

Sustainability Challenge Grant Final Report

Date Submitted: 01/22/17

Project Title: From SEE(E)D to (S)STEM: Scientists, Engineers, Entrepreneurs, Educators & Designers developing didactic tools to promote Sustainability, Science, Technology, Engineering & Mathematics

Report Submitted by: Eduardo Santillan-Jimenez

Reporting Period: 10/15/16-01/31/17

Progress made in Q4:

- The input of the students participating in the See Blue STEM Camp, the input of the Bioenergy 2016 attendants that were exposed to the game, along with the input of the faculty, staff and students participating in this project, has been used to develop a more advanced prototype of the videogame. In order to accomplish this, the graphic interface of the video game has continued to be developed with the assistance of Jessica Moore, a College of Design undergraduate student working full time for one month on this project. In turn, the graphics developed by Jessica Moore have been incorporated into a game engine with the assistance of Carter David Henning, a College of Engineering undergraduate student working full time for one month on this project.
- This more advanced prototype has been used by students participating the in STEMcats program (<https://stemcats.as.uky.edu/>) on 10/17/16 and 11/07/16 as one of the “Fun-Science” activities, which are activities that get students further interested in a particular area of science, or help them learn a little more about that area of science.
- The video game being developed was prominently featured in a presentation made at the 2016 Kentucky Science Teachers Association Conference program. The full bibliographic information for the aforementioned presentation is as follows: E. Santillan-Jimenez. *Energy is elementary: Supporting elementary science education by enhancing energy literacy*. Kentucky Science Teachers Association 44th Annual Conference, Lexington, KY, Nov. 10-12, 2016.
- Used the game as one of the hands-on activities of the STEAM night event at Dixie Magnet Elementary School on December 13th.
- The effectiveness of a) exposing K-12 students to the game; and b) involving college students in this project, was assessed by a CoEd undergraduate.
- This project was featured on the first issue of 38°84, a publication of the UK College of Design covering stories of design and place (see below).
- An application to the internal UK competition to submit a proposal to the American Honda Foundation was prepared, sent in and accepted. Therefore, a proposal is currently being finalized and will be submitted shortly to the

American Honda Foundation in order to request the funds necessary to continue work on this project.

- Presented an activity (the Fuel-ed videogame) to ca. 25 elementary school students at Cassidy Elementary (12/07/16). A number of UK students from groups traditionally underrepresented in STEM attended this event, thus fulfilling the commitment made in the original proposal to involve minority engineering students in taking the didactic tool to be developed to K-12 institutions.
- Presented an activity (the Fuel-ed videogame) at the STEAM night at Dixie Magnet Elementary School (12/13/16).
- Efforts are underway in order for UK College of Education students involved in the development of the game to utilize the video game in K-12 classrooms where they are working as student teachers.

Please attach representative photos or video of your progress to date to the email and submit this form and photo documentation to Shane Tedder (shane.tedder@uky.edu).

Please see photograph taken during the STEMCats event below.



Summary of the project

In this project, UK science, engineering, entrepreneurship, education & design – SEE(E)D – students, faculty and staff worked together to develop a system for the production of didactic tools to be used in outreach efforts designed to promote sustainability, science, technology, engineering, and mathematics – (S)STEM – to underserved K-12 students. This was done by utilizing as a case study a game that had been conceived and used to teach K-12 students about complex and often misunderstood energy and sustainability issues. We improved the game by having educators and designers strengthen the graphical and pedagogical aspects of the game to ultimately facilitate and deepen the understanding of K-12 students of the important sustainability issues presented.

Objectives

Our goal was to create awareness among UK students as to the potential of their disciplines to effect positive economic, environmental and social change and to teach sustainability concepts to K-12 students. Thus, this project had three main objectives: 1) to integrate sustainability into the curriculum of SEE(E)D students; 2) to help them strengthen UK's outreach efforts in (S)STEM education by developing a sustainable system for the production of didactic tools; and 3) to involve students in the use of these tools to promote sustainability to underserved K-12 students.

