The Defining Challenge of Our Age – Climate Science across the Liberal Arts Curriculum

More than half a decade ago, UN Secretary General Ban Ki Moon called climate change "the defining challenge of our age" and challenged the world's nations to address this issue. The 2007 report by the Intergovernmental Panel on Climate Change (IPCC) painted a picture of growing scientific consensus about the causes and consequences of 20th Century climate change. Climate change and its causes are important topics throughout the geology, geography and environmental studies curricula at Gustavus, and climate change is increasingly taught within a societal framework in these fields (Bralower et al., 2009). That the Nobel Peace Prize was awarded to the IPCC suggests that climate science touches every corner of human endeavor and, thus, has an important role to play across a liberal arts curriculum. Closer to home, the Gustavus faculty in 2012 adopted a resolution on anthropogenic climate change that charged the College to take action to reduce its greenhouse gas emissions and recognized climate change as an issue that is broadly relevant to nearly every discipline on our campus.

The project described in this narrative was born out of an informal discussion when a Religion Department faculty member inquired whether the geoscientists on campus had climate science resources to share. This conversation and subsequent ones led to members of the geology department hosting a faculty development workshop to share resources on climate science and evaluate interest in an interdisciplinary climate teaching initiative. This workshop was very well attended (approximately 15% of Gustavus faculty were present, representing 17 departments and programs from all divisions of the College). Feedback from this workshop suggests that our faculty see climate change as a topic that emerges in many disciplines and that deserves increased attention in many courses. For example, Economics courses might address economic threats related to changes in agricultural productivity; Communications Studies courses might use climate science to catalyze discussions about pseudoscientific arguments; Chemistry courses might address changes in ocean chemistry. Both the science and the human implications of climate change cut across disciplines and are relevant to the liberal arts curriculum. Although little scholarly literature exists regarding this kind of interdisciplinary teaching, the prominence of "climate change debate" in the popular media suggests that all college-educated students need a basic understanding of climate change and must understand the scientific basis for conclusions about climate change. This project seeks to develop a set of climate science modules, developed by faculty with climate science expertise, that will allow non-specialist faculty (in science and non-science fields) to introduce climate science in their courses, increasing the level of climate science literacy and setting the stage for meaningful interdisciplinary discussions of the role of climate change across the liberal arts curriculum.

GOALS OF THIS PROJECT

We seek to increase climate science literacy among Gustavus students and improve student understanding of the implications of climate change in disciplines across the liberal arts curriculum at Gustavus Adolphus College by

(1) Identifying and removing barriers for faculty incorporation of climate-related content in courses outside the geosciences.
(2) Developing climate science primers and modules for use by non-specialist faculty in existing non-geoscience courses in the humanities, social sciences, arts, and natural sciences.
(3) Implementing modules in existing Gustavus courses and assessing the impact on student climate literacy.

Major Project Elements

Each of the project goals above will be addressed as an element of a curriculum development loop – a series of stages that begins with a teaching circle, proceeds through instructional resource development, and finishes with implementation of instructional resources in the classroom. During each loop, 2-3 climate science modules will be developed, implemented, and assessed. Whenever possible, we will adapt or build upon existing InTeGrate resources and activities available on the SERC website, particularly when Gustavus faculty needs overlap with existing resources (e.g., elements of the *Climate of Change* and *Carbon, Climate, and Energy Resources* modules might be well-suited to our project, as well as the forthcoming *Climate Facts vs. Climate Fiction* modules for humanities courses). We expect, though, that a substantial portion of the activities will be original. Below, we describe the three stages of a curriculum development loop.

Stage 1, Teaching Circle – Identifying and removing barriers to climate teaching.

To initiate each curriculum development loop, we will host a *teaching circle* – a collaborative faculty development workshop – about teaching climate change in disparate disciplines. In these workshops, faculty from non-geoscience disciplines will identify barriers, brainstorm ideas for incorporating climate change into their courses, and articulate needs for climate science content in their courses. Over the course of the three-year project, we will hold 4 teaching circles to initiate each development phase. We expect that each teaching circle will begin with a climate science primer, emphasizing how climate science literacy might be relevant to a broad cross-section of disciplines. We will capture climate primers as podcasts in order to build a resource base and to involve interested faculty who did not attend teaching circles.

