HIGH SCHOOL EDITION
Journal of Student Research
Volume 11 Issue 3 (2022)

Multidisciplinary Climate Change Education: Determining Effectiveness Through Comparative Analysis

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ABSTRACT

Climate Change Education (CCE) is one of the most widely-recognized mitigative solutions to the climate crisis, but research suggests that most global and national CCE policies and curricula are ineffective. A reason for this is that existing CCE curriculum consists of purely science-based pedagogy, despite the fact that multiple studies suggest that a multidisciplinary approach—involving humanities and the arts rather than just science—would be more effective. A case study was conducted at a select California high school, and compared the effectiveness of multidisciplinary CCE to the existing, science-focused CCE, in terms of Climate Literacy (CL) outcomes in students. CL encompasses climate change knowledge, credibility assessment skills, communication skills, and climate-related behavior, four factors that are important determinants when evaluating CCE effectiveness. Using survey research and structured interviews, the CL of students who took 3 or greater Advanced Placement (AP) courses was compared to that of students who took less than 3 such courses. Involvement in Advanced Placement (AP) classes, college-level classes offered to students by the College Board, was used as an indicator of being exposed to multidisciplinary CCE, and was compared to the effects of the Next Generation Science Standards (NGSS) which are currently in use in California. The research found that CL within students was significantly greater in AP students in terms of climate change knowledge, credibility assessment, and communication; but climate-related behavior was low in both groups of students and did not seem to be affected by educational curriculum.

Introduction

Climate Change Education (CCE) is one of the most widely-recognized mitigative solutions to the climate crisis, therefore it is crucial that the most effective methods of CCE are being implemented globally. According to various research, however, this fails to be the case. In their 2019 analysis of the state of climate and environmental education in secondary schools around the world, Ritchie et al. found that very few countries showed a significant increase in environmental literacy rates across an eleven year period—from 2005 to 2016—despite the concurrent or even prior implementation of CCE in various forms. In the United States specifically, a 2020 study conducted by the National Center for Science Education found many failures within the CCE standards of various states, including: the promotion of "false debate", implying that the issue of climate change (CC) has two sides, when in reality the phenomenon is agreed upon by the overwhelming majority of scientists; failure to explicitly discuss climate change; and failure to urge students towards climate change solutions in a hopeful manner.

A possible reason for the ineffectiveness of current CCE, especially in the United States, is that most CCE is taught purely in scientific disciplines. This is unanticipated, as much literature, such as Læssøe et al. (2009) and Wise (2010), argue for an interdisciplinary approach to teaching about climate change, encompassing physical science, social sciences, and the humanities. This disconnect between existing educational resources and research-based sug-

gestions demonstrates that there is a misconception or lack of perceived validity surrounding a multidisciplinary approach to CCE, pointing towards a necessity for empirical research to be conducted on this issue. Therefore, this research paper will look to add evidence-based research to the existing knowledge on multidisciplinary climate change education, with the initial research question being "Does multidisciplinary climate change education lead to greater climate literacy within students than existing, science-focused curricula do?"

Literature Review

Education Impact on Climate Literacy

Before beginning this research, it is important to understand the existing knowledge on how education affects climate literacy (CL). In this study, climate science literacy is defined, in accordance with a U.S. government CCE framework, as "an understanding of [one's] influence on climate and climate's influence on [them] and society". CL, encompassing both knowledge and action, is the goal of all CCE; as in order to be effective, education must not only incur knowledge about CC in its recipients, but make sure that this knowledge is applied by them in their thinking, decisions, and actions in an overall effort to mitigate the climate crisis. In reviewing the literature regarding education's impact on CL, it is notable that most researchers make a distinction between evaluations of CC knowledge and CC action, rather than encompassing both of these factors into the participants' overall CL. For the purposes of this literature review, studies who examined either education's effect on CC knowledge or its effect on CC action, in addition to those that examined the effect on both aspects together, were evaluated.

Most research agrees that educational curriculum has a positive impact on climate change knowledge within students, however, uniform conclusions are not reached in regards to curriculum's impact on climate change behavior or action. Meyer (2015) used a regression discontinuity design in order to establish a credible causal relationship between CCE and CL. Previous research had succeeded to incur similar findings, but Meyer's study is especially important as it eliminated all other confounding variables in order to find CCE's conclusive impact on CL. Meyer's analysis indicated a causal relationship between education and CL—the education was shown to increase individuals' concern with social welfare, and by consequence encouraged them to act in a more pro-environmental way. Similarly, Chankrajang and Muttarak (2017) and Wang et al. (2022) both found that greater educational attainment, within Thai and Chinese students respectively, correlated with greater probability of pro-environmental attitude and behavior. These three studies seem to reach a consensus about CCE's impact on CL—curricular CCE improves both the climate change knowledge and actions of students.

