Exploring the Impact of Gamified Role-Playing on Climate Change Knowledge and Nature Relatedness: Evidence from an Online Undergraduate Course on Environmental Health

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Abstract: In an online environmental health course, undergraduate students worked in teams of five and were immersed in a team-based climate change case study set in the Amazon rainforest. Each student was assigned a character role—a logger, a farmer, a conservation biologist, an environmental activist, and a policymaker. We aimed to understand whether student character assignments influenced their climate change knowledge, environmental concern, and connection to nature. Regression models were generated to test for differences in the outcome variables between characters at pre- and post-test. We observed higher gains in the nature relatedness scores for students assigned the logger role. After controlling for previous climate change knowledge, first-generation college students had lower climate change knowledge at the end of the course compared to non-first-generation students, but low-income students had higher climate change knowledge at the end of the course compared to non-low-income students. Environmental concern had no change over the term; scores were high during the pre- and post-survey for all students. There may be potential to develop a connection to nature by assigning students to play specific characters. Also, despite ongoing work to support first-generation college students, there remain opportunities to develop academic support programs for these students.

Keywords: undergraduate climate change education; environmental health curriculum; gamification; role-playing; team-based learning; case-based learning; problem-based learning; online course

1. Introduction

Young people will face the consequences of climate change throughout their lives to a greater degree than previous generations [1]. Given the high stakes of inaction on climate change, it has never been more urgent to ensure that university students learn about climate change from broad, interdisciplinary perspectives that include connections to the social determinants of health and social issues more broadly [2,3]. Further, there is an immediate need to transform the way we teach undergraduate students about climate change so they are prepared to engage with the challenges of meeting international climate goals and preventing the most catastrophic global climate repercussions of these changes [3]. To address student engagement with climate change beyond the classroom, designing course outcomes must move beyond student learning objectives to heighten students’ environmental concern and connection to nature. This is of critical importance as educators work to cultivate student interest in tackling global climate change beyond their time at the university.

1.1. Background

The human need for a connection to nature is described as biophilia or “the innate tendency to focus on life and lifelike processes” [4] (p. 1). The biophilia hypothesis states...
that “human dependence on nature...extends far beyond the simple issues of material and physical sustenance to encompass...the human craving for aesthetic, intellectual, cognitive, and even spiritual meaning and satisfaction” [5] (p. 21). Research over the past five decades has focused on the interrelationship between humans and nature and how the strength of this connection can shape environmental concern and pro-environmental or sustainability behaviors (e.g., [6–8]). For instance, individuals who participate in outdoor recreational experiences have a heightened level of environmental concern compared to individuals who do not recreate in nature [8]. Those who participate in appreciative nature experiences (e.g., hiking or bird-watching) have greater levels of environmental concern compared to those who participate in more consumptive or mechanized nature experiences (e.g., fishing, snowmobiling) [7,9]. Moreover, appreciative outdoor leisure activities have also been shown to increase perceptions of environmental change [10]. Two recent meta-analyses conclude that there is a positive relationship between connection to nature and pro-environmental behavior [11] and that time spent in nature is positively associated with a connection to nature, which in turn is associated with an increase in pro-environmental attitudes and behaviors [12]. Importantly, recent work by Knight and Hao finds that a greater enjoyment of nature corresponds with a higher level of concern about climate change [13]. Individuals with higher levels of nature relatedness, or connection to nature, also have higher levels of climate change issue engagement [14].

National data show that 72% of American adults believe that climate change is happening and 43% state that they have been personally harmed by the impacts of climate change [15,16]. A heightened concern about climate change is evident among young people, as demonstrated in one instance by high school students participating in Fridays For Future walkout strikes [17]. In fact, more than half of American teenagers state they are afraid of climate change and roughly a quarter have taken action to express their views on climate change through school walkouts, protests, or writing to an elected official [18,19].

Although young people demonstrate concern around the impacts of climate change and may actively participate in civic actions to elevate awareness about climate change, their climate science literacy is relatively low [20]. Focus groups of college students have revealed that they often believe climate change or its effects are linked to other environmental issues including damage to the ozone layer or marine pollution, for example [20]. As science educators, we have an opportunity to combat such misunderstandings in our courses. Recent work on teaching sustainability and climate change in service-learning courses shows that students become empowered to take action against climate change as they increase their knowledge of environmental stewardship as it relates to climate change [21,22].

Formal and informal environmental science education has the potential to kindle nature connectedness as well as pro-environmental behaviors and perspectives in students. For instance, field trips and other similar educational nature experiences can increase participants’ connection to nature and willingness to engage in pro-environmental behaviors [23]. Immersive virtual reality is another way to explore environments being shaped by climate change; these virtual experiences can increase knowledge about climate change, spark interest in learning about the drivers of climate change, and increase pro-environmental behavior [24].

