TEACHING PORTFOLIO

Certificate in College Teaching

Ariel L. Morrison, Ph.D.

Department of Atmospheric and Oceanic Sciences
University of Colorado Boulder

10/15/2020

TABLE OF CONTENTS

Introduction

In this portfolio I present my philosophy of university teaching, how my philosophy has informed my teaching practice, the evaluation of my effectiveness as a university instructor, and my future goals as an educator. I teach courses about climate change – the science behind it, its impacts, and how to mitigate or reverse its effects. Part of my research has also focused on finding the most effective ways to improve student engagement in learning about climate change. Overall I have pursued a certificate in college teaching and written a teaching portfolio because I want to teach climate science classes at a small liberal arts college.

The portfolio is structured as follows:

In Section I, I present my teaching philosophy with examples of how I incorporate my active learning- and dialogue-focused philosophy in my classroom. Section II shows the ways in which I assess summative and formative student learning, with examples in Appendices B and C. I also describe how my own teaching has been evaluated and how I have addressed comments from my evaluations (Appendix D). Outside of the classroom I have also sought opportunities to develop myself professionally as an educator and as a researcher in the field of geoscience education research. In Section III I describe the pedagogical workshops I have attended, the research I have done, and the conference talks I have presented to develop myself professionally as an educator. I show examples of my education research in Appendix E. Section IV is my diversity statement. As a woman in STEM, I want to use my platform as a teacher and a mentor to increase the representation of women in science. I have encouraged my students to participate in research programs and mentored a non-traditional student in her own research project. I finish the portfolio with my CV in Section V, which demonstrates my dedication to teaching, academic development in the field of education research, and student mentoring experience.

I. Philosophy of Teaching and Learning

Climate change is one of the most pressing issues of our time, and most undergraduate students are aware that the burden of dealing with climate change impacts will fall to their generation. How do we best engage students when learning about climate change science, the disparity of climate change impacts, and the best adaptation and mitigation strategies, while still keeping students optimistic about the future of our environment? Through my teaching strategies I aim for three goals: 1) empower students to be active and ethical citizens with regard to the natural world, 2) encourage students' critical thinking about science claims from the media and from primary sources, and 3) promote students' agency in controlling their future.

For students to become active and engaged with combating climate change, they must first understand the science behind a changing climate. Understanding and retaining information requires students to be engaged in the material. My strategy to maintain student engagement is to use several different active learning techniques, designed for a variety of learning styles. For example, my lesson on the ozone hole incorporates several types of activities, from verbal lectures to tactile hands-on activities to visual drawings. I write out and verbally explain the four chemical reactions for the natural creation and destruction of ozone. Whenever I explain complex multi-step concepts for the first time, I include cartoons to give students a literal picture of what is happening in the environment. In this case, I crowdsource ideas from students on what polar stratospheric clouds look like and how they contribute to ozone destruction, working with the class as a whole to accurately depict the process of polar ozone depletion. To understand ozone chemistry and simulate catalytic ozone destruction, students use Legos to build and destroy 'ozone' Lego molecules with a single 'chlorine' Lego atom. Importantly for empowerment of active and engaged citizens, students left the course feeling like they could have meaningful discussions about climate change. At the beginning of the semester, only 56% of students said they "strongly agreed" or "agreed" that they were equipped to talk about global warming with their peers and family members, compared with 99% at the end of the course.

Another way that I encourage students' moral growth with regard to climate change is by practicing critical thinking. One example of a formative assessment I would like to include in a future course is a journal exam. Reading and thinking critically about primary literature develop students' intellectual and reflective habits. To develop these habits, students would be taught specifically how to read journal article figures, extract information, and evaluate the authors' conclusions. A journal exam assesses the following skill: in the absence of a title, abstract or conclusion section, can students extract the essential information and evaluate the conclusions in a peer-reviewed journal article? By honing this skill, students gain the ability to make independent conclusions and not rely on secondary sources of information to decide a course of action.

Overall, I see my classroom as a place for pushing boundaries and I strive to push my students beyond their expectations of themselves. To improve my own teaching, I have trained in skills such as managing large STEM labs and classroom conflict resolution, watched videos of myself teaching to evaluate my strengths and weaknesses in the classroom, and sought student feedback periodically throughout the semester. Part of my teaching philosophy was developed in direct response to student feedback: "tell us something good." I incorporate lessons on climate solutions, such as carbon sequestration and the improved availability of green energy sources (see Appendix A for course syllabus). Informing students that their personal, political, and economic choices influence the Earth's future climate trajectory gives them a sense of personal responsibility for the environment, pushing them to be better informed about climate science, impacts, and solutions.

II. Assessment and Evaluation of Student Learning and My Own Teaching

Student Assessment

In my recitation sections and guest lectures, students' knowledge and understanding were assessed in formative and summative ways. Students were evaluated through a variety of activities – in-class worksheets (Appendix B), multiple choice and short answer homework questions, clicker questions, presentations, exams and group papers. In my guest lectures, I wrote clicker questions to test students' immediate grasp of the material (see sample clicker question slides in Appendix B). Students had two minutes to think about the question, discuss with their peers, and click in. If more than 50% of the class got the question wrong, I would review the material again and students would re-attempt the clicker question. Students received participation points for clicking in an answer, but were not graded on whether they answered correctly. In my second semester's recitation I also graded the first midterm exam. I wrote my own points rubric for grading the short answer questions (see Appendix C) to ensure that all answers were graded fairly. I specifically covered the short answer question material in my recitations before the exam, so grading students' answers was a good way for me to assess how effectively I had taught the material.

In my second semester's recitation I opened the classes with a group discussion question related to lecture material that the class had already covered that week. Questions were intended to be both open-ended and review. Students had 5-10 minutes to discuss with each other and look at their notes. I walked around and spent time with each group of students to hear their thoughts (observed during one of my Peer Consultations; see Appendix D), and if necessary I worked through the question with them, trying to guide them with some leading questions to expand their thinking and rationale. We discussed the question as a class afterwards. If no students volunteered an answer, I would call on a group that I knew had solid ideas (since I believe it reduces fear of cold calling if students know they have good answers) to get the class talking.

Outside of class I met with many students during office hours, review sessions, and one-on-one exam preparation. Some students attended my office hours every week to get help on homework. Providing homework help was a good way for me to assess students' out-of-class work, since students always at least *attempted* the homework questions before asking me for help. In office hours I could see where students consistently struggled. If enough students struggled on the same questions, then I reviewed those questions and concepts during that week's recitation.

Evaluation of My Own Teaching

My teaching has been evaluated by my peers, by a faculty member of the Atmospheric and Oceanic Sciences department, and by my own students. In the following sections I describe how my teaching has been assessed, the outcome of my teaching assessments, and how I have addressed feedback from those assessments.

Peer Observation

I had two peer consultations during my recitation classes: Threshold Concepts in the Discipline and Analysis of Teacher's Interactions with Students (see notes in Appendix D). Overall, I found the peer observations to be especially helpful for improving my teaching. For my Threshold Concepts I chose the subjects of ozone depletion and chemical reactions in the atmosphere since atmospheric chemistry can be a difficult subject for students. I knew before teaching the class that ozone depletion can be troublesome for students, but talking about *why* it is a difficult subject was helpful for thinking about how I would teach the class. For example, many students in my class were non-STEM majors and expressed nervousness about math on homework or exams, so I knew that balancing chemical equations could be a stumbling block for them. I intended to break down the equations into multiple steps and give the students hands-on activities to balance the equations so that the concept was less abstract. In class, students worked as small groups to break down "ozone molecules" made of Legos. After watching the evaluation video, I believe that the hands-on Lego activity was helpful for improving understanding of *how* ozone molecules break down (and students enjoyed the active learning technique of breaking down and building up molecules made of Legos), but there were still some bounded parts of the class and activity. One of the biggest ways in which the Lego activity was bounded was that the activity gave no sense of the location of ozone loss, which is an important part of the lesson. I had focused so much on a fun and accessible atmospheric chemistry activity that I had neglected some of the important information in the lesson. For example, I wanted students to know that ozone depletion requires the presence of polar stratospheric clouds, and Antarctica is the only place in the world where it is cold enough for these clouds to form. The Lego activity did not touch on this concept at all. In retrospect, I could have made the Lego activity a little more complex and informative by giving the students two sets of Legos – one for the Arctic and one for the Antarctic - and only including a Lego base for polar stratospheric clouds in the Antarctic set. Making the Lego activity more informative would have also met one of the learning goals: why does the ozone hole only form over Antarctica and nowhere else on Earth? I believe the students would have understood more of the science behind the "fun" activity if I had more clearly connected the activity to the learning goals.

Watching the videos of myself interacting one-on-one with students also helped me improve my engagement with students in small group discussions and when I was lecturing in front of the whole class. For example, the videos helped me to see where I was guiding students to the correct answer, and when I was just giving a student the answer instead of guiding them. The biggest changes I made in response to the peer observations were 1) deliberately connecting class activities to learning goals to show students how the activities helped them learn the material (for example, if I redid the Lego lesson above I would have stopped the class periodically to talk about what each Lego configuration meant scientifically); and 2) asking more leading questions in our small group discussions so students could reach the answer themselves, instead of talking students through to the answer.

Faculty Observation

A faculty member from my department observed one of my classes. Overall the feedback was very positive and highlighted aspects of my teaching that I hope to continue: speaking clearly to reach the whole class, moving around the room to talk directly to small groups of students, and not over-using my slides and PowerPoint as teaching tools. A comment that came up in both the peer and faculty observations was that I could not speak directly to a group of students because their desk was blocked off in a corner (see Desk Layout in Appendix D). While I will not have complete control over future classroom layouts, I am now aware of what constitutes an "unproductive" classroom layout. One change I would like to incorporate in future classrooms is to make sure the classroom and desks are organized so that I can easily have small group discussions with all students. If I cannot talk to some students in the room, then I will never interact with them and make sure their questions are being answered.

Student Feedback

In my recitation courses I solicited written feedback from the students before their first midterm. I took the initiative on writing and gathering feedback from the feedback survey (Student Satisfaction and Concerns Survey; see Appendix D) since it was not part of the original course syllabus. I wanted to understand how students were benefitting from recitation, what worked for them, and what I could improve. Overall, responses were very positive; students appreciated the worksheets and activities that I created specifically for recitation, saying that the extra practice helped cement concepts and information from lectures. Several students also mentioned that they liked my one-on-one teaching when they had questions about the worksheets ("Walking around for help on activities; being available and kind when help is needed," "Explain things in depth; I like how you clarify things!"), which was a teaching strategy that I refined and tried to do more in response to the peer observations of my classes. From a quantitative perspective, students reported feeling very comfortable asking me and their peers for class-related assistance, rating their comfort as 9.7/10. Since the worksheets and activities were so helpful, and since many students asked for more detailed review of the worksheet answers ("Maybe specific mini-lecture on worksheet concepts that several people have trouble with," "Go over the most difficult question from the previous week's quiz together"), I shortened my lectures at the beginning of class and expanded the time allotted for worksheets and activities. This expanded the time that students could ask me for one-on-one explanations of the concepts that they found particularly confusing or difficult. In addition to student feedback during the semester, I also received quantitative and qualitative evaluations at the end of the semester (Faculty Course Questionnaires (FCQs); see Appendix D). On average between my four class sections, I received an overall instructor score of 5.44/6.

III. Professional Development in Teaching

In order to improve my teaching and expand my professional experience with education research, I attended pedagogical workshops at the University of Colorado, conducted my own geoscience education research as part of my Ph.D. and postdoctoral research, and presented my research at international conferences. In this section I describe how these professional development activities impacted my teaching.

Pedagogy Workshops

During my time as a graduate student I attended 21 pedagogical workshops. The subjects ranged from how to use humor and technology in a classroom to conflict resolution to best practices for teaching and managing large STEM classes.

Based on feedback from my peer observations (Section II), I wanted to improve on connecting slides and worksheets to the day's learning goals. From the workshop "Aligning Course Assignments with Learning Goals" I learned to develop a recitation plan by starting with the top three or four big ideas that I want students to know at the end of the class and building back from there, instead of just writing slides that fit well together but were not necessarily well-connected to the learning goals. This workshop also helped me think about learning goals in terms of actions instead of complex over-arching ideas. Here I describe a possible learning goal and the assessable actions students could take to understand the concept:
Learning goal: Why is CO_2 a greenhouse gas?
Assessable actions: Draw a molecule of CO_2 and N_2. List the type of radiation that each molecule interacts with. Compare what happens when each molecule interacts with that radiation, ending with how the interaction between the molecule and radiation impacts Earth's temperature.

Another workshop that influenced my teaching was Elevate Your Teaching Voice. I attended this workshop before teaching my recitation sections, so the workshop was particularly helpful for overcoming 'imposter syndrome' and nerves about having my own class. Some advice that I found both helpful and humorous was to talk with a pencil between my teeth while standing in the Henry VIII 'power pose' – actions that were supposed to improve articulation, speaking speed, and confidence in front of the class. I have also applied this advice to practicing for conference presentations, such as those described below.

Thesis Research

In Appendix E I present an example of work I have done to develop as an academic professional in the field of education research. For part of my Ph.D. research I used biometric sensors to investigate which teaching strategies are most effective at increasing student engagement in learning climate science. Using skin conductivity as a proxy for engagement, I found that students in a controlled educational setting were most engaged by dialogue activities, compared with engagement in worksheets and videos, and this result was true regardless of students' academic background, prior level of climate science knowledge, or other demographics such as political affiliation. My research was published in *Climatic Change* (see Appendix E for the abstract and citation).

