I. Title Page

Taking Laboratories Virtual: Evaluating the Effectiveness of Video Based Online Laboratory Experiments in Fire Safety Courses through Analysis of Student Assessments

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Department of Engineering Technology and Construction Management
Program of Fire Safety Engineering Technology

II. Abstract

This study will analyze the ability of video based laboratory exercises to teach students the specific learning objectives for a lesson. To accomplish this goal, assessments will be taken before and after the completion of the virtual laboratory exercises and student opinion surveys will be administered and analyzed. This type of information is critical as the UNCC student population grows and laboratory spaces become less available and for distance education students who do not have access to campus facilities.

Virtual labs have been used in teaching science for many years in fields such as chemistry and physics. The virtual lab is beneficial because it allows the students to do many simulated experiments without the cost, danger, and time constrain of actual experiments. Fire Safety related combustion can occur at a wide variety of length and time scales. Some reaction happen very fast which are difficult for the human eye to see and other reactions occur so slow that they cannot be completed in a typical class period. Some situations occur in small spaces which cannot be viewed by the human eye and some fire types occur at large scales which will not fit into the typical academic laboratory space. The use of virtual laboratories allows student to analyze the types of fires that cannot be done in a typical academic laboratory space. In addition, some science experiments such as reactive chemistry can be inherently dangerous and difficult to control which can lead to injuries when mishandled. By doing virtual laboratories students are able to see the results of reactions without the danger of experimenting with combustion processes.

III. Budget Request form

Budget Request for SOTL Grant
Year 2017

Joint Proposal? ____ Yes _X_ No

Title of Project: **Taking Laboratories Virtual: Evaluating the effectiveness of video based online laboratory experiments in Fire Safety courses through analysis of student assessments**

Duration of Project: 2 year

Primary Investigator(s): Scott R. Rockwell Ph.D.

Email Address(es): srockwel@uncc.edu

UNC Charlotte SOTL Grants Previously Received (please names of project, PIs, and dates): N/A

Allocate operating budget to Department of: ETCM

		Year One
Account #	**Award**	**January to June**
Faculty Stipend	Transferred directly from Academic Affairs to Grantee on May 15	$ 3850
911250	Graduate Student Salaries	$0
911300	Special Pay (Faculty on UNCC payroll other than Grantee)	$0
915000	Student Temporary Wages	$2000
915900	Non-student Temporary Wages	$0
920000	Honorarium (Individual(s) not with UNCC)	$0
921150	Participant Stipends	$0
925000	Travel - Domestic	$2500
926000	Travel - Foreign	$0
928000	Communication and/or Printing	$0
930000	Supplies	$0
942000	Computing Equipment	$0
944000	Educational Equipment	$0
951000	Other Current Services	$0
	Year One Total	$ - 8350

		Year Two
Account #	**Award**	**July to June**
Faculty Stipend	Transferred directly from Academic Affairs to Grantee on May 15	$0
911250	Graduate Student Salaries	$0
911300	Special Pay (Faculty on UNCC payroll other than Grantee)	$0
915000	Student Temporary Wages	$2000
915900	Non-student Temporary Wages	$0
920000	Honorarium (Individual(s) not with UNCC)	$0
921150	Participant Stipends	$0
925000	Travel - Domestic	$2500
926000	Travel - Foreign	$0
928000	Communication and/or Printing	$0
930000	Supplies	$0
942000	Computing Equipment	$0
944000	Educational Equipment	$0
951000	Other Current Services	$0
	Year Two Total	$ - 4,500
	GRAND TOTAL (Year One + Year Two)	$ - 12,850

Attachments:

Narrative on how the funds requested will be used:

The student stipend will be used to pay an undergraduate student for 200 hours (at $10/hour, 10 hours/week for 20 weeks) of work over the course of each year. The student will to conduct the in class surveys as the IRB will likely requires someone other than the PI conduct the surveys. The student will also code and conduct simple analyses of the results and assist with the writing of the paper to be submitted for publication in the Journal of Excellence in College Teaching and presentation of the results at UNCC. The travel funds will be used for the PI and student to present at the 2018 and 2019 Lilly Conference on College Teaching in Miami Ohio. The 2018 conference presentation will allow the initial results to be presented and provide an opportunity to get feedback on the study methodology from educational experts to utilize during the second year of the study. Conference registration is $475 per person and the rest of the travel funds will cover the cost of travel and hotel.