Each teaching circle will identify a focus area for connecting climate science with liberal arts education. This identification process is itself a crucial part of this project. When interested faculty work to identify places where climate change is relevant for their courses, it increases the likelihood of long-term adoption of these resources and improves their usefulness Thus, each focus area will emerge from the shared interests of the participating faculty, but we expect that each will be broadly interdisciplinary and will make use of one or more dimensions of climate science in several existing courses in multiple disciplines. For example, participants might identify sea level rise as an issue relevant for courses in economics, political science, art, physics, and public discourse. In each case, the teaching circles will seek to discover faculty needs; what students must know in order to discuss climate change; and what classroom activities and resources are required. At the end of each teaching circle, the participants will have identified 2-3 climate science modules and/or primers that address these needs.

Assessment of brainstorming & development. We will ask faculty attending teaching circles to assess their knowledge and comfort level regarding climate science, both before and after climate primers and query the usefulness of primer material for grounding discussions of climate change. Faculty participating in teaching circles will articulate specific areas of intersection between climate and their course content and will provide feedback about potentially useful dimensions of climate science. This information might come from personal experience or from discipline-specific literature. The project steering team will compile responses and create an online resource of discipline-specific questions, outcomes and activities. The Gustavus Library has offered to host such resources on their public resource webpage, making them readily accessible to the campus, K-12 students and teachers, the nearby community, and other colleges and universities.

STAGE 2, DEVELOPMENT – CREATING MODULES THAT WORK

Faculty with climate science expertise (see list of key personnel) will use the output from teaching circles to develop short modules that introduce novice, non-geoscience students to climate science. We expect that these modules will be relatively short (15 minutes to 1 hour), as they are intended to be embedded within a humanities, social science, art, or natural science unit whose main objective lies beyond the climate science itself. In addition, the development team will enlist the aid of geoscience students in building the modules. The Geology Department has experienced significant success with using students to assist with development of inquiry-oriented teaching and outreach materials, and these students can be hired via the campus work-study program, at no cost to the project.

Modules will be tested and refined by participating liberal arts faculty members outside the geosciences, drawn from our list of participating faculty (see list of key personnel). Gustavus has successfully used this module development paradigm for a program in which master teachers developed, and a larger set of teachers tested, activities for high school students related to the science themes of our Nobel Conference. During climate science module refinement, non-specialist professionals play the role of novice students and test the timing, pedagogy, and logistics of each module, providing feedback that proves invaluable in creating teaching materials that are useful, engaging, and practical to implement.

Assessment of module development. We will seek feedback at each stage of module development to ensure that modules are appropriate for the student audience, easy to implement by non-specialists in a variety of classroom types, error-free, and engaging. The module testers will use the InTeGrate Curriculum Development and Refinement Rubric to evaluate the content and pedagogy of each module. Assessment will also evaluate the degree to which each module supports the particular non-geoscience content for the courses in which it will be used. For example, the connection between sea level rise and human habitation on coastlines should be obvious for a module that seeks to introduce sea level rise as a prelude to discussions of the economic and social consequences of growth near the sea.

STAGE 3, IMPLEMENTATION – INTO THE CLASSROOM

For initial classroom implementation, modules will be delivered by the development team, thereby ensuring that the module developers see the strengths and weaknesses of the modules in real classroom settings, allowing a final phase of refinement. After initial implementation, the adopting faculty member will deliver the module during the next offering of that course (typically the following semester or one year later). This ensures sustainability of the implementation, as the adopting faculty member takes ownership of the module and becomes increasingly comfortable with climate science content. Module developers will offer additional training for other faculty members interested in adopting modules.

Assessment of implementation. We will use a variety of tools, including the components of the Geoscience Literacy Exam (Steer et al., 2012), open-ended feedback forms, and direct observation of engagement with the modules. Both the initial implementation and ongoing use of climate modules will be assessed, and students in target courses will be surveyed prior to module implementation, to obtain a pre-intervention baseline. Instruments will be developed that query students about (1) the effectiveness of the module itself; (2) their self-reported understanding of climate science fundamentals; and (3) the key learning objectives of the module, including the non-geoscience objectives. Thus, we will gather learning gain data (students' understanding of an aspect of climate science) and student perceptions (students' beliefs about their learning), as

well as a student-level evaluation of the activity itself (engaging, clear). Participating faculty will be asked to include exam questions, essay responses, or other course-embedded assessments that allow evaluation of students' retention of climate science information over the course of the semester. Results will be used to refine modules, and the development team will compile and disseminate these results to project participants and will share them with the InTeGrate assessment team.

