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Sparking Students' Interest: Teaching About International Climate Negotiation with a Renewable Energy Transition Simulation Game

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ABSTRACT

International climate negotiations stall when countries do not view problems outside of their national interest or do not consider renewable energy as collectively beneficial. This is not inevitable. Political science university educators can help students view climate negotiations beyond national interest and imbue needed negotiation skills through the use of simulation games. Simulation games can depict uneven distribution of existing energy infrastructure, wealth, natural resources, and population – all of which make the energy transition "geopolitical." By negotiating policies and trading inputs, technology, resources, or knowledge with other countries, it is possible to phase out fossil fuels. This study imparts lessons learned from a European project to turn the concept of international cooperation on the energy transition into a simulation game called '*Geovania*.' Game sessions reinforced the learning objectives to teach students about the politics of renewable energy transitions, gave practical experience negotiating, and portrayed the two-level domestic/international interface. In this study, we begin with the need for simulation games on the geopolitics of energy transitions, present the development of this game, and offer observations from instructors who developed and used this game in their classrooms. The results include cumulative insights from 14 sessions in six countries with 292 university students. We find that the game sparked students' interest in the energy transition, in part due to the features of the digital interface, and that skilled facilitation can build on students' understanding of material to meet various course objectives.

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Introduction

University educators shape the ability of the next generation to solve global sustainability challenges (Maniates 2017). One of the key functions of teaching environmental politics is to cover the international politics of climate change mitigation, which occurs in

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diplomatic negotiations. In teaching about climate negotiations, instructors show how countries have pledged to reduce greenhouse gas emissions through a transition away from fossil fuels to renewable energy. To do this, instructors can incorporate insights from climate negotiations into their lectures or take students to directly observe the United Nations Framework Convention on Climate Change Conferences of the Parties (Snorek and Gilmore 2023). Another option is to use simulations in the classroom to put students into decision-making roles (Rooney-Varga et al. 2021; Sterman et al. 2015; Brown 2018). Simulations are an appealing option because they instill negotiation skills in students, which are the same competencies used by diplomats to make commitments to phase out fossil fuels (Kinley et al. 2021). Simulation games require students to develop their own arguments while learning to recognize others' perspectives.

In simulation games, players are put into situations in which their actions change the outcomes of a game. Simulation games are not rational choice thought experiments because they do not assume a player's actions. This is fitting because climate change should not be construed as an international tragedy of the commons in which countries relentlessly pursue their own interests by using carbon-based energy sources at the expense of global climate stability. Instead, if countries have the chance to negotiate their interests, they might choose to cooperate (*a la* Ostrom in Sarker and Blomquist 2019). In this case, the cooperative choice is to phase out fossil fuels and make the switch, or a transition, to renewable energy. Various policy instruments can be used to do this. Transition policy includes various measures throughout the energy system in the form of investments, subsidies, nationally determined contributions (NDCs) to reduce emissions, urban planning measures, and others (IRENA 2023). Transition management, or choosing from these policy options, is inherently political and requires tradeoffs (Meadowcroft 2009). Simulation games offer educators a chance to strengthen students' ability to negotiate while teaching about policy options.

Industrialized countries must swiftly transition away from fossil fuel energy sources in order to stay within acceptable limits of global warming (IPCC, Intergovernmental Panel on Climate Change 2022). Energy transitions require actors to negotiate differing viewpoints, definitions, and understandings of environmental problems and technological solutions. Multilateral negotiations between countries can generate a common understanding of problems and actions (Kinley et al. 2021) if parties consider the implications of their actions on others (Gupta et al. 2023). Meaningful climate agreements, those in which a consensus is reached, can be achieved when actors are not stubbornly tied to their own viewpoints (Bernardo et al. 2021). To do this, it is imperative to shift the focus of climate negotiations toward the opportunities of the energy transition.

Sustainability education research suggests that transformative learning experiences happen when individuals step out of traditional, formal instructional settings and engage with each other in less formal settings (Singer-Brodowski 2023). Games make challenging, complex topics more approachable and engaging. They enhance substantive knowledge while boosting critical thinking skills (Shellman and Turan 2006). Putting students in the driver's seat as political decision makers gives them a chance to experience what it is like to prioritize competing social, economic, and environmental goals, while thinking in the realm of what is technologically feasible. Sustainability games reveal how actors could be affected by technological shifts and assist players to uncover

pathways to improve societal outcomes. Simulation games fit within the broader mission of higher education to offer opportunities for students to reflect on their own and others' worldviews. The ability to cooperate with others is a fundamental competence for students in sustainability (Brundiers et al. 2021).

Active learning is becoming more common in courses, particularly where universities have an entrepreneurial, student-focused approach. Digital tools can enhance active learning; for example, in the form of "flipped" classrooms in which a lecture is prerecorded and class time is used for less structured interactions (Bain 2021). Digital options also connect learners and instructors across continents or parts of the world. Courses on sustainability, climate agreements, and the politics of the energy transition are a good fit for these types of interactions because environmental and social problems are global.

Learning across geographies is hence an important factor for preparing the next generation of decision-makers. European universities are a natural testing ground. The ministers of the European Council ask member states to support educational programs that teach about sustainability transitions (European Council 2022). It also declared 2020-2030 the "digital decade," setting a target to have basic digital skills or professional competencies in 80% of the adult population (European Commission 2021).