This was done by working with education and design students to improve the graphical and pedagogical aspects of a game devised and used to teach K-12 students about energy sustainability, and through a business plan created by entrepreneurship students around the development of this type of didactic tool to ensure that this effort is sustainable from an economic perspective. As the revised version of the game was used in (S)STEM education outreach events targeting underserved K-12 students, minority engineering students were involved to expose K-12 students to inspirational individuals, while education students were involved to assess the effectiveness of the game in improving sustainability and STEM learning outcomes. By focusing on underserved K-12 students, we – in a socially equitable way – increased their awareness of sustainability issues, as well as their interest in STEM fields and in protecting ecological integrity.

Methods

Our project employed as a starting point a game board and flashcard-based activity developed and used by the PI to teach K-12 students about the transformation of different starting materials to fuel and about the economic and environmental costs associated with this transformation. In this activity, students are exposed to important sustainability concepts as they are helped to understand the differences between fossil fuels and biofuels and come to realize that biofuels are not only renewable, but they close the carbon cycle and reduce the carbon emissions that cause global warming. This represents a fair amount of information of a considerable degree of complexity, which means that every effort should be made to help students understand the material fully and in an age appropriate manner.

To this end, UK SEE(E)D students were engaged in this effort through courses, studios and outreach activities taught or directed by the PIs. In this way, students acquired the science, design and pedagogy knowledge and applied it to the development of an improved version of the current game, one with enhanced graphical and pedagogical elements capable of increasing the effectiveness with which the material is taught to K-12 students. In this way, students at the college level were made aware and acquired a deeper understanding of sustainability issues, all while gaining a new appreciation of the importance of outreach efforts to the advancement of UK's sustainability mission and values.

This work was done by UK College of Design students under the direction of Prof. Rebekah Radtke in the spring semester of 2016 and was finalized during the summer of 2016 with the assistance of one undergraduate working full time for one month. In addition, the game was aligned with pedagogical best practices and its effectiveness, which will be done by UK College of Education students with the guidance of Profs. Margaret Schroeder and Brett Criswell in the spring semester of 2016 with pilot testing at outreach events led by CAER and the College of Education. This work was finalized during the summer 2016 with the assistance of one undergraduate working full time for one month in conjunction with the undergraduate design student. Moreover, a business plan around a system designed to produce this type of didactic tool – was developed by students participating in the UK Venture Studio of the Von Allmen Center for Entrepreneurship, along with the game engine, by an entrepreneurship student (who is also a videogame developer) working on this project for one month. Finally, minority engineering students participating in a mentoring program directed by the PI (<http://enr-mentoring.caer.uky.edu>) will be involved in taking this game to underserved K-12 schools, albeit students in the Sayre School were also exposed to the game to test the effectiveness of the latter with students of all backgrounds.

Outcomes

Student/community engagement and the use of campus as living laboratory

The video game developed through this project has already impacted over 250 K-12 students participating in different initiatives, including Scientists in the Classroom events, STEM/Energy nights, and the See Blue STEM Camp. Notably, most of these efforts targeted underserved K-12 institutions with high percentages of minority and/or free and reduced lunch students, which means that the game has engaged a considerable number of individuals from groups traditionally underrepresented in STEM. Along these lines, it should be noted that minority UK engineering students have been purposely involved in deploying the didactic tool to be developed at the events involving the aforementioned K-12 institutions, which has exposed K-12 students from groups traditionally underrepresented in STEM to inspirational individuals with whom they can identify. In addition, over 150 undergraduate students have been involved in the development of the video game's prototype, which has extended the impact of this work to include youth up to 21 years of age. Notably, the effectiveness of both the game and of involving UK students in its development was assessed using reliable instruments developed by experts in

education, results showing that the game is effective in increasing the concern and the knowledge of students (both at the K-12 and at the undergraduate level) on each of the issues tested.

Published or planned scholarly products

Conference Presentations:

- Bioenergy 2016 (Washington, D.C., July 12-14, 2016)
- Kentucky Science Teachers Association 44th Annual Conference (Lexington, KY, Nov. 10-12, 2016)

Featured Media Outlets + Next Steps:

- WRFL Green Talks radio program
- 38°84° Magazine publication of the UK College of Design

New collaborations

Successful internal UK submission to the American Honda Foundation for future funding in the next project phase.