Has funding for the project been requested from other sources? ___ Yes _X__ No. If yes, list sources.

IV. Letter of Support

UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE *of* ENGINEERING

Department of Engineering Technology and Construction Management

9201 University City Boulevard, Charlotte, NC 28223-0001
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October 19, 2017

Scholarship of Teaching and Learning Grants Committee
Center for Teaching and Learning

Dear Review Committee:

I am pleased to support the Scholarship of Teaching and Learning grant proposal by Dr. Scott Rockwell, titled *Taking Laboratories Virtual: Evaluating the Effectiveness of Video Based Online Laboratory Experiments in Fire Safety Courses through Analysis of Student Assessments*. This proposed project will assess the effectiveness of video based laboratory exercises for teaching concepts where physical laboratory experiments are not viable due to safety, time, cost, or space constraints. Innovative instructional strategies such as this are quickly becoming a necessity to meet the demands of continued increased enrollment of both on-campus and distance education students.

The results of this project will also be used to support proposals for extramural funding to expand the work not only within the university, but also beyond campus for instruction in K-12 school as well as professional development for first responder training. Thus, I enthusiastically support this project.

Sincerely,

Anthony L. Brizendine

Anthony L. Brizendine, Ph.D., P.E.
Professor and Department Chair

V. Project Narrative

a. Specific Aims

1. The overall purpose of the project is to analyze the ability of video based laboratory exercises to teach students the specific learning objectives for a lesson in an equivalent or better than hands on laboratory exercises.
2. The specific objective to be achieved in this project is to evaluate assessments in a fire science laboratory class which utilizes video based exercises rather than live fire exercises and analyze the assessments to determine student competency in the subject matter.
3. The specific research question in this project is: Can video based laboratory activities provide and equivalent learning experience to hand on laboratory exercises and ensure students learn the material specified in a set of laboratory learning objectives?
4. The rationale behind this project comes from the fact that as the UNCC and other universities student populations grow and laboratory spaces become less available along with distance education students who do not have access to campus facilities at all there still needs to be a way to deliver laboratory experiences and training to all students. The virtual lab is beneficial because it allows the students to do many simulated experiments without the cost, danger, and time constrain of actual experiments. Some science experiments such as reactive chemistry can be inherently dangerous and difficult to control which can lead to injuries when mishandled. By doing virtual laboratories students are able to see the results of reactions without the danger of experimenting with combustion processes. This type of work has previously been studied in a fire science class room but only student opinion data was collected. This study extend the previous work and focus on determining the effectiveness of teaching students the material covered in the course learning objectives.

5. The impact of this study is growing as more programs become offered in a distance education method. Specifically for UNCC, the Fire Safety Engineering Technology program recently lost their offsite laboratory space where ETFS 2264L Fire Behavior and Combustion Lab was previously taught. Currently there is not space available on campus to conduct this specific population is approximately 40 students per year. But the implications will affect all STEM programs and allow them to conduct a wider range of laboratory exercises with more students especially in the distance education space. The virtual laboratories Dr. Rockwell created at Eastern Kentucky University allowed their FSET degree to receive ABET accreditation without requiring a residency period or materials to be mailed to students. ABET is currently evaluating how they would like to handle virtual laboratories and this work could go a long way in convincing the review committee that video based laboratory exercises are a legitimate way to teach students the skills they need in STEM curriculum. As the number of online student around the country increases the importance of being able to meet the learning objectives in a distance education mode becomes more and more critical. Video based laboratory exercises also potentially allows people with disabilities to be more engages than with traditional experiments.

b. **Literature Review**

The use of virtual labs has been proven as an effective way to help students learn a variety of topics. It would be beneficial for science instructors to have access to a virtual lab so that their students can benefit from this mechanism as-well. The use of virtual laboratories in education has a long history in literature (Hill and Slator 1998; Mohler 2001; Alexiou, Bouras et al. 2005). Even teachers themselves have been educated using virtual laboratories (Blankenship and Kim 2012). Blended learning or combining virtual and online instruction

