Developing Interactive Simulation Models to Focus Faculty-Student Interactions on Learning Outcomes in an Online Non-Major Science Class

1. Abstract

Maintaining an atmosphere of active and engaged learning in one of the most difficult challenges in adapting courses to the online environment. The DECSYS courses have benefited by relying on Vensim for modeling systems thinking dynamics and ecological processes. While Vensim is a strong modeling tool, the installation and user interface presents a hurdle to students that is usually mitigated through instructor interaction in an active learning environment: a solution that has proved untenable in the online format. This grant will firstly fund the repurposing of systems models that have already been developed in Vensim into a Forio simulation that explores systems behavior without student model development - precedent for this has been successfully achieved at MIT Sloan School. Secondly, we intend to test the effectiveness this implementation across thirty DECSYS classes from online and classroom settings. The resulting data will be presented at conferences and submitted for publication to improve online development of non-majors science courses and to help export our pedagogy among a broader audience.

2. How the Project Advances Online Learning

Support for the pedagogical value of the Nexus principle of active learning continues to grow. Recent analyses have found that active learning approaches improve students outcomes, particularly for students at the bottom of the proficiency distribution (Freeman et al., 2014). Many of the benefits of flipped classrooms may in fact be attributable to the active learning that is central to those approaches (Jensen, Kummer and Godoy, 2015). Here at PhilaU, we have successfully deployed the DECSYS 208 course in a fully flipped classroom model in order to maximize opportunities for active learning, to generally positive feedback from both students and instructors.

One of the reasons that we chose to flip the DECSYS classroom was our perception that at some point this class would need to be taken online. In terms of the “content” of a course - which for lack of a better word we will use to describe all lectures or lecture-like objects delivered remotely in the flipped classroom experience - flipped and online courses are identical. The class was in fact offered in an online format in Spring 2015, and the course content was successfully deployed in the new format.

The major challenge that we experienced in the transition to the online version of the course is in creating meaningful opportunities for active learning to take place. In a flipped classroom the instructor interacts intensely with students during class time. It is obvious that this creates **many opportunities for feedback**, and that **feedback is immediate**. Less appreciated is the fact that the most **difficult or frustrating activities are conducted in the presence of the teacher**, where students can be quickly set back on track or simply encouraged to keep trying. In the online environment, by contrast, there is *necessarily some delay between a student query and an instructor response*, which ultimately results in *fewer opportunities for feedback*. The result is that *the potential for frustration and giving up on an activity increases*.

One way that we have addressed the feedback question is through the use of pre-built simulation models, sometimes known as “flight simulators.” Within the context of a simulation, students can manipulate some aspect of a system, and view the results of that manipulation in real time. For example, in the example shown at left (**Figure 1**), students use a simulator called [C-Learn](), a simulation developed at MIT that models aspects of global climate change in the context of international climate agreements. Students input different policy decisions for groups of countries, and the results of those decisions are immediately shown as in the graphs below.