The findings stated above are contradicted, however, by Nattavudh Powdthavee's 2020 study on the causal relationship between education and CL within a nationally representative sample of U.K. citizens. He examined the effect that an educational reform increasing the minimum school leaving age had on CL, hypothesizing that greater educational attainment due to increased time in school would have a positive effect on CL. His analysis of national survey results found that there was a sharp increase in climate change knowledge caused by the education reform, but significant evidence was not shown to determine whether the reform had an impact on pro-environmental behavior. The contradictions between Powdthavee and Meyer demonstrate that there is a gap in understanding regarding how curricular CCE impacts climate-related behavior. Since climate-related behavior or action are important aspects of CL, this research paper, in comparing the effects of multidisciplinary CCE versus science-focused CCE on the CL of students will add necessary knowledge to this topic.

Multidisciplinary Climate Change Education

Now that the effect of curriculum-based CCE on CL has been established, previous literature on the effectiveness of multidisciplinary CCE must be examined. As stated earlier, almost all research evaluating the most effective forms of

CC pedagogy recommend the use of a multidisciplinary approach—that being, an approach that incorporates all subjects, such as science, arts, and the humanities into CCE, rather than just science. Hansen and Kirkeby (2010) compared Norwegian students' knowledge about the greenhouse effect and the ozone layer from 1989 to 2005. The method used was a questionnaire, and it was found that student knowledge in 2005 had improved significantly from the first test in 1989 due to improved CCE pedagogy, including the synthesis of *multiple disciplines*—such as scientific, ethical, political, and more—of the climate change problem in order to best empower students to solve the issue. Having a holistic understanding not only encouraged the students to take action, but also helped them better retain knowledge of scientific concepts. Similar research was conducted by Hens and Stoyanov in 2014 through their in-depth analysis of the "cascade effects" of CC. They came to the conclusion that understanding the effects of CC "[necessitated] knowledge from physics, chemistry, biology, ecology, geography, health sciences, socio-economics, ethics, philosophy and policy", establishing that climate change is a multidisciplinary issue and must be taught as such. Additional research regarding CCE in the last two decades, such as Læssøe et al. (2009), Wise (2010), and Duram (2021) all recommend the use of multidisciplinary CCE.

Research Goal

Despite the overwhelming amount of research that suggests multidisciplinary CCE is the most effective method for developing CL within students, global and U.S. national policies have failed to adapt. As stated prior, this indicates a misconception between what current research suggests and the perceived validity of multidisciplinary CCE. This research hypothesizes that a reason for this misconception is that existing research has yet to compare the effectiveness of multidisciplinary CCE to that of science-focused CCE in terms of CL outcomes. If it is proven that multidisciplinary CCE is *more* effective than the existing curriculum, than policy and curriculum developers will be encouraged to adjust existing curriculum towards a multidisciplinary approach.

To add, much existing research regarding CCE indicate many gaps in this field. Researcher Allison Anderson noted that many studies struggled to find findings with statistically significant meaning or conclusions, stating that "there is a need for additional evidence-based research" on this topic. Additionally, Anderson noted that future CCE research should take care to specify and evaluate *existing* educational tools that produce positive CCE outcomes in "numerous and diverse settings". Ardoin et al.'s systematic review of environmental education (EE) research, specifically focusing on EE outcomes on K-12 students, stated that only 34% of significant EE research was conducted in regards to high school students, with most research being targeted at middle-school and elementary students. This demonstrates a need for more research regarding EE to be conducted in secondary education.

Based off of these gaps in research, the driving question of this research paper was narrowed to "Does the multidisciplinary nature of climate change education present in Advanced Placement courses lead Advanced Placement high school students to have greater climate literacy than their counterparts who take the California state science-focused curriculum?". For further clarification, Advanced Placement (AP) is a widely-recognized program created by the organization College Board, that offers a total of 38 different collegiate level courses across a variety of disciplines for secondary school students. In line with Anderson's suggestion for future research to evaluate *existing* educational tools producing positive CCE outcomes in *numerous* and *diverse* settings, this research paper selected participation in the AP program as a primary comparative variable. As of 2020, the AP program was supported by 31 states and D.C., demonstrating an impact in more states than the Next Generation Science Standards (NGSS), which is currently the most widely-adopted form of CCE within the U.S.. The wide scope of AP indicates that the results of research conducted in this study can be generalized to many states, and therefore has great implications for aiding in creating a nation-wide CCE system in the future.