We followed this call by developing a digital teaching tool called Geovania: a game focused on international cooperation and political challenges around renewable energy and the energy transition. The game provides opportunities to learn about two-level negotiations—from domestic agenda-setting, bilateral trade agreements, to international negotiations—using insights from international relations and comparative politics. In our estimation, preexisting games did not go far enough in simulating the negotiation process while simultaneously portraying the technical dimensions of renewable energy and domestic considerations that go along with them. In this study, we impart lessons learned in developing, testing, and using Geovania as a component of university education. The main political science learning objectives are to teach students about the politics of renewable energy transitions, give practical negotiating experience, and to portray the two-level domestic/international interface.

Games: a solution for teaching geopolitics in sustainability education

It is not always possible to clearly separate the drivers and barriers of sustainability transitions. The complexity of the subjects being covered is high (society, technology, economics, and the natural environment), and usually there are a multitude of factors and causes leading to a given outcome. Society, industry, and policy makers must therefore consider hypothetical transition pathways through mid-century and beyond. Beyond subject area knowledge, education in sustainability can provide students with problem-solving competencies and the ability to collaborate successfully with experts and stakeholders (Wiek, Withycombe, and Redman 2011; Brundiers et al. 2021). These competencies are difficult to teach in a lecture; they have to be developed by learners themselves (UNESCO 2017, 10). University instructors can facilitate practical experiences to help students increase their ability to apply problem-solving approaches (Brundiers, Wiek, and Redman 2010, 312). This can be done with cross-cultural role-playing learning-by-doing immersive experiences (Kensicki et al. 2022), but transferable

tools are needed to bring sustainability topics into the broader discipline (Annelin and Boström 2023), e.g. for political science courses that do not have a specific focus on sustainability or the energy transition.

The use of simulation games in teaching

Games can empower students as leaders by practicing diplomatic skills in a low-risk setting. Players make decisions and experience the consequences of the decisions, providing transformational experiences. Games do not propose solutions but give players a chance to experience a new situation that involves discovering a new strategy together (Garcia et al. 2022). They are not calibrated for a specific outcome and thus allow for the use of individual intuition (Duke and Geurts 2004). In this sense, they teach problem-solving skills (Kim et al. 2018). Games lower the stakes of real-world problems and prompt the self-driven search for alternative solutions.

Games also have a wide range of benefits connected to sustainability education. They are appealing in the university classroom because they increase the interest and attention span for complex topics. They can increase student motivation through competition (Burguillo 2010). Games have been used as icebreakers, as tools to create awareness about a topic, to explore a complex situation, to experiment with different solutions, or even to support political decision making (Duke and Geurts 2004). Games increase players' ability to identify opportunities for cooperation (Conca, Ostovar, and Tekenet 2024).

Simulation games are a subcategory of games. They are "experiential, rule-based, interactive environments, where players learn by taking actions and by experiencing their effects through feedback mechanisms" (Mayer 2009, 825). Simulation games teach professional skills such as filtering information and attention to detail, and social skills such as self-control, confidence (Cercel 2022), agency and empowerment (Garcia et al. 2022). Confidence improves student learning, because it instills a motivation to learn new skills and master new information. Instructors can help students build and maintain this confidence by trusting them to experiment with the material (Bain 2021).

Simulation games and the global climate

In reality, countries have failed to negotiate and implement a level of carbon dioxide emission reduction that would prevent harmful impacts from climate change. In a game setting, an alternative reality is possible. Simulation games allow players to simplify a complex issue and can incorporate physical/technical and social/political challenges at the same time (Mayer et al. 2009). There are winners and losers in the energy transition, and the rules of international interaction are changing. Social science research shows that energy transitions have progressed unevenly across countries, even within a single geographical region such as Europe (Sattich and Inderberg 2019; Pérez, Scholten, and Smith Stegen 2019). States tend to make energy decisions primarily in the pursuit of being independent with the goal of boosting national security; this may include steps toward sustainability, but the connection between energy security and green energy solutions is not necessarily a direct one (Sattich et al. 2022). Multilateral institutions might provide the right setting for cooperation. At the same time, multilateral institutions

have demonstrated their own types of failures, including limited membership, overly informal design, and lack of member commitment (Van de Graaf 2013; Wilson 2015). The dynamic nature of international climate negotiations is suited to role-playing simulation games.

Some climate games are quite simple, and only require a blindfold and a large drawing surface ('Hit the Target' from Meadows 2016), and others have digital platforms that can accommodate variable inputs and then produce a dashboard display (C-ROADS Climate Interactive). Reviewing the use of climate games, Gerber et al. (2021) find only 36% of the climate games have a focus on energy and only 10% of games simulated multiple levels of governance. Role-playing international relations games (Asal, Miller, and Willis 2019; Parmentier 2013) do not, by default, cover the energy transition or give feedback about the consequences of negotiated outcomes at the domestic level. Schnurr, Elizabeth De Santo, and Craig (2013) developed a role play with environmental objectives, showing the complexity of international negotiations and negotiation skills. This exercise simulates the Convention of Biological Diversity with multiple stakeholders (nations, NGOs, industry). Thus, there is still a gap in climate games that address negotiations at domestic and international levels regarding the use of renewable energy.

Our objective was to show students that outcomes of the international negotiations affect the policy making on national level and that the resources and power of nations differ over the course of the simulation, based on earlier decisions. In international relations theory, this is commonly referred to as a "two level game," implying that international negotiators are beholden to their domestic population and that the change over time in domestic conditions plays a role in international negotiations (da Conceição-Heldt and Mello 2017).