Dissemination Strategy

Our model, using a combination of face-to-face interdisciplinary workshops, publicly available climate science podcasts, and classroom resources, is one that is transferrable to a wide variety of institution types and is flexible enough in scale that it could be implemented in only a few courses or as a pervasive theme across disciplines on a campus. It is our aim, therefore, to make the resources we develop available to the widest audience possible. We are excited about the opportunity to share the climate science resources on the SERC InTeGrate website. The Gustavus library will host a climate science resource page, accessible from its public resources page and linked to the disciplines participating in the project. Hosting by the Gustavus library will provide for broader accessibility by K-12 students and teachers and by the public. Gustavus's faculty development center, the Kendall Center for Engaged Learning has committed to supporting workshops to engage additional faculty and to disseminate the results of the project on campus. In addition, the Mid-States Consortium for Math and Science is interested in hosting a faculty development workshop that would allow us to disseminate results to the thirteen institutions in the Consortium. Finally, we hope that this project will lead to presentations at GSA and/or AGU meetings and at least one publication about the interdisciplinary use of climate science data, published in a journal such as *Journal of Geoscience Education*.

Strategy and the Needs of Gustavus

At the Teaching Climate Change workshop in February 2014, we modeled a climate science module that could be used in non-science classrooms and surveyed faculty attitudes and needs regarding climate change instruction. The response from the ~30 attendees was overwhelmingly positive, and many participants indicated a desire to have access to the kinds of information we presented in this workshop. We also administered a survey, which indicated that many instructors (13 of 26 respondents) believe their courses have connections to climate science that they would like to explore more thoroughly. Additionally, 12 respondents answered that their courses would benefit if they had a better understanding of climate science, with 13 indicating that a lack of climate science knowledge is (5) or might be (8) a barrier to incorporating more climate content in non-geoscience courses.

Gustavus has a tradition of interdisciplinary teaching, scholarship, and outreach. Nine interdisciplinary programs, involving faculty from nearly every department on campus, serve to link departments through an interdisciplinary network. Environmental Studies (ES), for example, includes faculty from 10 departments, from the physical sciences to the arts. Such a network makes interdisciplinary teaching easier and has helped develop an institutional culture of teaching across disciplinary boundaries.

Additionally, Gustavus science faculty members have experience with this kind of interdisciplinary curriculum development. A recent NSF CCLI award to an interdisciplinary faculty team supported the development of 18 laboratory modules (1-2 hours long) that linked concepts of sustainability to fundamental topics in STEM fields. Similarly, our most visible campus-wide events, the Nobel and Building Bridges conferences, are explicitly interdisciplinary

and challenge students, faculty, and visitors to see connections among disparate disciplines surrounding complex themes. This project, which aims to increase climate literacy by building on the interdisciplinary, collaborative framework already in place at Gustavus, is well-suited to the campus culture, faculty interests, and student body. The products of this work, modules and primers, will also be widely transferable to a variety of institutions that also might be interested in improving climate science literacy in a diverse array of disciplines.

ADMINISTRATIVE SUPPORT

A key advantage to this project is that it requires minimal effort and cost to sustain after the funding period. We have found that the most enduring curricular reforms are those that were developed by the faculty, in response to specific, articulated needs. Innovations that require a permanent source of additional funds or a large cohort of dedicated faculty are difficult to sustain, regardless of administrative enthusiasm for the project. Against that backdrop, we deliberately constructed this project to be flexible and high-impact, as well as inexpensive to maintain beyond the funding period. Modules can be updated or adapted by the development team or by adopting faculty, making it easy to add faculty members to the project. Similarly, assessments will be readily available and adaptable to a variety of course types.

The faculty development center at Gustavus (Kendall Center for Engaged Learning) has generously offered to support teaching circles for brainstorming and to provide a venue for dissemination of results and follow-up conversations. The Kendall Center provides ongoing faculty development opportunities and is particularly enthusiastic about opportunities to highlight innovations and curricular changes that cross disciplinary boundaries. In addition, the Kendall Center calls for course development grant proposals every year and can support continued innovation around this theme, even after the InTeGrate project is complete.