Methodology

Defense of AP as a Multidisciplinary CCE Resource

This study will be using participation in AP classes as an indication that a student has been exposed to multidisciplinary CCE. By definition, multidisciplinary education is education that combines several academic disciplines in an approach to a topic or problem. College Board states that AP courses are offered in a variety of disciplines including "the arts, english, history and social science, math and computer science, the sciences, and world languages and culture". By nature, this makes the AP program overall a multidisciplinary education resource. To further evaluate whether CCE was involved in a multidisciplinary fashion within AP courses, an analysis was made of the Course and Exam Descriptions of each offered AP course. Use of the words "climate", "climate change", and "environment" in the context of climate change were recorded, and it was determined that education regarding climate change was present in enough of the AP courses to be considered multidisciplinary.

An important item to note when evaluating the AP program is that College Board does not standardize the curriculum or pedagogy that teachers may use when teaching the class. The Course and Exam Description does, however, provide a guide for AP teachers to utilize when developing a curriculum. Although there is no strict standardization in terms of how AP classes are taught, a valid assumption can be made that knowledge conveyed to students is still similar enough to make generalizable conclusions. According to College Board, all schools must go through a "Course Audit process" in order to offer an AP class. This process allows College Board to give AP teachers *clear* guidelines on the curricular requirements for each course, and it certifies that all offered AP courses, across various high schools, meet a standardized college-level criteria. These factors, along with the fact that all AP classes are designed to prepare students for the same standardized test at the end of the course, ensure that the knowledge students acquire from AP classes is uniform enough to make the results of this research replicable and generalizable.

Research Goal and Defense of Methods

The goal of this research is to determine whether there is a statistically significant difference in climate literacy between students who have been exposed to multidisciplinary CCE through taking various AP courses and those who have received the majority of their CCE from the California science-focused curriculum. This study will use a causal-comparative design involving a mixed-method case-study. A causal-comparative design "seeks to find relationships between independent and dependent variables after an action or event has already occurred": in this research, the independent variable is "amount of AP classes taken" and the dependent variable is "climate literacy".

A case study is intensive research conducted on a focused sample of the population, with the goal of generalizing results to a larger group of cases. Additionally, the term "case study" implies that the sample being studied is "not perfectly representative of the population". Since there is no national standard curriculum for CCE within the U.S., state CC curriculums are extremely diverse. Additionally, although AP classes are used across a wide array of states, each state, district, and school have different requirements and resources when it comes to providing AP classes. Both of these factors make it difficult to conduct this comparative analysis at a multi-state, or even multi-school, scope since the two factors being compared are the amount of AP courses taken versus the "standard" curriculum, so it is necessary that this study is conducted at a singular high school. The case study in this research will be conducted at a high school in California, a state that adopted the NGSS in 2013. The NGSS are purely science-based standards and do not extend beyond the science discipline; they currently encompass CCE in California's state curriculum. The high school being examined in this case study offers or has offered 27 out of the 38 available AP classes. It should also be noted that AP exam pass rates at this high school are at or above-average for the majority of classes offered, indicating that students *are* receiving adequate education on the topics outlined by the College Board for each course, demonstrating that the use of AP is especially valid in this case study.

In a systematic review of environmental education research over the past 20 years, specifically focusing on EE outcomes on K-12 students, Ardoin et al. found that the most common methods of data collection in this discipline were "knowledge tests" and "attitudinal scales", at 82% of the sample of 119 papers, and interviews, at 29% of this sample. Therefore, in line with established CCE research, this research utilized both survey research and structured interviews in order to collect quantitative and qualitative data to best answer all aspects of the research question. All data collected was from high school students at a select California high school. Four factors were used to measure the climate literacy of students per the definition of climate literacy provided by *Climate Literacy: The Essential Principals of Climate Science*. These factors and their descriptions are seen in Table 1. Climate Change Knowledge (CK) was measured using survey research due to the quantitative nature of the data. Credibility Assessment (CA), Communication (CO), and Climate-Related Behavior (CB) were measured through the coding and analysis of structured interview responses—these three factors required evaluation of in-depth explanation from participants in order to be measured. All four factors were measured in the two samples being compared, and then statistical analyses were conducted to determine if there was a significant difference in climate literacy between the two samples. These two samples are described in Table 2. It was determined that students who took less than 3 AP classes were not adequately exposed to the multidisciplinarity of AP's CCE curriculum, therefore they were placed in Sample 1.