All these factors went into the development of a game that simulates international and domestic politics, give feedback about the consequences of decision making and give participants a simulated environment to phase out fossil fuels. This leads to the learning objectives of the game Geovania: 1) to understand the politics of the renewable energy transition, 2) to improve students' knowledge of international negotiations, and 3) to teach the international relations construct of a "two-level game."

Method: Creating a digital 'geopolitics of renewables' simulation game

We used an inductive research design involving game developers, university teaching faculty, energy experts, and student players. We used the triadic game design philosophy of Harteveld (2011) and the game design approach of Duke and Geurts (2004). The triadic game design philosophy shows that in the development of simulation games, designers must take three different worlds into account: reality, meaning, and play.

- The world of reality: from this perspective, the objective is to develop a valid representation of the real-world issue. Within this world, boundaries have to be set about what is taken into account and what is outside the scope of the game.
- The world of play, where the design of the game is the main task. From this perspective, playability is the focus.

- The world of meaning: the game needs to contribute to reach the previous mentioned learning objectives. The objectives between the different worlds could conflict. For example, a detailed, highly realistic, representation is too much for a player to handle, which reduces the playability.

Game designers balance these different worlds to develop a playable, realistic and meaningful experience (Harteveld 2011). The design process incorporates conceptualization and setting the boundaries of how reality is portrayed (Duke and Geurts 2004). We did this collaboratively to ensure that the social aspects of the game were considered, using interaction between researchers and subjects (van der Poll, van Zyl, and Kroeze 2019). In this way, feedback from game players and instructors was used to revise the game concept and the digital interface during its development.

The development steps are outlined below: setting the stage; conceptual design; developing the game; testing the game; and use, evaluation, and reflection. Throughout all steps, we reflexively evaluated our choices through team deliberation. Although these steps are listed linearly, this was an iterative process in which we made improvements after testing.

Setting the stage

The first step was defining the objectives of the game and setting the requirements. We started from the objective of increasing knowledge of the energy transition in an international environment using an alternate, simplified reality. The starting point was a negotiation game developed for a course called "Sociotechnology of future energy systems" which is part of the M.Sc. degree in Complex Systems Engineering and Management at Delft University of Technology. We kept the multi-level governance elements showing tensions between national objectives and international collaboration and the differing level of importance of the energy transition relative to other problems. A key addition was to put the game online to make international collaboration between universities possible. The Covid-19 pandemic made the use of digital teaching tools more common and generally increased the demand for digital teaching and learning solutions.

Conceptualization

The team developed an extensive list of boundaries, factors, and relevant relationships for the energy transition and geopolitical content. The list named factors including energy sources and carriers, country profiles, landscapes, available resources, and population. The cause-and-effect relationships, such as a reduction in a country's emission profile if efficiency gains are made through enhanced knowledge, or if fossil fuel plants are decommissioned, was based on IRENA reports, expert knowledge, and Intergovernmental Panel on Climate Change (IPCC) reports. Based on this overview of the system, we set the following boundaries:

- One generic energy carrier. The focus of the game is changing energy sources and international negotiations and not on the technical challenges of different energy carries (e.g. H_2 or liquid natural gas).

- No "grid" delivery infrastructure. For the same reason as above, we consider that the infrastructure is available or can be built.
- 'Other' issues and resources are represented in food and housing. Food requires agriculture and housing is in cities and villages.
- Four countries with unique geographical characteristics that influence the starting position of negotiations. Cover types of mountains, water, and deserts make different facilities possible. Countries have varying amounts and/or levels of (non-)renewable energy, agricultural land, food production, and population.
- National political interests and domestic processes (such as citizen preferences and/or protests, elections, or historical path dependence) are left out or deemphasized. They have the potential to be overly complex, difficult to grasp, and distract from the goal of increasing negotiations between countries.

Developing the game

There are two main stages of gameplay: 1) building and demolishing land features (such as agriculture, housing, energy production facilities, forest); and 2) bilateral negotiations between countries and multilateral summits. The ground-based activities produce energy, food and housing, increase or reduce CO_2; and the negotiations evoke promises to trade resources or reduce emissions on the continental scale. The digital interface makes it possible to play online and eliminates calculations by hand.[1] In the simulation tool, players build, demolish, and exchange resources. The model updates the values after taking actions at the end of the round. The negotiations and discussions are face-to-face, which can be done on location or using teleconferencing platforms.

The software proceeds stepwise starting with communication between server and clients before building the functions. After each step, the functionalities were tested with the design team. The interface and game flow were also tested and improved based on input from other partners and students.

Testing the game

The game concepts were pre-tested by the development team with volunteer students in October 2021 and in live undergraduate and graduate university classes at the Delft University of Technology[2] (these tests of the printed and digital materials occurred on 19 October 2022 and 9 January 2023 with 16 and 13 students, respectively). To evaluate the game, we used a combination of written student comments and facilitator feedback. A written survey supplemented the participants' oral comments. These written comments were collected at the end of the sessions. The observations of the facilitators focused on player interactions, the interface, and the learning objectives. In each classroom debriefing, there were also notations about the materials, room arrangement, amount of time required, and the computing requirements that were used to make improvements. In separate meetings, facilitators discussed each session and reflected on whether there was room for improvement.

