Article

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SUSTAINABLE STATES: a role-playing game for sustainability education

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Active learning is a more effective approach than passive learning, and formats such as role-playing games (RPGs) can be more effective still due to perspective shifting that students undertake during participation. This is especially the case for environmental and geosciences education, but to date, RPGs are sparsely used in this space and when they are, they tend to be highly specialized and non-generalizable. Here we will describe Sustainable States, a general purpose RPG developed for environmental diplomacy education which features learning objectives in Earth sciences, political sciences, and soft skills. Sustainable States has been deployed at several universities globally and we will specifically describe the outcomes at two (Arizona State University in the USA and Universidade Estadual de Campinas in Brazil). Although requiring additional work to simplify game rules and help students achieve the stated learning objectives, initial results show high levels of engagement and strong potential to become a powerful general education tool for environmental and geoscience topics.

Introduction

Meta-studies have clearly demonstrated that active learning is more effective than passive learning, yet passive learning persists because it is more information dense and there is often skepticism about using an approach that scientists personally did not experience during their formal education (Waldrop, 2015). Role-playing games (RPGs) are a form of incredibly engaging active learning that help students learn and retain not just topical knowledge but also to develop interpersonal skills, yet they remain rare in formal classrooms due to their complexity, narrow-topic focus, and widespread attitudes that games are frivolous and do not belong in formal learning environments (Camargo et al., 2007; Grande-de-Prado et al., 2020; Gomes et al., 2023).

RPGs have been found to be especially effective in environmental education and motivating environmental action, both through applications in formal classrooms and in professional development settings where they often compensate for a lack of environmental science education during formal schooling (Camargo et al., 2007; Myers et al., 2012). Current sustainability challenges, from climate change to plastic pollution to overexploitation of resources, are a result of complex socio-economic factors that are often compounded by general ignorance of Earth and environmental sciences. In many places around the world, there are no formal courses in geosciences or Earth system science at the primary and secondary school levels, with the topic in some cases subsumed into "natural sciences" or "geography" and taught by teachers who have no formal training in Earth and environmental sciences (Greco and Almberg, 2016). This has allowed "alternative facts" to supplant scientific consensus in the minds of many people around the world, with climate change being an especially ripe field for conspiracy stories, but often extending to other topics as well, making it much more difficult to successfully tackle complex sustainability and quality-of-life problems.

Until recently, most scientists thought that a lack of "scientific literacy" is to blame for the persistent ignorance about important scientific topics. If this is the case, simply teaching more facts about science and its discoveries should rectify the problem. But this approach has been found to be ineffective, if not counterproductive. In fact, in politically polarized societies such as in the US, increasing levels of scientific literacy have been found to correlate with an *increase* in susceptibility to misinformation (Kahan et al., 2012). This occurs specifically because those who are scientifically literate and politically ideological are more susceptible to motivated reasoning, where they use logic learned through a scientific education to reject evidence that conflicts with core tenets of their identity and ideology. Instead, it is "scientific curiosity" that is better correlated with improved resistance to misinformation (Kahan et al., 2017). People who are scientifically *curious* are more likely to explore "counterfactuals" and read studies and articles that may present ideas that conflict with their identity and hence become less susceptible to motivated reasoning and misinformation.

RPGs, by having students assume roles that may be contrary to their preferred perspectives and ideologies, allow students to perspective shift and potentially increase their levels of curiosity since they are performing in an unfamiliar intellectual space, which necessitates exploration to understand that space. This creates the potential for RPGs, such as

Sustainable States, to play a dual role in both relaying factual information about environmental science while also curating curiosity in students.

Sustainable States

Sustainable States is an educational role-playing game prototype under development at Science Voices, a US-based nonprofit organization working on challenging problems in global science education. The RPG, co-developed by co-authors Lennon and Horodyskyj, is intended for use in both environmental science and political science classes so that students in each get exposure to important concepts in Earth and political sciences that play important roles in making society-level decisions related to Earth system challenges.