1.2. Research Motivation

The challenge for educators, then, is to design and create educational experiences that open the door for students to gain greater insight into climate change repercussions. We posit that role-playing in education provides such meaningful opportunities for students to practice their reasoning and argumentation skills, build empathy, and experience a new perspective. Role-plays that address climate change scenarios can mimic the debate and consensus-building processes found in the real world, although the sophistication of the argumentation may vary [25]. Students participating in a role-playing activity reported increased knowledge about climate change as well as increased pro-environmental
behaviors [26]. Since Paschall and Wüstenhagen struggled with student engagement and a lack of student energy in their online sessions [26], we incorporate scaffolding, goal-setting, and support to overcome these issues.

One way to scaffold and support student learning in virtual environments is through the use of teams, team assignments, and regular virtual team meetings. Collaborative learning experiences and teamwork provide myriad opportunities for learner growth and are especially important for first-generation college students [27–30]. This also holds true for synchronous teamwork sessions in online courses where small group activities can help to build community [31]. Synchronous, video-based discussions in an online course may allow students to develop higher levels of cognitive presence, defined as “the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse in a critical community of inquiry” [32] (p. 11) [33,34].

Our motivation for this work was underpinned by the desire to immerse students in a collaborative role-playing scenario involving characters with diverse backgrounds, values, and perspectives on climate change. Active and collaborative learning in teams has been shown to increase student engagement and ultimately increase learning performance [35]. As a complement to the diversity among the character roles, we aimed to organize students into diverse teams for the small group activities. The benefits of culturally diverse teams in educational settings include the development of team-level cultural intelligence, which can enhance team performance in the course [36]. Moreover, gender-diverse science teams have been shown to create ideas with greater impact and novelty [37], which is especially important when considering possible solutions to wicked problems like climate change.

1.3. Course Context

For this project, we examined student environmental concern, nature connection, and climate change knowledge in an online lower-division undergraduate public health course, Environmental Quality and Health (EQH). EQH has a substantial focus on climate change and covers a range of topics in environmental health, including epidemiology, toxicology, policy and regulation, zoonotic and vector-borne diseases, and water quality and availability. In addition, modules specifically addressing climate change are included on a range of topics, such as air quality, climate change literacy, community engagement in climate change adaptation and mitigation efforts, the social determinants of health, and environmental quality and psychological health. EQH is one of many courses available to any undergraduate on our campus to satisfy the three-course Science and Technology general education requirement. In addition, EQH is one of four courses that students majoring in Public Health can take to satisfy the major’s lower-division requirements.

We acknowledge that many online courses tend to lack robust interaction among students. Our goal for the design of EQH was to create an engaging and engrossing experience that promoted sustained interaction among all students, the instructor, and the teaching assistants. To achieve this, students in EQH are able to engage in the course materials both asynchronously (e.g., recorded mini-lectures, readings, supplemental videos, interactive online lessons) and synchronously (e.g., discussion sections). The EQH discussion sections take place virtually via video conferencing technology built into the Canvas LMS [38,39] once per week for 7 weeks of the 10-week quarter. During these discussion sections led by teaching assistants, students collaborate (while role-playing in character) with their team to complete the week’s assignments. More information about the team aspect of the course, including student learning objectives, team meeting agendas, weekly assignments, and the structure and facilitation of the group work, can be found in Supplements S1–S3.

1.4. Case Study

The genesis for our pedagogical approach for EQH was a case study located on the website of the National Center for Case Study Teaching in Science [40]. Entitled “The Deforestation of the Amazon: A Case Study in Understanding Ecosystems and Their Value”, the case instantly hooks the reader. In the first paragraph, we encounter an imaginary
and heated dialog among a farmer, a logger, and an environmentalist arguing about deforestation in the Amazon from different points of view. We used this model depicting different stakeholders in conflict as a jumping-off point for a key aspect of the course design. To the three personas in the aforementioned case study, we added a conservation biologist and a policymaker (see Table 1). We then proceeded to design the lessons to generate debate during student interactions in their small teams. Our goal was for students to engage in the complex issue of deforestation through the lenses of perspectives that may have been different from their own. Our secondary goal was for students to leave the course with an appreciation for the complex interplay between climate science, multiple levels of environmental policy making, and community stakeholders.

Table 1. Character descriptions with number of participants assigned to each character.

<table>
<thead>
<tr>
<th>Character Name</th>
<th>Brief Biography</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maria</td>
<td>Maria is a policy development specialist for the World Health Organization. She is based in Geneva, Switzerland, but regularly travels through Latin America for work. Rachel currently works for an environmental non-profit in Belém, Brazil. She previously worked for Greenpeace, the World Wildlife Fund, and the Rainforest Action Network. Marco is a farmer who lives outside of Belém, Brazil. To support his partner and their children, he grows soybeans on a small plot of land that is cleared of trees. Antonio is a logger and he lives near Belém, Brazil. To support his partner and their children, he works for a logging company. Carolina is a conservation biologist who lives in Rio de Janeiro, Brazil. She is visiting Belém, Brazil, as part of her research on the health of the rainforest.</td>
<td>26</td>
</tr>
<tr>
<td>Rachel</td>
<td>Rachel currently works for an environmental non-profit in Belém, Brazil. She previously worked for Greenpeace, the World Wildlife Fund, and the Rainforest Action Network. Marco is a farmer who lives outside of Belém, Brazil. To support his partner and their children, he grows soybeans on a small plot of land that is cleared of trees. Antonio is a logger and he lives near Belém, Brazil. To support his partner and their children, he works for a logging company. Carolina is a conservation biologist who lives in Rio de Janeiro, Brazil. She is visiting Belém, Brazil, as part of her research on the health of the rainforest.</td>
<td>26</td>
</tr>
<tr>
<td>Marco</td>
<td>Marco is a farmer who lives outside of Belém, Brazil. To support his partner and their children, he grows soybeans on a small plot of land that is cleared of trees.</td>
<td>26</td>
</tr>
<tr>
<td>Antonio</td>
<td>Antonio is a logger and he lives near Belém, Brazil. To support his partner and their children, he works for a logging company.</td>
<td>30</td>
</tr>
<tr>
<td>Carolina</td>
<td>Carolina is a conservation biologist who lives in Rio de Janeiro, Brazil. She is visiting Belém, Brazil, as part of her research on the health of the rainforest.</td>
<td>31</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>139</td>
</tr>
</tbody>
</table>