Game use

The simulation can be used in political science courses (namely, international relations) and environmental studies (namely, energy transition or climate politics). We ran the simulation 14 times in six countries with 292 participants: Germany, Norway, the Netherlands, the United States, China, and Italy. The players were undergraduate and graduate university students. Table 1 lists the universities, locations and numbers of participants.

We tailored the messaging for the classroom settings. In the political science classroom, the focus was directed toward the dynamics of negotiations, and the interests of stakeholders. In the environmental studies classroom, the focus was on the dynamics and dilemmas of the energy transition. In all instances, the students were prompted to examine subject material with an interdisciplinary lens.

The game has 16 roles, and is designed for 16 players when each role is taken on by a single player. If there are fewer players, players can take on multiple roles. If there are more players, multiple players can be assigned single roles to accommodate up to 32 players. The basic version of the game requires 4 hours, but this can be adapted for slightly shorter or longer sessions. The first step is for students to familiarize themselves with their country roles and learn the rules of the game. The negotiation phase begins a round, followed by a general assembly. These phases together make a round, which lasts about 25 minutes. The number of rounds could be reduced for a shorter session (some of our test sessions were two hours), or spaced between multiple sessions to provide an extended version (one of our test sessions took place over two days and reached 8 rounds, another took place in a 6-day intensive course). The stages of gameplay are depicted in Figure 1. These stages take place iteratively, they can be repeated to fit the amount of time available. Following the gameplay, the instructors facilitated a debriefing session to explicitly reflect upon the learning objectives.[3]

Table 1. Overview of Geovania game sessions between January 2023 and September 2024.

Session Date(s)	Host University (and location if not main campus)	Number of Players
18 January 2023	Technical University of Munich	28
25 May 2023	University of Stavanger	16
9 June 2023	Delft University of Technology	26
13 October 2023	Delft University of Technology	17
15 January 2024	Delft University of Technology	12
5 February 2024	Technical University of Munich	28
13 February 2024	University of Stavanger	21
5-9 April 2024	University of Minnesota	12
16 May 2024	University of Stavanger	17
12 June 2024	Technical University of Munich	24
30 June 2024	Delft University of Technology	14
23 August 2024	NorRen Summer Program (University of Oslo with Norwegian University of Science and Technology, University of Bergen, and Norwegian University of Life Science), Langesund Bad Norway	27
9 September 2024	Tsinghua University (with Technical University of Munich, Imperial College, and Yale University, China	30
26-27 September 2024	Südtirol, Italy (Technical University of Munich, University of Stuttgart, and FAU Erlangen-Nürnberg)	20

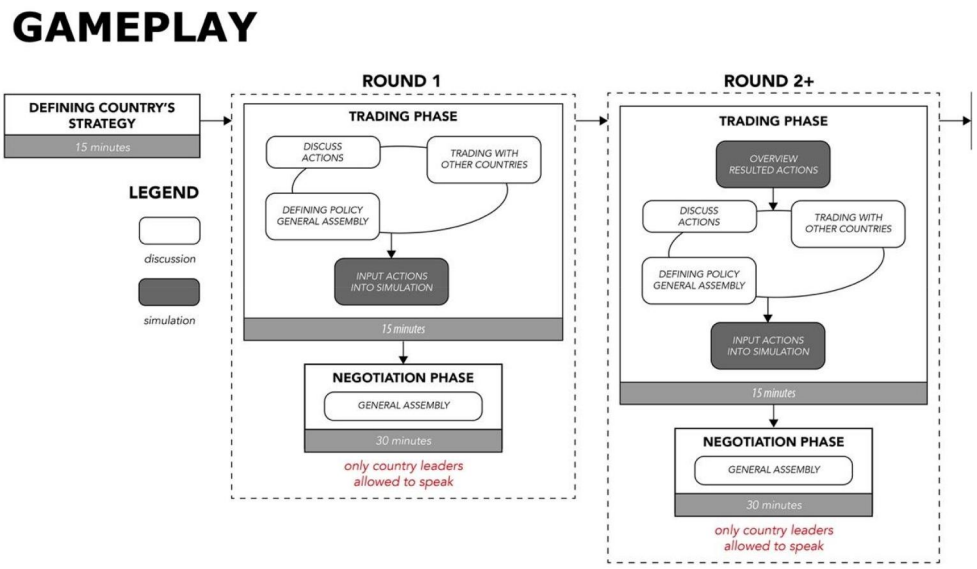

Figure 1. The phases of the simulation game include an initial strategy-setting session, proceeded by rounds of trading and negotiations.

Geovania: the geopolitics of renewables

The energy transition poses a two-level challenge to countries. First, they need to increase the amount of renewable energy whilst navigating domestic political forces. Policy packages generally include the subsidization of clean technologies, pricing CO_2 emissions, network investments, or setting strict vehicle standards. Such efforts have a direct effect on companies' competitiveness, people's energy access, income distribution, employment possibilities, educational programs, and state revenues. This makes the transition politically contested; the costs and benefits are not equally distributed among groups. Policy makers hence need to balance the interests of different domestic actors whilst providing energy that is available, affordable and sustainable.

