Purdue Engineer of 2020 Seed Grant Final Report

Please return to
***Michael Harris, ARMS, by* Oct. 15, 2009**

1. Project Information

Contact Name: Daniel DeLaurentis, Sean Brophy, Kathleen Howell
Project Title: Multidisciplinary Insights for Learning Engineering Aerospace Design (MILEAD)
Award Amount: $40,000

Abstract:

Innovation in complex aerospace systems lies in synthesis of individual specialties across diverse disciplines; the best design engineers must also be the best multidisciplinary collaborators. Engineers are also called to think technical problems in the context of business and social issues surrounding them, while facing the twin challenge of the twenty-first century: technology and globalization. The convergence of advanced software and the networked computers means that team structures are increasingly dispersed geographically, sometimes globally.

To address these issues, learning researchers have been investigating a variety of online collaboration tools for the engineering research and education. As a part of this broader effort, our team is currently studying an (unorthodox) use of virtual worlds, a media typically used in video games, especially in the context of team collaboration. For the PE2020 project, we proposed to develop video-based lectures to be shared in the virtual world for the purpose of team projects. We study the roles of these combined multi-media in a formal engineering education setting. We also make these video clips (the learning material) available via web browser to the non-virtual-world user students and to the public. The PE2020 funding supports the "script writing," the filming (many are done in a Pro-Ed studio by professional camera-person), the post-editing (sometimes the CGT lab was used), and the development of C++ code to interface the video with the virtual-world program. The funding also covers the assessment of these efforts.

This report provides the synopsis of our activities and findings. Our PE2020 project has lead to collaborations with researchers on campus and to two NSF-funded projects (one with Brophy as PI and DeLaurentis as Co-PI, and one being a component of the Network for Earthquake Engineering Simulation, or NEES, award).

2. Project Goals

Goals and Objectives:

Some of the target attributes we have focused were the aspects of engineers working on team-based project with multi-disciplinary teams, where engineering problems are solved in the context of business and social issues. While we structured our design course to specifically address these issues, we turned to the PE2020 funding to develop a tools and methods to facilitate activities that can achieve these goals. One idea we pursued was the library of videos that are created and shared by faculty and students over 2D web-based programs and our 3D virtual-world program. By tracking the viewer activities (user logs, text conversations regarding the videos, etc.), we investigated the effectiveness of such multi-media learning resources. We also wanted to study if the same tool can help faculty members leverage each other's knowledge, thus enabling "cross pollination" among courses and curricula.

These big goals were then translated into specific development goals in the following five phases: (1) faculty members (the experts) develop educational content specifically for our purpose (2) film videos in a variety of settings, including in the Pro-Ed studio, in the casual office settings (with professional camera crews), at Purdue Airport for the jet-engine lecture by the Aviation Technology professor, and in the classrooms to simply stream/record lectures using web-cam, (3) edit and post-process these videos (sometimes advanced CGT lab was used), (4) make these videos available in our virtual-world program and in the web-based programs such as YouTube, Ustream, and Blackboard, and (5) assessment of our project from both technical and learning points of views. A variety of video formats and delivery methods were tested to identify the advantages and disadvantages of different approaches.

Please list the project's key results to date:

A series of video-based lectures and presentations were developed by Professor James Longuski (from School of Aeronautics and Astronautics in College of Engineering) who discussed about space missions and by Professor J. Mark Thom (from Aviation Technology in the College of Technology) who discussed about jet engines. The Principal Investigator of this project (Professor Daniel DeLaurentis) also developed number of videos on aircraft design.

The total of these videos amounted to close to 65 hours. The lion share of our effort in script writing, filming, and editing were devoted to 20 video clips that amounted to 5 hours — much of praise from students was attributed to this professionally-crafted portion. (Responses were overwhelmingly positive: "Video lectures were terrific supplement to the course," "being able to watch them at my own pace, re-watching the same part, or skipping some steps to save time was beneficial, especially for the exam time and for the project.") For the remaining 60 hours, 30 hours worth of lectures were recorded using a hand-held camera with bear-minimum editing, and the other 30 hours were recorded using a webcam with no editing.