1.5. Research Questions

To understand whether student character assignments influenced their climate change knowledge, concern for the environment, and connection to nature, we formulated these research questions:

1. To what extent do different character assignments heighten students’ nature relatedness?
2. What influence does the course and respective character assignments have on students’ knowledge about climate change and environmental concern?

2. Materials and Methods

2.1. Study Context

This research was conducted at a large, public, minority-serving research university on the west coast of the United States. The university is designated as both a Hispanic-Serving Institution (HSI) and an Asian American and Native American Pacific Islander-Serving Institution (AANAPISI). During the academic year, courses run quarterly for 10 weeks plus a finals week.

2.2. Participant Recruitment and Incentives

There were 139 students who participated in the study. In addition to being enrolled in the EQH online course, students self-selected into one of five virtual discussion sections based on their day and time preference. We sent two surveys (pre- and post-test) to all students using the announcement function of the course learning management system,
yielding an 81.3% survey response rate. Survey participants were awarded 2.5 points (<1% of total points for the quarter) for completing the first survey and 2.5 points for completing the second survey. We distributed the first survey at the beginning of the quarter and prior to the start of the team discussion sections, and distributed the second survey at the end of the quarter after the team discussion section meetings ended but prior to the release of final grades. Reminder notifications were sent to students before the survey deadlines.

2.3. Exclusion Criteria

Any student enrolled in EQH was eligible to participate in this study and participation was voluntary. Some participants took the surveys more than once, but we only analyzed the first attempt. Students who did not complete the surveys were excluded from the study. Institutional Review Board approval was granted before recruitment (IRB HS# 2018-4211).

2.4. Measures

The first and second survey had an identical set of questions designed to evaluate students’ connection to nature, their level of environmental concern, and their level of climate change knowledge at the beginning and end of the quarter. Survey data were collected electronically using Qualtrics [41]. The pre- and post-test survey used in this study is available in Supplement S4.

2.4.1. Nature Relatedness

We used the six-item short-form version of the Nature Relatedness Scale (NR-6) [42] to assess students’ subjective connection with nature and the natural environment. Participants responded using a five-point Likert scale ranging from 1, disagree strongly, to 5, agree strongly. The order of the six items was randomized by the survey software. NR-6 scores were calculated by averaging participant responses to the six items.

2.4.2. Climate Change Knowledge

Ten items assessing participants’ overall climate change knowledge were adapted from questions included in a national study of Americans’ knowledge of climate change [43]. Participant responses to the items were scored as 1 (correct) or 0 (incorrect) for each item or subitem, as appropriate. Likert-type true/false responses (i.e., “definitely true”, “probably true”, “probably false”, “definitely false”, or “don’t know”) were converted to simple true/false dichotomous variables for ease of analysis. Questions were removed from analysis if fewer than 25% of participants answered them correctly as suggested by Leiserowitz and colleagues [43]. Scores were calculated as a percentage for each participant based on their total number of correct answers.

2.4.3. Environmental Concern

We evaluated students’ attitudes of environmental concern toward themselves, others, and the biosphere using a 12-item scale [44]. Participants rated their environmental concern using a seven-point Likert scale ranging from 1, not at all important, to 7, extremely important. Overall environmental concern was calculated by averaging the responses to the items. The sequence of the items was randomized by the survey software.

2.5. Character Assignments

Students enrolled in EQH are assigned to one of five different character roles and asked to embody these characters throughout the quarter and especially when they are meeting with their team in the discussion sections and collaborating on related assignments. The characters include a policymaker, a conservation biologist, an environmental activist, a logger, and a farmer (Table 1). The randomization process that character assignments were based on is detailed below.
Demographic Data

Unique identifiers were collected from all participants who took the surveys. Demographic data, including gender identity, first-generation college student status, low-income status, race/ethnicity, transfer status, and major at admission, were obtained from institutional data records and linked to the corresponding survey responses.

