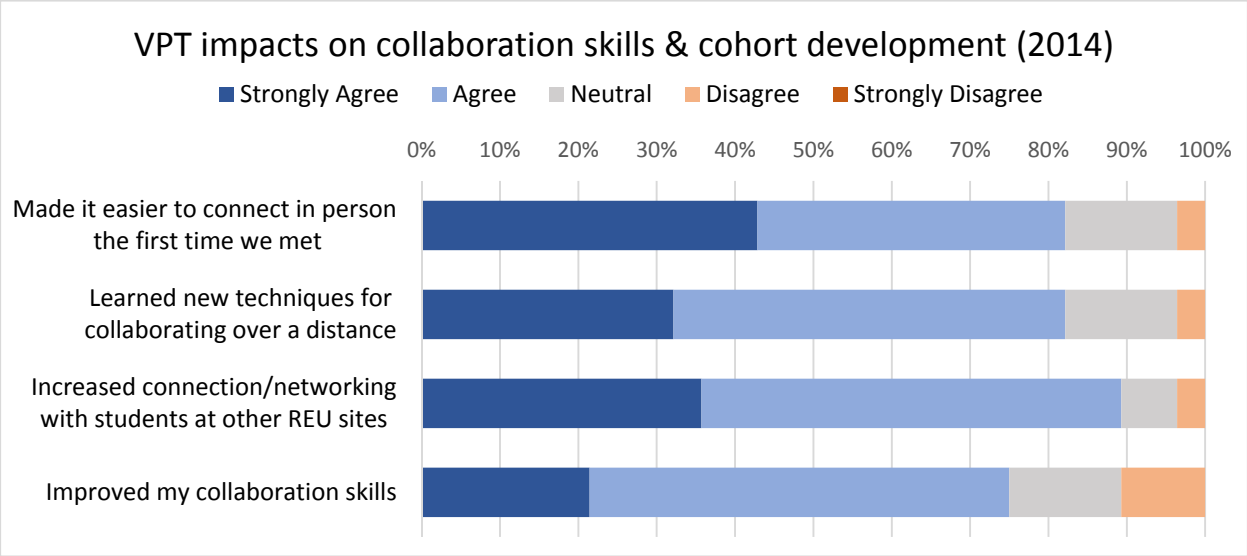


**Figure 6: 2014 students' perceptions of the impact of participating in a VPT to develop collaboration skills and make connections with peers.**

The data in Figure 7 indicate that 68% of the students agreed they received help from their Virtual Peer Teams to improve the quality of their work. This is somewhat lower than the 82% of students in 2013 that indicated that peer review of products in the REU network helped them complete their REU products (Figure 2). Note, the questions were asked slightly differently in 2013 and 2104 so it is difficult to directly compare these two results. Another potential benefit of the VPTs is having knowledgeable peers to assist with technical problems that might occur when working on a research project. Only 25% of the students indicated that they turned to members of their VPT for assistance. Likely many of them relied on their graduate student mentor or REU students in their local cohort.