We also overcame technical challenges to stream these (2D) videos inside of the 3D environment of our virtual world. To achieve this goal, we interfaced a web-rendering technology behind Google Chrome into our virtual-world program by writing our own custom code in C++. The funding from PE2020 partially supported this effort.

To make these videos available for the non-virtual-world users, we employed a variety of web-based programs, including the Blackboard Course Management Systems (when we

restricted the viewers to the registered students), YouTube (when we made the videos available to the public), and Ustream (when we interacted with the students in real time).

The synopsis of our findings is discussed in the Assessment section. Finally, our PE2020 project has lead to collaborations with researchers on campus and to such NSF-funded projects as SIDD and NEES.

3. Project Dissemination (check any that apply)

X The PE2020 seed grant has resulted in new collaborations with:

Dr. James Longuski
Professor of Aeronautics and Astronautics
College of Engineering, Purdue University

Dr. Dan Hirleman
Professor and Head of Mechanical Engineering
College of Engineering, Purdue University
(Principal Investigator of the NSF-funded GlobalHub Project)

Dr. Bill Watson
Assistant Professor of Educational Technology
Director, Purdue Center for Serious Games and Learning in Virtual Environments
Department of Curriculum & Instruction, Purdue University

Dr. Lorraine Kisselburgh
Assistant Professor of Communication
Department of Communication, Purdue University

X Programs created with the PE2020 seed grant have been exported to the following groups:

Our videos, developed for the test groups of our virtual-world users, are accessible through YouTube and our course website as well as through the Blackboard Course Management System. Students of AAE251 in the past four semesters (100 students per semester on average; 400 students to date) have already made use of these videos.

Use of the web-hosting site YouTube also means that viewers from all over the world are directed to our videos. We continue to receive comments from non-student viewers (over the world; one has specifically indicated that he or she was from England).

☐ Other:

4. External Dissemination

Please check any of the following that apply and provide appropriate details below.

☐ Published Papers (complete reference)

☐ Submitted Papers

X Conferences or Seminars

Name: Masa Okustu, Daniel Delaurentis, and Sean Brophy
Presentation Title: Aerospace Engineering Design Course via Virtual World
Date: October 14-16, 2009
Location: MODSIM World Conference, Virginia Beach, Virginia.

Name: Masa Okustu, Daniel Delaurentis, and Sean Brophy
Presentation Title: Teaching Engineering Design Course via Multi-Player Online Serious Game
Date: September 15-18, 2008
Location: MODSIM World Conference, Virginia Beach, Virginia.

Name: Masa Okutsu, Daniel Delaurentis, and Sean Brophy
Date: April 2009
Location: ITaP TLT Conference, Purdue University.

Name: Jason Liu, Masa Okutsu, Daniel Delaurentis, and Sean Brophy
Date: Summer 2009
Location: Summer Undergraduate Research Fellowship (SURF) presentations.

X Website address:

1. *aerohub.org* (for our virtual-world program and serious-game effort).
2. *aae251.wikidot.com* (for some of the publicly-viewable videos; videos posted on the Blackboard Course Management System are restricted to the AAE251 students.)

☐ Other (explain below)

5. External Funding

X Yes, we have applied for external funding

Funding agency:_***NSF EEC, "Supporting Innovative Design Decisions (SIDD) through Cyber-enabled Learning Environments***"_____

Status: X Awarded ☐ Pending ☐ Denied

If "Denied" do you plan to resubmit or submit elsewhere?

☐ Yes. Agency name:_____

☐ No. Reason for not resubmitting:

☐ No, we did not apply for external funding.

If 'No', please list reasons:

6. Assessments

We have successfully projected 2D videos inside of the 3D virtual world. This integration worked well for the instructional purposes. Despite the video-game appearance of the virtual world, its users learned just as much as the classroom students. This finding was verified using several measurements, including the exam and the project grades of 140 students who are enrolled in AAE251. (In some measures, the virtual-world group performed better than the real-world group, but these differences were not measurable statistically).

Without the loss in their learning quality, the virtual-world group actually had the advantage of being able to attend lectures and team meetings from any computer. The students can potentially save large commuting time this way. In addition, because the instructor can always position camera and microphone in their optimum positions, the audio/visual quality of the virtual-world lectures could arguably be made better than the large lecture hall with students sitting in back rows. The virtual-world users could also ask questions during the lectures, as players of massively multi-player online games would routinely do. Because of the nature of text chat, these multi-user conversations can be carried seamlessly without disrupting the lectures.