Table 1. Factors of climate literacy.

Factor	Description
(1) Climate Change Knowledge	Understands the essential principles of Earth's climate system.
(2) Credibility Assessment	Knows how to assess scientifically credible information about climate.
(3) Communication	Communicates about climate and climate change in a meaningful way.
(4) Climate-Related Behavior	Is able to make informed and responsible decisions with regard to actions that may affect the climate

Table 2. Description of samples.

Sample 1	Sample 2
Students who have taken less than 3 AP classes, and are therefore more impacted by California's science-focused CCE curriculum.	Students who have taken 3 or more AP classes, and have therefore been exposed to multidisciplinary CCE.

Survey Research

The survey created to measure CK consisted of two parts. The first part included 8 statements regarding the scientific processes behind climate and climate change, with the response being formatted in a 5-point Likert scale from "confidently disagree" to "confidently agree". Participants were instructed to choose their answer on the scale based on

how confident they were in the validity of the statement, a selection of 3 on the Likert scale was denoted as "completely unsure". The use of a 5-point Likert scale was determined as the most accurate form of measurement due to Taddicken et al.'s 2018 study analyzing the most effective methods for measuring climate change knowledge. Their research suggested that using a 5-point Likert scale, taking into account both knowledge and confidence, was the most effective as it reduced inaccuracies in measurement caused by participants guessing, and it more clearly indicated misperceptions that participants had of climate change. The 8 statements used were formulated based off of a Delphi study conducted by Jarrett et al. which developed a concept inventory encompassing the key scientific concepts behind climate change. These concepts were formulated through quantitative and qualitative data collected from academics, researchers, and high-school teachers, as well as an extensive literature review. The conceptual statements formulated in the study were reworded in order to ensure accessible understanding for secondary school students. Taddicken et al's research showed that there was a difference in how participants respond to falsely-worded versus truthfully-worded statements, so four of the eight statements in the survey were adapted to false statements and ordered randomly to reduce wording bias. The statements used in the knowledge test can be found in Table 3. Part 2 of the survey asked questions to differentiate the samples, such as number of AP classes taken, grade level, G.P.A., and courses taken for the purpose of further analysis and to reduce confounding variables. The survey was distributed to as many students as possible within the scope of the case study and all responses were voluntary and anonymous, in line with ethical research guidelines.

Responses to the knowledge test were coded with points being assigned to the level selected on the Likert scale, with the greatest amount of points being awarded for a confidently-held correct answer and the least amount for a confidently-held incorrect answer. These points were then added up to measure each participants' CK. The point assignment method can be found in Table 4.

Table 3. Knowledge test statements.

Knowledge Test Statements **Responses: Likert Scale 1-5 "Confidently Disagree" to "Confidently Agree"** *** Indicates falsely-worded statement**
The amount of carbon on Earth is not fixed, it changes over time.*
Only human sources can create and reduce greenhouse gases in the atmosphere.*
The Greenhouse Effect is caused by the absorption of infrared light by greenhouse gas molecules, which is then re-radiated back to the Earth's surface.
The climate has not changed drastically in the past (over all of Earth's history).*
Weather and climate are the same thing.*
Greenhouses gases include, but are not limited to: carbon dioxide (CO2), nitrous oxide (N2O), water vapor (H2O), and ozone (O3).
The overwhelming majority of the atmosphere consists of NON-greenhouse gases.
Depletion of the ozone layer has a very minimal effect on global warming.

Table 4. Knowledge test point assignments.

Status of Answer	Points Awarded
Confidently-held, correct	15
Less confidence, correct	10
Completely unsure	5
Less confidence, incorrect	2
Confidently-held, incorrect	0

Structured Interviews

CA, CO, and CB were measured using targeted questions within structured interviews. It was necessary for a significant amount of the factors to be determined using structured interviews due to the CO factor, which necessitated an evaluation of the nature of participants' qualitative responses in order to measure this factor. Interview responses were transcribed by the researcher and were organized through deductive coding. Deductive coding is a process that begins with a predefined set of codes which are then assigned to collected data. For each factor, responses were coded as either achieving that factor of climate literacy or failing to achieve it. Achievement of CA and CB was determined purely based off of participant responses to targeted questions, but achievement of CO required a more subjective approach. CO was determined based off of the participant's confidence and clarity, perceived by the researcher, in responding to interview questions throughout the entire interview, in order to best determine if the participant was able to meaningfully communicate about climate change. The structured interview questions can be found in the appendix. In line with ethical research guidelines, participation in interviews was voluntary and all identifiable information regarding participants was kept confidential.