Second, energy transitions and great power rivalries mutually influence each other (Scholten, Criekemans, and Van de Graaf 2020; Hafner and Tagliapietra 2020; Sattich et al. 2022). The shift from fossil fuels to new forms of energy creates new industrial opportunities and competition and ways to diversify and secure energy. Global politics, in turn, enables and constrains trade possibilities, creates new unwanted dependencies, e.g. in critical materials or transport bottlenecks, and urges countries to onshore exposed supply chains (Schreurs 2023) or use alternative technologies and energy sources. Countries need to navigate this uncertain environment, outside their direct control, if they want their domestic and the global energy transition to succeed. They need to make sure they have the necessary resources to implement their domestic energy transition while ensuring other countries also do their part. The former implies not only access to the necessary know-how, critical materials, and capital to install and transport renewable energy but also ensuring oil and gas imports for the duration of the transition to prevent an interruption of services. Trade, international cooperation, and the creation of shared opportunities are considered vital for a fast transition and overcoming existing path-dependencies (Van de Graaf and Colgan

2016; Quitzow et al. 2019; Scholten, Criekemans, and Van de Graaf 2020). Otherwise, we risk entering a "dirty nationalism" scenario in which countries remain invested in fossil fuel energy (Bazilian et al. 2019). This is a matter of ensuring commitment and managing the uneven costs and benefits the energy transition brings among countries. Commitment comes mostly in the form of making sure countries adhere to their nationally determined contributions (NDCs) under the 2015 Paris Agreement on climate change (Keohane and Victor 2016). Preferably, they would step up their efforts as current pledges are not on track to meet the 2-degree Celsius target (UNEP 2022). Ensuring a just transition, or sharing the burdens and benefits of renewable energy, as well as managing the uneven progression of energy transitions in different countries is likely to be a key dimension of ensuring this commitment (Sattich and Inderberg 2019; Pérez, Scholten, and Smith Stegen 2019).

The global renewable energy transition is hence multi-faceted, intersects national and international politics, whilst also having cross-national dimensions (Schreurs 2020, Meckling and Hughes 2018; Svobodova et al. 2020). A focus on energy geopolitics emphasizes the stalemates and power relations between countries, which can be at times "intense and highly disruptive" (Sachs in Hafner and Tagliapietra 2020). This way of thinking reflects realist and liberal institutionalist perspectives, and less of a normative perspective in which countries cooperate because they have shared values and morals.

Goal of the game

The premise of the game is that players represent hypothetical countries, on an imagined continent, 'Geovania' (see Figure 2). Players interact in simulated internal strategy

Figure 2. The game is based on a continent with four countries. The basemap was digitalized into landcover tiles for the Geovania simulation.

setting, and in bilateral, multilateral, and continental negotiations. In the decision making they have to take into account the long-term political consequences and on country level balances the needs of the population in order to deal with the first challenge.

The goal of the game is to reduce overall carbon emissions on the continent to stave off the worst effects of climate change. At the same time on country level, players must make sure to have enough resources (housing, food and energy units) for their people. The impact of climate changes can be limited if emissions are reduced in a timely manner. On an alternating basis, players work together internally in domestic country groups, and externally in international negotiations to determine the prices they will pay for resources and the trades they are willing to make or the financial packages they are willing to give in order to shift to wind, solar, and hydropower energy production. During negotiation rounds, they will externally discuss the policies they want to enact in their country and/or on the continent.

Game phases

The game is played in different rounds, representing five years, consisting of two phases each round (see Figure 1 above). Before the first round starts, the players get time to read the materials and set a strategy for their country. The first phase of a round consists of bilateral trading of resources and building or demolishing houses, agriculture, energy production facilities and green areas. In the second phase, the general leaders convene to discuss international policies in the General Assembly. Other players can advise the general leaders but are not part of the assembly; they can continue trading and building. After the assembly, the simulation advances to the next round, and resources are updated. In case, the CO_2 emissions are too high, events occur, such as storm, fires or floods. These events demolish land tiles and buildings.

It is advised to play at least three rounds, with six rounds to cover a 30-year period; however, the exact number of rounds will depend on the specific context of the course. The game ends when the CO_2 emissions are zero or when the time is over.

Reflection and feedback

After game play, reflection started within the country teams. The players were asked to look at the final scores and answer two questions: 'Are you satisfied with the results and why or why not?' and 'Did you follow your own strategy, or did you change this during the game and why?' Then, the larger group shared experiences with each other. The precise set-up varied, however, had four general phases:

1. Sharing emotions: were you happy, frustrated or angry with other players? It is important to share this and to make a distinction between emotions in and outside the game.
2. Sharing experiences: discuss what happened in the game, why players made certain decisions, and if these had the expected effects or reactions. Depending on the focus of the game, more attention can be given to the measures taken or the international cooperation.

3. Translation to reality: discuss how the experiences can be translated to the real-world situation and/or the theory discussed in the course.
4. Next steps: in the final phase, link to other course activities.

Reflection is important, and sufficient time is needed for discussion. As the game contains many dimensions of the geopolitics of the energy transition, the facilitator should be prepared to distill the most important elements for the students.

Findings: Pedagogical and topical insights

We sort our findings into two main sections: pedagogy and topical insights related to the geopolitical nature of the energy transition. The game is a teaching tool that requires students and instructors to be actively engaged. Participants in our sessions often quickly entered (and remained in) the negotiating mindset, and were engaged throughout the sessions. In one student's words, the session was "Really engaging and I completely lost track of time." The high level of engagement lent itself to achieving the learning objectives. These learning objectives are led by instructors who can highlight various elements of the game in the debriefing session.