For my postdoctoral research, I built on my thesis research and analyzed an entire semester of biometric and observational data from 17 undergraduate students enrolled in a large introductory climate science class at the University of Colorado Boulder. The goal of this research was to determine if learning activities that were most engaging in a controlled setting were also engaging in a real classroom setting. I found that, similar to the results from a controlled setting, dialogue activities like peer discussions were very engaging. Class discussions, however, were not engaging. I believe that in a large introductory class with 200+ students, it is difficult to engage more than a few students in a discussion, but students are engaged when they talk one-on-one with their peers. Exams, equations and clicker questions, as "high-stakes" activities with perceived or actual consequences (i.e., grades or participation points), were also very engaging. Unsurprisingly, lectures and other passive activities such as watching videos were not engaging in-class activities. The results from my postdoctoral research have further motivated me to include small group discussions and clicker questions or Kahoot quizzes in my classes.

Conference Presentations

I presented my geoscience education research three times at annual American Geophysical Union (AGU) conferences. Most recently I presented a poster (see Appendix E) on my postdoctoral research. Conferences have been a valuable way for me to gather feedback from other educational professionals and to learn more about the latest research in geoscience education research.

IV. Diversity Statement

I aim to foster excellence through inclusivity in my classroom and academic community in three main ways. The first way is related to my identity as a woman in STEM. I have been very fortunate in my opportunities as a female scientist – nearly all my graduate and post-graduate advisors have been women, and I have been strongly supported throughout my entire science career. As a teacher and a mentor, I want to pay these opportunities back to my students and increase female representation in STEM. One opportunity that I credit as a great launch pad for my research career was the Research Experience for Undergraduates (REU) program. When my Learning Assistant wanted to start doing research, I introduced her to the REU program and wrote one of her reference letters when she applied. As part of my future commitment to amplifying the voices and experiences of women scientists in the classroom, a college course I would like to design and teach, Climate Change Communication, primarily focuses on work and writings by women scientists (Appendix F). While I believe that STEM has become more inclusive to women since I started my science career in 2008, I also believe that it is part of my job as a teacher to continue this trend by guiding interested female students towards research opportunities.

Outside of the classroom I seek to increase diversity in STEM by mentoring non-traditional students. I was a research mentor for the summer Research Experience for Community College Students (RECCS) program; my mentee had returned to college to finish her degree after having children. She and I developed a summer research plan that she could adapt to her family schedule. We created a very flexible work environment with tasks that she could complete from home. Ultimately her project was so successful that she became the first student from the RECCS program to be a co-author on a paper based on her fellowship project. My mentoring experience met two of my diversity goals: to increase the representation of both women and students with non-traditional academic paths in STEM.

Finally, climate change as a discipline lends itself to a discussion on the diverse experiences of people already affected by climate change. In my classes I emphasize the unequal distribution of impacts such as sea level rise and extreme heat waves; climate change disproportionately affects low-income and heavily populated countries that produce very little greenhouse gas emissions. For a class activity students calculated the per capita CO_2 emissions of many small countries (e.g., the Maldives and Marshall Islands) compared to the U.S.A., and then looked up the percentage of each country's population that has already been directly affected by climate change. The activity quantifies the disproportionate nature of climate change impacts. This is a way to bring the concept of privilege into a science classroom without guilt or blame. Students recognize that they are not personally responsible for global disparities in climate change impacts. They also see that they are often sheltered from 1) thinking about how climate change affects their daily lives and 2) most of the impacts themselves. Learning about the inequality of climate change is the first step towards acquiring the tools necessary to dismantle the inequality around climate change impacts.

V. Curriculum Vitae

ARIEL L. MORRISON

2433 Pine Street, Boulder, CO, USA 80302 • ariel.morrison@colorado.edu

EDUCATION

University of Colorado Boulder

2019 **Ph.D.** in Atmospheric and Oceanic Sciences

2015 **M.Sc.** in Atmospheric and Oceanic Sciences

Boston University

2010 **B.A. cum laude** in Earth Sciences

TEACHING EXPERIENCE

2018 - 2019 **Teaching Assistant - Recitations**
University of Colorado Boulder
ATOC1060: Our Changing Environment – Department of Atmospheric and Oceanic Sciences

2014 - 2016 **Guest Lecturer**
University of Colorado Boulder
ATOC1060: Our Changing Environment – Department of Atmospheric and Oceanic Sciences

2013 - 2014 **Teaching Assistant - Lectures**
University of Colorado Boulder
ATOC1060: Our Changing Environment – Department of Atmospheric and Oceanic Sciences

MENTORING AND OUTREACH

2019 - 2020 **Volunteer** - Denver Museum of Nature and Science, Denver, CO

2018 **TEDx Salon** - "The Melting Arctic," Boulder, CO

Mentor - Research Experience for Community College Students (RECCS), University of Colorado Boulder

2016 **Instructor** - Boulder Preparatory High School

RESEARCH EXPERIENCE

2020 - **Postdoctoral Research Fellow**
Department of Earth and Ocean Sciences, University of Victoria
Victoria, BC, Canada

- Quantifying influence of clouds on Southern Ocean heat uptake using reanalysis datasets and satellite observations
- Analyzing teleconnections between Antarctic clouds and El Nino climate states

2019 **Postdoctoral Research Fellow**
Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder
Boulder, CO

- Analyzed biometric and self-reflection data from an undergraduate climate science class to determine which teaching methods are most effective at engaging students while learning geoscience. Results show that incorporating high-stakes activities such as exams and clicker questions can increase student engagement by over 100%.
- Wrote open-source Python script for biometric skin sensor data analysis, which will be widely used in all skin sensor research at the University of Colorado Boulder.

2014 - 2019 **Graduate Research Assistant**

Department of Atmospheric and Oceanic Sciences, University of Colorado Boulder
Boulder, CO

- Isolated the Arctic cloud response to sea ice using a novel masking method and CALIPSO satellite observations, and found no evidence that clouds weaken sea ice albedo feedback (Morrison et al., 2018).
- Ran Community Earth System Model 1 (CESM1) for the first time with a lidar simulator and opaque cloud diagnostics to predict a positive Arctic cloud feedback in the future, indicating that clouds will accelerate rate of Arctic sea ice loss (Morrison et al., 2019a).
- Designed and executed education research project validating the use of biometric skin sensors for measuring student engagement while learning about climate change science (Morrison et al., 2020).

PUBLICATIONS

2020 **Morrison, A.L.,** S. Rozak, A.U. Gold, and J.E. Kay, Quantifying student engagement in learning about climate change using galvanic hand sensors in a controlled educational setting. Climatic Change, 1-20. DOI: 10.1007/s10584-019-02576-6.

2019 **Morrison, A.L.,** J.E. Kay, W.R. Frey, H. Chepfer, and R. Guzman, Cloud response to Arctic sea ice loss and implications for future feedback in the CESM1 climate model. Journal of Geophysical Research: Atmospheres, 124: 1003-1020

2018 Frey, W.R., **A.L. Morrison**, J.E. Kay, R. Guzman, and H. Chepfer, The combined influences of observed Southern Ocean clouds and sea ice on top-of-atmosphere albedo. Journal of Geophysical Research: Atmospheres, 123: 4461-4475.

Morrison, A.L., J.E. Kay, H. Chepfer, R. Guzman, and V. Yettella, Isolating the liquid cloud response to recent Arctic sea ice variability using spaceborne lidar observations. Journal of Geophysical Research: Atmospheres, 123: 427-490.

2016 Kay, J.E., T. L'Ecuyer, H. Chepfer, N. Loeb, **A. Morrison**, and G. Cesana, Recent Advances in Cloud and Climate Research. Current Climate Change Reports, 2(4): 159-169.

Kay, J.E., L. Bourdages, N. Miller, **A. Morrison**, V. Yettella, H. Chepfer, and B. Eaton, Evaluation of cloud phase in the Community Atmosphere Model version 5 using spaceborne lidar observations. Journal of Geophysical Research: Atmospheres, 121(8): 4162-4176.

2011 Orlosk, J.L., J.M. Walker, **A.L. Morrison**, and J. Atema, Conditioning the crab Carcinus maenas against instinctive light avoidance. Marine and Freshwater Behaviour and Physiology, 44: 375-381.

GRANTS

2019 **Innovative Research Proposal** – "Assessing the potential of biometric sensors to measure engagement and learning in the classroom"

Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado
Amount: $25,000
Funding period: June – December 2019
PI: Dr. Jennifer E. Kay
Role on project: Postdoctoral Research Fellow

2016 - 2017 **STEM Chateaubriand Fellowship** – "Processes controlling seasonal variability in the vertical structure of Arctic Ocean mixed-phase clouds"
Office of Science and Technology of the Embassy of France in the United States
École Polytechnique, Palaiseau, France
Amount: $7,000
Funding period: January – May 2017
PI: Dr. Helene Chepfer
Role on project: Ph.D. Fellow

INVITED TALKS

2019 "Cloud response to Arctic sea ice loss and implications for future feedbacks in the CESM1 climate model." American Geophysical Union, San Francisco, CA, December 2019

"Arctic cloud and sea ice feedbacks from satellite observations and a global climate model." American Physical Society, Boston, MA, March 2019

2018 "Cloud response to Arctic sea ice loss and implications for future feedbacks in the CESM1 climate model." American Geophysical Union, Washington, D.C., December 2018

2016 "The Observed Cloud Response to Arctic Sea Ice Loss." American Geophysical Union, San Francisco, CA, December 2016

CONFERENCE ABSTRACTS

2019 "High-stakes activities increase student engagement in an introductory climate science class: evidence from biometric sensors." American Geophysical Union, San Francisco, CA, December 2019

2018 "Using hand sensors to evaluate the impact of educational activities on student engagement in climate change." American Geophysical Union, Washington, D.C., December 2018

2017 "The Observed Cloud Response to Arctic Sea Ice Loss." European Geophysical Union, Vienna, Austria, April 2017

"Arctic cloud response to sea ice variability and implications for future feedbacks in climate models." American Geophysical Union, San Francisco, CA, December 2017

"Measuring engagement and learning outcomes during a teacher professional development workshop for climate science." American Geophysical Union, San Francisco, CA, December 2017

"CALIPSO Observations of the Cloud Response to Recent Arctic Sea Ice Loss." Expecting EarthCare, Learning from A-Train (EECLAT), St-Valery-sur-Somme, France, January 2017

2016 "Assessing the use of polar bear hooks in learning climate science." Earth System & Space Science Poster Conference, University of Colorado Boulder, December 2016

"Seasonal variability in vertical profiles of Arctic Ocean liquid clouds." CloudSat/CALIPSO Science Team Meeting, Newport News, VA, February 2016

2015 "Processes controlling seasonal variability of Arctic Ocean liquid cloud profiles." Earth System & Space Science Poster Conference, University of Colorado Boulder, November 2015

"How is Arctic sea ice loss affecting our clouds?" Graduate Climate Conference, Woods Hole, MA, November 2015

2014 "Is losing our sea ice affecting our clouds? A story about stability in a warming Arctic." CloudSat/CALIPSO Science Team Meeting, Alexandria, VA, October 2014

Seminars

2020 "Arctic cloud response to sea ice loss in satellite observations and a global climate model." HiLAT Project team meeting, Pacific Northwest National Laboratory, Richland, WA, June 2020

2019 "Arctic cloud response to sea ice loss in satellite observations and a global climate model." University of Utah, Atmospheric Sciences seminar, Salt Lake City, UT, January 2019

Fellowships and Awards

2018 **Excellence in Teaching Award**
Atmospheric and Oceanic Sciences Lab/Recitation Instructor
University of Colorado Boulder

2015 **Outstanding Student Presentation Award (OSPA)**
"Cloud response to Arctic sea ice loss and implications for future feedbacks in the CESM1 climate model," American Geophysical Union conference, Washington, D.C.

2009 **First Place, 'Aerosols, Clouds, and Precipitation' category**
"Processes controlling seasonal variability of Arctic Ocean liquid cloud profiles," Earth System & Space Science Poster Conference, University of Colorado Boulder

Research Experience for Undergraduates (REU)
Shannon Point Marine Center, Western Washington University, Anacortes, WA

Service and Professional Memberships

2019 - American Meteorological Society member

2016 - American Geophysical Union member

2019 - 2020 American Mathematical Society member

2019 - 2020 American Physical Society member

2018 **Student speaker**
Department of Atmospheric and Oceanic Sciences colloquia series
University of Colorado Boulder

- Gave inaugural departmental colloquia student talk, "Observed and simulated cloud response to Arctic sea ice loss from CALIPSO and CESM1"

2016 - 2017 **Board member**
U.S. Association for Polar Early Career Scientists (USAPECS)

- Curated video playlists and organized watch parties for Polar Film Fests 2016/2017 during Polar Week
- Recruited speakers for and organized polar early-career panel at 2017 AGU conference

2015 - 2016 **Outreach student committee member**
Department of Atmospheric and Oceanic Sciences, University of Colorado Boulder

2018 - **Reviewer**
Journal of Geophysical Research: Atmospheres, Scientific Reports, Journal of Atmospheric and Oceanic Technology, Journal of Climate

Appendix A

Syllabus for ATOC 1060:

Our Changing Environment

Nicole Lovenduski

August 27, 2018

1. Basic Information

Professor: Nicole Lovenduski, nicole.lovenduski@colorado.edu, 303-492-5259
Office hours: Tuesdays 9-11am in SEEC N151B

Teaching Assistant: Ren Smith, warren.p.smith@colorado.edu (Thursday recitations)
Office hours: Mondays, 1-3pm in SEEC N240

Teaching Assistant: Ariel Morrison, ariel.morrison@colorado.edu (Friday recitations)
Office hours: Mondays, 10:30am-12:30pm in Norlin Commons

Learning Assistant: Hunter Rose, hunter.rose@colorado.edu (Thursday recitations)
Learning Assistant: Tzigane Martin, tzma6903@colorado.edu (Friday recitations)

Course materials/webpage: access via Canvas (https://canvas.colorado.edu)

2. Course Description

This course discusses the Earth's climate system for non-science majors, focusing on the role of the atmosphere, oceans, and land surface. Describes atmospheric circulations, ocean currents, the terrestrial biosphere, and anthropogenic perturbations to the climate system.