(Graham) is helpful for on campus students because they get the benefit of doing the virtual laboratories that would be too expensive or time consuming to set up and conduct during a single semester. The effectiveness of using virtual labs in many different subjects has been studied including: mathematics (Farmer 1998), chemistry (Tuysuz 2010), neuroscience (Bish and Schleidt 2008), chemistry (Tatli and Ayas 2010), physics (Yang and Heh 2007). Since fire science is a mixture of chemistry, physics, spatially dependent concepts, these studies should apply directly to the usefulness of virtual laboratories in fire behavior classes. Virtual labs also give access to experimental experiences to students with disabilities as studied by Bargerhuff et al. (Bargerhuff, Kirch et al. 2004) and does not expose students with limited motor control to combustion situations. Virtual labs have been shown as effective ways of helping people with different learning styles and cognitive needs grasp concepts (Sonnenwald and Li 2003; Klahr and Li 2005). Virtual labs have been shown to be effective in not only traditional science courses but also topics as varied as cybersecurity (Nance, Hay et al. 2009), economics (Greiner, Jacobsen et al.), and medicine (Grant and Davis 2007). The use of virtual labs in the medical field is of specific interest as a comparison with fire scientists because in both fields doing actual experiments are time consuming to set up, potentially risky, and expensive.

The benefits of the use of online virtual laboratories in education is described by Alexiou et al. (Alexiou, Bouras et al. 2005). There are four main benefits to using virtual labs as opposed to physical laboratory experiments in on campus classes. First the virtual lab avoids any physical hazard associated with a laboratory experiment. Second, many experiments cannot be done because of time and monetary constraints. The time associated with the setting up and the cleanup of laboratories can use up a large amount of available course time. Third, the cost

for many facilities to build and maintain a physical laboratory is prohibitive. Fourth, there are some experiments, such as those with very large or small scales, which cannot be accurately observed with the normal eye and are better perceived through computer simulation. With the increase in online education the benefit of the use of virtual laboratories is even more pronounced. Without virtual laboratories students are either forced to make site visits to the campus which can be cost prohibitive or miss out on the laboratory experience all together. The benefits of using virtual laboratories in online classes to increase the level of active learning potential is described by Hill and Slator (Hill and Slator 1998). These virtual laboratories and environments reduce the amount of passive learning required and can benefit students with a variety of different learning styles that may struggle in a lecture setting. Blended learning or combining virtual and online instruction (Graham) is also helpful for on campus students because they get the benefit of doing the virtual laboratories that would be too expensive or time consuming to set up and conduct during a single semester. Virtual labs have been shown to be effective in not only traditional science courses like chemistry (Tuysuz 2010), but also topics as varied as cybersecurity (Nance, Hay et al. 2009), economics (Greiner, Jacobsen et al.), and medicine (Grant and Davis 2007). The use of virtual labs in the medical field is of specific interest as a comparison with fire scientists because in both fields doing actual experiments are time consuming to set up, potentially risky, and expensive. Virtual labs also give access to experimental experiences to students with disabilities as studied by Bargerhuff et al. (Bargerhuff, Kirch et al. 2004) and does not expose students with limited motor control to hazardous situations.

The benefits and drawbacks of virtual laboratories were compared with authentic wet laboratory experiments by Olson (Olson 2006). This work found that virtual laboratories can be

considered equal in value to authentic laboratories because they can address different learning styles, offer more flexibility, and lead to an open ended environment for inquiry. For the benefit of virtual laboratories to be equal the purpose of the laboratory investigation needs to be the "what", "when", and "why" of a concept rather than a physical experimentation technique itself.

c. **Methods**

This project will involve survey students on their opinion of using virtual laboratories and the analysis of pre and post laboratory quizzes to assess the students' knowledge of the subject matter specified in the learning objectives in the course. Pre and Post assessment assignments will be part of the course and be conducted 4 times evenly distributed during the semester. Student opinion surveys will be conducted at the midpoint and end of the semester. Current student assessments using the video based laboratory exercises will also be compared with previous semester assessments which utilized hands on fire experiments as much as possible. Some part of the previous semester experiments will be recreated and recorded so there can be direct comparison. Average student scores on assessments will be compared and a t-test will be conducted to determine if the results are significant. There will be approximately 40 students in ETFS 2264L Fire Behavior and Combustion Lab in the spring semester of 2017, if the majority of students agree to complete the voluntary survey and allow their grades to be included in the study a more indepth statistical analysis of the results may be completed. Depending on the demographics of the student population an ANOVA analysis may be done to analyze if there is a variance in the learning of different groups. Due to the relatively small number of participants each semester there is a limited amount of statistical analysis that can be done with a single year worth of data. To attempt to

rectify this, data will continue to be collected in a second year so that more data can be collected and allow a more detailed analysis to be completed.