We used a systematic randomized design to balance the teams on these demographic variables: (1) exposure to climate change-focused coursework through their major (yes if student was majoring in public health, physical sciences, or biological sciences, otherwise no); (2) female gender identity (yes/no); (3) persons excluded because of their ethnicity or race (PEERs) (yes/no) [45]; (4) first-generation college student (yes/no). Very few students (n = 4) changed teams during the quarter and none changed characters. Most changes occurred in the first week of the quarter (before the first team meeting) and one student changed teams in the middle of the quarter. We have provided descriptive statistics to show the randomization overall (Table 2) and by team (Table S1), as well as by character assignment (Table S2). More information about the systematic randomized design can be found in Supplement S5.

Table 2. Participant demographic information.

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th>EQH %</th>
<th>Character % Mean (SD)</th>
<th>Team % Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants who are:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>68</td>
<td>68 (7)</td>
<td>70 (19)</td>
</tr>
<tr>
<td>Black, Latinx, Pacific Islander, Indigenous to the US and its Territories</td>
<td>47</td>
<td>47 (8)</td>
<td>47 (28)</td>
</tr>
<tr>
<td>First-Generation</td>
<td>46</td>
<td>46 (5)</td>
<td>47 (29)</td>
</tr>
<tr>
<td>Low-Income</td>
<td>35</td>
<td>34 (9)</td>
<td>33 (26)</td>
</tr>
<tr>
<td>Transfer Students</td>
<td>17</td>
<td>16 (7)</td>
<td>18 (19)</td>
</tr>
<tr>
<td>Discipline:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Health</td>
<td>41</td>
<td>41 (8)</td>
<td>40 (26)</td>
</tr>
<tr>
<td>Physical Sciences, Information and Computer Sciences, Engineering, Biological Sciences</td>
<td>16</td>
<td>16 (7)</td>
<td>16 (20)</td>
</tr>
<tr>
<td>Social Sciences, Social Ecology, Education, Business, Humanities, Art</td>
<td>43</td>
<td>43 (7)</td>
<td>45 (25)</td>
</tr>
</tbody>
</table>

Note: Only one student was majoring in Humanities and one in Art. Percentages, means, and standard deviations rounded to the nearest whole number.

2.6. Data Analysis

For our analysis, we used R version 4.1.2 [46] to calculate descriptive statistics and generate regression models to test for differences in the outcome variables (nature relatedness, climate change knowledge, and environmental concern) between characters. Table 3 provides the research questions, goals, variables used to address each research question, as well as the corresponding statistical tests and where the results can be found.
Table 3. Research approach.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Goal</th>
<th>Variables Used</th>
<th>Statistical Test</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RQ1: To what extent do different character assignments heighten students’ nature relatedness?</strong></td>
<td>To identify differences in nature relatedness across characters</td>
<td>character assignment</td>
<td>Overall F-Test</td>
<td>Table 4, Figure 1</td>
</tr>
<tr>
<td></td>
<td>To examine the relationship between nature relatedness post-test scores and character assignment as well as student demographic characteristics</td>
<td>pre-test nature relatedness scores, character assignment, gender, PEER status, first-generation status, low-income status, transfer student status, and major</td>
<td>OLS regression and best subsets regression</td>
<td>Table 5</td>
</tr>
<tr>
<td><strong>RQ2: What influence does the course and respective character assignments have on students’ knowledge about climate change and environmental concern?</strong></td>
<td>To identify differences in climate change knowledge across characters</td>
<td>character assignment</td>
<td>Overall F-Test</td>
<td>Table 6, Figure 2</td>
</tr>
<tr>
<td></td>
<td>To examine the relationship between climate change knowledge post-test scores and character assignment as well as student demographic characteristics</td>
<td>pre-test climate change knowledge scores, pre-test environmental concern scores, character assignment, gender, PEER status, first-generation status, low-income status, transfer student status, and major</td>
<td>OLS regression and best subsets regression</td>
<td>Table 7</td>
</tr>
</tbody>
</table>

Data visualizations include box plots [47] providing the minimum, 25th percentile, median, 75th percentile, and the maximum (see Figure S1 for further discussion). To test for the difference in paired differences for nature relatedness, climate change knowledge, and environmental concern for the five characters, we conducted an analysis of variance (ANOVA) using an overall F-test [48,49]. We checked the assumptions of the ANOVA to ensure that the nature relatedness, climate change knowledge, and environmental concern variables were normally distributed, the standard deviations were equal (the ratio of the sample standard deviations were within reasonable limits of 0.50–2.00), and the groups (characters) were independent. We assume that the assumption of independence is reasonable given that each character completed individual assignments as part of the course.