Game Structure

The game is centered around nine fictional countries operating on a single continent (Figure 1). Each country has a unique governance type and ideology, which allows students to explore various types of ideologies and regime structures (centralized, semi-centralized, decentralized) and the constraints that they place on decision-making. Each country is further subdivided into smaller states and provinces with local histories and cultures that create contradictions and internal politics that students must navigate when developing country-wide policies. When joining multiple classrooms together into one experience, different classrooms use different continents that exist in the same world, which allows for independent play for each classroom, with the opportunity for international linkages for global scenarios (such as climate change). Students play in groups of 3-6, and each group plays the legislative role of a single country for the full six weeks.

Although real countries can be used for the game, fictional countries are far preferable. When students fixate on real countries, they tend to simply copy those countries' histories, cultures, and policies without developing a true understanding of those countries. Additionally, they tend to limit the actions they take to what they think is politically feasible within those countries and don't explore the full solution space that may be available to them. Creatively remixed fictional countries allow teachers to create an exploration space that limits student copying and encourages them to take ownership of these nations as they develop a wider set of solutions than they would consider based on real world politics.

Game phases are split into two parts: 1) internal policy and 2) international diplomacy. During the internal policy phase, students develop policies that they would like to implement in their countries based on challenges that they have identified, ideological priorities, or the thematic event for the week. Policies may or may not be implemented, depending on the regime type:

1) Centralized regimes (dictatorships, monarchies) - implement policies into law automatically

2) Semi-centralized regimes (republics, representative democracies) - require a vote by representatives of states and provinces to determine if the policy becomes law

3) Decentralized regimes (pure democracies, anarchies) - require a vote by the majority of people in the country to determine if the pol-