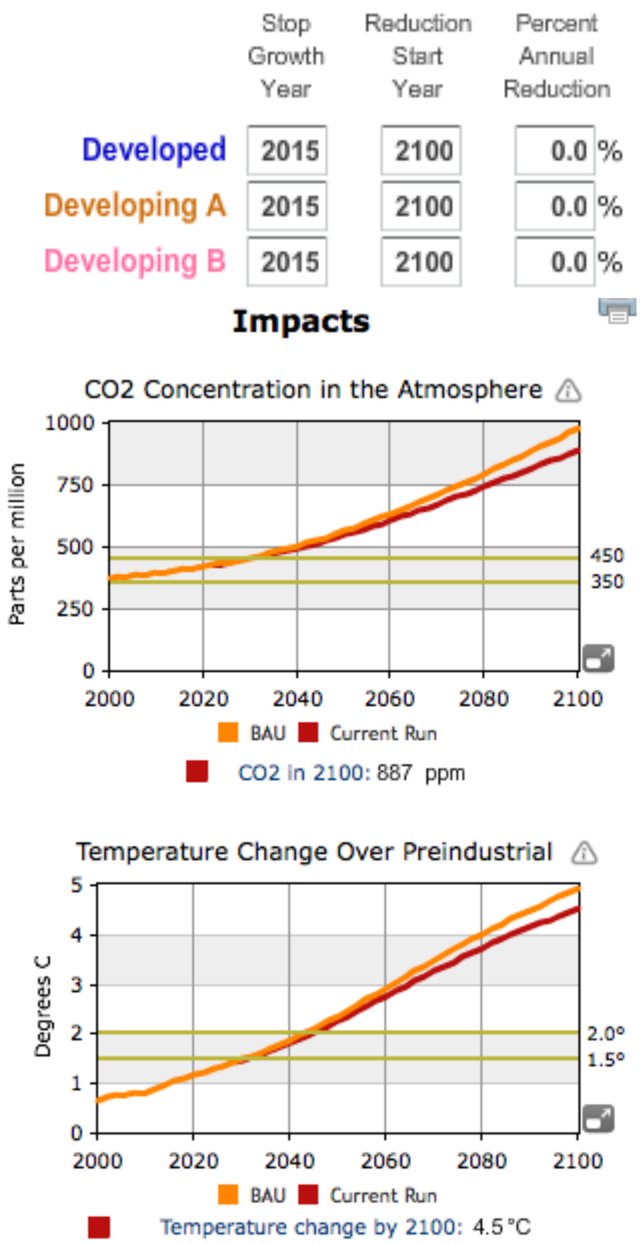

Figure 1 Inputs and outputs of a “flight simulator” teaching model

Because the simulation is responsive to student input, feedback occurs. A well-designed simulation of this sort can lead students to discover information for themselves rather than being presented with information from the instructor. For example, in the climate simulation we ask students to attempt to address climate change under a variety of scenarios. Many interventions that seem substantial actually result in minimal effects on climate (**Figure 1**). Students coming to this realization on their own is more valuable than the same information as a bullet point in a lecture.

The use of this technology is not without a downside, however. In particular, it creates a new source of frustration - the technology itself. Student technical and computer proficiency presents a major hurdle when using technology to advance learning outcomes. In a classroom setting, instructor oversight and input helps students pass these hurdles together; however, **as the remote platform of online courses do not allow for as many immediate interactions, technical problems can linger and direct student and instructor energy away from course learning outcomes.**

In our particular case, the DECSYS 206 and 208 courses rely heavily on a piece of software called [Vensim](), a free systems dynamic modeling software. We have developed a library of teaching simulations that run in this software. One of the issues that we face when modeling in Vensim is that as a full-featured dynamic modeling software it has a user-interface environment that exceeds our students' learning needs (**Figure 2**). The interface is designed for researchers, and lacks transparency and user-friendliness present in consumer software. It is also stand-alone program that must be downloaded and installed on student computers - a surprisingly difficult task for a substantial minority of students. **These difficulties are greatly amplified in the online course.**