3. Meetings and Places

Lectures: EDUC 220, 9-9:50am on Mondays and Wednesdays

Recitation 011: DUAN G1B25, 5-5:50pm on Thursdays
Recitation 012: MUEN E064, 3:30-4:20pm on Thursdays
Recitation 013: SEEC S125, 9-9:50am on Fridays
Recitation 014: SEEC S125, 10-10:50am on Fridays

4. Grading

Exam 1	Exam 2	Final Exam	Quizzes
25%	25%	25%	25%

Numerical grades for the exams will be based on class-wide curves. Online quizzes will not be curved, but the lowest quiz grade will be dropped for each student.

a. Exam 1

Exam 1 will be administered during recitation on 10/4 or 10/5. Exam 1 will cover Lectures 1-9. The TAs will review for Exam 1 during recitation on 9/27 or 9/28.

b. Exam 2

Exam 2 will be administered during recitation on 11/1 or 11/2. Exam 2 will cover Lectures 10-17. The TAs will review for Exam 2 during recitation on 10/25 or 10/26.

c. Final Exam

The final exam will be administered on Wednesday, December 19 from 1:30-4pm in EDUC 220. The final exam will cover Lectures 1-29. The TAs will review for the final during recitation on 12/13 or 12/14.

9. CUClickers

The use of clickers (available at the CU Bookstore) is intended to promote student learning by informing the professor what the students are thinking, and by providing a forum for students to learn from each other. Most (but not all) lectures will require students to answer questions using the clicker. Students will have the opportunity to earn up to 4 clicker points per lecture. Students who earn at least 50 cumulative clicker points will be awarded 1 extra credit point on their final course grade. Students who earn at least 75 cumulative clicker points will be awarded 2 additional extra credit points on their final course grade (3 extra credit points maximum). Clicker questions will begin on 8/29 and continue through 12/12.

10. Recitations

Recitations provide a small-group setting for students to review and discuss concepts learned in lecture. Thursday recitations will be led by TA Ren Smith with assistance from LA Hunter Rose; Friday recitations will be led by TA Ariel Morrison, with assistance from LA Tzigane Martin.

It is expected that students will participate in recitation. Starred recitations (*) on the course calendar indicate those in which new material will be presented. If you participate in at least 9 of the starred recitations, your lowest exam score from the first two exams (i.e., either Exam 1 or Exam 2) will not count toward your final grade. In this case, your grading will look like this:

Exam 1 or Exam 2 (whichever is higher)	Final Exam	Quizzes
50%	25%	25%

5. Attendance and Participation

It is expected that students will attend all lectures and participate in all recitations. Material required for quizzes and exams may be presented in lectures and recitations and not elsewhere. Lecture slides will be posted on the ATOC 1060-010 Canvas webpage after each class, but may not contain all information presented in class.

6. Textbook and Reading

There is no required textbook for this course. Reading material will be posted on Canvas under the *Reading* Module.

7. Quizzes

Once a week, a quiz is due on Canvas (on Wednesday by 9:00am). Registered students can log into Canvas (https://canvas.colorado.edu) with their CU identikey.

The online quizzes are intended to help you recall and apply concepts learned in lecture and recitation. They will also help you to develop problem solving and quantitative skills. Some basic math and critical thinking will therefore be required. You may use the reading material and your notes to answer the quiz questions. You may also discuss the quiz questions with your classmates.

Each online quiz will be available for one full week, allowing you to access the quiz as many times as necessary. During this time, you may begin a quiz and the Canvas system will save your progress automatically (you can confirm this by checking the "last saved" time near the submit button). You may then leave the quiz and come back to it at a later time. Once you have finished all questions and are satisfied with your answers, click *Submit Quiz* at the bottom of the page. **Do not forget to submit your quiz!** Unsubmitted quizzes will receive a grade of zero. You are permitted only one submission per quiz.

You may submit a completed quiz early if you expect other coursework and obligations to interfere with the due date. **Late quiz submissions will not be accepted under any circumstances.** Computer or internet connection problems are not valid excuses for late submissions, so do not wait until the last minute to submit.

Your lowest quiz score will be dropped from your final grade. This is intended to accommodate students who miss a quiz due to religious holiday observance, illness, or another obligation.

8. Exams

Three exams will be administered during the semester. These exams will test your knowledge of concepts learned in lecture and recitations, and material gleaned from the reading assignments. All exams will be in multiple choice format.

11. Topics and Concepts

In this course, you will learn about the physical, chemical, and biological climate system. You will also learn how human activity has polluted and changed the global climate system. This course will cover three units and introduce you to several key concepts.

a. Unit 1: The Physical Climate System

Topics and key concepts: atmospheric radiation balance; atmospheric temperature and pressure; latent and sensible heat; Hadley, Ferrel, and Polar Cells; Coriolis effect; wind stress; oceanic temperature, salinity, pressure, and density; Ekman transport, geostrophic currents; thermohaline circulation

b. Unit 2: The Chemical and Biological Climate System

Topics and key concepts: atmospheric chemical composition; atmospheric lifetime; oceanic residence time; ocean carbonate chemistry; leaf photosynthesis; net ecosystem exchange; ocean phytoplankton productivity and food webs; coral reefs; El Niño

c. Unit 3: Anthropogenic Changes to the Climate System

Topics and key concepts: ozone depletion; deforestation; ocean dead zones; global warming; natural climate variability; anthropogenic climate change; ocean acidification; geoengineering and emissions mitigation

12. Class Schedule (subject to change)

Week	Monday	Wednesday	Recitation	Reading
1	8/27: Introduction	8/29: Global Energy Balance	Maps & Graphs*	1/3
2	Labor Day - No Class	9/5: Atmospheric & Oceanic Properties	Radiation*	3/5
3	9/10: Atmospheric Meridional Circulation	9/12: Latent & Sensible Heat Canvas Quiz 1 Due	Latent & Sensible Heat*	4
4	9/17: Coriolis & Wind	9/19: Ekman Transport Canvas Quiz 2 Due	Poleward Heat Transport*	4/5
5	9/24: Ocean Gyres	9/26: Deep Ocean Circulation Canvas Quiz 3 Due	Review for Exam 1	5
6	10/1: Atmospheric Composition	10/3: Oceanic Composition	EXAM 1 Lectures 1-9 Readings 1, 3, 4, 5	8
7	10/8: Ocean Carbonate Chemistry	10/10: Leaf Photosynthesis Canvas Quiz 4 Due	Residence Time*	8/9
8	10/15: Net Ecosystem Exchange	10/17: Ocean Phytoplankton & Food Webs Canvas Quiz 5 Due	Photosynthesis*	8/9
9	10/22: Coral Reefs	10/24: El Nino Canvas Quiz 6 Due	Review for Exam 2	8/9
10	10/29: Ozone Depletion	10/31: Deforestation & Dead Zones	EXAM 2 Lectures 10-17 Readings 8-9	17/18
11	11/5: Global Warming Evidence	11/7: Global Warming Causes	Ozone*	14/15
12	11/12: Anthropogenic Emissions	11/14: Atmospheric Impacts Canvas Quiz 7 Due	Talking Climate*	15/16
13	Fall Break - No Class	Fall Break - No Class	Fall Break - No Class	
14	11/26: Terrestrial Impacts	11/28: Oceanic Impacts Canvas Quiz 8 Due	Sea Level Rise*	15/16
15	12/3: Ocean Acidification I	12/5: Ocean Acidification II Canvas Quiz 9 Due	Acidification*	15/16
16	12/10: Geoengineering the Climate	12/12: Global Warming Solutions Canvas Quiz 10 Due	Review for Final Exam	
		FINAL EXAM Wednesday, Dec 19 1:30-4pm EDUC 220 Lectures 1-29 Readings 1, 3-5, 8-9, 14-18		

13. Other

a. Disabilities

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition or injury, see Temporary Medical Conditions under the Students tab on the Disability Services website.

b. Classroom behavior

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. For more information, see the policies on classroom behavior and the Student Code of Conduct.

c. Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code (honor@colorado.edu); 303-492-5550). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the Honor Code Office website.

d. Office of Institutional Equity and Compliance (OIEC)

The University of Colorado Boulder (CU Boulder) is committed to fostering a positive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (including sexual assault, exploitation, harassment, dating or domestic violence, and stalking), discrimination, and harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or cureport@colorado.edu. Information about the OIEC, university policies, anonymous reporting, and the campus resources can be found on the OIEC website.

Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

e. Religious observances

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, you are asked to contact me at least two weeks in advance of a conflict due to a religious observance so that appropriate accommodations can be made. See the campus policy regarding religious observances for full details.

Appendix B

ATOC 1060 – Week 8 Recitation

Photosynthesis Worksheet

Name:

The chemical equation for photosynthesis is:

$106\ CO_2 + 16\ HNO_3 + H_3PO_4 + 122\ H_2O + \text{light} \rightarrow (CH_2O)_{106}(NH_3)_{16}(H_3PO_4) + 138\ O_2$

1. Conceptual Understanding

1) Is the oxygen concentration in the ocean is higher in the surface or at depth? How do you know?

2) Farmers typically add fertilizer to their crops that contains high concentrations of nitrate and phosphate. Why might some of this nitrate and phosphate be left over after the farming season ends?

3) In the ocean, the decomposition of plankton organic matter is referred to as *remineralization*. The equation for remineralization is the reverse of the photosynthesis equation above. For every 32 moles of inorganic nitrogen produced in remineralization, how many moles of oxygen gas are consumed?

4) If water upwelling to the surface ocean has a nitrate concentration of 8 mmol m^{-3} and a phosphate concentration of 0.1 mmol m^{-3}, which nutrient is likely to limit phytoplankton photosynthesis?

2. Crafting the perfect recipe

$106\ CO_2 + 16\ HNO_3 + H_3PO_4 + 122\ H_2O + \text{light} \rightarrow (CH_2O)_{106}(NH_3)_{16}(H_3PO_4) + 138\ O_2$

Each group should take one bag of Legos. Different colored Legos represent different molecules in the photosynthesis reaction:

- Blue Legos represent 122 water (H2O) molecules
- Red Legos represent 106 carbon dioxide (CO2) molecules
- Yellow Legos represent 16 nitric acid (HNO3) molecules
- Purple Legos represent 1 phosphoric acid (H3PO4) molecule

Take 10 blue, 8 red, 4 yellow and 3 purple Legos out of the bag. Leave the rest in the bag.

1) Assemble as many "organic matter" molecules as you can by stacking a blue, red, yellow and purple Lego on top of each other (make sure they are easy to disassemble). How many can you make?

2) Did you use all the Legos that you pulled out of the bag? Why are you unable to make more organic matter molecules? What is the limiting reactant in this situation?

Now simulate the upwelling of deep nutrients in the ocean by removing 4 more purple Legos and 1 more yellow Lego from the bag.

3) How many organic matter molecules can you make now? Why is this number different?

4) What is the limiting reactant now?

5) Would you be able to make more organic matter if you added more blue or red Legos? Why or why not?

Week 13 Recitation Assignment

- Today: Prepare a **3-minute presentation**, and start on a more detailed **1-page climate proposal**.
- For your presentation, use **PowerPoint** (or similar application).
- For your climate proposal, use **Word** (or similar application).
- Where applicable, draw from previous week's recitation worksheets.
- The presentation and proposal are due on D2L dropbox.
- On Monday, April 29, each national delegation will present to the entire assembly.
- In recitation next week, you will read, discuss, and comment on other nations' climate proposals.
- On Wednesday, May 1, we will hold open discussion and negotiation proceedings.

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

Content of 3-minute presentation: Five slides

1. Vital background on your nation, including economy.
2. Population change. See detailed instructions below.
3. List of climate vulnerabilities, or climate change impacts of concern.
4. Summary of key *observed* and *projected* changes in climate relevant to your nation.
5. Very brief overview of your **climate proposal**.

Content of 1-page climate proposal

- Introduction: Briefly summarize the content of slides 1-4 of presentation.
- Propose a detailed international strategy/policy aimed at climate change mitigation that your nation would agree to including any specific pledges.
- For inspiration, review the key elements of the Paris Agreement and various national pledges…
  - http://ec.europa.eu/clima/policies/international/negotiations/paris/index_en.htm
  - http://www.carbonbrief.org/paris-2015-tracking-country-climate-pledges

Detailed instructions for population projections.