TIMELINE

Each curriculum development loop includes a teaching circle, module development, and two stages of implementation, with assessment occurring at each stage. Dissemination of modules and preliminary data to the Gustavus community and to the InTeGrate program will occur at the end of each loop; final compilation, presentation, and publication of results will occur at the end of the project timeline. Below is a chart that outlines a series of development loops occurring during the funding period.

Loop #	Teaching circle	Development	Implementation	Second delivery	Disseminate
1	Sum 2014	Sum 2014	Fall 2014	Sp 2015-Fa 2015	Fall 2015
2	Fall 2014	Jan 2015	Spring 2015	Fa 2015-Sp 2016	Spring 2016
3	Spring 2015	Sum 2015	Fall 2015	Sp 2016-Fa 2016	Fall 2016
4	Fall 2015	January 2016	Spring 2016	Fa 2016-Sp 2017	Spring 2017
Writing, conference presentations, dissemination of final results				Spring-Summer 2017	

REFERENCES

Bralower, T.J., Feiss, P.G., Manduca C.A., 2009, Preparing a new generation of citizens to face Earth's future: *Liberal Education* 94(2):20.

Steer, D.N., Iverson, E., Manduca, C.A., 2012, Developing a geoscience literacy exam for assessing students' earth, ocean, atmospheric, and climate science literacy: *Geological Society of America Abstracts with Programs* 44(7):351.

BUDGET – JULY 2014 – JULY 2017

The project budget supports faculty time to participate in teaching circles, to develop modules and climate primers, to test modules prior to classroom implementation, to implement modules for the first time, develop assessment tools and collect/analyzed/disseminate assessment data, and to disseminate project results. Support for several activities will be provided by the Gustavus library (GL), Kendall Center for Engaged Learning (KCEL), and the Mid-States Consortium (MSC). Incidental costs, such as photocopying, will be borne by the participating departments.

Teaching circles (4)	$3,400
$100 per participating faculty member (5-8 faculty at each teaching circle); cost to be split with Kendall Center (see letter of support)	
$250 per project leader (2 leaders per teaching circle)	
Food and space costs borne by KCEL (see letter of support)	
Module development (12 modules)	$10,800
$600 per module (1 developer for each module; split if 2 developers)	
$100 per faculty module reviewers (3 each module)	
Student assistance in development and testing borne by Gustavus	
Assessment coordination ($1,500 per year; summer salary)	$4,500
Liaison to SERC/InTeGrate assessment specialists	
Develop tool to assess faculty needs and understanding of climate science	
Develop review tools, based on SERC activity rubric	
Develop tools to assess student learning	
Both a general tool, used for all modules, and module-specific questions	
Collect, analyze, and disseminate data	
Dissemination ($1,500 per year, summer salary; years 2 and 3 only)	$3,000
Adapt resources to library website; work with library information specialists	
Liaison to SERC/InTeGrate web specialists	
Adapt resources for posting on InTeGrate website; update postings	
Workshop hosted by MSC – costs borne by MSC (see letter of support)	
Benefits for faculty salary costs (15.8%)	$3,429
Total	**$25,129**

KEY PERSONNEL

The ***module development team*** is composed of Gustavus faculty with expertise in climate science. These faculty will facilitate teaching circles and develop climate modules. Short vitae for each are included.

Julie Bartley, Geology Department and Environmental Studies Program (project lead)
James Dontje, Environmental Studies Program
Jeff La Frenierre, Geography Department and Environmental Studies Program
Cindy Johnson, Biology Department and Environmental Studies Program
Michele Koomen, Education Department
Laura Triplett, Geology Department and Environmental Studies Program

Faculty from across campus have expressed interest in participating in teaching circles, testing modules, and/or implementing modules in their courses. We expect to be able to add faculty to this list as the project progresses and we identify climate science themes, disciplines involved in each development loop, and topics for the modules and primers.