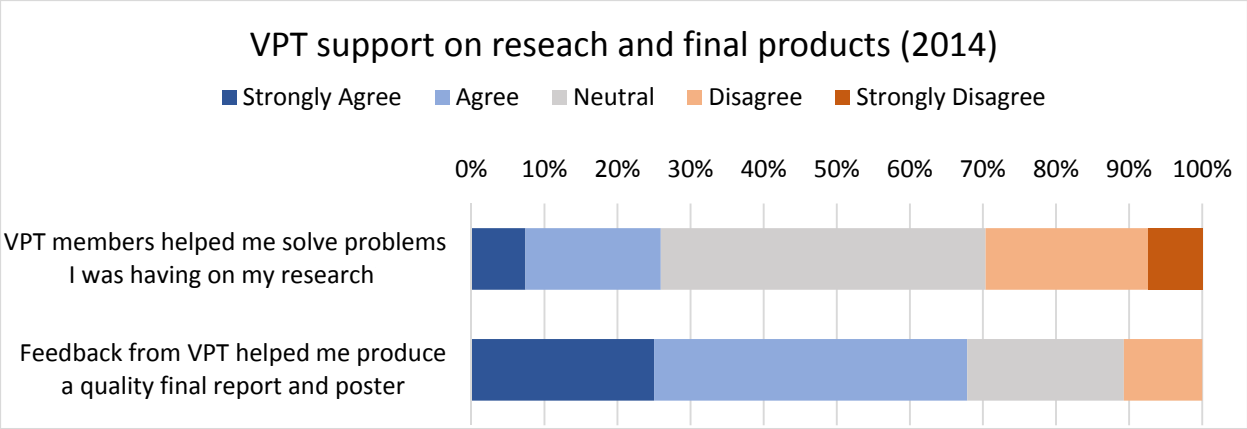


**Figure 7: 2014 students' perceptions of the impact of participating in a VPT on their research and final products.**

Figure 8 illustrates the benefits of the technologies the 2014 VPTs adopted to support their workflow on their tasks. These were mostly free applications, some of which were native technology that they were already familiar with before starting the program. Their use resulted in nearly all the students feeling confident in using the technologies to support their learning and broadened their understanding of what other research was being done at other test facilities. This technology use was significantly greater than in 2013. A positive outcome for the overall goals of the REU program is that 100% of students learned about projects and other NEES sites from their peers.

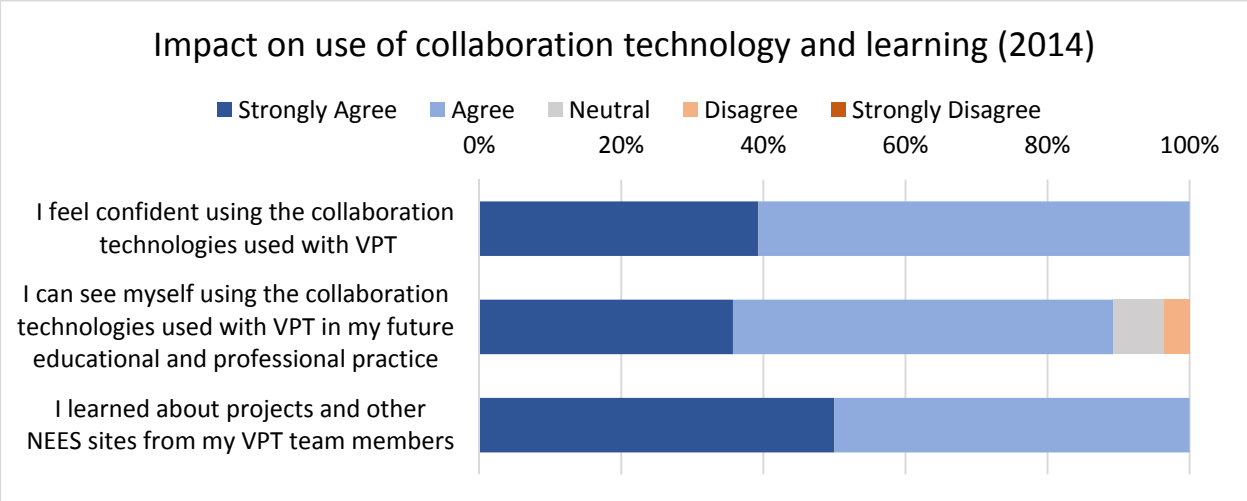


**Figure 8: 2014 students' perceptions of the impact of VPTs on their use of collaboration technologies and their learning**

## Discussion

This paper describes the impact of using technologies to support the collaboration and cohesiveness of Virtual Peer Teams (VPT) in a multi-site REU program. VPTs exhibited many of the same characteristics as virtual teams in industry. Team members were geographically distributed and communicated primarily through technology. They used a mixture of synchronous and asynchronous communication technologies. Because they were at different

labs, they reported to different supervisors (project mentors and laboratory managers). They struggled with time zone differences and technology complexities. Like industry virtual teams, they needed more structure and well-defined goals and tasks to be productive. Finally, consistent with the literature on virtual teams they found the in-person meetings very satisfying ways to reinforce and improve the connections with their team members.

The REU leadership team explored a range of technologies to support connecting students across all participating research facilities. The primary technologies were "native" to undergraduates, though several experimental collaboration tools were piloted as possible ways to promote teams' productivity and interaction (e.g. InterLACE and QuakeQuest). These tools were chosen because they supported team collaboration and workflow. In addition, these technologies were available, affordable, and easy to use. Several lessons were learned on how to successfully integrate these technologies into the REU learning experiences.