To present evidence of the impact of character assignment, student demographics, and pre-test scores on post-test scores, ordinary least squares (OLS) regression was used. We used OLS regression because nature relatedness, climate change knowledge, and environmental concern are quantitative variables that have an approximately normal distribution. We separately modeled the post-test scores of nature relatedness as well as the post-test scores of climate change knowledge to address our specific research questions. More specifically, we wanted to control for pre-test scores and examine whether there would be an increase in the post-test scores based on character assignment and student demographic characteristics (gender, PEER status, first-generation status, low-income status, transfer student status, and major). The assumption of the OLS model is that there is a linear relationship between the predictor variables (pre-test nature relatedness scores, character assignment, gender, PEER status, first-generation status, low-income status, transfer student status, and major) and the response variable (post-test nature relatedness scores). Further, environmental concern was included in our regression model of climate change knowledge because climate change knowledge, especially knowledge of the causes of climate change, may be an important driver of environmental concern [50]; the linear relationship between predictor variables (pre-test climate change knowledge scores, pre-test environmental concern scores, character assignment, gender, PEER status, first-generation status, low-income status, transfer student status, and major) and the response variable (post-test climate change knowledge scores) was modeled. Assuming we have a sample of \( n \) independent observations, \( (x_i, y_i) \), we obtain estimates for \( \hat{\beta}^T = (\hat{\beta}_0, ..., \hat{\beta}_k) \). Let \( Y \) be
the response variable (post-test scores) and let \( x^t = (x_1, \ldots, x_k) \) be the \( k \) predictors in the model and \( \varepsilon_i \) be the random error for the \( i \)th student, which is given by:

\[
y_i = \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k + \varepsilon_i.
\]

Model Selection
First, we built a model where we included all the predictors and the response variable. Next, we performed best subsets linear regression using the bestglm package in R [51] where we selected the model with the lowest Akaike Information Criteria (AIC). The AIC indicates a balance of model fit with generalizability [52,53]. The AIC is given by:

\[
AIC = -2ln(L) + 2k,
\]

where \( L \) is the likelihood and \( k \) is the number of parameters of the model. The AIC is based on the log-likelihood (a measure of how likely the observed data are, given a model) and is penalized as the parameter complexity increases. The reason for the penalty is that adding parameters into a model can lead to overfitting of the data. Therefore, the AIC strikes a balance between the best model fit and the model complexity.

To summarize, in step 1, we fit a model for all possible subsets of covariates (pre-test scores, character assignment, and student demographics) with the response variable (post-test scores) and calculated the corresponding AIC for each model. In step 2, we chose the best-fitting model and interpreted our results.

3. Results
The results of our analysis of paired differences in the pre-test and post-test scores for nature relatedness, climate change knowledge, and environmental concern are presented below along with the findings from our regression modeling.

3.1. Nature Relatedness
The summary statistics of the paired differences in the pre-test and post-test scores for the NR-6 for each character reveal that being assigned to the environmental activist (Rachel), farmer (Marco), logger (Antonio), and conservation biologist (Carolina) had a positive impact on nature relatedness scores (Table 4). Before taking into account any other variables, there was not a significant difference in the nature relatedness scores for the different characters (Figure 1).

Table 4. Results of nature relatedness scores at pre-test and post-test with paired differences.
respective character assignments have on students' knowledge about climate change and environmental concern?

To examine the relationship between climate change knowledge post-test scores and character assignment as well as student demographic characteristics pre-test climate change knowledge scores, pre-test environmental concern scores, character assignment, gender, PEER status, first-generation status, low-income status, transfer student status, and major

OLS regression and best subsets regression

Table 7

Figure 1. Paired differences in nature relatedness scores by character assignment. Paired differences in nature relatedness scores (post-test nature relatedness—pre-test nature relatedness). The overall F-test and respective \( p \)-value for the difference in means of the nature relatedness paired differences across the five character assignments are presented at the top of the plot. See supporting information for assistance in reading box plots if needed. Character assignments are the following: policymaker (Maria), environmental activist (Rachel), farmer (Marco), logger (Antonio), and conservation biologist (Carolina).

The regression results for the nature relatedness scores are presented in Table 5. After adjusting for the nature relatedness pre-test scores, many of the characters (conservation biologist, farmer, and environmental activist) are similar to the policymaker (Maria). However, we find that the logger’s character has significantly higher nature relatedness post-test scores compared to the policymaker (\( p = 0.047 \)). It is of note that the conservation biologist character is trending toward significance (\( p = 0.079 \)). Regardless of their character, students with higher nature relatedness pre-test scores have higher nature relatedness post-test scores (\( p < 0.001 \)).

Table 5. Full and best subset regression models for nature relatedness post-test scores.
Table 5. Cont.

<table>
<thead>
<tr>
<th>Model</th>
<th>Variables</th>
<th>Estimate</th>
<th>SE</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best Subset</td>
<td>Intercept</td>
<td>1.67</td>
<td>0.247</td>
<td>1.18 2.15</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Nature relatedness pre-test</td>
<td>0.574</td>
<td>0.059</td>
<td>0.457 0.691</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Character—Policymaker (RG)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Character—Environmental Activist</td>
<td>0.130</td>
<td>0.162</td>
<td>−0.190 0.450</td>
<td>0.423</td>
</tr>
<tr>
<td></td>
<td>Character—Farmer</td>
<td>0.313</td>
<td>0.156</td>
<td>0.004 0.623</td>
<td>0.047</td>
</tr>
<tr>
<td></td>
<td>Character—Logger</td>
<td>0.274</td>
<td>0.155</td>
<td>−0.033 0.582</td>
<td>0.079</td>
</tr>
<tr>
<td></td>
<td>Character—Conservation Biologist</td>
<td>0.274</td>
<td>0.155</td>
<td>−0.033 0.582</td>
<td>0.079</td>
</tr>
</tbody>
</table>

Note: Full regression model was statistically significant, adjusted $R^2 = 0.402$, $F(12, 126) = 8.74$, $p < 0.001$. Best subset regression model was statistically significant, adjusted $R^2 = 0.413$, $F(5, 133) = 20.39$, $p < 0.001$.