- Go to the World Bank website: http://data.worldbank.org/data-catalog/population-projection-tables
- Click "DATABANK" link on right side of page. DATABANK
- Select the check box next to your country.
- Expand "Series" and select "Population, total"
- Expand "Time" and click the gray button with a picture of a check mark, to select all available times.
- Click "APPLY CHANGES" in the dialog box in the middle of the page.
- Along the top, click "Chart"
- Click the download button on the upper-right side of the graph (looks like a down arrow).
- Select "Download PNG image"
- Save the image file to your computer and drag it into your PowerPoint slide.

The following is an example of how your 1-page Model U.N. proposal may be structured. It is a template, so your proposal should have more detail, especially in the last section where you propose climate change mitigation/adaptation techniques. Use the sources we reviewed in class as the starting point for your information/references. Please include specific cited numbers where appropriate – for example, by how much sea level will rise along your country's coastline by 2100.

COUNTRY

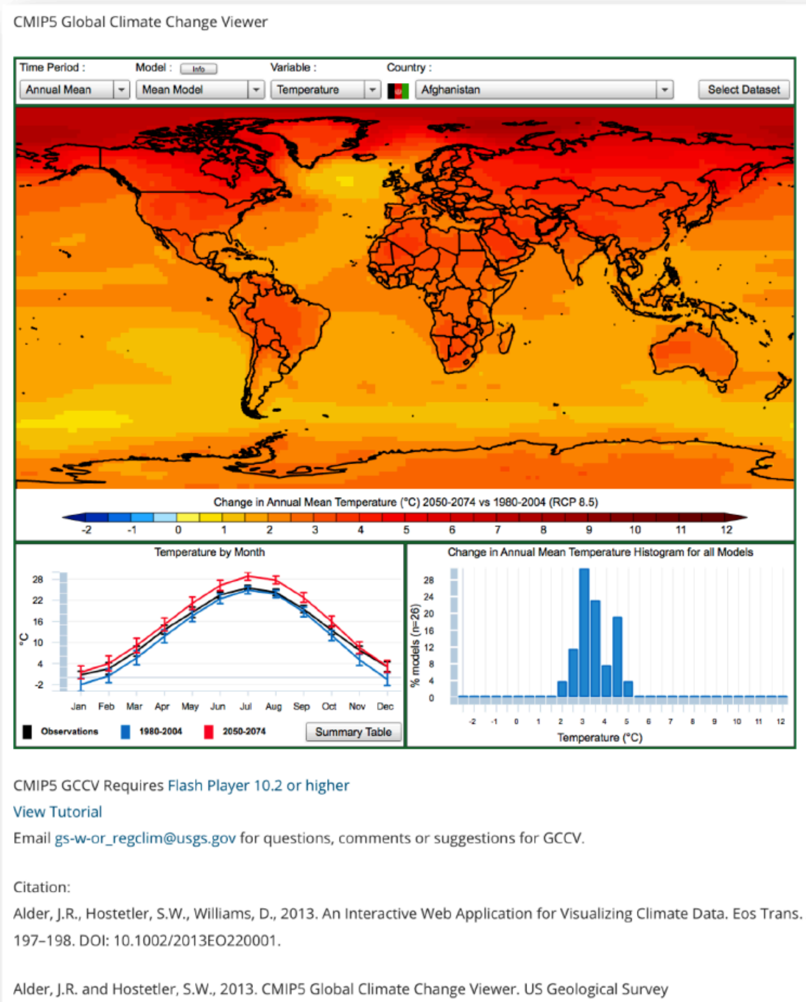
XX is a small island/mountainous/desert country with a population of XXXX. It is located at YY latitude and ZZ longitude. Its tropical/mountainous/desert region give it a typical hot and dry/monsoonal/cold alpine climate.

Observations over the past century/two decades/ten years show that XX is experiencing warming/sea level rise/droughts. Mean summer temperatures have increased by XX over the past century, while mean winter temperatures have increased by XX (REFERENCE). Climate models predict that XX will experience a larger-than-global warming trend in the future (specific numbers; REFERENCE). As a result, XX will likely see many climate refugees fleeing the low-lying cities/urban areas/deserts.

Since sea level rise/flooding/drought is XX's largest climate concern, we propose a strategy of climate change adaptation as well as mitigation. The primary climate change concern is flooding of low-lying cities. Therefore, our first local strategy is to build sea walls around XX cities. Sea walls will protect XX people, which is YY% of XX's total population.

- Changing to renewables, making our existing ones more efficient
- Solar, wind farms, hydroelectric, nuclear
- Carbon taxes
- Sea walls
- Geoengineering – greening of deserts, planting trees
- Reduce emissions
- Make other countries do everything
- What will it cost? Is it feasible for our country to do this?

Hands-on activity: Analyze climate model predictions yourself



USGS CMIP5 Global Climate Change Viewer

http://regclim.coas.oregonstate.edu/visualization/gccv/cmip5-global-climate-change-viewer/

Investigate climate model simulations (including future predictions) of surface climate.

Time Period: Leave **Annual Mean** selected.
Model: Leave **Mean Model** selected.
Variable: Play with **Temperature** and **Precipitation.**
Country: Just click on the map to change country.
Select Dataset: This is where you can change **emissions scenario** and **time period** (but leave CMIP5 selected).

Explore for ~10 minutes. Get a general feel for the following:

- How would you generally describe the global pattern of predicted change (in T or P)? How does this depend on emissions scenario (e.g., RCP4.5 vs. RCP 8.5) or time period (*e.g.*, mid-century or end-of-century)?
- For any country or two, how well does the "mean model" simulate today's climate (T or P)?
- How do the predicted changes (T or P) manifest seasonally?
- How much do the different models agree (or disagree) on the predicted changes in annual mean surface climate?

Appendix C

Sample Clicker Question Slides from Guest Lectures

CLICKER QUESTION #5

- **Why do summer clouds affect the strength of the surface-albedo feedback?**

A. Clouds increase the top-of-atmosphere albedo and slow down the surface-albedo feedback.
B. Clouds increase the top-of-atmosphere albedo and enhance the surface-albedo feedback.
C. Clouds decrease the top-of-atmosphere albedo and slow down the surface-albedo feedback.
D. Clouds decrease the top-of-atmosphere albedo and enhance the surface-albedo feedback.

CLICKER QUESTION: WHY IS LIMESTONE IMPORTANT FOR THE CARBON CYCLE?

A. Semi-permanent reservoir for atmospheric CO_2
B. Removes CO_2 from surface ocean so ocean can dissolve more atmospheric CO_2
C. Human activities could change its effectiveness as a carbon reservoir
D. All of the above.

Rubric for Midterm Questions

ATOC 1060: Our Changing Environment — Spring 2019 (Karnauskas)

Rubric for short answer questions, Midterm #1

Part II. Short answer (write directly on page)

1. Provide a complete explanation for why the great subtropical ocean gyres flow in the same direction as the overlying surface winds. Please use clear diagrams if it helps to illustrate your explanation.

Beginning with the atmospheric general circulation, surface winds flow anticyclonically (or clockwise, in the Northern Hemisphere) over the subtropical ocean basins. Ekman transport causes the upper layer of the ocean to flow 90 degrees to the right (in the Northern Hemisphere) of the winds, which in this case means flowing inward toward the center from all surrounding points and converging in the center. This convergence of the Ekman transports leads to downwelling (a.k.a. Ekman pumping), warming of the upper layer, and elevation of the sea surface in the center of the basin. The resulting sea level 'hill' causes geostrophic currents to flow in an anticyclonic (or clockwise, in the Northern Hemisphere) around the hill. Thus, the gyres flow in the same direction as the winds.

Rubric:

- For full credit, student must correctly include (i) Ekman transports converging, (ii) elevated sea surface height, (iii) geostrophic flow in the wind direction (5 points)
- For a correct written description but incorrect diagram: 4 points
- For correct diagram but incorrect written description: 3.5 points
- For saying that pressure gradient force and Coriolis effect act together: equivalent of geostrophic flow
- For each correct explanation: 1.5 points
- If student mentions each explanation but incorrectly: 2.5 points
- If student mentions each and one is wrong: 4 points
- If student mentions each and two are wrong: 3 points

2. Given that sea surface salinity (SSS) is determined primarily by the balance between precipitation, evaporation and advection of salt by currents within the ocean, explain why SSS is low near the equator. You must give *two* reasons why SSS is low near the equator.

Near the equator, rainfall is high (associated with the ascending branch of the Hadley circulation, a.k.a. the ITCZ), winds are light and humidity is high. Evaporation depends on wind speed and humidity such that low wind speed results in low evaporation and high humidity also results in low evaporation. Thus, precipitation is higher than evaporation near the equator (P>E). Since precipitation is always freshwater and dilutes salinity, and evaporation concentrates salinity in the ocean, this inequality of P and E leads to low SSS near the equator. Additionally, there are a couple of major riverine sources of freshwater near the equator (*e.g.*, the Amazon outflow into the equatorial Atlantic), which results in low SSS.

- For full credit, student must correctly describe at least two of the following:
  - High rainfall
  - Light winds
  - High humidity
  - Large freshwater input by rivers
- Full credit can be given for a very brief version of the above that covers two or more of the above conditions, or simply that precipitation is high and evaporation is low.
- If student only states one of the above (*e.g.*, "SSS is low on the equator due to high rainfall"): 3 points
- If student mentions any of the above factors: 1 point each, even if not described correctly
- If student mentions 2 factors correctly and 1 wrong: 4.5 points

Appendix D

Peer Consultations

Pre-Consultation Template: Threshold Concepts in the Discipline, 11/9/2018

Purpose of the Pre-Consultation:
- To establish comfort and trust in the consultation process.
- To establish shared vocabulary surrounding threshold concepts and what makes particular concepts hard to teach.

Directions:
- Meet with the graduate teacher beforehand; let the graduate teacher know that the consultation is confidential and focused on the teacher's improvement, that they do not have to divulge anything they do not want to, and that you have been in their position before and know it can be uncomfortable. Tell the teacher you will take notes and return them within one week to them and gtpcert. They should check with you if they are not sure if this has been done.
- Explain the consultation process and emphasize that it is formative, not evaluative.
- Take notes on any observations you have during the class period.
- Get the time and room number for the class.
- Have the teacher tell you where to set up the camera.
- If the teacher wants to keep a copy of the video, either download the file onto the teacher's personal computer OR share it with them through your Google Drive. Please erase the video before returning the camera to the GTP office.
- Explain that the video will not be shown to anyone other than them and the Lead.
- **Log the VTC in your Lead Plan and send notes to gtpleads@colorado.edu and gtpcert@colorado.edu**

Consultant: Danielle Lemmon
Department: ATOC
Teacher Name: Ariel Morrison
Department: ATOC
Date Filmed: 11/9/2018
Date Notes Returned:

I. Explanation of the process for the Threshold Concept Consultation.

Read to the teacher:
This videotape consultation will explore the idea of "threshold concepts" in your lesson. Threshold concepts are "difficult concepts to teach," and existing frameworks allow us to break these concepts down and consider how students experience them during and after the lesson. During this consultation you will identify a threshold concept in your lesson and dissect it according to the threshold concept framework. I will then videotape your class, and during our consultation we will watch the video and try to identify moments in your lesson that align with the elements of the threshold concept framework.

I will now read the characteristics of a threshold concept, and I will ask you to reflect upon your lesson plan for the class I will videotape. The goal is to begin thinking about the ways students will experience key concepts during and after class.

First, when learning a threshold concept, the learner experiences it as:

1. **Troublesome.** This means students may find a concept counter-intuitive, alien, or incomprehensible when it is first explained. What might be troublesome about the content you are presenting?

A big part of it is that we'll talk about chemical reactions. If the students haven't been exposed to chemistry then that's a big stumbling block for them.

2. **Bounded.** This means students might find that a word or concept is being used differently from how it is understood outside the discipline. What might be bounded about the content you are presenting?

Ozone hole is a "bad" effect of climate change. They don't know it's localized, they don't know how it relates to climate change. They probably didn't know that there was a specific piece of legislation that was successful in slowing down ozone loss. The ozone that protects us is limited to the stratosphere and students don't know that.

3. **Liminal.** This means students may find a concept to create an uneasy sense of being lost, afloat or disconnected. What aspects of the content might cause the students to experience being in a liminal space?

The process of how ozone is destroyed in the atmosphere. All the different steps and how you can break down ozone or not have it be created in the first place. Also, why is it localized to the south pole.

After learning the concept, the learner experiences it as:

4. **Integrative.** This means students will be able to bring together different aspects of the field that did not seem related. What might be integrative in the content?

Anthropogenic climate change and human health impacts. A direct connection between GHG emissions and adverse health consequences. Balancing equations is relevant here!

5. **Transformative.** This means that understanding the content will transform how the student thinks about and views the discipline and the world. What might be transformative in the content you are presenting?

This is the first time in class we've talked about how legislation can impact climate change. We've only talked about how climate change works, not about what we can do to slow it down. Counterfactual image of CFC if legislation had not been enacted.

7. **Discursive.** This means that when a student has learned the concept, his or her vocabulary and expression change; that is, his or her discourse is altered or enhanced. What about the content might affect the students' discourse?

Being able to talk more knowledgeably about ozone loss. Being able to talk about the Montreal Protocol. Paris Climate Agreement – students have heard that there's no way to get the world to agree. But history shows it's not true that we wouldn't be able to agree on something in the future.