We found that students who watched lecture videos (recorded or streamed real time) in the virtual-world tend to multi-task; sitting in front of a computer makes it easy to work on other tasks at the same time. This freedom is a double-edged sword. While some students used the advantage to look up resources related to the lecture or task at hand, temptations to check private emails and Facebook updates were also great. As discussed earlier though, these advantages (or distraction, depending on the point of view) did not translate into measurable difference in the learning outcomes.

However, beyond the fact that users of our virtual world could communicate with each other while watching recorded or streamed videos, we did not observe large advantages of using the virtual world as a place to watch videos compared to *other online collaboration tools*. (Our virtual world does have capabilities no other online tools have, but we limit our conversation only to the specific studies performed under the PE2020 grant.)

We have also made the videos viewable via YouTube, Ustream, and Blackboard Learning System for the non-virtual-world audience. We have found YouTube particularly useful in organizing our videos. Our current conjecture, based on the experience gained from the PE2020 project, is that short video lengths and the links to other related videos also proved valuable in the educational context. For instance, we find that students spend more time watching videos clipped down to shorter duration (under 10 minutes) than the lecture-length videos (50 minutes). There is a negative correlation between the video usage and its length, in which shorter videos had disproportionally larger viewership. If true in general (our sample size is too small to be conclusive), this suggests a shift in the way multi-media shall be used. Rather than current the “Pro-Ed” format, the model that might work better is that of YouTube, which contains short (but numerous) videos which themselves are linked to other related videos.

7. Future Plans

The finding that our students in virtual world can achieve educational objectives of the traditionally-taught class has inspired a variety of collaborations with other researchers at Purdue. We are now part of such NSF-funded projects as SIDD and NEES. They represent natural next steps beyond the PE2020 project. We are currently preparing a manuscript for publication (Journal of Engineering Education).

Much of data we have collected to date on team collaboration in our mixed media format are yet to be analyzed. Professor Lorraine Kisselburgh from Department of Communication is collaborating with us in this area.

Our future plan does include technical work as well. Currently, multiple users of our virtual world can watch and discuss each other about videos only when these videos are streamed in real time (e.g. when they are attending lectures), but not when recorded videos are accessed. As a result, students cannot effectively collaborate when watching recorded video, because recorded video is not synchronously displayed in other users' screens. This issue must be addressed.

The videos that we posted on YouTube continue to be watched by students of AAE251 and by the public. Already, four semesters with approximately 400 students went through the process of learning via the multi-media developed through the PE2020 grant. The current enrolment trend is approximately 100 students per semester. So, about 1000 students would learn from these videos in a five-year period. (This is the projection to the next three years.)

8. Lessons Learned

Our project was largely success. However, we found that there are two major constraints when expanding our project beyond the current scope.

The first issue was the challenge in organizing multi-media resources. Organizing videos was not like organizing PDF files. The memory size of lecture video is orders of magnitude greater than a PDF files covering the same materials. The files sizes of higher-quality videos are exponentially bigger. The sheer memory size posed an administrative challenge as the number of in the collection grew. Any task took long time to do. Since the file size was too large to email we had to constantly transport files back and forth in CD, flash drive, and eventually a terra-byte external hard drive. Once the video were in the final form, we stored them in a server, which also made it difficult to edit later (we had several people involved in various aspects of video production). Additional hardware would be required to accommodate the memory and streaming capacities beyond the current level.

Another problem we did not realize initially was the issue of intellectual property. In short, although professors would own the intellectual property of textbooks and lecture notes he or she writes, lecture performance, as it turned out, is owned by the university. This means that a professor would be breaking an employee agreement by posting lecture videos on YouTube. For this reason, we used YouTube only for videos that are explicitly outsourced (made 100% based on the PE2020 project), while other videos created by the instructor of the course are posted on Blackboard which can restrict users only to the enrolled students. A brief consultation with the university legal staff indicated that synergistic teaching and collaboration based on publicly viewable videos, at least in a way we originally envisioned, would likely infringe on employee agreements with the university. We have not pursued this issue further.