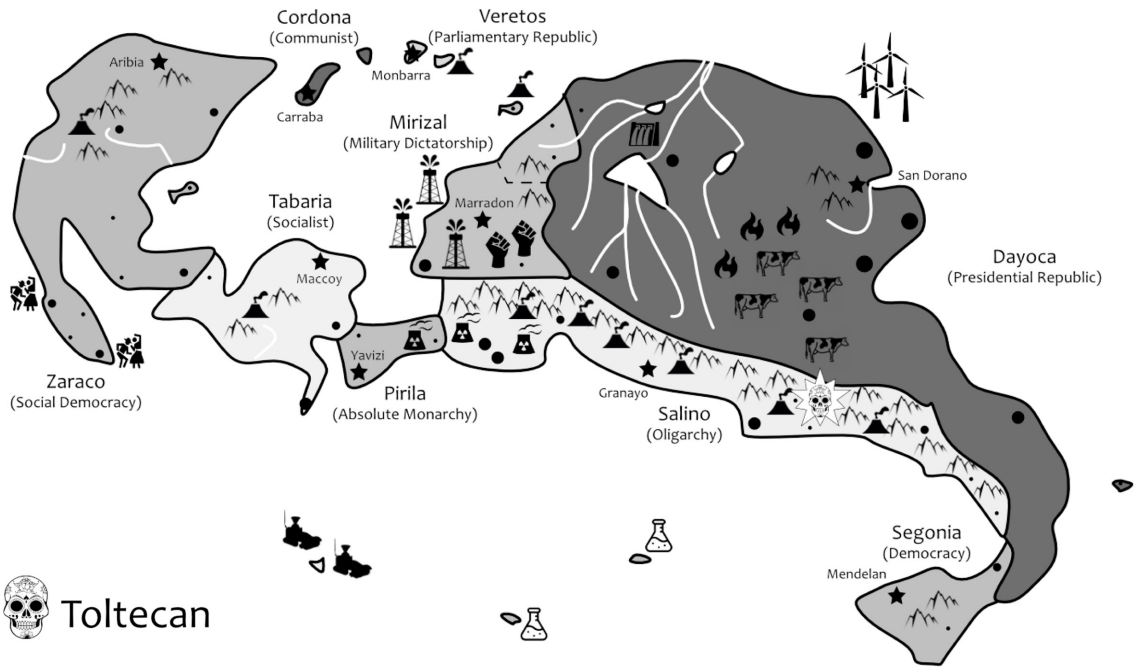

Figure 1. Toltecan map, used with Brazilian students in 2021 and 2022 deployments. The Toltecan map is broadly representative of maps used in Sustainable States. Maps typically feature nine countries each with a different ideology and regime structure. Most maps feature disputed border regions and are seeded with potential events (illustrated here for students with icons) that can be utilized by teachers to construct scenarios. On the Toltecan map, seeding events include tourism-fishing conflicts (Zaraco), deep sea mining (Tabaria, offshore island), highly active tectonic zones (Veretos, Salino), break-away regions (Mirizal), rainforest deforestation (Dayoca), indigenous land use (Mirizal, Dayoca), cultural heritage sites (Salino), and off-limits research zones (Segonia, offshore islands). Students receive more detailed information and data on each of their countries through private Google Drive links.

icy becomes law

Policies that become laws impact the game in ways determined by the gamemaster (the teacher and his or her assistants) and have downstream effects in subsequent weeks.

During the international diplomacy phase, students are presented with a global challenge and spend class time negotiating treaties, alliances, trade pacts, and other diplomatic agreements (both public and secret) that impact the game in subsequent weeks. Each country receives private data and motivations for winning "event points" that empowers and incentivizes them to form alliances or act against countries that threaten their national interests.

Curriculum

The curriculum is currently split into six weeks, a deliberate design decision to make it easier for teachers who are interested in using the RPG to integrate it into an existing class. Additionally, as a key component of the RPG is to create real international experiences between participants at different universities in different parts of the world, the six week structure is easier to incorporate into overlaps between vastly different school schedules. The experience is split into two three week sections (Table 1).

In the first three weeks, students are introduced to a "core curriculum" that includes an introduction to basic science and governance, resource distribution, societal institutions, trade routes, and international trade. Parallel to these learning topics is a gradual introduction to the game mechanics, starting with an introduction to the fictional countries that students will be role-playing including their internal culture and politics as well as how to access and utilize data to make decisions (week 1), how to develop internal country policies to address challenges or ideological objectives (week 2), and meeting with other players to negotiate international relationships that are formalized as treaties (week 3). The typical events utilized during this opening sequence are an exploration and internal audit of natural resources that students have available to them within their country (week 2) and the establishment of trade relationships between nations to acquire resources that may not be present but are of strategic value (week 3).

The second three weeks build upon these basics and introduce advanced topics such as passing policy into law (which differs in different regime types), addressing conventional hazards to a country (which introduces risk management topics), and addressing systemic hazards (which introduces systems science). Students work with the existing game mechanics mastered in previous weeks to explore scenarios in more detail, so that the focus shifts from learning the structure of the game to learning environmental science and political science topics. The second half of the RPG teaches core topics related to laws and hazards and can be paired with a variety of Earth system topics, depending on the priorities of each classroom (Table 2).

Learning Objectives and Evaluations

Learning objectives in the *Sustainable States* RPG are focused on science, governance, and interpersonal skills (Table 3). Since the RPG is an active learning experience, the learning objectives are focused as

Table 1. Sustainable States schedule

Week	Title	Topics	Game Mechanics
1	Introduction	Philosophy of science, nation structures, regime types	Country exploration, posting public announcements, data review
2	Resources and Institutions	Element origins, Earth system processes, resource distribution, institutional types, toleration for dissent	Building internal country policies
3	Policy and Trade Routes	Stakeholders, policy development, motivated reasoning, trade routes, infrastructure	Developing international treaties
4	Law and Power	Law passage/implementation in various regime types, hard power vs. soft power, accountability, [energy, heat, electricity, fuel sources, power plants][(a)]	Passing policies into law under various regime types
5	Conventional Hazards	Cause-and-effect relationships, risk management (identification, analysis, prioritization, response, monitoring), [geodynamic hazards, geomorphic hazards][(a)]	(none)
6	Systemic Hazards	Systems science, tragedy of the commons, resilience, inclusive governance, [atmospheric circulation, greenhouse gasses, feedbacks, climate change][(a)]	(none)

[(a)]Topics marked with brackets [ ] indicate science topics that are variable depending on which scenarios are used in the second half of the experience. The listed topics here are for the Climate Sequence.