8. **Substantial.** This means students may achieve a new way of understanding the discipline or their place in the world. How might learning the content create substantial changes in how the learner views his or her self or the world around them?

Related to all the other answers. You have a concrete example of how your actions can impact the climate – both in positive and negative ways. Just by exposing students more to chemical equations, I hope they walk away more comfortable with them. Seeing information displayed in a chemical reaction scares them off learning the content.

Do you have any further questions? I look forward to visiting your class.

Consultation Template: Threshold Concepts in the Discipline

I. Checking in on the classroom and filming experience

Ask the teacher the following questions and record the answers:

1. How is the class going and how did the class go?

The class overall is going really well. The students seem interested in the material. They are asking a lot of insightful questions during both lecture and recitation. They are integrating material from other classes and from the news. The class on Friday went well – it was a hard topic for them because there are a lot of different steps you have to remember. Almost all of them came in with questions about ozone reactions to office hours. I think the recitation helped solidify their understanding of ozone, but they probably need a little more time and help to understand what we went over.

2. Do you have any challenges with the class or the students?

Not really – they are really good students. When I ask them questions, it takes them a while to say anything/respond. It's always the same where we have the same couple of people answering the questions. I wish there was wider participation in our back and forth in the classroom.

3. Are there any observations, thoughts, or comments you have about the filming?

I noticed I was walking back and forth a lot and you had to move the camera, but apart from that no.

II. Methodology.

Read to the teacher:
This consultation will use the threshold concept framework (APPENDIX A) to better understand your lesson and how students experienced it.

a. Your job in this consultation is to observe your teaching and to think about which portions of the lesson are **troublesome, bounded, or liminal**. Whenever you think your students are experiencing one of these three concepts, please stop the video and explain what students are likely to be experiencing. Also, think about what parts of the class will lead to realizations that are **integrative, transformative, discursive,** and **substantial.** I will also add my observations to help guide our discussion.

b. As we watch the video, we will also watch the body language of the students and discuss how different students might be receiving or not receiving the information and why.

c. You don't need to take notes because I will write down everything you say. After the consultation, I will type up and return the notes to you. The notes are confidential and are designed to help you remember the consultation, to work on your plan, and to access appropriate resources as needed.

d. Remember, this is a non-evaluative process. I am neither judging nor evaluating you.

III. Watching the video and analyzing the presentation of a threshold concept

Read to the teachers
Now, let's watch the video. We'll watch it for several minutes, so you can observe how you were explaining your content for the day and how students were receiving it. You will use the threshold concept framework (APPENDIX A) to help identify how students are experiencing your teaching of the core concept.

Teacher's comments during the video:

If the teacher is quiet or seems confused, stop the video after a few minutes and ask:

Is anything "transformative, bounded, or liminal" about the first part of the lesson?

How do you think students are receiving the lesson right now?

What else are you thinking about that I can't see?

What is the body language in the class?

There are a lot of steps going on in this process – and if they don't understand the point of that slide then it would be an easy place to get lost (liminal). I think the way the slide was designed was clear (broken down into steps) and the title of the slide was the learning goal. You should learn how ozone is produced and destroyed. But because there are a lot of steps you have to understand in order, that can be liminal. The idea for ozone as a subject – you have to know what your eventual goal is which is why it can be troublesome.

--- it can be bounded in the chemical equation space??

They know the terminology associated with chemical reactions. One thing that weirded me out during office hours was that they didn't know that O3 meant ozone.

I pulled in this figure to bring in how we make conjectures based on physical observations. We base a lot on theory and it helps a lot to see an unidealized world. Additionally, I should face them more and not face the slides.

This is why we have hands on activities for them. I think you're right that chemical equations can be abstract. Using legos to break things apart and put things back together gives them a sense for what actually happens during the chemical reaction.

---In which ways do you think using the legos might be bounded?

The legos by themselves are just stacking different colors together, you're not making something **new**. You can break apart molecules and form something new, but it's a very simplified way of showing what's going on. There are some really important parts they are not getting from the hands-on activity. Plus, they aren't getting anything about the seasonal timing of these reactions.

IV. Summarizing and reviewing the teacher's notes.

Read to the teacher:
Now, I'll read back the notes. Listen for recurring issues and patterns in what you said. We will use this information to identify an issue that you may not have been aware of before this VTC.

Now read the teacher's comments back to them.

After watching the video and hearing what you said, which concepts from the threshold concept worksheet are the most illuminating when applied to your lesson?

a. For this particular subject, realizing all the aspects that were liminal was helpful. Students need an end goal to work towards, especially when there are a lot of steps in a process that they're learning.

b. Overall, this lesson was very integrative because we've already done a lot with chemical reactions. They've learned what limiting reactants are, and I've been trying to drive home that in order to destroy ozone you need two key ingredients (NO and Cl). We've talked about CFCs but we haven't discussed why they are so damaging to the environment until we talked about ozone.

c. Transformative with the Montreal Protocol. We see how climate change is occurring, but we're not spending a lot of time on solutions. We don't spend much time talking about things we could do to mitigate climate change impacts. These students are young and it's important to highlight not just what we've done wrong, but also what we've done right. I wanted to be hopeful.

V. Identifying and discussing an issue.

Now that we have watched the video and discussed threshold concepts in your teaching, what are you now more aware of?

The importance of explaining what the end goal of the lesson is. Continually tying back to a specific learning goal. And maybe a review at the end of things that I thought were particularly difficult.

What could you change or integrate into your lesson plans tomorrow, next week, and next semester in order to account for what you have learned today?

Having many modules within a lesson plan that promote meta cognitive learning. I don’t think anyone actually connects each slide to the learning goals. They see it more as an outline rather than what they should be learning. This is probably the biggest change I would make.

Pre-Consultation Template: Analysis of Teacher's Interactions with Students 2/14/2019

Purpose of the Pre-Consultation:

- To establish comfort and trust in the consultation process.
- To establish shared vocabulary surrounding classroom interactions.

Directions:

- Meet with the graduate teacher beforehand; let the graduate teacher know that the consultation is confidential and focused on the teacher's improvement, that they do not have to divulge anything they do not want to, and that you have been in their position before and know it can be uncomfortable. Tell the teacher you will take notes and return them within one week to them and gtpcert. They should check with you if they are not sure if this has been done.
- Explain the consultation process and emphasize that it is formative, not evaluative.
- Take notes on any observations you have during the class period.
- Get the time and room number for the class.
- Have the teacher tell you where to set up the camera.
- If the teacher wants to keep a copy of the video, either download the file onto the teacher's personal computer OR share it with them through your Google Drive. Please erase the video before returning the camera to the GTP office.
- Explain that the video will not be shown to anyone other than them and the Lead.
- **Log the VTC in your Lead Plan and send notes to gtpleads@colorado.edu and gtpcert@colorado.edu**

Consultant:
Danielle Lemmon

Department:
ATOC

Teacher Name:
Ariel Morrison

Department:
ATOC

Date Filmed:
2/14/19

Date Notes Returned:
4/12/19

<u>Read to the teacher:</u>
Interactional analyses represent a standard method of classroom observation that compares what a teacher thinks he or she is doing with a recorded sample of the class. It allows the teacher to examine his or her interactions with students and to correct, improve, or become aware of possible issues.

1. I will film your class for 50 minutes.

2. The video will focus primarily on your interactions with students.

3. While the camcorder is filming, I will use the Interactional Analysis Form to record your interactions with students. This will essentially be a "bean counting" type of activity that keeps track of different types of communication between you and the students.

4. As always, this video and consultation are confidential. I am here to record your responses and help facilitate reflections on your teaching and your interaction with students during class time.

Record the teacher's answers to the following questions.

1. How is your class, and what is your relationship generally like with your students?

The class is good having small group discussions amongst themselves. They are good at talking with me one on one. They are not engaged in the overall class discussion, like as a large group I don't get a lot of interaction. They talk a lot to each other, they feel comfortable asking me questions, so I try to focus more on small groups than focusing on large class discussions.

2. How do you invite students to participate in class?

I give them the class discussion topic. It's always a question. I read that to them and then I say discuss with your neighbors or your group. By week 5, they feel comfortable with each other. I let them discuss for 10 minutes, I will walk around and probe and see what they think. Give suggestions and guidance if they don't know anything about the subject. When I get back to the top of the class, I give a summary of what I heard and elicit questions from the class.

The discussion questions are moderately difficult, and meant to introduce the topic?

Yes, for example today we will be talking about how CO2 gets into the atmosphere. With the monsoon question, it's still an area of active research so there is not always a correct answer for it.

3. What do you think your students would say about your class and your teaching?

They probably think that the discussion questions are difficult because they aren't just based on what we've gone over in lecture. They must pull in outside knowledge and think about more than one subject. I hope they like the energy level. They work on the worksheet, they get a lot of discussion, and a lot of help. It's more than just sitting there and listen to me talk. The classes I had last semester were a lot more engaged and they interacted with me more. We tried to include actual activities and I think that helped.

4. What role(s) do you think students' backgrounds and identities (i.e. race, gender, nationality, etc.) may play in the class and/or your interactions with students?

I have several students for whom English is not their first language. They tend to all sit together. I had this last semester as well, but they interacted a lot more with me. The classrooms are set up really poorly (physical space) this semester. The chairs are smushed into the corner, and the students don't engage as well. I've noticed that with some answers, they don't answer the question or try to answer it at all. I don't get very many opportunities to sit down and talk to them.

Apart from that, it's an intro science class so many students aren't science majors. There's a lot of academic diversity, so for a lot of them they may be in the mindset: "science is hard, so I can't do it." This affects their ability to understand the material.

I try to interact with as many students as possible. Because it's organized weirdly it's hard to get to them all I don't feel like my interactions have been different with them at all based on any identity politics.

5. How might you react if you heard a student make an offensive or threatening comment to another student or the class?

Fortunately, I've never had to account for this. I think I'd try to bring the class back to a neutral point and try not to single any student out. Make a general comment to the class that the classroom is an environment for learning and for civil, constructive discussion. It would depend on what the comment was. We can talk about how these comments hurt the civil discourse we have around this subject. Climate change is a weird science because there is a lot of uncivil discourse around that subject. Thus, it could be an opportunity to talk about this. I'd probably try to pull the student aside afterwards, speaking to them after lecture.

6. Have you tried any strategies to make your class more inclusive?

No, but one thing I could do would be to have multiple levels of the discussion. So maybe they could get up and talk to someone from the other side of the room. Then the groups could connect and talk about different ideas. For the most part I don't think students knew each other or had friends in the recitation. So, they just sat wherever they wanted to and those became their groups. So, most of the students that talk to each other know each other well. And there's a gender balance at least.

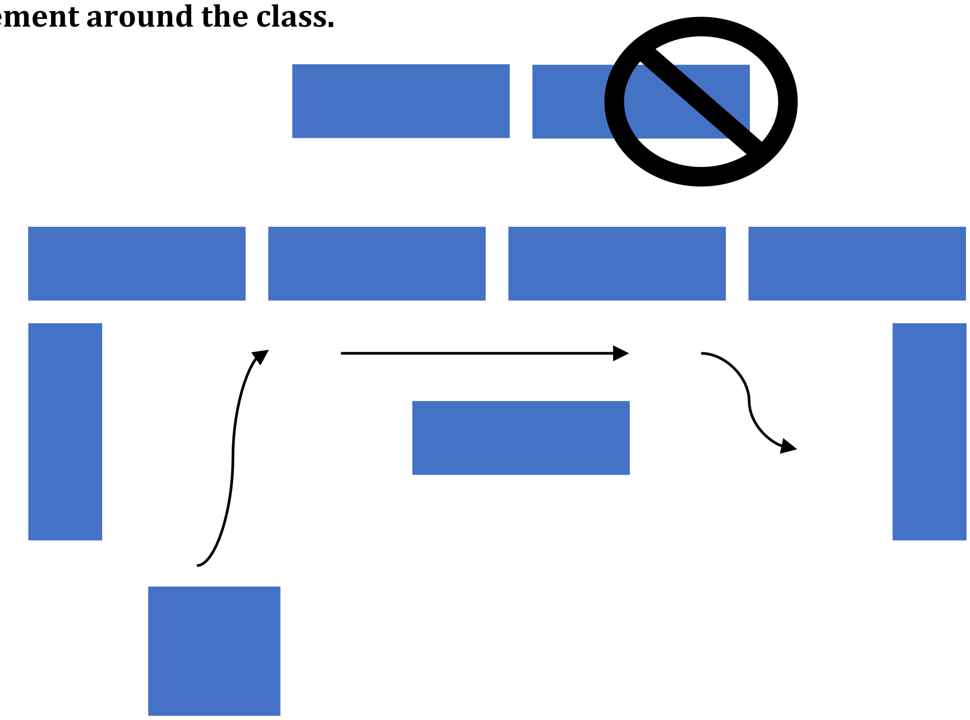
7. Is there anything you would like me to pay attention to during filming?

Since the focus is already on teacher-student interaction, no.

Desk Layout and Tally Sheet (For Use During the Observation). Please Print off and bring to the classroom observation.

For each question or comment in class, either by the teacher or a student, make a tally in each of the three following categories:

1. Seating arrangement (tally which "desk" participates). Make comments or mental notes if the teacher is not helping certain students and make note of the instructor's movement around the class.