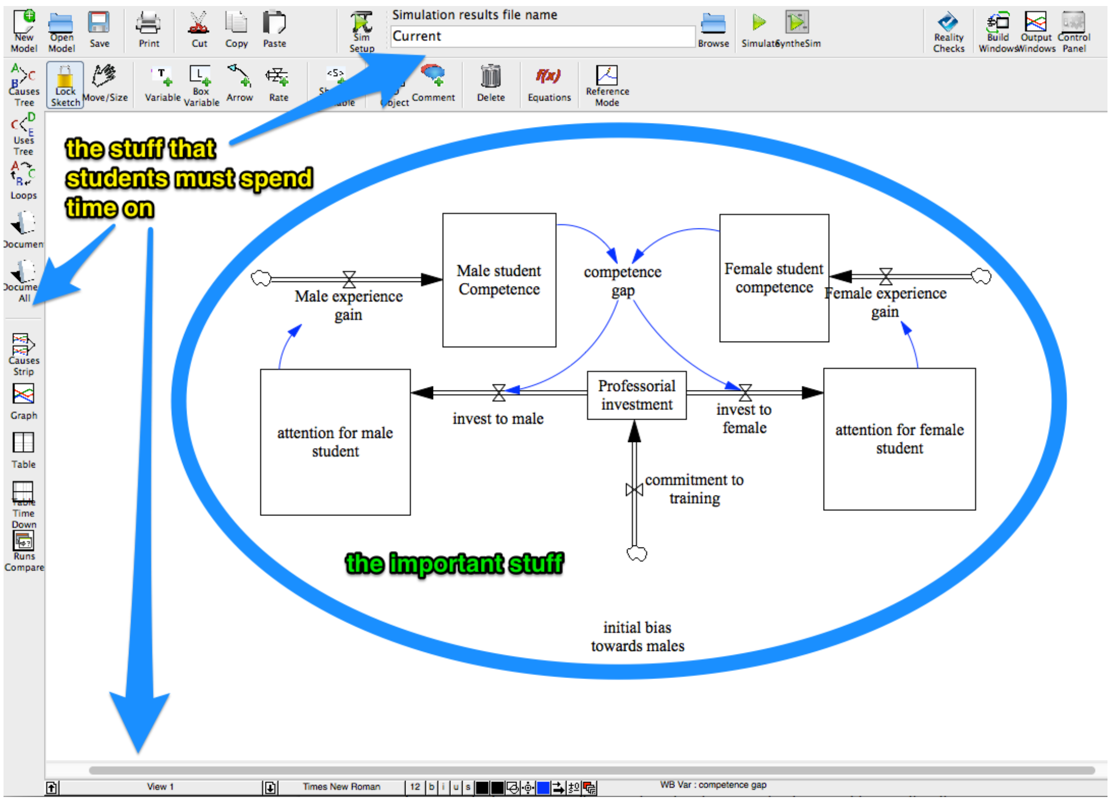

Figure 2 The Vensim user-interface.

Why does this matter? Instructors must be familiar enough with the software to not only deploy it correctly but to trouble shoot it across diverse computer systems, and it is known that faculty frequently identify lack of technical proficiency as a reason to not teach modeling techniques (Skaza 2013). **This requires a substantial input of instructor energy that would otherwise be focused on the course learning outcomes**. Secondly, when technological hurdles are in place, **the assessment of course learning outcomes becomes confounded with student technical proficiency**. Were high performing students those who best understood the underlying concepts, or did the software filter out some students who would otherwise have demonstrated competency?

The solution as we see it is to maintain the sophistication of our teaching models while reducing the technical sophistication needed to engage with them. We will use the online simulation software Forio to create user-friendly, learning outcome focused simulation models that will run within a student's browser. Instructor-developed Forio simulations allow instructors to create flight simulators for complex systems. The climate change models shown above are in fact examples of Forio implementations created at the Sloan School of Management at MIT . These simulations allow students to explore complex systems behavior within pre-determined constraints.

Along with reducing the technical expertise necessary to interact with the model, thoughtful development of the user interface can encourage students down pathways of exploration that are likely to provide meaningful results, rather than overwhelming students with the near-infinite options embedded in a complex system. In other words, **simulations can be tightly tailored to the course learning outcomes**, a strategy that has been shown to be successful with sustainability students (Sterman, n.d.) . Additionally, by providing online students with a gaming scenario, they can learn from their mistakes without affecting their self-esteem (Orlando, 2011).

We have established that Forio models can be productively developed from our existing systems models. Two examples in which the online simulation is functional, but still lack sophisticated user interfaces, can be viewed at: http://forio.com/simulate/jklemens/

Finally, the teaching models developed in DECSYS are likely interesting to other users. As currently formulated, however, their usefulness is restricted to educators or other users who are currently familiar with the Vensim software. As the reach of the DECSYS class expands beyond PhilaU, and as we ramp up online offerings at PhilaU expand to include new Masters Programs and executive-ed offerings we find that **many of the tools that we use in the classroom are unavailable in these new settings because of their reliance on the Vensim software. Converting our teaching models to an online, interactive, experience will allow us to export our existing pedagogy to these new settings.**

3. Specific Project Goals and Learning Outcomes

Goal 1

For the past two years, a group of instructors have been building a library of Vensim models that illustrate principles of biology, environmental science, and systems thinking as taught in the DECSYS courses. We intend to **convert that set of existing teaching models into interactive simulations** in Forio for use in DECSYS online classes, and to explore their use in the on-campus version of the course as well. Particular attention will be paid to creating a clear consistent user interface that emphasizes ease of use, interaction, and interpretation of these models. These simulations collectively account for a substantial proportion of the material covered in the DECSYS courses.