Table 2. Topics for alternative end sequences ("developed" indicates a sequence that has been previously deployed, "under development" indicates a sequence that has not yet been finished and tested)

Topic	Climate Sequence (developed)	Plastics Sequence (under development)	Deforestation Sequence (under development)	Geoheritage (under development)
(Week 4) Law	Energy Sources and Power Plants	Fossil Fuel Extraction and Manufacturing	Agriculture and Animal Husbandry	National Parks and Indigenous Rights
(Week 5) Conventional Hazards	Hurricanes, Floods, Volcanoes	Mine Waste, Landfills	Wildfires	Earthquakes, Landslides
(Week 6) Systemic Hazards	Climate Change	Plastics Pollution	Mass Deforestation	Land Use Conflict

Table 3. Weekly science, governance, and soft skills learning objectives

Topic	Science Learning Objectives	Governance Learning Objectives	Soft Skills Learning Objectives
(Week 1) Science and Governance	Explain how observations and assumptions are used to construct scientific models and how models are tested, refined, and utilized to make decisions	Explain how culture (values and priorities of a people), regime (decision-making structures), and ideology (power relationships between people and regime) influence governance	Discuss the strengths, weaknesses, and interests of team members
(Week 2) Resources and Institutions	Describe how energy released by fusion and fission processes result in element creation in stars, incorporation into planets, and redistribution and uneven concentration across Earth's surface	Explain how toleration for dissent maintains healthy institutions and the importance of institutional health on the ability to identify, locate, extract, redistribute, use, and resolve disputes about resources	Explain your group's communication norms and how dissent is handled, and then document norms in group agreement
(Week 3) Policy and Trade Routes	Explain how the geosphere, hydrosphere, and atmosphere interact to create or stymy trade routes	Explain how policies take inputs and convert them through activities into results	Determine the roles people are playing on the team and how internal and external factors are shaping your group
(Week 4) Law and Power	[Climate Sequence] Explain how various fuel sources are converted into electricity	Explain how policies are converted into laws in various regime types and what role accountability plays in various regime types	Evaluate your group and compare the internal norms that have developed with the norms you planned
(Week 5) Conventional Hazards	[Climate Sequence] Describe the various types of geodynamic (earthquakes, volcanoes, tsunamis) and geomorphic (hurricanes, floods, tornadoes) hazards	Describe the steps required for proper risk management (identification, analysis, prioritization, response, monitoring)	Evaluate your group and compare the team roles and diplomatic connections that have developed to what you planned
(Week 6) Systemic Hazards	[Climate Sequence] Explain how greenhouse gasses influence geomorphic processes (atmospheric circulation, ocean circulation) through complex cause-and-effect relationships	Describe how inclusive governance helps manage systemic risk	Take yourself out of the heat of the moment and reflect on the experience (mindfulness)

much on skills and abilities as they are on content knowledge. Evaluation takes place at both group and individual levels. At the group level, team assignments typically include initial development of national flags and mottos, domestic policies, and international treaties. Inter-team negotiations are fluid and teams must strategize and adjust to changing circumstances. During the international diplomacy phase, teams are given scenario objectives and are assessed as a group at the end of each scenario on whether they were able to meet their objectives or not. To ensure shared understandings of game objectives and the underlying scientific or governance concepts, individual members are assigned brief quizzes and writing assignments. Also, within the teams, students evaluate each other as collaborators on a rubric that can be