Grades from previous semester will be compared to the current course. If possible individual assignment grades from previous courses will be compared to current assignments using videos of the same type of experiment and/or recording from previous semesters. If possible videos and instrumentation data from previous semesters will be used so that individual assessment grades can be compared directly in a hands on vs video based format.

d. **Evaluation**

This project will be successful if the evaluation of student assessment data shows that video based experimental projects are as or more effective as hands on experimentation. The expectation is that students will be able to observe more from recordings of fire experiments than they would from in person experiments since the students will be able to watch the recording more than once, be able to have a viewpoint much closer than the student would likely be able to stand for large experiments such as room fires, potentially see multiple angles of the fire behavior, and be able to refer back to the recording when doing analysis and calculations about the experiment rather than relying on the memory of the activity.

Student opinion surveys will be collected along with pre laboratory exercise and post laboratory exercise test data based on the laboratory learning objectives. Student assessments from previous semesters of the live fire data will be collected and compared as available.

e. **Knowledge Dissemination**

The results of this study will be submitted to the Journal of Excellence in College teaching.

Dr. Rockwell has previously made a presentation at the 2016 Lilly Conference on College Teaching describing results from a student opinion survey on the use of virtual laboratories in a Fire Behavior and Combustion course. This project did not include evaluation of student assessment methods. The results of this previous study will be combined with this work for publication in the peer reviewed journal article and will be submitted for presentation at the 2018 Lilly Conference on College Teaching. The results will be presented during UNC Charlotte's Teaching Week and/or a proposal will also be presented to the UNCC Teaching and Learning Center to host a workshop on creating virtual laboratories and prerecorded video based learning activities.

f. **Human Subjects**

The researchers are currently working through the CITI refresher training in order to be able to submit the IRB application to allow students to be surveyed and grades to be analyzed for published research purposes.

g. **Extramural Funding**

This project will provide test data to justify a Federal Emergency Management Agency (FEMA) Fire Protection and Safety (FP&S) proposal to create virtual laboratories to teach assist with teaching fire dynamics to the fire service and create k-12 instructional materials utilizing virtual laboratories. The Society of Fire Protection Engineers was awarded a similar grant by the FEMA FP&S program in 2008 to create a Chemistry of Fire set of instructional materials for high school students.

h. **Timeline**

Spring semester 2018 – course assessment data and student surveys will be collected

Spring semester Week 1 – assign pretest module 1

Spring semester Week 4 – assign post-test module 1

Spring semester Week 5 – assign pretest module 2

Spring semester Week 8 – assign post-test module 2, administer student opinion survey 1

Spring semester Week 9 – assign pretest module 3

Spring semester Week 12 – assign post-test module 3

Spring semester Week 13 – assign pretest module 2

Spring semester Week 16 – assign post-test module 4, administer student opinion survey 2

Summer 2018 – Assessment and survey data will be analyzed

Fall 2019 – Results from initial data analysis will be presented at Lilly Conference

Spring 2019 – second round of course assessment data and student opinion surveys will be collected

Spring semester Week 1 – assign pretest module 1

Spring semester Week 4 – assign post-test module 1

Spring semester Week 5 – assign pretest module 2

Spring semester Week 8 – assign post-test module 2, administer student opinion survey 1

Spring semester Week 9 – assign pretest module 3

Spring semester Week 12 – assign post-test module 3

Spring semester Week 13 – assign pretest module 2

Spring semester Week 16 – assign post-test module 4, administer student opinion survey 2

Summer 2019 – assessment and survey data will be analyzed

Fall 2020 – Results of multiyear data analysis will be presented at the Lilly conference and a journal paper will be submitted to Journal of Excellence in College Teaching

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