Much of the educational value of simulations lies in debriefing

Since we could not include all details of a political system in the game, we simplified the roles and procedures involved in governing a country, and explained in the instructor's manual that the simplified version of reality would mean that a debrief session is required to make sense of the simulation. In the race to reduce (or achieve net zero) emissions, no single player alone wins. This means the energy transition brings about coordination issues across two levels: both within countries (between different stakeholders) and across borders (between different countries). Because it takes time to experience these multi-level interactions, iterative rounds of bilateral trade and multiple international general assemblies are needed. Students commented that international cooperation is a "chaotic" process that requires "fast decision-making." While the leaders are meeting, the other players continue trading and making other decisions. This makes developing coherent policies and the execution of these policies difficult, but not impossible. This meant that instructors and facilitators needed to manage expectations, the amount of time available to play the game, and ensure that enough time remained to debrief.

Questions about the level of detail of the policies, exceptions for countries, and especially consequences when countries break the rules were common from students. Besides the challenges on continent level, on country level the players also experienced the challenges of prioritization of the energy transition versus social welfare with some side discussions about the relevance of the long-term effects of climate change if people need food immediately. Another dilemma players observed and discussed is the choice between optimally sharing resources versus trying to become self-sufficient. In most sessions, players started with self-interest and collected resources to become self-sufficient, resulting in trading but little cooperation.

The student feedback was wide-ranging. Sometimes players focused on technical programs which were relatively simple to address. For example, problems with the digital interface could be solved quickly (if a team stopped the game, they could log back in and rejoin). However, some of the problems required non-technical fixes. We observed that some students needed more support in starting negotiations, or more assistance in understanding the briefing materials. The solutions for problems related to the learning objectives required more reflection. In the case of supporting students to begin the negotiations, we added an agenda for the general assembly and some policy suggestions. We viewed solutions for these non-technical challenges, e.g. problems related to student comprehension, as strongly linked with the skills of facilitators. We sought to develop these skills through the enhancing the facilitator manual to provide more detailed guidance.

The game was intended to demonstrate that the energy transition requires decisions to be made internationally and domestically. Every decision for or against specific energy technologies represents an economic tradeoff, and when countries prioritize their own needs, others may suffer. Because starting positions are different, the speed of the continent's energy transition hinges on players. The game defines success in continental terms and in doing so, offers players a chance to develop cooperative relationships that emphasize the imperative to improve conditions in all countries. The two-level concept was taught through gameplay.

However, some of the sessions resulted in country groups feeling that they failed. For example, players from one of the countries stated that they were hamstrung by not having financial capacity to purchase food required for their population, let alone energy. Therefore, we find that the learning objective, the imperative to cooperate internationally while still attending to domestic needs, was achieved but not always in the manner that we anticipated. In the reflection, special attention has to be given to these experiences. In order to make it possible for players to start with minimal preparation, we did not specify what type of political system a country has. We also did not give many details about the historical development of a country or prior relations between them. In this quest for simplicity, we may have set the bar too low for societal needs and demands. Players found the use of a single tradeable commodity, food, unsatisfactory. It was supposed to represent all of a population's needs. What is more, they could ignore the population's food needs, intentionally causing deadly famines. In subsequent rounds, the population decline would result in tax revenue decline, but this may have been minor relative to the financial returns from energy or food exports. Thus, for students familiar with gaming, the simulation seemed easy to hack in pursuit of one's own individual material interests. Perhaps the simulation shows students examples of how *not* to act. If players decide to accept the decline of the population, or if they avoid considering the standard of living, it requires a discussion of ethics, or a deeper reflection on human migration in response to the impacts of climate change. The debrief provides the instructor the chance to identify which discourses (e.g. ecological modernization theory, sustainable development) the students are familiar with and where there might be a need for additional curriculum content, especially if students are conflating concepts such as energy efficiency and economic growth with improvements in human development (Langhelle 2000).

The instructors and facilitators are critically important; they should allot enough time in the course to discuss the relevant material needed to understand the simulation. The game is a tool to be embedded in a course or other learning setting. Students needs to be prepared and there has to be reflection afterwards. In almost all the test sessions, players commented that they would have liked more time for the reflection. As the game contains competing messages, instructors need to define some key takeaways from the session. If the game is used in a course to emphasize international collaboration and negotiation, more guidance can be given in the general assembly. If the message is more about the different scenarios of the transitions, more attention should be given to the actions and decisions made by the players. Facilitators also need to be prepared for unexpected actions in the game, such as strategies that are not logical or require an ethical discussion.

The energy transition is geopolitical

In addition to pedagogical insights, we suggest that geopolitics will continue to be of critical importance in the energy transition. If the game sessions can be viewed as experiments on human interaction, ours show that countries are involved in trade interdependencies that involve some countries providing inputs (in this case food, energy, or technological knowledge) and others consuming them. No single country was designed to be self-sufficient. This could be seen as an inherent bias of the game design, but has justification in historical and current real-world constraints. No single country today can provide all the inputs that are needed (or desired) by its population.

If a country exploits another, or invades it for natural resources, there are shocks for other countries' supply of energy and food. This was the case with the fictional country, Bourgguay, which often met its needs by seeking low prices for its resources. This matches with the reality of the security implications of globally integrated supply chains (Schreurs 2023). Bourggouy and Amarana, neighboring countries, often focused on 'reshoring' or 'friendshoring' supply chains while continuing to remain partially dependent on fossil fuel energy. This matches the risk of "dirty nationalism" scenario (Bazilian et al. 2019).