The exercise of generating these models will also serve to **generate in-house expertise on developing online simulation exercises**. This expertise will enable us to more functionally export our NEXUS pedagogy and is potentially relevant to many courses across campus.

Goal 2

To determine the efficacy of this approach we will implement the Forio gaming modules (experimental) in online sessions (N=2) and half of the classroom sessions while maintaining the Vensim models (control) in the other classroom sessions (N=8 each). **We hypothesize that on-campus students presented with the Forio simulations will outperform students presented with our Vensim models, and**

that use of Forio models online will close some the gap in skill acquisition that we have observed between the online and on-campus courses (Figure 3). We will compare treatments through common assignments stressing the learning outcomes from each model using the existing evaluations and assessment structures (represented by rubrics) for the class. The population will consist of DECSYS 206 and 208 students in Fall 2015 and Spring 2016. In addition to measuring learning outcomes, students and instructors will be surveyed about their experiences with the Forio simulations and Vensim systems models.

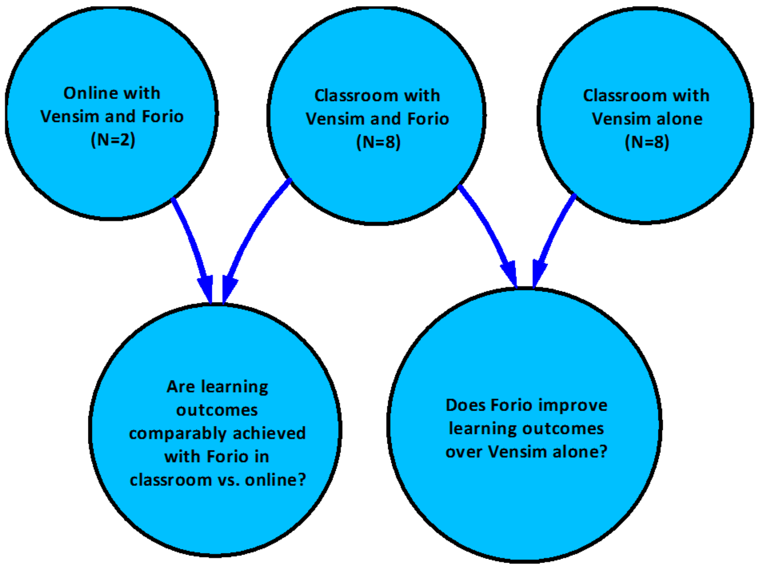

Figure 3 Experimental design. Lower left: we compare online (upper left) and classroom (upper center) classes using the Forio model. Lower right: we compare classrooms with instructor-developed Forio simulations (center) and classrooms with student-developed Vensim simulations.

Project Learning Outcome:

We will learn about how differences in the presentation of simulation models to students affects their achievement in both the online and classroom environment. We hope to apply this knowledge to support the development of course materials at PhilaU that go beyond the standard recipe of online lectures and interactive discussion boards.

4. Description of Activities and Timeframe

Late Summer 2015 - Develop Forio gaming modules from pre-existing Vensim models. These gaming modules will be made publicly available through Forio, obtain IRB approval for research based on these modules.
Fall 2015 - Deploy models in online and half of on-campus courses as described above, deploy survey instrument.
Spring 2016 - Replicate study from Fall, data management and analysis, publication preparation.
Early Summer 2016 - Project write-up, dissemination of results.