Table 4. Summary of test deployments, 2021 and 2022

Semester	Format	Group	Context	Engagement Level
Early 2021	Online	[USA] Arizona State University (50 students)	*Do You Want to Build a Nation?* (upper-level political science course)	High overall engagement, 3 withdrawals
		[Brazil] Universidade Estadual de Campinas (6 students)	Independent Volunteers	High engagement
		[Indonesia] Khairun University (6 students)	Independent Volunteers	Complete disengagement
Late 2021	Online	[USA] Arizona State University (47 students)	*Do You Want to Build a Nation?* (upper-level political science course)	High overall engagement, 2 withdrawals
		[Brazil] Universidade Estadual de Campinas (26 students)	*Geosciences Practices in Basic Education* (upper-level geography course)	High overall engagement, with some non-English speaking groups engaging less
		[Ukraine] Lviv Polytechnic National University (10 students and teachers)	Independent Volunteers	Minimal engagement
Late 2022	In Person	[USA] Arizona State University (49 students)	*Do You Want to Build a Nation?* (upper-level political science course)	High overall engagement, 1 withdrawal
	In Person	[Brazil] Universidade Estadual de Campinas (45 students)	*Geosciences Practices in Basic Education* (upper-level geography course)	High overall engagement, with some non-English speaking groups engaging less

simple (rating 1-5) or more complex (e.g., across criteria such as reliability, effort, and collaboration). This peer evaluation incentivizes active and inclusive participation during the RPG.

Student Response

Sustainable States has been run as a multi-institution experience for several semesters and has included students from Arizona State University (ASU, USA), Universidade Estadual de Campinas (UNICAMP, Brazil), Lviv Polytechnic National University (Ukraine), and Khairun University (Indonesia). More details on the runs, including number of participants and level of engagement, are listed in Table 4.

The universities where *Sustainable States* has been run are ones where co-author Horodyskyj has had affiliations and worked in-person over the past few years. Early iterations of the RPG focused on creating an international experience for students at every partner school. The success or lack of success of the experience depended very much on the accountability structure provided by a formal class. At both Khairun University (Indonesia) and Lviv Polytechnic (Ukraine), where the experience was offered to interested students (and some teachers) as an extracurricular activity, the lack of accountability structures resulted in the students becoming disengaged and eventually dropping out of the experience, despite showing early interest in this unusual form of learning. Additionally, the novelty of an RPG active learning experience proved to be extremely disengaging to students who were expecting lectures and exams, as that is the primary educational structure that is common in many places around the world.

In the latest iteration of the experience (late 2022), the focus narrowed to ASU (USA) and UNICAMP (Brazil) as the primary institutions for deployment, as both had faculty who were invested in implementing the experience within active learning classes and collecting data on its outcomes. At ASU, a version of *Sustainable States* is deployed within the political science course *Do You Want to Build a Nation?*, an upper level political science course which focuses more on the political aspects of the RPG. At UNICAMP, a version of *Sustainable States* is deployed within the geosciences teaching course *Geosciences Practices in Basic Education*, an upper level geography course designed to expose future teachers to novel forms of teaching. In late 2022, the versions operated separately, with a collaboration during the climate change event in week 6.

Insights from ASU Deployments (USA)

A precursor of *Sustainable States* has been taught at ASU for nine years and has historically focused on governance. The upper-division course, *Do You Want To Build a Nation?*, integrates normative theory, international relations theory, and public policy. The instructor, co-author Lennon, created the course in part to develop students' interpersonal and soft skills, including public speaking and team-work, and to develop their understanding of the human and climate impacts of public policies. Student-team decisions impact other teams and the flow of the course, and the excitement of war has been a recurring component. For example, in the ASU deployments, wars frequently disrupt many scenarios, including the climate change one. Failure to reduce emissions, which is a frequent consequence of distraction by war, then negatively impacts subsequent diplomatic events. In the three iterations discussed here, two of the classes successfully reduced emissions by working across groups. In the Late 2022 iteration, the ASU students were supposed to coordinate with each other and the UNICAMP teams to collectively reduce emissions. While the UNICAMP teams reached out with collective solutions, the ASU teams were embroiled in multiple wars and failed to coordinate and help solve the global problem into which UNICAMP students put a lot of work to solve, which resulted in a negative reaction from UNICAMP students.