The initial implementation of the VPT activities assumed the technologies were native to students' academic practice. While some basic online training materials were available to help users operate these technologies, they were not sufficient. Learning the technologies became a barrier to their widespread adoption. In the first year (2013) the REU leadership naively expected that students would naturally integrate these technologies into their workflow. Based on results from this evaluation study, students readily adopted familiar asynchronous tools like email and text to manage basic communication and share information. Therefore, they were able to perform the simple tasks of sharing information and getting some level of feedback from their peers about their work. However, this asynchronous communication did not adequately support the program goals of forming a cohesive social and intellectual cohort invested in supporting each other's research and learning about the various projects in the network. The synchronous technologies like Google Hangouts were a new experience for most of them and were an unfamiliar technology in a professional context. A few students remarked that some of their peers were having difficulty using the technology for professional interactions. That is, students may have been familiar with using the net meeting technologies as a way to visit with their friends and family, but were less prepared to use these in a professional setting with colleagues they had not yet met and engage in interactions to produce an outcome. In addition, students found learning so many new platforms and switching back and forth between all of them frustrating.

The second iteration of the VPTs in 2014 included several critical changes to address the issues of the first implementation. The REU leadership recommended a limited set of specific technologies for VPT collaboration including Google Docs, Google Hangouts for VPT meetings, WebEx for full program meetings, email, text, and chat. VPT membership was assigned to maximize geographic and demographic diversity, yet cluster projects with similar objectives and research tools (e.g. MATLAB or specialized software) in an effort to increase the potential that virtual team members would ask each other for assistance on their projects. In addition, minimizing the difference in time zones was considered in forming teams. At orientation, which was online through WebEx, the team members met and were given instruction on how to use the recommended technologies. Also, students were trained on how to give critical, but positive, feedback on one another's research projects. The orientation emphasized that reviewing others' work is an important part of gaining the skills to become a good researcher. That is, providing

authors with critical feedback is important to the professional development of both the author and their reviewer. Additionally, rubrics were provided to the VPTs to guide the development of their products and to improve the consistency and quality of feedback to peers. Finally, the VPTs were given the expectation that they would meet weekly to discuss their progress, receive feedback on their work, and work on a collaboration project together. This small scaffolding of their process assured they were meeting regularly and gave them a focus and purpose to meet.

Overall, the structure and objectives of the VPT activities established student buy-in. Several students did complain that team members were ignoring their feedback or that their peers were not giving sufficiently detailed feedback. In a future implementation the REU leadership would recommend reviewing some of the peer feedback during the program and providing critiques and ongoing guidance on the quality of the feedback. Nearly all the students agreed they became more connected with their peers on virtual teams because of their routine meetings. However, the success of this approach still relied on the guidance and structure provided by the REU leadership team to define tasks, create rubrics, set deadlines, and provide reminders to submit work. In addition, the use of technology to achieve professional goals appears to increase their comfort level with participating in virtual meetings. These are critical skills needed in today's work environments.

The free technology tools that the REU Leadership recommended appear to be robust and accessible to students. Therefore, the Internet bandwidth and crashing applications are not barriers to a quality experience between users. However, challenges still exist with operating system and browser compatibility, access to the Internet on a secure network and establishing conference phone lines. In one unexpected incident a student used her cell phone for a webinar, went over her allotted minutes and incurred a $140 bill for the call. Facility Information Technology (IT) procedures required IT authentication for installation of various tools, or the facility machines required external microphones. Therefore, students often resorted to using their personal laptops. Students were provided microphones and headphones with microphones upon request.

Future implementation of the program could benefit from teams performing a shared design or research activity. The two activities assigned to the VPTs were adequate for sustaining some level of interaction with their peers. However, they did not necessarily push the teams' collaborative skills toward generating and synthesizing new knowledge. The initial concern was that team members could not afford to take time away from their research. However, they were also given the expectation that they were working a full 40 hours a week. Therefore, it may be possible to expect VPTs to identify and collaborate on some additional research project. Then tools like InterLACE and Google Docs could become even more important resources for their productivity. Further the additional research project would develop their skills to use technology to manage the process of collaborating completely virtually.