3.2. Climate Change Knowledge

The summary statistics of paired differences in the climate change knowledge pre-test and post-test scores for each character showed that being assigned to the characters of farmer and logger had a positive impact on the climate change knowledge scores (Table 6). Prior to taking into account any other variables, there was not a significant difference in climate change knowledge for the different characters (Figure 2).

![Figure 2](image-url)
Table 6. Results of climate change knowledge scores at pre-test and post-test with paired differences.

<table>
<thead>
<tr>
<th>Character</th>
<th>Pre-Test</th>
<th>Post-Test</th>
<th>Paired Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Policymaker</td>
<td>69.12</td>
<td>12.71</td>
<td>73.76</td>
</tr>
<tr>
<td>Environmental Activist</td>
<td>70.81</td>
<td>10.59</td>
<td>71.04</td>
</tr>
<tr>
<td>Farmer</td>
<td>67.53</td>
<td>14.99</td>
<td>74.77</td>
</tr>
<tr>
<td>Logger</td>
<td>71.27</td>
<td>11.00</td>
<td>78.73</td>
</tr>
<tr>
<td>Conservation Biologist</td>
<td>69.54</td>
<td>14.66</td>
<td>70.87</td>
</tr>
</tbody>
</table>

Table 7 summarizes the regression results for the climate change knowledge scores.
After adjusting for the climate change knowledge pre-test scores, students who identify as first-generation college students have significantly lower climate change knowledge post-test scores ($p = 0.015$) and students who identify as low-income have significantly higher climate change knowledge post-test scores ($p = 0.016$). The environmental concern pre-test scores are trending toward significance in the model ($p = 0.065$).

Table 7. Full and best subset regression models for climate change knowledge post-test scores.

<table>
<thead>
<tr>
<th>Model</th>
<th>Variables</th>
<th>Estimate</th>
<th>SE</th>
<th>95% CI</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full</td>
<td>Intercept</td>
<td>11.28</td>
<td>3.79</td>
<td>3.77, 18.79</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>Climate change knowledge pre-test scores</td>
<td>0.402</td>
<td>0.092</td>
<td>0.220, 0.583</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Environmental concern pre-test scores</td>
<td>0.741</td>
<td>0.485</td>
<td>−0.218, 1.70</td>
<td>0.129</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>0.011</td>
<td>0.919</td>
<td>−1.81, 1.63</td>
<td>0.991</td>
</tr>
<tr>
<td></td>
<td>PEERs</td>
<td>0.590</td>
<td>0.840</td>
<td>−1.07, 2.25</td>
<td>0.484</td>
</tr>
<tr>
<td></td>
<td>First-generation</td>
<td>−2.27</td>
<td>0.879</td>
<td>−4.00, −0.526</td>
<td>0.011</td>
</tr>
<tr>
<td></td>
<td>Low-income</td>
<td>1.77</td>
<td>0.900</td>
<td>−0.009, 3.552</td>
<td>0.051</td>
</tr>
<tr>
<td></td>
<td>Transfer</td>
<td>1.09</td>
<td>1.12</td>
<td>−1.12, 3.30</td>
<td>0.331</td>
</tr>
<tr>
<td></td>
<td>Major—other STEM</td>
<td>−0.352</td>
<td>1.27</td>
<td>−2.87, 2.16</td>
<td>0.782</td>
</tr>
<tr>
<td></td>
<td>Major—non-STEM</td>
<td>−0.797</td>
<td>0.874</td>
<td>−2.53, 0.932</td>
<td>0.363</td>
</tr>
<tr>
<td></td>
<td>Character—Environmental Activist</td>
<td>−0.814</td>
<td>1.31</td>
<td>−3.41, 1.78</td>
<td>0.535</td>
</tr>
<tr>
<td></td>
<td>Character—Farmer</td>
<td>0.821</td>
<td>1.31</td>
<td>−1.77, 3.42</td>
<td>0.532</td>
</tr>
<tr>
<td></td>
<td>Character—Logger</td>
<td>1.48</td>
<td>1.24</td>
<td>−0.981, 3.94</td>
<td>0.236</td>
</tr>
<tr>
<td></td>
<td>Character—Conservation Biologist</td>
<td>−0.636</td>
<td>1.26</td>
<td>−3.32, 1.85</td>
<td>0.614</td>
</tr>
</tbody>
</table>