Additional Funding

Summer Research and Creativity Fellowship 2016 from the Office of Undergraduate Research (UGR),

Recipient: Carter David Henning

Reflection

We found it was helpful to have students involved in the project as a part of their coursework and also to engage the students interested in the project to continue their involvement by having them work as undergraduate researchers. The students and faculty benefited from the multidisciplinary approach and the opportunity to work across campus and research centers. Because the collaboration was so fruitful, the team is continuing to pursue funding externally and to develop the project more.

Budget Analysis:

As we were targeting the development of effective, versatile and distributable didactic tools, we focused our development efforts on the production of a digital game. This allowed our team avoid incurring any expenses in terms of direct consumables and travel. Indeed, focusing on the development of a digital tool eliminated the need of money for travel, materials and supplies, allowing for most of the funds requested to be dedicated to personnel. Thus, as was originally budgeted, of the \$25,184 requested all funds spent were used to support the PIs and 3 undergraduate students from different majors for the time they dedicated to this project. Due to rate at which the funds were disbursed, the PIs took a conservative stance regarding the rate at which the funds were spent, which is why residual funds are still being used to compensate the video game developer, who will finish work on the project by 01/25/17. Any residual amount will be invested in the type

of materials needed so the game can continue to be taken to K-12 classrooms and used to support experiential sustainability education.

Visuals

The two images below are excerpted from the CoD publication feature on the project:

Game On

"Who would've thought interior design students would be designing video games?" said Rebekah Radtke, assistant professor in the School of Interiors.

Soon enough, both she and several of her students would realize this when her spring 2016 studio worked on a video game project with Dr. Eduardo Santillan-Jimenez of the Center for Applied Energy Research.

Dr. Santillan-Jimenez started a program called Scientists in the Classroom, where scientists and engineers would visit grades K-12 to conduct hands-on STEM activities. Dr. Santillan-Jimenez specializes in biofuels, and since they aren't necessarily classroom compatible, he came up with a type of board game to explain their ecological impact.

This led to Dr. Santillan-Jimenez earning a sustainability challenge grant to turn the analog version into a video game. This is where Radtke and her students came in to help strengthen the graphic component of the game.

Radtke's studio, along with student Jessica Moore who worked on the game over the summer, helped with the "game play" component (how people interact with the game).

Using the video game as a teaching tool has provided Dr. Santillan-Jimenez with a whole new educational model. "We keep hearing from teachers that science is not very popular as a teaching topic, even for teachers because they feel insecure in the material," he said. "They appreciate having us scientists come out to engage students and teach content; they're appreciative of us trying to develop tools that they can use."

Radtke agreed, and is grateful to have been given the opportunity to take part in a project that hits close to home. "[With this video game] we are increasing energy literacy in a state with preconceived ideas so it's harder to have conversations about these things," she said. "If everyone has this knowledge from this game, it makes it more accessible." ○



Right: Dr. Eduardo Santillan-Jimenez of the Center for Applied Energy Research shows a prototype of the new science video game to a group of students. Assistant Professor Rebekah Radtke's studio helped with the graphic components of the game (above).



The image below is the poster presented at the Sustainability Forum:

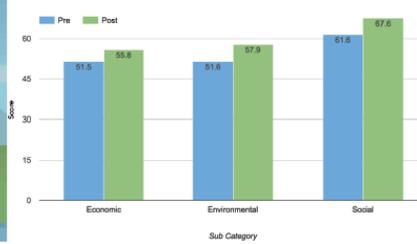
FROM SEE(E)D TO (S)STEM Scientists, Engineers, Entrepreneurs, Educators & Designers developing didactic tools to promote Sustainability, Science, Technology, Engineering & Mathematics

FUEL-ED: Educational Video Game

As part of the "From SEE(E)D to (S)STEM" project, a recipient of a UK Sustainability Challenge Grant, Fuel-Ed was created as a graphics-based interactive video game. The game is targeted at elementary school students and allows them to follow the processes of transforming different materials into fuels and associated economic and environmental costs. Fuel-Ed is the product of a collaborative project between scientists at the UK Center for Applied Energy Research and faculty and students in science, education, engineering, entrepreneurship and design, aimed at promoting sustainability and science in the next generation.