If emissions continue to increase unabated, disasters will happen. This makes the risk of not making a transition higher than the short-term geopolitical tradeoffs involved with it. We realized early on that we cannot simply transpose our thinking of the 'old' geopolitics of fossil fuels toward the new system. Despite the fact that wind, solar, and hydropower are available in more places than petroleum or coal sources, energy independence is still elusive. For example, just because a country has open land and sun does not mean that it will have the resources, materials, finances, or manufacturing capability to harness photovoltaic energy. Observations from the game play also show these dependencies and while countries could share knowledge about the technology, this has a price. Countries will continue to be entangled in international interdependencies regarding cross-border flows of technology, capital, and energy. The energy transition will affect the existing interdependencies and create new ones (for example by making new cross-border infrastructure necessary or beneficial to reach CO_2 emissions reductions). Some technologies were received more favorably than others: solar was relatively well-received while nuclear

generation was controversial, and wind was sometimes ignored. The obvious choice in many of the simulation runs was solar, given the availability of land for it. On- and offshore wind production was not always deployed, and its use varied with players' ability to identify the hypothetical sites where it could be located.

Countries can choose to use comparative advantage in trading, if there is a coastline for offshore wind development domestically, but partners have swaths of sunny desert areas, it follows that countries can become specialists in particular renewables. Some players may come with their own preferences and aversions. For example, there were varying interpretations of the role of nuclear power generation. For some players representing Bourgguay, nuclear energy was viewed as undesirable, and was phased out along with coal. For others, it was seen as a viable low-emission technology. Through the simulation, players gained an awareness of the variation in source, location, and mode of delivery for renewable energy.

Discussion: Reflecting on games and the energy transition

In this section, we reflect on our experience simulating the energy transition. Perhaps most notably, it is not clear whether conflictual or cooperative outcomes are more or less likely in the simulation. In either instance, though, students learned about the politics of renewable energy transitions, gained practical experience negotiating, and experienced the two-level domestic/international interface. Players in test runs did not always share resources, but when they did, they realized that the switch to renewable energy sources was timelier and more efficient. The players sometimes focused on the general assemblies, and cooperative continental policy frameworks were put forward. Other times, they used a "country first" strategy and developed trading preferences to the exclusion of others. We found the simulation game is akin to a vehicle that is steered in different directions based on the needs of the instructor and the course.

Student interest levels were high in all test sessions, despite varying outcomes. This reinforces that political science simulations are worth pursuing because they have the potential to boost student engagement with the material (Clark and Scherpereel 2024). The key to achieving the learning objectives in the case of Geovania was to keep the them broad enough to accommodate an interdisciplinary group with varying levels of existing knowledge. Our objectives—to show the possibilities of renewable energy, to give practical experience negotiating, and to show the two-level game—could be achieved, even if the simulation resulted in a standoff in which overall emissions were not reduced. As one facilitator stated, students learned that "The stakes are high, which explains why the negotiations are hard."

Thus, while we cannot say for certain that the simulation avoids the pessimism in existing sustainability games, we did turn students' gaze toward the international implications of an energy transition. Pessimism stems from the perspective propagated by international relations realists that climate change is a collective action dilemma that diplomats will fail to solve (Brown 2018). We avoided the impression that it is a tragedy of the commons that can only observed from a distance (as in

Meadows 2016), however, as players were actively involved in making decisions. Players who became engrossed in role-playing surprised themselves with their own enthusiasm.

In test runs, the overall need for the energy transition was uncontested, yet there was variation in opinions of how this should be accomplished. The complex interdependencies between countries in achieving it at a continental scale was where individual player perspectives came in. Here, we noted intersubjective understandings actions and consequences. Games are interpreted differently by individuals, and these intersubjective perspectives influence the outcome (Landers et al. 2018). Our players saw the reduction of fossil fuel consumption as an important goal, but some viewed it as secondary to the wealth (or financial growth) of a country. In the trading rounds for these players, more time was spent discussing the price of a traded resource, rather than the resultant reduction in CO_2 emissions. Though the same reality existed (as represented by energy production and consumption), the gameplay interactions were perceived with varying rates of success, depending on the perspectives of the players. When students viewed renewable energy as antithetical to economic growth, it was helpful to highlight this in the debriefing session. In one test session, when the simulation game was held in conjunction with a university-wide sustainability event, some motivated students strategized to grow their economy through building additional renewable energy capacity to export to the other countries. In this debriefing session, it was beneficial to highlight this strategy as "decoupling" or a reduction of fossil fuel energy consumption that coincides with a growing economy, made possible by the increased use of renewable energy (Handrich et al. 2015).

The secretive element of negotiations is preserved in the Geovania game, since players directly negotiate with their counterparts from other countries. Even the leaders of the countries were not privy to these conversations, which sometimes only bilateral. Diplomacy is also emphasized, in the General Assembly where country leaders present their positions and make the case for new continental policy initiatives. Success in both of these comes when players can synthesize large amounts of input, and confidently make an argument. This is supported in the literature as a key benefit of gamification in the study of international relations by Cercel (2022), who found in a multi-year study that gamification in international relations increased competencies such as self-control and confidence. In debrief sessions we found the players who set goals for their country did not become overly emotional, anecdotally reported more positive views on how the negotiation proceeded.

