Students demand high-quality climate change course offerings

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Large numbers of Americans of all ages are interested in learning more about climate change education (CCE) (Perkins et al. 2017) and high schools have the opportunity to contribute to that learning. The Next Generation Science Standards (NGSS Lead States 2013) attempt to address climate change for high school students across disciplines. Despite the presence of climate change in NGSS, most high schools do not dedicate a class specifically to climate change or even to Earth Science. This leaves the burden of CCE to physics, chemistry, and biology classes, which often make space for it by mentioning the topic in ancillary form (Monroe et al. 2013).

While it should be common practice to talk about climate change throughout the curriculum (NGSS Lead States 2013), only addressing climate when it comes up in other classes results in students graduating high school still unable to articulate the causes or effects of climate change as well as what needs to be done to address the problem (Monroe, Oxarart, and Plate 2013; Reid 2019; Schreiner, Henriksen, and Kirkeby Hansen 2005). Even if building climate change into other science classes was an effective strategy for teaching climate science, students would still not have gained climate literacy because CCE should also incorporate societal effects and climate justice (Stapleton 2019).

To leave students with applicable knowledge, CCE must be interdisciplinary. This allows students to address the most important questions—ones left out when CCE is just taught from an Earth Science perspective—such as “How might farmers adapt to changing climatic conditions? How might such adaptations affect the price of staple foods, such as corn or wheat?” (Monroe, Oxarart, and Plate 2013). Many articles reference what CCE should do (Chang and Pascua 2017; Monroe, Oxarart, and Plate 2013; Monroe et al. 2017; Reid 2019; Schreiner, Henriksen, and Kirkeby Hansen 2005; Stapleton 2019). None of these lists can be accomplished in passing (Supplementary Materials 1; see Online Connections). A stand-alone climate change course provides time for students to develop needed synthesis and skills and allows teachers in other classes to address climate change as it naturally comes up. In this case study, we provide evidence of that demand and propose a path for schools to deliver on it.

The study site
The Battle Creek Area Mathematics and Science Center (BCAMSC), a STEM school operated by Battle Creek Public Schools in Battle Creek, Michigan, began providing an interdisciplinary mini-course in climate change in 2004. Recognizing the impor-
tance of CCE and reflecting on the limits of the mini-course, a one semester class was developed to replace it. After failing to find a developed curriculum (Monroe et al. 2017) or other high schools offering a climate change course, we created our own with university guidance. This semester-long, high school–level course was designed to meet the NGSS as well as the standards of quality CCE mentioned above. This course was piloted during the 2020–2021 school year and was open to all 11th and 12th graders enrolled at BCAMSC. Due to the COVID-19 pandemic, the entire pilot was taught virtually. Activities that were to be hands-on were recorded as demonstration videos.

Course structure

Because the course was piloted during virtual learning, a flipped classroom was used. Direct instruction and discussion provided information when we were unable to find or create labs or activities to convey the information (e.g., the difference between weather and climate). Labs or demonstrations demonstrated the physical phenomena.

Class time also included other interactive activities: a daily climate-related current event, a Journal Club discussion, and work on a semester project. Current events placed climate change into social context and were shared by one student per class. Students signed up by alternating between popular and scientific sources. The differences between the two types of sources and what can be learned from them was discussed on an ongoing basis.

In Journal Club students read and discussed primary literature every few weeks. The readings were selected from scientific literature that aligned with topics in the class. This included the free-to-download IPCC Synthesis Report (2014), which served as the textbook for the course. Scaffolding reading at this level requires helping students identify the most important parts of the reading, such as figures and conclusions, and recognizing that it is okay to not understand every aspect of an article.

A semester project served as the final component of the course where students designed a project in consultation with the instructor (aligning with one or more NGSS Science and engineering practices) that had potential for results or a product that would be usable by someone at the conclusion of the course (e.g., climate assessment of local natural area or city). Students were encouraged to submit their projects to the potentially interested groups or organizations (e.g., Department of Transportation or city planning commission) once complete.

Because climate change misconceptions abound (McNeil and Vaughn 2012), we identified common misconceptions ahead of time and provided tools to prevent or resolve these noncanonical understandings. One of the most common misconceptions of climate change is that all environmental problems are the same thing (Schreiner, Henriksen, and Kirkeby Hansen 2005; McNeil and Vaughn 2012; Drewes, Henderson, and Mouzer 2018; Monroe et al. 2017). For example, many students are unable to distinguish the difference between chlorofluorocarbons resulting in a reduction of stratospheric ozone and carbon dioxide in the atmosphere resulting in increased temperatures; this information should be incorporated into the curriculum (McNeil and Vaughn 2012). Instead of telling students that the two can be confused, we start by discussing the ozone hole (because they are already familiar with it) and how ozone interacts with UV radiation before even mentioning the greenhouse effect and carbon dioxide interacting with infrared radiation. We then ask them to explain how the two phenomena are different and similar.

By starting the course with the science and then waiting until students start asking about social aspects, students are not lost through the transition; it becomes a more natural fit for a teacher who has not dipped their toes into social discussion before. With climate change broken up over a semester, the class is long enough for students to learn about the science and societal impact/climate justice.