**Conclusions**

Based on student feedback, the virtual peer teams successfully met the stated goals of fostering an REU community network and developing students' collaborative and technological skills for working in geographically distributed teams. Students reported less impact on the quality of their

final reports and posters. However, the REU leadership team saw an improvement in the quality of the products over previous years, when VPTs were not used. If the program had continued, additional modifications would have been introduced to increase the effectiveness of the teams. In particular, the REU leadership team would have periodically reviewed some of the peer feedback and provided critiques and ongoing guidance on the quality of the feedback.

Participating in a multi-site REU center like the NEES REU can be an extremely productive learning experience for students. Using VPTs and technologies to support their research and professional development will increase their readiness to participate in virtual teams in a professional setting, which are a growing industry trend. Working effectively and comfortably in a virtual team using technology as a primary form of communication requires training and experience. The REU participants illustrated the ability to adapt over the short 10 weeks. With careful planning and guidance of an REU leadership team, a large cohort of VPTs can productively work together, form a cohesive cohort of researchers, and develop skills to be competitive in a 21st century workplace.

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## References

1. Lipnack, J., & Stamps, J. (1997). *Virtual teams: reaching across space, time, and organizations with technology*. John Wiley & Sons.
2. Ale Ebrahim, N., Ahmed, S., & Taha, Z. (2009). Virtual teams: a literature review. *Australian Journal of Basic and Applied Sciences*, *3*(3), 2653-2669.
3. Ahuja, M. K., & Galvin, J. E. (2003). Socialization in virtual groups. *Journal of Management*, *29*(2), 161-185.
4. Society for Human Resource Management. (2012). *SHRM Survey Findings: Virtual Teams* [PowerPoint slides]. Retrieved from Society for Human Resource Management website: http://www.shrm.org/research/surveyfindings/articles/pages/virtualteams.aspx
5. Ramirez, J. A. (2012). The George E. Brown, Jr., Network for Earthquake Engineering Simulation (NEES): Reducing the impact of EQs and Tsunamis.*15th World Conference on Earthquake Engineering*, Lisbon, Portugal.
6. Brophy, S. & Anagnos, T. (2014). Large Research Center Education and Outreach: Lessons from 5 years of Distributed Collaborative Design, Development and Implementation. *121st ASEE Annual Conf*., Indianapolis, IN.
7. Hacker, T., Eigenmann, R., & Rathje, E. (2013). Advancing Earthquake Engineering Research through Cyberinfrastructure. *Journal of Structural Engineering*, *139*(7), 1099-1111.
8. Anagnos, T., Lyman-Holt, A., & Brophy, S. (2012). WIP: Linking a Geographically Distributed REU Program with Networking and Collaboration Tools, *119th ASEE Annual Conference*, San Antonio, TX.

9. Bergiel, B. J., Bergiel, E. B., & Balsmeier, P. W. (2008). Nature of virtual teams: a summary of their advantages and disadvantages. *Management Research News*, *31*(2), 99-110.

10. RW3 CultureWizard. (2012) *The challenges in working in virtual teams: Virtual teams survey report 2012*. Retrieved from RW3 CultureWiazrd website: http://rw-3.com/VTSReportv7.pdf

11. AIM Strategies. (2010). *Virtual teams trends report: A world that knows no boundaries*. Retrieved from AIM Strategies website: http://aim-strategies.com/AIMVTTrendsReport.pdf

12. Coopey, E., Danahy, E., & Schneider, L. (2013). InterLACE: interactive learning and collaboration environment. In *Proc. 2013 Conference on Computer Supported Cooperative Work Companion*, 11-14. ACM.

13. Warburton, S. (2009). Second Life in higher education: Assessing the potential for and the barriers to deploying virtual worlds in learning and teaching. *British Journal of Educational Technology*, 40(3), 414-426.

14. Second life. www.secondlive.com [URL] Last visited January 29, 2015.

15. Siemens, L. (2011). The balance between on-line and in-person interactions: Methods for the development of digital humanities collaboration. *Digital Studies/Le champ numérique*, *2*(1). http://www.digitalstudies.org/ojs/index.php/digital_studies/article/view/184/236