Results

Survey Research

The survey collected data from 141 participants, slightly over 7% of the population in this case study. The greatest proportion of respondents were in 11th grade at 51.8% (n = 73), followed by 10th graders at 20.6% (n = 29), 12th graders at 15.6% (n = 21), and 9th graders at 12.1% (n = 17). The respondents were divided into the two samples being compared, with Sample 1 having a sample size of 55, and Sample 2 having a sample size of 86. The two samples are defined in Table 2, above. Results from the survey are found in Figures 1, 2, and 3. Statistical analyses were conducted to determine whether the difference in scores between the samples were significant.

The distribution of climate change knowledge scores of all participants was determined in Figure 1 in order to gage the climate knowledge of all students regardless of curriculum taken. The mean climate change knowledge score for all students was 62.5 (S = 14.24). The highest possible score for participants to achieve was 120, and the highest achieved score was 105 from two participants. The lowest possible score was 0, and the lowest achieved score was 34.

Figure 2 divides the climate change knowledge scores of participants into the two samples being compared. For Sample 1 the mean climate change knowledge score was 58 (S = 11.94), while for Sample 2 the mean climate change knowledge score was higher at 65.37 (S = 14.9). The difference in climate change knowledge scores between the two samples was determined to be statistically significant with $p = 0.002$ ($p < 0.05$). A possible confounding variable in this comparison could have been grade level, as general knowledge likely increases with age and educational attainment, so this same analysis was conducted within 11th grade and 12th grade participants. The results of this analysis are shown in Figure 3. It was found that within 11th grade, students in Sample 1 had a mean climate change knowledge score of 56.3, while students in Sample 2 had a greater mean score of 64.5. Within 12th grade, students in Sample 1 had a mean climate change knowledge score of 48.7, while students in Sample 2 again had a greater mean score of 69.9. These results were found to be statistically significant with $p = 0.038$ and $p = 0.041$ respectively ($p < 0.05$).

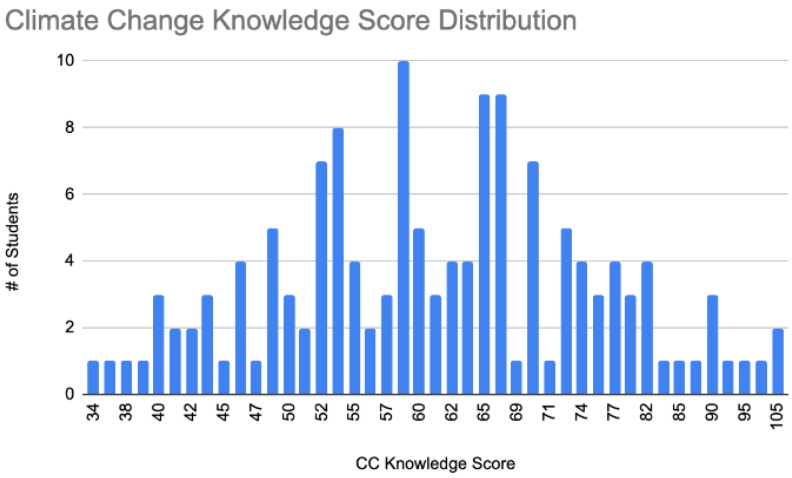

Figure 1. Climate Change Knowledge score distribution.