<u>2. Types of Interactions (tally):</u>

Question/answer about content: 6
Personal connection with student: 0
Follow-up question or comment: 2
Praise: 0
Unsolicited question or comment by student: 0
Uncertain or unproductive response by the instructor: 1,2
Other:

<u>3. Tally questions for the class or the teacher:</u>

Questions for the class (tally): 1
Questions for individuals (tally): 5

Consultant's Notes:
The class is typically quiet during class discussions, but is more active during group discussions. Because of lack of teaching resource, many students not active with the teacher are not necessarily active with the assignment.

Video Consultation Template
Analysis of Teacher's Interactions with Students

Before watching the Video: Record the teacher's answers:

1. How has the class been going and how do you think this class went?

The class in general has been going pretty well. The subject was harder for this particular class. It was a lot harder because we didn't go over it in lecture so it was the first time they were exposed to the material. It turned into one on one help rather than discussion. This recitation went better than the second, which went so badly. The students at the end got mildly angry and confused, and I was confused about how to help them. Everyone was talking at the same time and it was a mess. That was the first time it had ever happened.

2. What were you aware of as you were interacting with students?

I was aware that they could tie concepts together when given a little bit of a hint, but sometimes starting them off was… most of them needed a push in the right direction and that seemed to be unique to this subject. The other times when I've gone around, they had a pretty good idea of how to articulate it. But with this one, they just didn't know how to start. But for some, after I talked them through it, they said they understood it.

3. Do you have any questions, comments, or concerns before we begin to go over the analysis of your class?

My LA and I have never asked if we could go off script, but some weeks are harder than others. I wouldn't have made this worksheet.

If it's not the first equation they've been presented with in class, it's one of the first. People always ask is there math, do I have to bring a calculator… so I wanted to assure them that this giant equation wasn't something they had to memorize.

<u>Read to the teacher:</u>

A. Thank you for letting me visit your class. I videotaped while you taught, and I also kept tallies of who spoke in your class, how often, whether you spoke to the class or to individuals, and whether your interactions with students were: *Specific Questions about Content, Personal Connection With Students, Follow-up Questions, Critical / Dismissive, Uncertain / Unproductive, Praise,* or *Other.*

B. My job as consultant is to explain what I observed and noted. You observe and comment on your own interactions, and then I will help you formulate a plan and provide you with useful resources that address a specific teaching issue.

C. Your job is to watch your own interactions: what kind of interaction is it, to whom was it directed, what was the result?

D. When we finish your observations, my notes, and the video, we will discuss what you would like to work on. Then we will make a plan for how you might like to change your own classroom interactions based on the information we gain today.

E. After the consultation, I will type up and return the notes to you. The notes are confidential and will help you to remember the consultation. Do you have any questions?

F. First, we will go over my notes, and I will point out patterns from the data. (Refer to observation tallies). Then, we will watch the video, and we can compare, explain, or question my observations. Now, we will watch the video. You can stop it whenever you want to comment on an interaction that you had with a student.

Teacher's comments while sharing the tallies:

I think the seating chart is accurate. It's generally how it works out, and that is my normal flow. Sometimes if someone has a direct question it changes.

I think the number of leading questions I give definitely depends on the group (and content).

Teacher's comments while watching the video:

I'm definitely engaging these two girls, this guy seems totally zoned out. And I'm not checking in with him. This is the problem I run into a lot when talking to people is that you can't talk to more than 2 at a time.

He's definitely "listening," he's nodding, but it was hard to directly engage him.

I'm giving them some leading questions. I could've given them more given this is a harder subject. They look engaged in what I'm saying, but I could probably like, I don't know.

I engage with the person who talks to me, but not others.

I notice the way I look at all of them to try and check in.

Given this, I am once again thinking that having them talk to each other… like do their groups and then talk to other people… as in Josh and I can't get to everyone and we're only talking to 4 at a time, would be good.

I think three people is about the max that I can talk to and feel like I'm engaging all of them.

I could've probably gotten this whole side and broad casted. But I like smaller groups because I could feel like I'm directly talking to more of them.

After discussing my notes and watching the video, what would you like to work on for future classes? Or, what have you become more aware of that you didn't recognize before this consultation?

One thing in retrospect that I should've done for this particular class is that there was a group of 4 that was waiting for me to come discuss with them. They were simply waiting for help. I could've asked the group I talked to first to go help them while I was helping others, thus facilitating more discussion. This would not only have taught those students, but given the other students a chance to solidify.

Let's brainstorm some ideas. What are some things you could try in the future?

Having them help each other out would be the number one thing. Tiers of discussion.

Small groups, 2 or 3 people. Find another group, the group becomes 4-6, and then I can address larger groups if they have questions.

Checking in with everyone in a group and specifically addressing each one of the students. Not just taking their nods as a sign that they're engaged and understanding the material.

Rearranging the desks. Figuring out which environment best facilitates discussion and maximizes how many students I speak to.

At this point you may look at the Appendix Pages. Appendix A gives strategies for engaging a wider array of learners; Appendix B gives a list of activities for engaging more students in class.

Now, what are 2-3 things you could incorporate tomorrow, next week, and next semester?

1. Tier discussions.

2. Reorganizing the room.

APPENDIX A

A Note on "Learning Styles"

KOLB, Myers Briggs, "Thinking Hats," and other learning style and personality indexes have been popular in teacher development since the 1980s. Debates continue about the claims made by such taxonomies (Do people really fit in quadrants and grids? Do self-reflexive questionnaires yield arbitrary answers? Does neuroscience support these claims?), but these tools endure because they can facilitate productive discussions, reflections, and insights into designing and assessing daily classroom activities. Moreover, they provide ideas for creating original lesson plans that may engage students who would otherwise not participate.

These models generally identify four "types" of students:

Debaters: learn by asking questions, playing devil's advocate, constantly raising their hand, blurting things out, and participating. Debaters may ask about or challenge your grading. They like to learn through dialogue and discussions.

Quiet Observers: learn by listening and thinking quietly. Quiet observers may be hesitant to take risks, share opinions, and take part in large group discussions. They like to think things through, watch others make mistakes, and thoroughly consider all options in their head. They do not externalize participation and therefore may seem like they are not paying attention.

Rationalists: Like to order, outline, and chart data. They are analytical and look for errors and precise, rational explanations. Rationalists love clear answers and will become frustrated and demand explanations when they confront ambiguity and variation.

Experiential & Creative: Like to create and relate new information to past experiences. They learn by telling and listening to stories, making personal connections with teachers, and brainstorming ideas. These types of students enjoy anecdotes and projects that require creativity. They may be bored or daydream during lectures if they do not understand how it may personally affect them.

APPENDIX B
Activities for Class

Warm-Up/Reviews:

A. **3-Concept Link** – Write three words, symbols, or images on the board and ask students to connect them
B. **Concept Cards** – Make large flashcards large enough for the class to see. Write down key concepts and then try to make links between them. You may want to tape them to the white board.

C. **Quizlet** – This mobile flashcard app lets students create digital flashcards. Have them practice vocabulary or key concepts quietly or in pairs.
D. **Whip Around** – Write concepts or problems on the board and then ask each student to provide an answer or just say something about it they remember. This will show where the class is at before you begin.
E. **Visual Thinking Strategies** – Have students observe a creative work, a math problem, or any other type of creation or formulation. Have them observe it for 5-10 minutes and write down what they "observe" and what they think is going on.

Organization:

A. **Metacognitive Explanation** – Clearly outline the course objectives and how you will achieve them through the next few activities.
B. **Socratic Method** – Pose a belief about something and then ask questions until you reveal the issue students will resolve or better understand by the end of class.
C. **Problem Solver** – Identify a problem and propose how the class will solve it.

Processing:

A. **Debaters:** *Discussions, games, role-play, comparisons and criticisms*
B. **Quiet Observers***: Journaling, Lecture, Review, In-Class Reading, Videos*
C. **Rationalists:** *Worksheets, structured lectures, data collection and analyses, puzzles*
D. **Experiential & Creative:** *Drawing pictures, sharing stories or photos, making posters, pamphlets, or other "real-world" activities*

Close and Review:

A. **Kahoot!:** Game-based review website that lets students use phones as clickers
B. **Main Point Walkback:** Have students recall or write down the main point of the class. Then have them walk back through how and why each lesson was set up.
C. **Rate the class:** on pieces of scratch paper, have students rate the class 1-5 (5 being the best) and explain why. Have them drop off their anonymous answers before they go.
D. **High/Low Value**: List 5 concepts (some important and some not) from that day's class and ask students to explain whether that idea is of high value or low value.
E. **What did you learn at school?** Ask students what they might say if their parents asked them what they learned in this class today.

Faculty Classroom Observation

ATMOSPHERIC AND OCEANIC SCIENCES

Faculty Peer Visitation Report		Semester	Spring 2019
Faculty Member	Ariel Morrison (TA)	Course & Section	ATOC 1060-014

Date April 11, 2019 Visitor Kris Karnauskas (Prof.) Place KTCH 1B84

This form is being used to observe and evaluate Ariel Morrison in regard to the CU Graduate Teacher Program, ***Certificate in Teaching Program****. This is the same form that tenured/tenure-track faculty into the ATOC department use to evaluate one another once per semester. The observation and evaluation is being conducted by Kris Karnauskas, a tenured Associate Professor in ATOC who is also the instructor of record in the overall course, ATOC 1060. The observation/evaluation is being conducted during one of the (mandatory) weekly recitation sections. On this form, "instructor" refers to Ariel.*

I. Statistics:

Students Registered ~25 Students Present ~20

Length of Lecture 50 minutes

II. Classroom: Comments on size, layout, lighting that may be pertinent to the style of lecture and effectiveness of presentations.

The size, layout and lighting of the room are appropriate for the recitation. The tables are arranged in a semi-circle with students facing toward the center/front of the room. Small-group discussions appear easy to get going with some encouragement from the instructor.

The instructor began with some subtle music and made a couple little jokes to bring the students to attention.

The instructor has a very clear voice—easy to hear from back of room.

The room is somewhat difficult to navigate and engage with students in the back corner, which is just an observation—not one that detracted from the instructor's effectiveness.

III. Instruction: Comments on the presentation of the material: points to be covered, relevance to the class, knowledge of subject matter, organization of lecture, explanation of terms and concepts.

The instructor began with some essential housekeeping like handing out graded worksheets, giving reminders of upcoming homework deadlines and other class-related activities.

The instructor also asked if students had any burning questions off the bat, as this is being conducted on the Thursday following a Mon/Wed lecture cycle. The instructor offered an open-ended question, stemming from a clicker question in lecture. The instructor went further and motivated and organized a small-group discussion in the first segment of the class around a meaty question she posed—both verbally and on the screen. Throughout this interactive and engaging activity, Ariel and her assistant (an LA) did an excellent job moving about the room, engaging with various small groups to listen and stoke the conversation. Following the small-group discussions, the instructor brought the whole class back to a full-class discussion and did an excellent job moderating the discussion with everyone in the room leaning forward, eager to chime in.

IV. <u>Instructor-Student Rapport</u>: Comments on student involvement and interaction with the instructor; opportunities for questions and discussion.

From what this observer/evaluator can determine, the instructor has a solid rapport with the students. She is very encouraging and disarming when it comes to exploring complex scientific tools and subjects. A few students had questions for her after the class period, in which she assisted as she could and also encouraged students to attend her office hours for further help.

V. <u>Style of Presentation</u>: Comments on physical movements, board/viewgraph technique, use of other resources, etc.

The instructor has an excellent command of the room; most students were listening attentively throughout most of the class, save for a cell phone check here and there. Great posture, movement, eye contact with students.

Ariel used a variety of techniques during the relatively short period. She did not over-use the projector, which is a common attribute of less experienced teachers. Ariel used PowerPoint slides appropriate, i.e., as props and visuals to go *along* with her overall plan of lesson/activities throughout the class.

VI. <u>Syllabus</u>: Comments on the syllabus, other written materials provided by instructor, including homework sets.

This question is not necessarily applicable, as the main course instructor (me, the observer/evaluator) prepares the syllabus and most of the materials. However, I will point out that Ariel is very helpful when it comes to pointing out areas for improvement and further development of materials. This is indicative of an interest in teaching with organization and cutting-edge teaching technology and methods, which bodes well for her future as a college-level instructor.

VII. <u>General Comments</u>: Comments on overall effectiveness of course as a learning experience. What long-term knowledge and insights appear to be provided by this course and this instructor?

The instructor shows all signs of being an effective instructor toward a positive learning experience for the teachers. The instructor brings a great deal of experience to her role as instructor (or recitation leader, in this case). Ariel is arriving at the end of her graduate career, so she speaks from a place of experience and authority on climate change.

I do not believe that I (or undergraduate students enrolled) would be able to tell the difference between Ariel (currently) and another professor with several years of experience teaching at the college level. When she is in the midst of her college-level teaching career (should she choose to go in that direction), I am confident she will be a well-respected colleague among her peers and well-liked by the students who take her course. Students she teaches will walk away having achieved the learning goals set forth.

VIII. <u>Strengths and Weaknesses</u>: In a constructive spirit, comment on the strong areas and weak areas (however minor or major) that you were able to observe.

Strengths:

Clarity, command and engagement with students.
Effective use of personality and humor.
Appropriate use of technology, but not over-doing it like some beginners.

Weaknesses:

It was very difficult to detect weaknesses in Ariel's teaching based on my observation.