Facilitation was also important for ensuring a smooth simulation. Instructors have the overarching perspective of what types of outcomes could occur based on their experience with particular groups of students. During the simulation, their actions make a difference. Their ability to identify barriers and opportunities for learning are an asset. Being aware of their influence, in overt and subtle ways, can help guide participants toward the learning objective. For this reason, we found it necessary to have an instruction manual for facilitators separate from the player materials. The finding that skilled facilitation can lead to improved game play is reinforced in the literature. Garcia et al. (2022) find that leadership is a critical dimension of environmental games, and that someone in a position of

authority must convene the game in order to create the incentive for full participation. Instructors are well-suited to take on this role in the classroom, as students will often participate in activities if they are part of a university course. Shaw and Switky (2018) also find that players benefit from specific instructions for their interactions, especially when it comes to country interactions that can either be cooperative or competitive. The facilitators function simultaneously as central coordinators, time keepers, referees, guides/storytellers, content experts, and non-playing characters.

It was not possible to include all relevant features of the energy transition. We acknowledge that inputs for renewable infrastructure such as minerals and metals, for instance, can be reused and recycled, reducing the cost of follow-up installations. We also did not differentiate between price of renewable facilities at the beginning of the game vs. toward the end, and we acknowledge that the presence of a continental delivery grid, or network, would facilitate trades. However, a grid is non-existent in the game's interface or printed materials. It was only possible to build a limited number and type of features on a single geographic tile. We did not simulate delivery roads or transport and therefore could not consider the role of hydrogen as a fuel source or transferring technology. Within the project team, we discussed which elements were most important. The main reason to include or exclude elements was whether they contribute to the learning objectives and the game is playable within the available time. Players have limited capacity to deal with different variables. The test sessions showed that some players are overwhelmed with too many possibilities and more complexity could lead to more difficulties in gameplay.

Thus, some game elements are "off the board" or unscripted, occurring in the negotiations and discussion. Successful games of the energy transition hinge on the creativity of the instructor, facilitators, and especially the players. Some players are more inclined to adopt and embrace their roles. Some of these differences were evident across study level (bachelor's versus master's students) and some of the differences were noted between test countries.

Some research dimensions were beyond the scope of this study. Future investigations could consider an experimental design using the game as an intervention with the potential to change players' willingness to cooperate. Here the focus would be on testing whether the experience of negotiating with others is associated with changes in perceptions, attitudes and preferences through the use of pre- and post- surveys (Rooney-Varga et al. 2021). It would also be possible to make a commercial version of Geovania for decisionmakers. Garcia et al. (2022) purport that strategy games could push policymakers to take sustainability more seriously. An additional dimension that was beyond the scope of this study was using the game outside the European context. The game was run in a non-European university to explore the possibility of tailoring it to a global audience.

Conclusion

Simulation games employ a 'learning by doing' approach to teaching about the transition to renewable energy. Games encourage active participation through role

play, and can accomplish multiple learning objectives related to the international politics of climate change: in our case, we emphasized the energy transition, negotiation skills, and the international relations notion of the two-level game. We acknowledge that it was impossible to have high levels of reality, playability, and meaning simultaneously and we had to prioritize some elements over the others.

Successful games of the energy transition hinge on the creativity of the instructor, facilitators, and especially the players. Some players are more inclined to adopt and embrace their roles. Overall, the game enabled learners to develop several competencies as described in the literature (see Wiek, Withycombe, and Redman 2011, 207-211). In particular, this includes anticipatory/future-thinking competence (the ability to collectively analyze, evaluate, and craft pictures of the future), strategic competence (the ability to collectively design and implement governance strategies toward sustainability), and interpersonal/collaborative competence (the ability to motivate, enable, and facilitate collaborative and participatory sustainability research and problem solving). Role-playing was a unique learning experience, which contributed to ongoing class discussions after the game.

The differing conflictual or cooperative tendencies fit with what the literature suggests about the geopolitical realities of the energy transition: some institutional arrangements will have to be scrapped and created new, and for better or worse, governance outcomes will be shaped by the tendencies of individual political systems (Pastukhova and Westphal 2020). Games can portray two-level geopolitical dimensions: including the country-level, continent-level and interaction between these levels. A simulation lets players explore different pathways toward renewable energy. Even though the game is "low-stakes" and designed to be fun, it teaches serious concepts. These concepts are perplexing to policymakers. Many realities of the transition to renewable energy that confound experts: how to balance the objectives of economic growth, energy security or peace and conflict resolution, with the negative side-effects of reliance on fossil fuels. This game offers, but does not guarantee, a chance to solve the problem of runaway greenhouse gas emissions collectively.

Notes

1. Unity programming software was used to build the digital game.
2. This study adhered to the Research Code of Conduct (particularly Item 13) at the Technical University of Munich. It also abided by the Technical University of Munich Mission Statement (Item 10). It was conducted according to the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) guidelines for the Humanities and Social Sciences and provided adequate human subject protections in compliance with the American Association of Political Science (APSA) Ethical Guidelines. Furthermore, we used the Netherlands Code of Conduct for Research Integrity, the Framework for Good Research Practice of Ghent University which abides by the European Code of Conduct for Research Integrity and adhered to the recommendations of the Norwegian National Research Ethics Committee of the University of Stavanger.
3. We developed a website with a player manual and materials to make the game publicly available. A separate facilitator manual is available to prepare instructors to facilitate a game session.

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