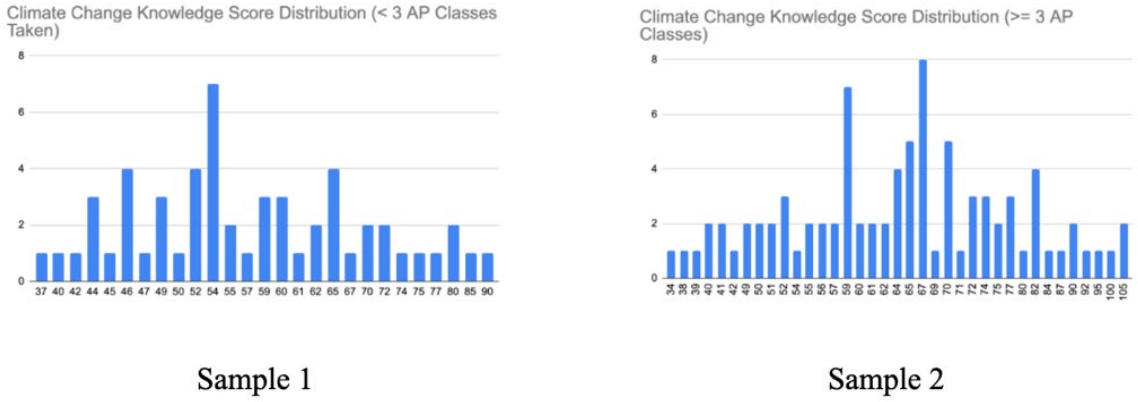

Figure 2. Difference in Climate Change Knowledge scores between Sample 1 and Sample 2.

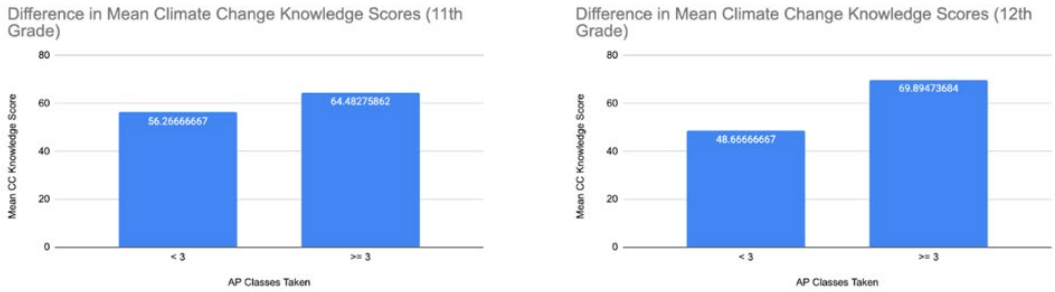

Figure 3. Difference in Climate Change Knowledge scores between samples within 11th grade and 12th grade students.

Structured Interviews

Structured interviews were conducted among 28 participants. The greatest proportion of participants were in 11th grade at 64.3% (n = 18), followed by 10th graders at 17.9% (n = 5), 9th graders at 10.7% (n = 3), and 12th graders at 7.1% (n = 2). The respondents were divided into the two samples being compared, with Sample 1 having a sample size of 13, and Sample 2 having a sample size of 15. The two samples are defined in Table 2. The variables being compared through the structured interviews are CA, CO, and CB, displayed in Table 5. Chi-squared tests were conducted to determine the statistical significance of results based off of coded interview responses. These results are found in Figures 4, 5, and 6 below. The most prominent qualitative themes found throughout participant interview responses are detailed in Table 6.

Figure 4 demonstrates the amount of students in each sample who achieved and didn't achieve the CA factor of climate literacy. It was found that 31% of students in Sample 1 achieved CA, compared to 73% in Sample 2. The correlation between taking 3 or more AP classes and achievement of the CA factor was found to be statistically significant with $p = 0.024$ ($p < 0.05$). Figure 5 demonstrates the amount of students in each sample who achieved and didn't achieve the CO factor of climate literacy. It was found that 15% of students in Sample 1 achieved CO, compared to 80% in Sample 2; these results were statistically significant with $p = 0.0002$ ($p < 0.05$). Figure 6 demonstrates the amount of students in each sample who achieved and didn't achieve the CB factor of climate literacy. It was found that 23% of students in Sample 1 achieved CB, compared to 27% in Sample 2. With $p = 0.83$ ($p > 0.05$), no significant correlation was found between curriculum taken and achievement of the CB factor.

Table 5. Factors of climate literacy measured through interviews. The shaded factors below were measured through the structured interviews.

Factor	Description
(1) Climate Change Knowledge (CK)	Understands the essential principles of Earth's climate system.
(2) Credibility Assessment (CA)	Knows how to assess scientifically credible information about climate.
(3) Communication (CO)	Communicates about climate and climate change in a meaningful way.
(4) Climate-Related Behavior (CB)	Is able to make informed and responsible decisions with regard to actions that may affect the climate