Student Satisfaction and Concerns Survey

How satisfied are you with recitation content, on a scale of 1 to 10?
(1 = very dissatisfied, 10 = very satisfied)

How comfortable do you feel asking your peers and instructors for class-related assistance?
(1 = very uncomfortable, 10 = very comfortable)

What is one thing you would like your instructor to continue doing for recitation?

What is one thing you would like your instructor to change during recitation?

Please list any comments/suggestions for your instructor for the remainder of the semester:

Student answers to the survey are on the following page.

How satisfied are you with recitation content, on a scale of 1 to 10?	How comfortable do you feel asking your peers and instructors for class-related assistance?	What is one thing you would like your instructor to continue doing for recitation?	What is one thing you would like your instructor to change during recitation?	Please list any comments / suggestions for your instructor for the remainder of the semester:
7	10	Genuinely interested and doesn't take things too seriously	More of it :)	Keep it up - doing an excellent job!
10	10	Worksheets and practicing equations, going over slides	Doing problems together before starting worksheets	Doing a great job so far!
		Worksheets	Worksheets as they relate to tests	Any and all info as it relates to the texts; clarify if we need to know equations for the tests because professor says we don’t
10	10	Demos		
8	8	Showing interactive examples	More videos	Going over worksheets from previous class
7	8	Teaching us the calculations/formulas we use in class	Have a few extra minutes where we can ask questions about that week's lecture or quiz	
10	10	Preparation for exams		
10	10			
9	10	Going into the lecture topics more in-depth		Just keep reviewing lecture topics well
7	10	More guidance	Going over how to do the problems with equations, hard to figure them out without instruction	
8	10	Explaining in detail		
10	10		Less math	

8	10	For worksheets to actually learn and understand the material and know how to execute our knowledge. These help me learn!		
	10	Explain how to use formula correctly	It's perfect	
10	10	Answering people's questions		
8	10	Walking around for help on activities; being available and kind when help is needed	Maybe specific mini-lecture on worksheet concepts that several people have trouble with	
7	10	Explain things in depth; I like how you clarify things!	Go slower and explain things broken down and I love when you teach me/explain stuff one-on-one	Can you hold other office hours besides Monday?
6	9	Explaining the main things we've gone over in lecture	Not give worksheets with problems that won't even be in the exam	Some of exercises we do in class seem to be kind of pointless
6	9	It is interesting but difficult		Post the slides before recitation
9	8	Go over the word problem questions together	Go over the most difficult question from the previous week's quiz together	
		Half lecture/half activity	Show videos of the activity/experiments we are doing	I enjoy recitations more than class!
8	10	Demonstrating concepts with hands on/visual experiments	Draw more clear conclusions from experiments (ice bath = bad)	
9	10	All of it! I think the exercises are particularly helpful	Maybe slightly longer presenting of info	This part of the course is super helpful to hammer home the information from lecture

10	8	Going over the material until everyone understands	Discussing quiz questions if possible	Hand back worksheets
7	10	Teaching me, it is helpful with visual demonstrations		Check if we understand math concepts in class if we understand it or need to work on it
10	10	Have a little presentation/update before the worksheet. Also that you go through stuff on the board when a lot of people struggle with the same.	Keep up the good work!	
10	10	Going over quiz questions	Letting us keep the worksheets to study from	
8	9	Having assignments instead of lecture	Go over the exam more	
7	3	Giving us worksheets to work on		
8	9	Being very helpful	More in depth slides?	
10	10	Learning the material in groups		
10	10	Walking around when we work and asking if we need any help	Maybe make the worksheets a little shorter so students who have to leave early have a better chance of finishing	I appreciate you letting students leave early and accommodating for the messed up bus schedule. Hopefully something will change soon. I also like how it feels more direct and intimate, I feel that it's easier to ask questions
7	10	Going more in depth on certain topics covered in lecture		

ATOC 1060 (013): Our Changing Environment (Recitation)

Fall 2018 | Ariel Morrison

28	Students Enrolled
13	Students Responded
46.43%	Response Rate

Quantitative

	0-3 hours	4-6 hours	7-9 hours	10-12 hours	13-15 hours	16+ hours	Not applicable	N	DNA	SD	M
Estimate the average number of hours per week you have spent on this course for all course-related work including attending classes, labs, recitations, readings, reviewing notes, writing papers, etc.	53.85% (7)	38.46% (5)	7.69% (1)	0% (0)	0% (0)	0% (0)	0% (0)	13	0	-	-

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate your personal interest in this material before you enrolled.	7.69% (1)	15.38% (2)	7.69% (1)	30.77% (4)	30.77% (4)	7.69% (1)	0% (0)	13	0	1.41	3.85

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate the intellectual challenge of this course.	7.69% (1)	15.38% (2)	15.38% (2)	30.77% (4)	23.08% (3)	7.69% (1)	0% (0)	13	0	1.38	3.69

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate how much you learned in this course.	0% (0)	0% (0)	7.69% (1)	38.46% (5)	23.08% (3)	30.77% (4)	0% (0)	13	0	0.97	4.77

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate the course overall.	0% (0)	0% (0)	7.69% (1)	30.77% (4)	38.46% (5)	23.08% (3)	0% (0)	13	0	0.89	4.77

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate the instructor's effectiveness in encouraging interest in this subject.	0% (0)	0% (0)	0% (0)	15.38% (2)	23.08% (3)	61.54% (8)	0% (0)	13	0	0.75	5.46

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate the instructor's availability for course-related assistance such as email, office hours, individual appointments, phone contact, etc.	0% (0)	0% (0)	0% (0)	7.69% (1)	15.38% (2)	76.92% (10)	0% (0)	13	0	0.61	5.69

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate this instructor's respect for and professional treatment of all students regardless of race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation, or political philosophy.	0% (0)	0% (0)	0% (0)	0% (0)	15.38% (2)	84.62% (11)	0% (0)	13	0	0.36	5.85

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate the instructor overall.	0% (0)	0% (0)	0% (0)	0% (0)	30.77% (4)	69.23% (9)	0% (0)	13	0	0.46	5.69

	Engineering	Natural Sciences	Social Sciences	Humanities	Other	Not applicable	N	DNA	SD	M
BD-D-ATOC-A01. My major area:	0% (0)	30.77% (4)	0% (0)	15.38% (2)	46.15% (6)	7.69% (1)	13	0	-	-

	A	B	C	D	F	Not applicable	N	DNA	SD	M
BD-D-ATOC-A02. Grade expected in this course (if taking Pass/Fail, estimate grade):	53.85% (7)	23.08% (3)	7.69% (1)	0% (0)	0% (0)	15.38% (2)	13	0	-	-

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
BD-D-ATOC-A03. How does this course compare to other physical science courses you have taken?	0% (0)	0% (0)	23.08% (3)	23.08% (3)	38.46% (5)	7.69% (1)	7.69% (1)	13	0	0.94	4.33

	None	1	2	3	4+	N	DNA	SD	M
BD-D-ATOC-A04. Number of other science courses, including math, you have had at CU.	23.08% (3)	7.69% (1)	38.46% (5)	15.38% (2)	15.38% (2)	13	0	-	-

Qualitative

Please offer constructive comments to your instructor regarding your experience in this course. If you wish to make comments *about* the instructor, you may wish to do so separately to the appropriate chair or dean. -

- I liked Ariel a lot. She was smart and engaged in the topic. I don't know why we practiced math problems in recitation that we weren't tested on in class.
- Great, down to earth teacher who does a good job at explaining materials
- I appreciate you being flexible when students had class on main campus 10 minutes later
- Hey, you! You did a great job encouraging interest in the subject and explaining it. Overall, I think the only thing I'd change would be to maybe have the course lectures recorded, but even then, that wouldn't help all that much. Putting the lecture slides up is more than enough.
- Offered a different style of explanation of the information which helped me understand it more so .
- thank you so much for all of your help this semester! you are a great teacher!! :)

ATOC 1060 (014): Our Changing Environment (Recitation)

Fall 2018 | Ariel Morrison

22	Students Enrolled
13	Students Responded
59.09%	Response Rate

Quantitative

	0-3 hours	4-6 hours	7-9 hours	10-12 hours	13-15 hours	16+ hours	Not applicable	N	DNA	SD	M
Estimate the average number of hours per week you have spent on this course for all course-related work including attending classes, labs, recitations, readings, reviewing notes, writing papers, etc.	61.54% (8)	15.38% (2)	23.08% (3)	0% (0)	0% (0)	0% (0)	0% (0)	13	0	-	-

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate your personal interest in this material before you enrolled.	0% (0)	15.38% (2)	15.38% (2)	23.08% (3)	30.77% (4)	15.38% (2)	0% (0)	13	0	1.29	4.15
Rate the intellectual challenge of this course.	0% (0)	7.69% (1)	0% (0)	30.77% (4)	38.46% (5)	23.08% (3)	0% (0)	13	0	1.07	4.69
Rate how much you learned in this course.	0% (0)	7.69% (1)	7.69% (1)	15.38% (2)	30.77% (4)	38.46% (5)	0% (0)	13	0	1.23	4.85
Rate the course overall.	7.69% (1)	7.69% (1)	0% (0)	15.38% (2)	30.77% (4)	38.46% (5)	0% (0)	13	0	1.54	4.69
Rate the instructor's effectiveness in encouraging interest in this subject.	0% (0)	0% (0)	15.38% (2)	7.69% (1)	30.77% (4)	46.15% (6)	0% (0)	13	0	1.07	5.08
Rate the instructor's availability for course-related assistance such as email, office hours, individual appointments, phone contact, etc.	0% (0)	0% (0)	0% (0)	15.38% (2)	15.38% (2)	69.23% (9)	0% (0)	13	0	0.75	5.54
Rate this instructor's respect for and professional treatment of all students regardless of race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation, or political philosophy.	0% (0)	0% (0)	0% (0)	0% (0)	7.69% (1)	92.31% (12)	0% (0)	13	0	0.27	5.92
Rate the instructor overall.	0% (0)	0% (0)	0% (0)	15.38% (2)	23.08% (3)	61.54% (8)	0% (0)	13	0	0.75	5.46

	Engineering	Natural Sciences	Social Sciences	Humanities	Other	Not applicable	N	DNA	SD	M
BD-D-ATOC-A01. My major area:	0% (0)	23.08% (3)	7.69% (1)	7.69% (1)	61.54% (8)	0% (0)	13	0	-	-

	A	B	C	D	F	Not applicable	N	DNA	SD	M
BD-D-ATOC-A02. Grade expected in this course (if taking Pass/Fail, estimate grade):	46.15% (6)	38.46% (5)	7.69% (1)	0% (0)	7.69% (1)	0% (0)	13	0	-	-

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
BD-D-ATOC-A03. How does this course compare to other physical science courses you have taken?	0% (0)	15.38% (2)	0% (0)	30.77% (4)	23.08% (3)	7.69% (1)	23.08% (3)	13	0	1.22	4.1

	None	1	2	3	4+	N	DNA	SD	M
BD-D-ATOC-A04. Number of other science courses, including math, you have had at CU.	7.69% (1)	30.77% (4)	38.46% (5)	7.69% (1)	15.38% (2)	13	0	-	-

Qualitative

Please offer constructive comments to your instructor regarding your experience in this course. If you wish to make comments *about* the instructor, you may wish to do so separately to the appropriate chair or dean. -

- Very helpful
- Recitation was always very interesting and you did well teaching it.
- Really great recitation. Learned a lot and it finalized subject matter I was previously unsure about knowing.

ATOC 1060 (013): Our Changing Environment (Recitation)

Spring 2019 | Ariel Morrison

23	Students Enrolled
7	Students Responded
30.43%	Response Rate

Quantitative

	0-3 hours	4-6 hours	7-9 hours	10-12 hours	13-15 hours	16+ hours	Not applicable	N	DNA	SD	M
Estimate the average number of <u>hours per week</u> you have spent on this course for <u>all</u> course-related work <u>including</u> attending classes, labs, recitations, readings, reviewing notes, writing papers, etc.	85.71% (6)	0% (0)	14.29% (1)	0% (0)	0% (0)	0% (0)	0% (0)	7	0	-	-

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate your personal interest in this material before you enrolled.	0% (0)	28.57% (2)	14.29% (1)	14.29% (1)	14.29% (1)	28.57% (2)	0% (0)	7	0	1.6	4

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate the intellectual challenge of this course.	0% (0)	28.57% (2)	42.86% (3)	0% (0)	0% (0)	28.57% (2)	0% (0)	7	0	1.59	3.57

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate how much you learned in this course.	0% (0)	14.29% (1)	14.29% (1)	14.29% (1)	28.57% (2)	28.57% (2)	0% (0)	7	0	1.4	4.43

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate the course overall.	0% (0)	14.29% (1)	14.29% (1)	14.29% (1)	28.57% (2)	28.57% (2)	0% (0)	7	0	1.4	4.43

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate the instructor's effectiveness in encouraging interest in this subject.	0% (0)	14.29% (1)	0% (0)	0% (0)	42.86% (3)	42.86% (3)	0% (0)	7	0	1.31	5

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate the instructor's availability for course-related assistance such as email, office hours, individual appointments, phone contact, etc.	0% (0)	0% (0)	0% (0)	0% (0)	14.29% (1)	71.43% (5)	14.29% (1)	7	0	0.37	5.83

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
***Rate this instructor's respect for and professional treatment of all students* regardless of race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation, or political philosophy.**	0% (0)	0% (0)	0% (0)	0% (0)	14.29% (1)	85.71% (6)	0% (0)	7	0	0.35	5.86

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate the instructor overall.	0% (0)	14.29% (1)	0% (0)	0% (0)	28.57% (2)	57.14% (4)	0% (0)	7	0	1.36	5.14

	Engineering	Natural Sciences	Social Sciences	Humanities	Other	Not applicable	N	DNA	SD	M
BD-D-ATOC-A01. My major area:	0% (0)	42.86% (3)	14.29% (1)	0% (0)	42.86% (3)	0% (0)	7	0	-	-

	A	B	C	D	F	Not applicable	N	DNA	SD	M
BD-D-ATOC-A02. Grade expected in this course (if taking Pass/Fail, estimate grade):	28.57% (2)	42.86% (3)	28.57% (2)	0% (0)	0% (0)	0% (0)	7	0	-	-

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
BD-D-ATOC-A03. How does this course compare to other physical science courses you have taken?	0% (0)	0% (0)	28.57% (2)	57.14% (4)	0% (0)	14.29% (1)	0% (0)	7	0	0.93	4

	None	1	2	3	4+	N	DNA	SD	M
BD-D-ATOC-A04. Number of other science courses, including math, you have had at CU.	0% (0)	14.29% (1)	0% (0)	28.57% (2)	57.14% (4)	7	0	-	-

Qualitative

Please offer constructive comments to your instructor regarding your experience in this course. If you wish to make comments *about* the instructor, you may wish to do so separately to the appropriate chair or dean. -

- I know you're right there with me when I say that recitation is a huge waste of everyones time, but thank you for being the best TA for the job. I appreciate you letting me slide with some of my missed classes and for being a real person instead of a kiss-ass like all other TA's.
- Recitation section is about as expected. Worksheets were all relevant though, which was very nice. Some classes have generic material that conflicts with the way the professor is teaching the subject. Makes it tough, but this course avoided that by giving the professor a say in it.