Deborah Downs-Miers, English
Mary Gaebler, Religion
Deborah Goodwin, Religion
Jon Grinnell, Biology
Tom Huber, Physics
Jeff Jeremiason, Chemistry
Scott Moeller, Arboretum
Chuck Niederriter, Physics
Jeff Owen, Economics & Management
Jessie Petricka, Physics
Anna Versluis, Geography
Jan Wotton, Psychological Sciences

GUSTAVUS

GUSTAVUS ADOLPHUS COLLEGE

March 20, 2014

Letter of Support

As Director of the John S. Kendall Center for Engaged Learning, the faculty development center at Gustavus Adolphus College, I write to express and confirm the Kendall Center's support for the curriculum development proposed in the attached grant proposal.

The Kendall Center will support teaching circles comprised of those associated with this project, provide stipends for those faculty meeting to workshop and develop curricula, and will gladly provide fora to enable dissemination of the teaching modules developed. In addition, existing curriculum development grants will enable faculty to continue this work after the grant period concludes.

We believe that this grant proposal reflects best practices in interdisciplinarity, faculty collaboration, and effective curricular development and look forward to working closely with project participant as they move forward in their work.

Cordially,

Alisa J. Rosenthal
Director, Kendall Center for Engaged Learning

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March 27, 2014

Dear Julie Bartley,

Congratulations to you and your colleagues for putting together such an interesting and well-constructed proposal. The proposal is full of rich ideas to increase climate science literacy on the Gustavus Adolphus campus. I believe the modules you develop in this project will be of interest to faculty from many disciplines, and at other colleges and universities across the country. As the Director of the Midstates Consortium for Math and Science (MCMS), I enthusiastically support your plan to use the connections among our 13 member campuses and the various programs we offer to engage in deep and ongoing conversations with faculty and staff at other colleges in the hopes that they will consider how they can adapt what you will be putting into place at Gustavus to strengthen their own climate science curricula.

The MCMS was founded by the Pew Charitable Trust 21 years ago and we currently serve 13 member campuses including Beloit College, Carthage College, Colorado College, Grinnell College, Gustavus Adolphus College, Hope College, Knox College, Lawrence University, Luther College, Macalester College, St. Olaf College, Washington University and The University of Chicago. The purpose of the Consortium is to provide professional development opportunities for students, faculty and staff on our member campuses. We do this primarily by sponsoring and supporting research symposia, workshops, speaker exchange visits between campuses and collaborative projects between multiple member campuses. For more information and specifics, visit www.mathsciconsortium.org.

In most years, we host several weekend workshops for faculty and staff. The topics vary, but are often associated with curricular innovations and interdisciplinary programs. For example, in October 2009, the MCMS sponsored a workshop at St. Olaf College, entitled "*Moving Campus Sustainability Forward through Collaborative Student-Faculty-Staff Projects*." This workshop attracted more than 50 participants from 12 of the member campuses. The next planned workshop, as you know, includes you, some of your chemistry colleagues and faculty from several other member campuses as hosts and is tentatively titled "*Scientific Instrumentation in the Undergraduate Curriculum*."

The project you have proposed here would be excellent fodder for faculty workshops through the Midstates Consortium. As we have discussed, there are two different possible focuses for the workshop you will plan with us on the proposed project. On one hand, earth science faculty at our member campuses may be interested in gathering to consider how they, too, might support climate science education on their own campuses. We are a small consortium, and not all of our campuses have geology or earth science departments, but the earth science faculty members I have met on my campus visits are highly committed and engaged teachers. Another direction would could take would be to promote the climate science primers and modules that you develop for faculty who are not specialists in this area. Our reach is limited to the natural sciences, mathematics, computer science, and psychology, but I believe the interest in your work would be very high among this group.

Our funding resources are somewhat flexible, but we typically encourage workshop organizers to work within a budget of $15,000 that would cover the travel, lodging and meal expenses for all participants as well as some of the planning and hosting costs. The Consortium office is experienced at helping plan the details of the meeting organization, allowing you to focus on the content, program, and schedule for the workshop. We hosted a workshop at Gustavus for the first time last summer, and this campus proved to be an excellent and cost-effective location.

In addition to a workshop, you may find great use for the speaker exchange and short-term consultation programs offered by the Consortium. These will help make it possible for you to have targeted and more tailored conversations with specific member campuses about climate change curriculum development. Best of luck with the proposal and I look forward to working with you and your colleagues in the next few years as you use the array of Consortium activities and connections to help spread the word about the innovative changes you will be making to your curriculum.

Sincerely,

Brandy S. Russell
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