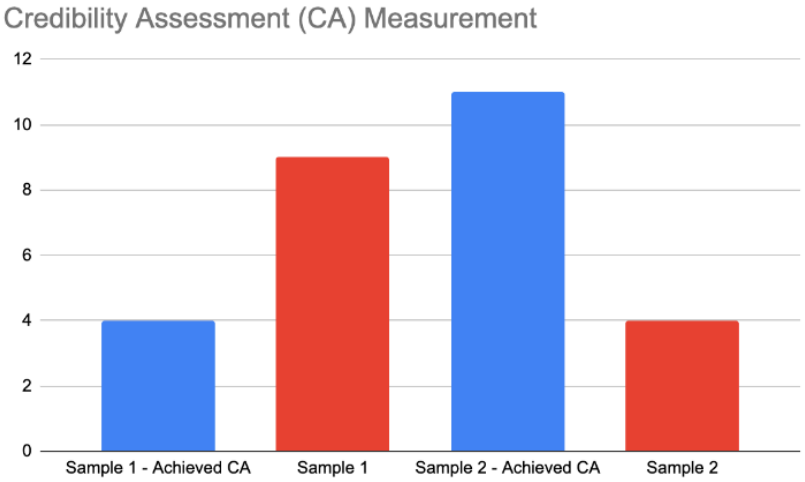

Figure 4. Credibility Assessment measurement. Blue indicates achievement of the Credibility Assessment factor. Red indicates failure to achieve the Credibility Assessment factor.

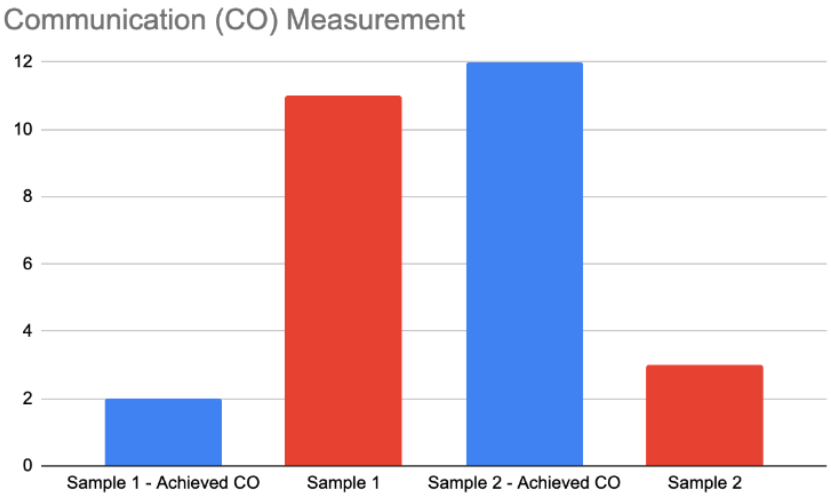

Figure 5. Communication measurement. Blue indicates achievement of the Communication factor. Red indicates failure to achieve the Communication factor.

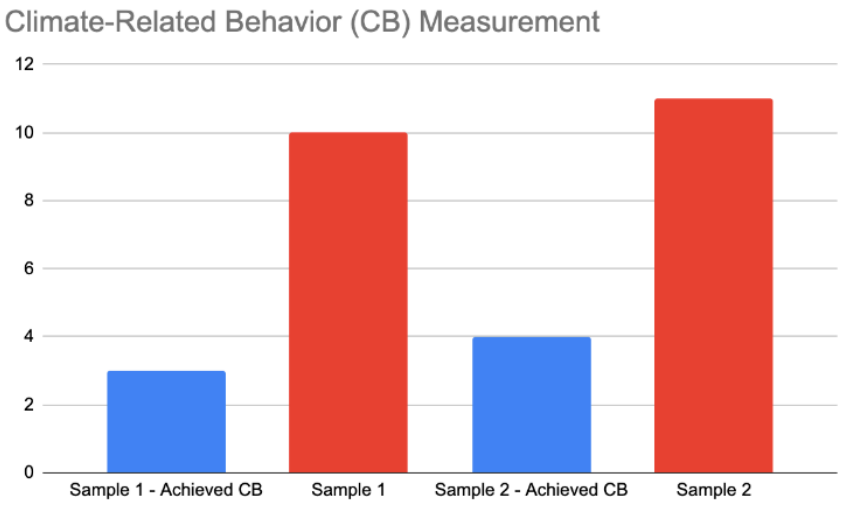

Figure 6. Climate-Related Behavior measurement. Blue indicates achievement of the Climate-Related Behavior factor. Red indicates failure to achieve the Climate-Related Behavior factor.

Table 6. Themes from structured interviews.