Results

During the pilot year (fall 2020 and spring 2021), 95 juniors and seniors out of 152 in the school enrolled in the course. All students had completed physics, biology, and chemistry as prerequisites. Thirty-nine juniors and 29 seniors in the fall semester completed the course survey. Those enrolled in the fall were evenly divided by gender (34 male, 32 female, 2 nonbinary/other). Students self-reported (n = 68) as living in urban (22.1%), suburban (51.5%), or rural areas (26.5%), suggesting interest exists regardless of urban-rural divide, even in counties with acceptance of global warming science below the national average (Howe et al. 2015). Before the pilot began, and again at its conclusion, fall semester students were given a short anonymous survey to determine the impact of the course on their views about climate change and the merit of the course for inclusion in the school’s schedule of courses. We recognize that these survey results come from the slightly more than half of the student body that self-selected to take the course and therefore do not represent a random sample of high school students.
Sixty-eight out of the 74 students (92%) enrolled during the fall semester participated in the survey. Overwhelmingly, the students found the class useful and believe that other high schools should offer a similar course (Figure 1). Despite this course providing an entire semester on climate change, 66% of the students (n = 67) said the class should be broken up over more than one semester.

When asked for other comments about the course (Table 2; see Online Connections), responses suggest that students enjoyed the class and left it feeling as if they understood the material. With the goal of refining the course for future students, survey respondents were asked if there were any activities or assignments that they believe were not useful. 93% said no (n = 68) (Supplementary Materials 2; see Online Connections).

Responses to questions about goals for the class were more nuanced (Figure 2) with no singular area dominating student curiosity. In all of the questions a substantial majority of the class agreed at some level with the statement in the survey question (somewhat agree, agree, strongly agree). When faced with wanting to “understand” versus wanting to “influence,” the students were more likely to have a neutral response in their desire to influence.

Discussion

This course offering found a high demand for quality comprehensive CCE in high school students. Numerous students who enrolled in the course expressly stated its importance—“I think this class was hands down the most useful and important class I have taken in high school…” or “I loved this class so much and I am so glad that I took this class” (Table 2). The students also recommended that other high schools offer a similar program (Figure 1). Though an entire semester was devoted to the course, a majority of students thought more time was needed.

As one student pointed out (Table 2), the course was not perfect in its pilot form. Returning to in-person instruction will reduce the need for direct instruction and increase the number of labs and hands-on activities. In the second iteration in spring 2021, Journal Club went more smoothly as teacher skills were developed to help students with challenging readings. This was the first experience most of the students had with reading peer-reviewed literature. Helping them get past the idea that they have to understand everything written to count the reading as successful was essential. If they could understand what the figures were saying, what they meant, and how they were created, it was good enough. Getting to read the IPCC Summary Report led one student to express that they felt like they were being given secret insider information. Journal Club showed students that there is more information known than shows up on the first page of a Google search. One student even said in class, “I didn’t know someone could know so much about anything.” The semester project presents the biggest challenge to improving the course. Students need substantial time to create a meaningful product but do not know enough during the first portion of the course to ask a strong question. If we are able to break up the class across multiple semesters as students want, the project will take place in semester 2. The current event structure went really well with students feeling they were getting to learn things that were happening at the moment.

Selling the idea of an elective course to administration usually involves whether students will sign up for it, whether there is a textbook, and how much its implementation will cost. Based on our survey results—which need to be viewed as anecdotal (Figure 1)—we believe student interest will not be a problem. Students want access to this material and want to understand it (Figure 2). Students expressed that taking a class on the topic was useful and should be offered at other schools (Figure 1). The IPCC Synthesis Report is a strong option for a textbook and is downloadable for free as a PDF, and the cost of supplies to run the class is nominal.
TABLE 3

Shared resources for establishing Global Climate Change as a high school course.

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<thead>
<tr>
<th>Material</th>
<th>Link</th>
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<tbody>
<tr>
<td>Instructor Handbook</td>
<td><a href="https://docs.google.com/document/d/1HqWq9LY3fZRBxYgcgv5E2HCCwK2QWBHNtDCrV7bXdc/edit?usp=sharing">https://docs.google.com/document/d/1HqWq9LY3fZRBxYgcgv5E2HCCwK2QWBHNtDCrV7bXdc/edit?usp=sharing</a></td>
</tr>
<tr>
<td>Video recordings of lessons prepared for a flipped classroom</td>
<td><a href="https://www.youtube.com/channel/UC806TECTbtw8WDKvpslOrpw">https://www.youtube.com/channel/UC806TECTbtw8WDKvpslOrpw</a></td>
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The Instructor Handbook is a living document that is continually updated as improvements are made to the course. It contains the resources used to teach the course including readings, slides, labs, and teacher notes.

Providing Global Climate Change or Honors Global Climate Change as an independent course at the high school level solves many of the problems in CCE today. Most secondary science teachers are not required to have any climate science training (Reid 2019), and though lack of teacher knowledge overall can be addressed with increased opportunities for professional development (Drewes, Henderson, and Mouzer 2018), 24% of high school teachers report a detailed understanding of climate science (Monroe, Oxarart, and Plate 2013). The independent class addresses teachers’ lack of knowledge by requiring only one qualified teacher per school.

Recognizing that lack of high school accessible resources was a major obstacle in putting the course together, we are happy to share curricular materials (Table 3) and insight. Based on what we have learned, we believe implementing a program similar to this at other high schools is readily achievable and highly desirable. Additionally, for teachers who want a ready-made course, we have modified this course for use in the Gooru platform (https://gooru.org/content/courses/play/42959c7c-d0a5-4a5e-a57f-d584925bfa52) where it is available to other educators.

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ONLINE CONNECTIONS

Table 1. https://bit.ly/3d1fFrp
Table 2. https://bit.ly/3QhLJ6

REFERENCES


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