Best Subset

<table>
<thead>
<tr>
<th>Model</th>
<th>Variables</th>
<th>Estimate</th>
<th>SE</th>
<th>95% CI</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercept</td>
<td>10.9</td>
<td>3.35</td>
<td>4.28, 17.5</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Climate change knowledge pre-test scores</td>
<td>0.395</td>
<td>0.088</td>
<td>0.221, 0.57</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Environmental concern pre-test scores</td>
<td>0.830</td>
<td>0.447</td>
<td>−0.053, 1.71</td>
<td>0.065</td>
</tr>
<tr>
<td></td>
<td>First-generation</td>
<td>−2.017</td>
<td>0.822</td>
<td>−3.64, −0.390</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>Low-income</td>
<td>2.10</td>
<td>0.862</td>
<td>0.397, 3.81</td>
<td>0.016</td>
</tr>
</tbody>
</table>

Note: Full regression model was statistically significant, adjusted $R^2 = 0.162$, $F(13, 125) = 3.05$, $p = < 0.001$. Best subset regression model was statistically significant, adjusted $R^2 = 0.173$, $F(4, 134) = 8.22$, $p = < 0.001$.

3.3. Environmental Concern

The environmental concern pre-test scores were predictive of the environmental concern post-test scores, but there were no other predictors in this model. It is of note that environmental concern was very high from the start of the course (Table 8).
Table 8. Results of environmental concern scores at pre-test and post-test with paired differences.

<table>
<thead>
<tr>
<th>Character</th>
<th>Pre-Test</th>
<th></th>
<th>Post-Test</th>
<th></th>
<th>Paired Differences</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LL</td>
<td>UL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Policymaker</td>
<td>6.43</td>
<td>0.61</td>
<td>6.48</td>
<td>0.58</td>
<td>0.05</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>−0.18</td>
<td>0.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Activist</td>
<td>6.01</td>
<td>0.79</td>
<td>6.20</td>
<td>0.70</td>
<td>0.19</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>−0.11</td>
<td>0.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmer</td>
<td>6.00</td>
<td>0.71</td>
<td>6.03</td>
<td>0.90</td>
<td>0.02</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>−0.32</td>
<td>0.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logger</td>
<td>6.15</td>
<td>0.72</td>
<td>6.41</td>
<td>0.50</td>
<td>0.25</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>−0.04</td>
<td>0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conservation Biologist</td>
<td>5.84</td>
<td>1.22</td>
<td>6.10</td>
<td>1.18</td>
<td>0.27</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>−0.06</td>
<td>0.59</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Discussion

We set out to understand the extent to which different character assignments in an online, lower-division environmental quality and health course heighten students’ nature relatedness. Our analyses show that being assigned to the characters of farmer (Marco), logger (Antonio), conservation biologist (Carolina), or environmental activist (Rachel) had a positive influence on participants’ nature relatedness scores. However, after we adjusted for the nature relatedness pre-test scores, the logger was the only character with significantly higher post-test scores compared to the reference group (policymaker, Maria). The students in the course learn that Antonio works as a logger for a big company, and he believes logging in the Amazon rainforest is driven by consumer demand in the United States. Antonio shares that he feels big-city environmentalists do not understand his way of life in Brazil.

Given Antonio’s background and focus on logging to provide for his family, one might expect that students assigned to play the role of logger would have constant or even decreasing nature relatedness scores between the pre- and post-test surveys. However, our results suggest that a student assigned the role of Antonio may instead have a strong, negative reaction to their character’s occupation as a logger. After learning about the ecosystem benefits that the Amazon rainforest provides for the planet, the students assigned to Antonio may develop an affinity for the Amazon rainforest and wish to protect the forest from negative actions like logging. This may, at least in part, explain the significantly higher nature relatedness post-test scores for students assigned to the character of Antonio. Our findings are consistent with existing studies that find a positive association between science or sustainability education, connection to nature, and pro-environmental behaviors (e.g., [23,54]).

Opportunities for immersive role-playing scenarios that include characters whose livelihood involves observable environmental degradation, like Antonio, could enhance nature relatedness among those students assigned to play that role. Building a connection to nature is more urgent than ever before. We are still within the small window of time where swift action to reduce carbon emissions can potentially limit global warming below dangerous levels [55]. To accomplish this, we must work in diverse teams across multiple levels and sectors to ensure that we develop policies, infrastructure, and technologies that support this goal [55]. Today’s students are tomorrow’s climate scientists, policymakers, product designers, and CEOs. Enhancing our students’ nature relatedness may help society to meet our crucial climate change goals.

In this study, we also wished to understand the influence the course and respective character assignments have, if any, on knowledge about climate change. We found that being assigned to the farmer or logger character had a positive influence on the climate change knowledge scores, but after adjusting for the pre-test scores, character assignment did not have an impact on climate change knowledge gains. It was not our intention for character assignment to impact climate change knowledge gains during the quarter, so this is a positive study outcome. However, after adjusting for the pre-test scores, we find that first-generation college students had significantly lower climate change knowledge post-test scores while low-income students had significantly higher climate change knowledge.
post-test scores. Studies of first-generation students have shown that students who are the first in their families to attend college face a number of structural barriers in STEM majors [27,56,57], as well as academic success barriers [58,59] and obstacles that decrease retention and bachelor’s degree attainment [60–62]. Although online courses may offer time flexibility for first-generation learners, an online learning modality may not always provide the extent or variety of communal learning opportunities that first-generation students prefer [27,28]. Importantly, our campus offers a number of academic success programs [63,64] for students who identify as first-generation and low-income college students; however, there are no programs specifically focused on supporting students’ online learning.