PRE-SURVEY + POST-SURVEY: STEM SEI Results (n=47)



COMMUNITY ENGAGEMENT: See Blue STEM Camp



INFORMATION ON BIOFUELS: Gives players general background information needed for gameplay

all about BIOFUELS

WHAT ARE BIOFUELS?
Fuels made from biomass. All material that comes from living things: the plants and animals.

WHY ARE BIOFUELS BETTER THAN FOSSIL FUELS?
Biodiesel are renewable! They can be made from crops that can be regrown every year. Biodiesel emit smaller pollutants than fossil fuels. They are made from crops that can be regrown every year.

GENERAL GAMEPLAY GOALS

Gain money by selling your products.

Use money to buy more equipment.

Use money to buy more land.

THE GREENHOUSE EFFECT

WHY IS CARBON POLLUTION BAD?
Carbon dioxide (CO₂) is a greenhouse gas. It traps heat in the atmosphere. This causes the Earth to warm up. This causes global warming. Global warming causes sea levels to rise. This causes flooding. This causes drought. This causes heat waves. This causes more extreme weather.

ASSESSMENT:

Our goal is to create awareness among UK students as to the potential of their disciplines to effect positive economic, environmental and social change as students learn and apply sustainability principles in all the aforementioned disciplines and are involved in teaching sustainability concepts to K-12 students.

The STEM Sustainability Engagement Instrument (STEM-SEI) was used to evaluate the effectiveness of the integration of the game as a means to increase their concern and knowledge regarding a number of sustainability issues.

While the data analysis was limited to the number of pre/post test paired tests available (n = 47), the results show the game does increase the concern and the knowledge of students on sustainability issues as tested using the STEM-SEI.

There was a statistically significant pre to post gain in the environmental subcategory on the STEM-SEI. While results should be interpreted cautiously due to the low n, these results do match prior research results (Little, 2014).

PRE-SURVEY + POST-SURVEY: Overall STEM SEI Results (n=47)



DISSEMINATION: Highlights + Acknowledgments

Additional Funding:
Summer Research and Creativity Fellowship 2016 from the Office of Undergraduate Research (OUR), Resident Center David Henning

Conference Presentations:
Bioscience 2016 (Washington, D.C., July 13-14, 2016)
Kentucky Science Teachers Association 44th Annual Conference (Lexington, KY, Nov. 10-12, 2016)

Featured Media Outlets + Next Steps:
WFLX Green Talks radio program
3576R Magazine publication of the UK College of Design
Successful Internal UK submission to the American Honda Foundation for future funding in the next project phase

COMMUNITY ENGAGEMENT: Testing of Analog Game



SCREENS FROM GAMEPLAY: Choices and information from the fuel process

CHOOSE BETWEEN THESE BIOMASS MATERIALS:

ALGAE SOYBEANS CORN

BIO DIESEL

Biodiesel cannot be used pure in trucks so you lose 1 point. Moreover distributing biodiesel costs money and emits carbon dioxide, so you lose 2 points. However, biodiesel is a valuable fuel so you gain 2 points.

DECIDE HOW TO TRANSPORT THE CRUDE OIL TO A PETROLEUM REFINERY WHERE IT WILL BE CONVERTED TO FUELS:

PIPELINE RAIL BOAT TRUCK

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PIPELINE RAIL TRUCK

COMMUNITY ENGAGEMENT: STEM Math Prototype Testing



PROJECT TEAM:

Eduardo Santillan-Jimenez
Rebekah Radtke
Margaret Mohr-Schroeder

Undergraduate Researchers:
Cater David Henning
Jessica Moore
Mollie Williams

FLASHCARDS: Students can use these during gameplay to help them make choices

TRUCK

Fastest mode of transport. Emits the most CO₂. Costs the most money.

AFRICA + THE MIDDLE EAST

Major oil producing regions. High oil prices.

RAILROAD

Second fastest mode of transport. Emits less CO₂ than trucks. Costs less money.

PIPELINE

Fastest mode of transport. Emits the least CO₂. Costs the least money.

MEXICO + SOUTH AMERICA

Major oil producing regions. High oil prices.

REFINERY

Converts crude oil into fuels. Emits CO₂. Costs money.