Overall, ASU students seemed to engage with the active learning setting and related material and reported improvements in their soft skills. As reported in 2021 and 2022 course evaluations, 91.3 and 87.8 percent of the students, respectively, agreed that "The course has helped me think about the subject matter in a new way." According to pre- and post-semester surveys, by the end of the semester, more students enjoyed engaging within their groups and found it easier to "speak their mind" and "be diplomatic" in contentious discussions. Specifically, by the end of the 2021 and 2022 offerings, 97 and 100 percent of students, respectively, agreed that they "Enjoyed debating in small groups" compared to the 70 and 66 percentages reported at the start of the semester. When considering how students handled contentious discussions, by the end of the semester, the percentage of students who found it "difficult to speak my mind when I disagree in small groups" was cut in half, on average, from 43 to 21 percent in 2021 and from 35 to 18 percent in 2022. Similarly, by the end of the semester, the percentage of students who found it "difficult to be diplomatic when I disagree in small groups" was 75 percent lower, on average, by the end of the course, from 24 to 6 percent in 2021 and from 13 to 3 percent in 2022. The enjoyment of and increasing ease with diplomatic engagement is encouraging. Anecdotally, ASU students' enthusiasm and engagement were apparent in their regular collaboration and negotiations in class and even outside of class time.

Because the ASU offering focused more on political regimes, ideology, and policy, there was more attention to military or economic advantage than scientific principles. Science objectives (e.g., how to address a hurricane emergency) were not well considered and provided only loose constraints for their preferred political or economic objectives. To address a hurricane emergency, for example, student teams only focused on the cost of a solution rather than its viability. The fictional aspect of the simulation allows students room for creative solutions (e.g., "clean nuclear" power or "carbon capture and sequestration" to address emissions), but most policies and treaties only scratched the surface of the scientific basis of the solutions. As a result, there is additional work to do to help bring better results for science learning objectives into the political science classroom.

Insights from UNICAMP Deployments (Brazil)

The engagement of UNICAMP started during the pandemic to provide students restricted to Zoom meetings an alternative learning format to explore. Initially in 2021, the format was tested by a group of student volunteers who were recruited via mailing lists targeting geography and geology students in the Institute of Geosciences. Six students answered the call and became deeply involved in the experience. They provided feedback to co-author Greco in order to better understand how to include *Sustainable States* in his existing geogra-

Figure 2. Late 2022 deployment at UNICAMP, Brazil. Students from the Salino and Tabaria groups negotiate during an international diplomacy round.

phy courses, especially ones focused on training future teachers. Many of these volunteers provided in-person support in future semesters so that they could remain involved with the experience, which they greatly enjoyed.

Geography students at UNICAMP are more focused on narrative and they tend to have a strict anthropocentric perspective, thinking about Earth science concepts and challenges only from the perspective of their impacts on humanity. As a result, it is often difficult to engage geography students in Earth science topics, which is consequential for those students who are educated to be future teachers of geography, a discipline that still includes the majority of the few Earth science materials in the Brazilian curricula in primary and secondary schools. With the *Sustainable States* RPG, students gained an opportunity to use their creativity to build narratives about their countries and solutions to environmental issues based on human relations, where they excel. This provided an excellent in-road to Earth science topics that geography students at UNICAMP would normally overlook.

The late 2022 deployment in the upper-level geography course *Geosciences Practices in Basic Education* provided an opportunity for students to both experience the RPG as a form of active learning and learn about the principles of RPG development for their future classrooms (through teacher training materials that bracketed the RPG experience each week). Several groups became hyper-engaged and major power players, eclipsing many USA groups in the process (Figure 2). The course was offered to both afternoon and evening classes and the major power players would cross between afternoon and evening classes for negotiations, or even engage in negotiations (and spying) outside of the class, such as in the general Institute public spaces and the university dining halls. The deployment culminated in a food and feedback party, at the request of the students, where they brought "traditional" foods from their fictional countries and offered feedback on the experience.