We wished to explore the impact that course content and character assignment have on environmental concern, if any. Students in this course began the quarter with high levels of environmental concern, and at the end of the quarter, student environmental concern remained at a high level. Research on the relationship between specific academic majors (e.g., environmental studies, biology, and outdoor recreation) and environmental concern finds that students in some majors have greater levels of environmental concerns than those in other majors, although the direction of this relationship is unknown [65,66]. Given that student environmental concern in our study was high from the start, the use of a different environmental concern measure with a greater range of possible scores could help us to understand the changes in environmental concern across the course.

4.1. Implications for Research and Practice

There are some important implications of this work for future teaching practice and research. Overall, there may be the potential to stimulate a connection to nature by assigning students in a course to play a character whose occupation centers on some facet of environmental degradation, which may force students to grapple with the complex realities of sustainability and local job availability. This should be done in a manner that does not vilify the character, but instead, brings forward their humanity, as we aimed to do with the logger’s character. For us, the character assignments served to transport students out of their own lives and into a scenario with different stakeholders, while exploring the essential ecosystem services that the Amazon rainforest provides locally and globally. Faculty looking to gamify their classes with role-playing may wish to employ similar characters and case studies. We recommend analyses similar to those presented here to test for unintended benefits for some characters compared to other characters.

Finally, students’ environmental concern was universally high in both the pre- and post-test, signaling the potential to build on this reservoir by developing additional measures of environmental concern that provide a more nuanced understanding of student concerns about the environment. Today’s college students are coming of age in a world that is already experiencing the impacts of global climate change. As we are a minority-serving institution, our students are likely to belong to frontline communities experiencing the first and the worst impacts of climate change. We recommend the further development of a measure of environmental concern that aims to evaluate the lived experiences of college students to better understand their level of concern across different domains.

4.2. Limitations and Future Work

We evaluated only one offering of an online environmental quality and health course at a single university. In the future, we plan to explore comparative analyses across the same course and across different courses on similar topics, both with and without character assignments as part of the course design.

It is possible that students self-selected into our course due to their interest in environmental quality and health, which may partially explain the high levels of environmental concern measured at pre-test and post-test. Future research could repeat this study in an introductory public health course where there may be increased variation in student environmental concern. Although this class fulfills a science and technology general edu-
cation requirement for all students on campus, most students were public health majors or other STEM majors. Public health and other STEM majors may have a higher level of environmental concern compared to non-STEM majors based on their prior coursework, exposure to information about global climate change, and their interests around the health of the environment in general. Repeating this analysis in a non-STEM or non-public health course that also centers on the topic of sustainability or climate change would provide a different context and the potential for different character roles. For example, repeating this study in a computer science course focused on how new forms of information technology can support the transition to a sustainable civilization would necessitate five new characters roles that are more relevant to that topic.

While students were able to self-select into the course itself, they were not able to select a character that may have resonated with them. Because we balanced character assignments and teams based on student demographic characteristics, we ensured that there was student diversity across the characters and teams. Diverse teams promote improved team performance and the production of salient scientific ideas [36,37]. Our study design ensured that we could look at the impact of the character aside from the impact of student demographics. The instructor was blind to the randomization, a process that could be useful for any courses with similar team-based activities.

5. Conclusions

Role-playing activities combined with small group work are one way to bring real-world experiences into an online course. When students embody an archetypal character as part of a teamwork assignment, this provides them with an opportunity to view the world through another perspective and set of lived experiences. We found evidence that students assigned to the logger working in the Amazon rainforest (Antonio) experienced greater increases in their nature relatedness scores across the course compared to the reference group (policymaker, Maria). This finding signals the potential for character-specific activities to enhance students’ connection to nature in an environmental quality and health course.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su16114484/s1, Supplement S1: Team Activities in Environmental Quality and Health (EQH) [38,39]; Supplement S2: Discussion Section Agendas; Supplement S3: Team Assignment Worksheets; Supplement S4: Questions Included in Pre-Test and Post-Test Surveys [42–44]; Supplement S5: Systematic Randomized Design; Table S1: Participant Demographic Information by Team; Table S2: Participant Demographic Information by Character; Figure S1: Box Plot Example.

Author Contributions: Conceptualization, M.G.R., K.D., and J.D.; Methodology, M.G.R. and K.D.; Software, K.D.; Validation: K.D.; Formal Analysis, K.D.; Investigation, M.G.R.; Resources, M.G.R.; Data Curation, K.D.; Writing—Original Draft Preparation, M.G.R.; Writing—Review and Editing, K.D. and J.D.; Visualization, M.G.R. and K.D.; Project Administration, M.G.R. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement: A study information sheet outlining the potential risks and benefits of the study, as well as instructions for how to opt-out of the study, was provided to all students involved in this research.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to student privacy.

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Conflicts of Interest: The authors declare that there are no conflicts of interest.

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