5. Project Assessment

For Goal 1, success will be measured by whether or not we have developed a set of publically available teaching simulations that will be published on the Forio Simulate site. Student course surveys will be amended to include specific questions about student interactions with the modules, much as we adjusted our internal assessments to seek student opinions on the lecture videos that were introduced in 2014-15. Further metrics of success would be the uptake and use of the models by other educators beyond PhilaU.

For Goal 2, the primary assessment of effectiveness of the gaming modules will be assessed for learning outcome achievement through the experimental design described above which will leverage our existing rubrics as metrics of success.

We will present this strategy and its results during the 2016 Nexus Teaching Week for evaluation by our peers, and, should the results of the study be robust, will target conferences (Target: Lilly Conference, National Science Teachers Association) and journals (Targets: *Frontiers in Ecology and Evolution* and *The Journal of College Science Teaching*, see below) in order to disseminate the results more widely.

6. Documentation and Dissemination

Simulation activities and instructions for their use will be distributed to DECSYS instructors and used in the approximately 30 section of DECSYS, including two online sections, that are taught each year. The simulations and instructions will also be made publically available through the existing Forio Simulate that is currently branded as a PhilaU project.

The results of this work will be presented at during Nexus Learning Week, at conferences, and in published format. We have identified *Frontiers in Ecology and Evolution* a publication of the ecological society of america that often focuses on educational issues and *The Journal of College Science Teaching*, a science pedagogy journal with a particular focus on non-majors science education as likely destinations for this work.

7. Project Personnel

Jack Suss has taught both versions of the DECSYS class at PhilaU since 2013 and has developed several of the teaching models currently used in the DECSYS classes. He will be the instructor for the online version of the class that will run in Fall 2015. He will design and code the interactive simulation models that are the product of Goal 1 of this proposal.

Jeff Klemens is coordinator of the DECSYS courses. His role will be to ensure that the learning tools created by Suss are fully integrated into the course curriculum and that the models fully support the existing learning outcomes and that they can be integrated into the existing assessment and evaluation structure for the course.

The personnel will collaborate on the project assessment, implementing the experiment at the core of the project and analyzing and presenting the resulting data together.

8. Budget Narrative

The budget is meant to support the adjunct professor PI for summer work on the project. We anticipate that this will require several weeks of intensive work, as the PI learns the differences between model development and presentation in Forio and Vensim, develops standards for the user interface to use in our classes, and then creates the online version of each existing teaching model. We are thus requesting $2,000 as a summer stipend for Suss to perform this work.

Because the work described will directly support the DECSYS courses Klemens is not requesting any faculty stipends or course releases for this project.

We have in included an additional $800 for conference travel. We anticipate that the results of this work, as functioning teaching instruments associated with lecture material that has already been made available online, will be of interest to science teachers beyond Philadelphia University. We plan to submit the work to the conference of the National Science Teachers Association or a similar conference and have assumed that both PIs would travel to the conference, ideally presenting complementary papers on this work.

I. Personnel	Comp.	# of Personnel	# of Hours	Totals	Notes1	Notes 2
Faculty Wages						
Principle Investigator (PI) Stipend:	$2,000	0		$0	Subject to FICA	Total PI stipends not to exceed $2,000.
Co-PI stipend:	$2,000	1		$2,000	Subject to FICA	
Secondary Investigator	$0			$0.00	Subject to FICA	
Other Faculty Participants	$0			$0.00	Subject to FICA	
Student Wages						
Undergraduate student workers (summer)	$7.25		0	$0.00	Subject to FICA	
Undergraduate student workers (academic year)	$7.25		0	$0.00		
Graduate student workers (summer)	$9.25		0	$0.00	Subject to FICA	
Graduate student workers (academic year)	$9.25		0	$0.00		
			Subtotal:	$2,000.00		
Employer-Provided FICA on Wages	7.65%			$153.00		
			Subtotal:	$2,153.00		
II. Non-Personnel Expenditures	Total Budget					
Equipment:				$ -		
Entertainment:				$ -		
Supplies, software, other:				$ -		
Travel (Transportation, Lodging, and Meals):	$ 800.00			$ 800.00		
			Subtotal:	$ 800.00		
			Grand Total:	$ 2,953.00	Grant Budget not to exceed $3,000	

9. Attachments

Mid-cycle report on ”Contrasting Faculty and Student Expectations in Online Learning and Applying Student Expertise to Bridge the Gap” A Nexus Learning Online grant awarded to J.A. Klemens. 1 April 2015.