ATOC 1060 (014): Our Changing Environment (Recitation)

Spring 2019 | Ariel Morrison

20	Students Enrolled
12	Students Responded
60%	Response Rate

Quantitative

	0-3 hours	4-6 hours	7-9 hours	10-12 hours	13-15 hours	16+ hours	Not applicable	N	DNA	SD	M
Estimate the average number of hours per week you have spent on this course for all course-related work including attending classes, labs, recitations, readings, reviewing notes, writing papers, etc.	75% (9)	16.67% (2)	0% (0)	0% (0)	0% (0)	8.33% (1)	0% (0)	12	0	-	-

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
Rate your personal interest in this material before you enrolled.	33.33% (4)	8.33% (1)	8.33% (1)	8.33% (1)	33.33% (4)	8.33% (1)	0% (0)	12	0	1.88	3.25
Rate the intellectual challenge of this course.	0% (0)	8.33% (1)	16.67% (2)	41.67% (5)	33.33% (4)	0% (0)	0% (0)	12	0	0.91	4
Rate how much you learned in this course.	0% (0)	0% (0)	33.33% (4)	16.67% (2)	33.33% (4)	16.67% (2)	0% (0)	12	0	1.11	4.33
Rate the course overall.	0% (0)	8.33% (1)	0% (0)	41.67% (5)	33.33% (4)	16.67% (2)	0% (0)	12	0	1.04	4.5
Rate the instructor's effectiveness in encouraging interest in this subject.	0% (0)	0% (0)	16.67% (2)	25% (3)	16.67% (2)	41.67% (5)	0% (0)	12	0	1.14	4.83
Rate the instructor's availability for course-related assistance such as email, office hours, individual appointments, phone contact, etc.	0% (0)	8.33% (1)	0% (0)	8.33% (1)	16.67% (2)	66.67% (8)	0% (0)	12	0	1.18	5.33
Rate this instructor's respect for and professional treatment of all students regardless of race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation, or political philosophy.	0% (0)	0% (0)	0% (0)	0% (0)	8.33% (1)	91.67% (11)	0% (0)	12	0	0.28	5.92
Rate the instructor overall.	0% (0)	0% (0)	8.33% (1)	8.33% (1)	25% (3)	58.33% (7)	0% (0)	12	0	0.94	5.33

	Engineering	Natural Sciences	Social Sciences	Humanities	Other	Not applicable	N	DNA	SD	M
BD-D-ATOC-A01. My major area:	0% (0)	16.67% (2)	33.33% (4)	0% (0)	50% (6)	0% (0)	12	0	-	-

	A	B	C	D	F	Not applicable	N	DNA	SD	M
BD-D-ATOC-A02. Grade expected in this course (if taking Pass/Fail, estimate grade):	50% (6)	25% (3)	25% (3)	0% (0)	0% (0)	0% (0)	12	0	-	-

	1 = Lowest	2	3	4	5	6 = Highest	Not applicable	N	DNA	SD	M
BD-D-ATOC-A03. How does this course compare to other physical science courses you have taken?	8.33% (1)	8.33% (1)	16.67% (2)	50% (6)	16.67% (2)	0% (0)	0% (0)	12	0	1.11	3.58

	None	1	2	3	4+	N	DNA	SD	M
BD-D-ATOC-A04. Number of other science courses, including math, you have had at CU.	0% (0)	25% (3)	16.67% (2)	41.67% (5)	16.67% (2)	12	0	-	-

Qualitative

Please offer constructive comments to your instructor regarding your experience in this course. If you wish to make comments *about* the instructor, you may wish to do so separately to the appropriate chair or dean. -

- She was a great TA. Very smart and always made us participate and encouraged it.
- Ariel is a straightforward and helpful TA and i rly appreciate her. She was helpful when we needed to study or had questions ab the worksheets
- Ariel was a very good TA and was very helpful.
- Sweetest TA ever. Also really knew how to explain complicated concepts in ways we could all easily understand. She was great!!
- I really appreciated Ariel Morrison's help during recitation, as well as with homework assignments. She is so understanding and thoughtful that it made approaching her with questions on material/assignments very comfortable. I appreciate all of her support throughout the semester.
- If you were more energetic and enthusiastic for the subject, students would be more eggar to learn.
- Especially at the beginning of the semester it was hard to tie in what was taught in recitation with stuff from class
- Ariel is great!

Appendix E

Climatic Change article abstract

Quantifying student engagement in learning about climate change using galvanic hand sensors in a controlled educational setting

A.L. Morrison, S. Rozak, A.U. Gold, and J.E. Kay

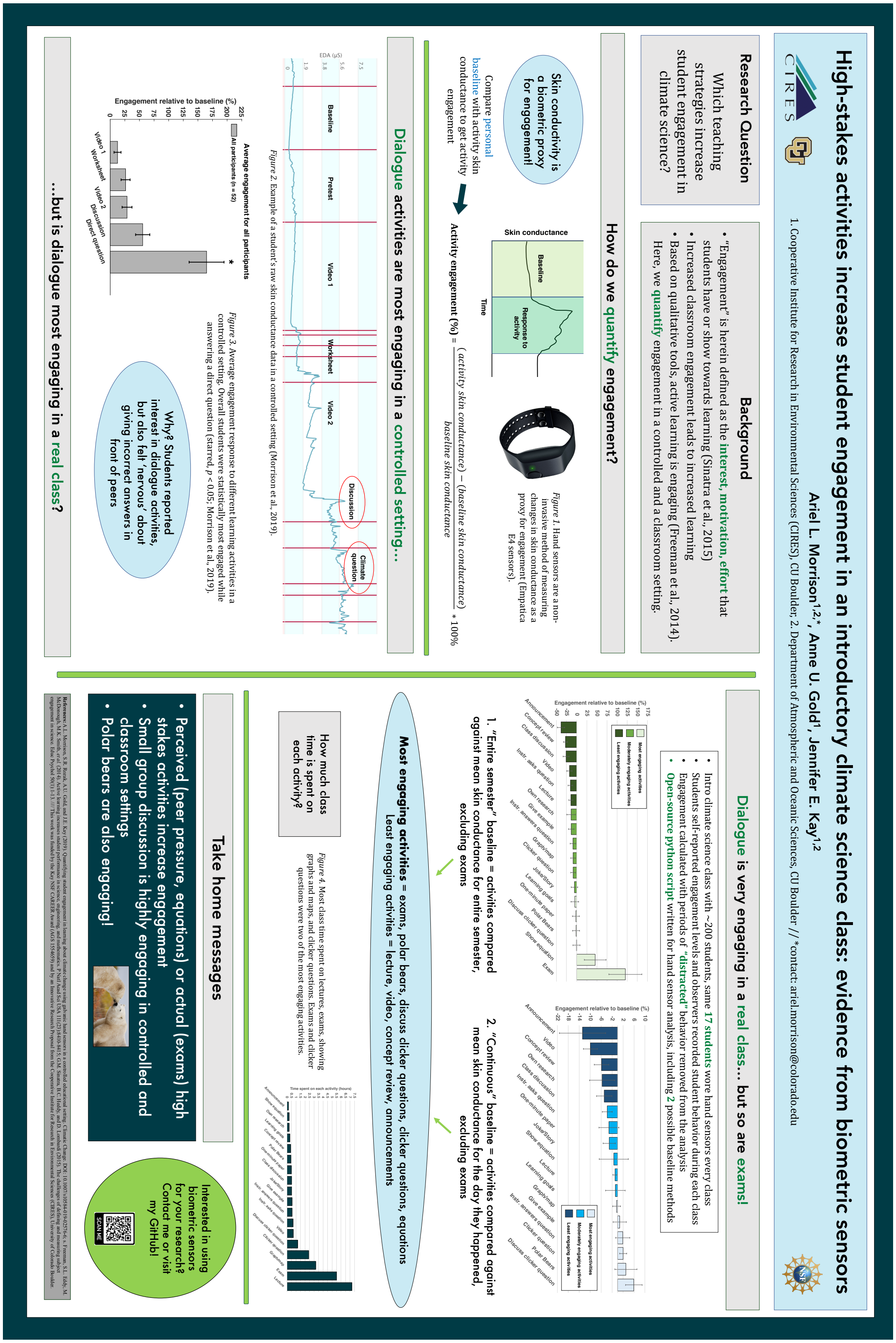
Abstract

Teaching climate change is complex because it requires a system-level understanding of many science disciplines, and also because students may have preconceptions about climate change. Previous work shows students learn and retain science content better when they are engaged in the learning process. Active learning strategies engage students in learning science, but the engagement impact of active learning has not yet been assessed in a controlled environment using both biometric and self-reporting tools. Here we analyze 52 university students' engagement during several common active learning strategies in a controlled research setting. We collected biometric data from all participants with hand sensors that measured changes in skin conductance as a proxy for engagement. Participants self-reported their engagement as a control. The combined biometric and self-reported data show that skin conductance data matched self-reported engagement, confirming that skin conductance is a robust proxy for engagement. Overall, dialogue was the most engaging activity, with engagement levels about 165% above baseline. Non-science majors had higher average engagement than science majors (137% vs. 53% above baseline, respectively). Notably, skin conductance data showed no statistically significant differences based on participants' political or religious affiliations. In summary, our results demonstrate biometric sensors' potential to measure and monitor engagement in a learning environment. Relevant for climate education, in-class dialogue increases student engagement in learning climate science and is especially effective for non-science majors.

Citation:

Morrison, A.L., Rozak, S., Gold, A.U. et al. Quantifying student engagement in learning about climate change using galvanic hand sensors in a controlled educational setting. *Climatic Change* (2020) doi:10.1007/s10584-019-02576-6

Poster presentation at the American Geophysical Union conference 2019



Appendix F

The following are descriptions of two college courses that I would like to design and teach in the future:

Communicating climate change

Designed for freshmen and sophomores, this course would investigate the means by which people communicate about climate change. By examining different communication strategies, students will contextualize the powerful intersection of data and storytelling within broader societal narratives that reveal how climate change is experienced and perceived differently by different populations. Which methods are employed to communicate to different sectors – e.g., the general public, politicians, and resource managers? Are celebrities or well-known figures good vehicles for disseminating information? How does the use of iconic climate change imagery, such as polar bears or wildfires, affect the reception of information? Course material would draw from the work of climate science communicators such as Katharine Hayhoe, Saffron O'Neill, Naomi Oreskes, and Greta Thunberg, plus Pope Francis's climate encyclical and the Yale Program on Climate Change's Six Americas study. Students would gain an understanding of methods used to communicate effectively (and ineffectively) about a difficult and sometimes divisive subject – knowledge that is broadly applicable to students' interdisciplinary studies.

Bi-polar climate change: Arctic vs. Antarctic climate change

The Arctic is the fastest-warming region in the world in response to anthropogenic greenhouse gas emissions, but Antarctic temperatures show very little trend. The minimum Arctic sea ice extent has decreased by 13% per decade since 1979, while the minimum Antarctic sea ice extent has increased 3% per decade over the same time period. Why are the Arctic and Antarctic responding differently to increasing greenhouse gas concentrations? What are the global implications for environmental changes at the poles? How uniform or regional are the observed and predicted changes? In this course I propose to answer the above questions and examine the physical mechanisms responsible for Arctic and Antarctic climate change. Students would use observational data from the GRACE satellite to study changes in the Antarctic and Greenland ice sheets, as well as climate model data from both a fully-coupled global climate model and an aquaplanet model to study polar amplification. The course would incorporate discussion of feedbacks in the climate system, reversibility of climate change impacts, and the societal implications of both Arctic and Antarctic climate change.