Theme	Select Participant Responses
(1) Many students in Sample 1 acknowledged that some of their CC information sources were unreliable, yet continued to use them.	"I see a lot of stuff about climate change on social media…in Instagram posts and Tiktoks. I know that it's not the most credible, but I don't really look anywhere else for information." - Student 4 (Sample 1) "I watch the news sometimes and get my information from there. I know that scientists and official academic sources are probably more accurate, but I don't really think that much about it." - Student 7 (Sample 1)
(2) Students stated that their individual actions wouldn't have an impact on the overall climate crisis.	"I recycle and try not to waste electricity by turning lights off…but I feel like those are really small things and I'm not sure if it even makes a difference." - Student 4 (Sample 1) "I don't think anything I do will really help make it better, it'll only get better if everyone does something which won't happen." - Student 17 (Sample 2)

Discussion, Limitations, and Implications

To reiterate, the four factors used to measure climate literacy within students were Climate Change Knowledge (CK), Credibility Assessment (CA), Communication (CO), and Climate-Related Behavior (CB). The data in Figures 2 and 3 demonstrate that Sample 2 had greater CK than Sample 1, indicating that taking 3 or more AP classes led to greater understanding and retention of the scientific processes behind climate change. Figures 4 and 5 demonstrate that Sample 2 also achieved CA and CO at significantly higher rates than Sample 1, establishing that taking 3 or more AP classes enabled students to better assess information about climate change, as well as communicate more meaningfully about the issue. The first qualitative theme in Table 6 also shows that Sample 1 was especially lacking regarding CA. Figure 6 demonstrates that there was no significant difference between Sample 1 and Sample 2 in terms of achieving the CB factor. This is consistent with prior research, such as Powdthavee (2020), that did not find significant relationships between education and CB. A common theme found in structured interview responses, shown in Table 6, suggested that many students did not think their individual actions could have enough of an impact on climate change. This indicates that future research needs to be done to eliminate this misconception, and determine what curricular practices lead to positive changes in CB within students.

Before making definite conclusions, it is important to understand the limitations within this study. The first being that AP classes are not standardized, and teachers can choose their own curriculum and pedagogy when teaching the course. This may lead certain AP students to not receive the knowledge necessary for each AP course, therefore confounding results in terms of CL outcomes. This was determined to not be too significant of a confounding factor within this research, considering that statistically significant differences were still found in the CL of Sample 1 and Sample 2, though this limitation should be taken into account when replicating this research through other case studies. Additionally, although this research hypothesized that the main difference between the AP CCE curriculum and California's CCE curriculum was that the AP curriculum was multidisciplinary rather than science-focused, there could be other differences between the two curricula impacting the results. Future research should look further into the differences between AP curriculum and existing CCE curriculum, beyond multidisciplinarity, that could have influenced results. Some of these factors could be education censorship, course rigor, and classroom environment, all of which were not investigated in this study due to time constraints. Finally, as discussed prior, no significant conclusion was reached regarding the type of curriculum's impact on climate-related behavior, indicating that a gap in knowledge remains on this topic. This may be because a small sample size was used for structured interviews due to time constraints and ethical guidelines, so future replication of this research should look to employing larger sample sizes in collection of qualitative data—possibly through the use of focus-group interviews, rather than the individual-interview method used in this research in order to reach a greater sample size.

Conclusion

Taking into account both the results and limitations of this study, since 3 out of the 4 factors of climate literacy were seen at higher rates within students in Sample 2 compared to Sample 1, it can be concluded that the multidisciplinary CCE present in the AP curriculum had greater positive CL outcomes in students than California's science-focused curriculum did. The results indicate that students who took 3 or more AP classes had greater knowledge, as well as greater credibility assessment and communication skills, relating to climate change than their counterparts who were more influenced by California's CC curriculum. As stated prior, there may be other differences between the AP CC curriculum and California's CC curriculum that contributed to this difference in climate literacy, but multidisciplinarity was a prominent difference between these two educational resources, indicating that it plays a significant role in the discovered climate literacy disparities. These findings add greater understanding of and validity to the implementation of multidisciplinary CCE within national and global curricula, a gap that was identified when beginning this research, as most existing curricula has yet to make a shift away from solely science-focused pedagogy. The

conclusions of this study suggest that existing climate change curriculum, such as that in California examined in this study, needs to shift towards multidisciplinary approaches. Furthermore, educational curriculum and policy developers should look at what other aspects of the AP curriculum caused this increase in climate literacy, and adapt these aspects into their curricula. Overall, if these changes are implemented, CCE nationally, and globally, will improve in effectiveness greatly, better educating students in order to help them play their part in mitigating and ending the climate crisis.

Acknowledgements

I would like to thank my AP Research teacher for the guidance and insight provided throughout the research process.

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