The Nexus Learning Grant named above had three main project goals. These goals are addressed individually below, followed by a section describing some substantial secondary products that have been enabled by this grant.

Goal 1 - “to create a gallery of different approaches to generating online teaching materials“

This goal was met and exceeded. We developed a gallery of lecture videos (available at this link) that was sufficient to enable a full classroom flip of the DECSYS 208 course in Fall of 2014. These lectures also served as the key content delivery mechanism for the online version of the course (DECSYS 208x) that was piloted in Spring of 2015.

Goal 2 - “to develop a survey to help understand student and faculty expectations for online content“

A survey was developed in and delivered to faculty and students. The surveys used the developed video lectures, as planned, and was designed to compare and contrast student and faculty responses to brief samples of contrasting video lecture formats, as well as to collect general opinions from both groups about methods of online content delivery. Participants rated the same material, presented in five different lecture formats, for characteristics related to student learning. We received over 300 student and over 100 faculty responses to the survey. Klemens has submitted a conference paper to the Conference of the Ecological Society of America, to be held August 2015, that will include results from this survey.

The results of the survey are still undergoing analysis, however, one very general conclusion is that students and faculty were much less sensitive to the mode of visual presentation than anticipated. A follow-up study is ongoing in which students are presented with with both the lowest and highest rated presentation modalities from the initial survey, but in segments of much longer length. This study will also incorporate student performance as well as preference.

Based on the sample sizes achieved and a literature review that has not managed to turn up similar studies, I will submit a paper that combines both sets of results to CBE life sciences education, a higher impact factor science ed journal.

Goal 3 - “to refine the spreadsheet that we are currently using for our own module development and make it generally available for online lesson planning“

We quickly realized that our tool for module development was much better at describing existing material than serving as a blueprint for content creation. We discarded our template after the development of the first modules, and instead developed a work-flow based on the one that the animation students learn as part of their preparation for practice, as it was clearly superior to the one we had created. This workflow was formalized by a student team working as part of the DECGEN course in Fall 2014. They created a series of intake documents, timelines, procedures, to support faculty development of video content in partnership with students. We plan to begin slowly scaling up this resource, including making these forms available to faculty, starting in Fall 2015.

Secondary Products

Because this grant was used to develop both technological infrastructure and in-house expertise in the creation of online content, there have been a number of tangible but unanticipated secondary benefits which have had broad impact across the university.

Several students have used the lights and camera equipment purchased with this grant to record material for other classes and programs, including textile design students creating portfolios and geodesign students creating project presentations.

Along with Jack Suss and Robert Fryer, Klemens presented the lessons learned from the flipped classroom experience in a workshop as part of Nexus Teaching Week titled “But how do I flip *my* classroom?”

The framework of students creating course content was imported as a “client” for the inaugural DECGEN course led by Neal Harner, Mark Sunderland, and Les Sztandera in Fall 2014. The theme of the client project was to create the institutional and intellectual infrastructure for creating a content-development studio on campus. Business and animation students participated in the class.

We have collaborated closely with the creators of the PhilaU Sustainable Design MOOC, who have taken advantage of the lighting and green screen setup, as well as sharing techniques back and forth between the courses.

The video room has been used for other purposes, including the creation of a welcome video to PhilaU’s online courses filmed by president Spinelli, and there are tentative plans to film a video introduction for students regarding the Hallmarks Curriculum in summer 2015.

Klemens, along with collaborators Chris Pastore and undergraduate Michael Hudson submitted a contribution that was accepted for publication in a forthcoming book about flipped classrooms (Klemens, Pastore & Hudson, *in press*). This contribution was based entirely on the experience funded by this grant.

Frank Wilkinson used the video gallery created by this grant as example material for upper-level students who were tasked with creating a unit of course content as the culminating experience for their class.

References:

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