Responses to the experience were generally positive, with some of the hyper-engaged groups showing sophisticated understanding of the major learning objectives and how they could or could not apply them to their play style, as demonstrated in their final reports:

"[translated from Portuguese] Petróleos de Mirizal, the state-owned oil company, nationalized after the Verdista revolution, operates at the economic level of society [week 2 learning objective, types of institutions]. For the same reason described above, that of total control of the Armed Forces and the Verdist ideology, the institution is unwilling to obtain new information to test its hypotheses about where to seek new resources or change operations [week 1 learning objective, role of assumptions and observations in building scientific models; week 2 learning objective, toleration for dissent]."

Reports submitted by students at the end of the RPG showed a strong focus on philosophy of science, governance, and soft skills learning objectives, especially in the first few weeks of the experience. Earth science learning objectives were more strongly highlighted in the final two weeks of the RPG during the risk analysis/disaster event and systemic risk/climate change event. Students accurately evaluated geomorphic, geodynamic, and systemic risks to their nations by integrating a variety of climate and tectonic data that was available to them. One hyper-engaged team devised an ecocidal strategy (through claims of intensified carbon dioxide emissions and strategic headwaters pollution) to pressure other teams into making concessions during negotiations, which opposing teams countered through emissions modeling to determine that the ecocidal team was lying about the intensity of their emissions, indicating a sophisticated grasp of the RPG's three categories of learning objectives.

The hyper-engaged groups, who often rewrote their histories in order to create antagonistic scenarios that would deliberately challenge their classmates' style of play and underlying assumptions, even commented on the level of engagement of other teams, saying:

"[translated from Portuguese] It would be even more fruitful for everyone if, truly, everyone had mobilized like Mirizal and Dayoca."

Despite the positive reception, the students complained about the confusing number of digital tools that were required to coordinate the experience and requested simplification of the game mechanics in the future to make it easier to deploy in their own future classrooms. Some of them have even begun this simplification process themselves, as at least one student reported creating a shortened and simplified version of the RPG to use with school kids at a local museum during a two-day event on climate change in 2023, demonstrating that the experience is having a lasting impact on introducing the concept of RPGs as useful pedagogical tools.

Conclusions

Climate change is just one of the substantial and complex environmental problems that requires an educated, coordinated, and energetic international response. Education in both geoscience and political science can improve impactful responses to these challenges by students but the educational paths still remain distant from each other. Existing curricula are understandably siloed by the different disciplines. *Sustainable States* helps bridge that connection not just through the integration of learning objectives from multiple fields but by also integrating disparate classes (e.g., political science and geography, American and Brazilian) into a shared experience. The active-learning format of this RPG (like many others) provides a few advantages as compared to traditional secondary and higher education teaching formats. By cre-

ating a narrative, the RPG helps students integrate various topics into a shared reality. The RPG allows students to shift their perspective while solving new problems. The fictional role-playing is an unfamiliar intellectual and political space, resulting in creative thinking from students, which we see frequently in all our deployments. Role-playing thus engages students and frees them from existing political solutions. Because the *Sustainable States* RPG is based on real scientific problems, such as climate change and natural disasters, the RPG conveys factual scientific information, much like other educational RPGs. Unlike other educational RPGs, however, the realistic but fictional world of *Sustainable States* prompts more creative problem-solving than the "real" political settings often favored in educational RPGs, which are often built to replicate very narrow settings, scenarios, and topics and have limited reusability or scalability. For both scientific and political topics, the game setting has the potential to develop students' curiosity and remain flexible for adoption into various classrooms due to its customizable design. And most importantly, the ownership that students feel over the countries they've led and decisions they've made leave them talking about the experience and what they've learned from it for years after the experience has concluded.

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