

Gamification of Climate Risk Mitigation in Global Education



**An Interactive Qualifying Project submitted to the Faculty of WORCESTER
POLYTECHNIC INSTITUTE in partial fulfillment of the requirements for the degree of
Bachelors of Science**

Submission Date: 29 April 2022

Submitted by:

Casey Chabra

Emily Jordan

Matthew LoVoi

Nicholas Orlovsky

Lucas Wilson-Wuestefeld

Submitted to:

Professor Svetlana Nikitina, WPI

Professor Ivan Mardilovich, WPI

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Abstract

This project contributed to the development of human generated climate change curriculum in global education by gamification. The proposed solution was inspired by the previously developed climate education game, the Climate Risk card game. We designed and tested a new game that would be educational as well as fun to those who played it. The development process included the brainstorming of key concepts, the creation of a prototype and a balanced ruleset, and testing the game with students who fit our target audience. The end result produced a product that met both of our criteria of fun and educational, however it remains to be tested with a larger demographic range.

Acknowledgements

We would like to thank the team of students and professors from the Financial University under the Russian Federation for presenting the original idea of our project. Without their original idea and work our project would not have had the necessary foundation.

We would also like to thank our advisors Professor Svetlana Nikitina, Professor Ivan Mardilovich and Professor Carol Stimmel. We thank them for all the feedback and guidance that they gave us throughout the project as well as their time and effort to ensure we did our best work possible.

Authorship

Section Name	Authors	Editors
1. Introduction	Team	Lucas Wilson-Wuestefeld
2. Background	Team	Emily Jordan
2.1 Introduction	Casey Chabra	Emily Jordan
2.2 Climate Change Impacts in Russia, Germany and the United States	Lucas Wilson-Wuestefeld	Emily Jordan
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2.3.2 United States of America	Casey Chabra	Emily Jordan
2.3.3 Federal Republic	Nicholas Orlovsky	Emily Jordan

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2.3.4 Education's Impact on Climate Change	Emily Jordan	Casey Chabra
2.4 Effectiveness of Gamification in Education and the Workplace	Casey Chabra	Matthew LoVoi, Emily Jordan
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3.5 Objective 4: Identify gamification strategies specific to board games and card games	Matthew LoVoi	Casey Chabra
3.5.1 Data Collection: Game Experience	Matthew LoVoi	Emily Jorden
3.6 Objective 5: Prototype the basic framework and layout of the game including how the game is played and the contents of the game	Nicholas Orlovsky	Matthew LoVoi, Casey Chabra

3.6.1 Ideation	Nicholas Orlovsky	Casey Chabra
3.6.2 Testing and Design Workshops	Nicholas Orlovsky	Lucas Wilson-Wuestefeld
3.6.3 Revising the game	Nicholas Orlovsky	Lucas Wilson-Wuestefeld
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1. Introduction

Climate change caused by humans in the past couple centuries is a significant problem impacting the health and viability of the entire planet. The term climate change refers to an overall change in average weather patterns that occur over a long period of time. The term is most often used to describe the general warming of the earth, as numerous regions across the world have experienced an increase in average yearly temperature. Changes need to be made to mitigate the impact of human activity on climate change, but business leaders do not yet have the required skills and knowledge to make climate-conscious actions. These professionals need to know about the effects of climate change along with the best ways to negate and reverse these issues. Educating current business students about the effects of climate change, will empower them to make climate active decisions in the future. Unfortunately, environmental studies such as climate change contributors and the best ways to deter these effects, are not compulsory in education systems across the world. By teaching students about climate change we will highlight these issues for future business leaders.

Utilizing new approaches to climate change education is an important tool in improving the climate outcome. One relatively new and successful technique is the use of gamification. Gamification is the process of including game elements into a curriculum in order to encourage engagement with the material (Hamari, 2019). The use of gamification in education has been proven to be a fun and effective way to teach students and adults alike, particularly in teaching real world applications. With climate change education, an attempt at a climate change game was developed by the Climate Disclosure Standards Board and Radley Yeldar in 2021. However, it is an elementary game that does not appeal to young adults, and even then, it has not been found to

be educational or engaging. The creation of a much more engaging and educational game will be better able to educate students and evoke change throughout universities and companies.

The goal of our project is to contribute to improving climate education in the university setting for business students, by producing an educational board game that allows these students to become more familiar and comfortable with the current risks to the climate. The game will introduce and develop knowledge of the current climate crisis and promote sustainability and environmental welfare for future business leaders. We will work to accomplish our goal by first evaluating the best ways for businesses to become more sustainable and climate neutral. We will also evaluate the level of climate education in Russia, Germany and the United States and areas for development. Then, we will administer the original climate game to American and German students and identify its areas of strength and areas for development. We will also identify gamification strategies specific to card games to ensure the highest level of engagement to whoever plays our educational board game. Finally, we will document the basic framework and layout of the game including how the game is played and the contents of the game.

2. Background

2.1. Introduction

In this chapter, we begin with a brief overview of the general problem of human generated climate change and its impacts on our regions of focus, Russia, Germany and the United States. Next, we examine the status of environmental education in these regions. Then, we discuss gamification, its advantages and challenges, and its impacts on improving education. We conclude by discussing current efforts to create a climate change game and the necessity to approach climate change education using gamification.

2.2. Climate Change Impacts in Russia, Germany and the United States

Climate change is a worldwide epidemic that is deteriorating the environment and the general well being of the world. Climate change is both a natural and artificially generated occurrence where overtime time the general climate and ecosystem of Earth has changed. Our project will focus on man-made contributions to climate change. Since the Industrial Revolution the climate of the earth has been rapidly warming due to human activity. This is causing damage to major ecosystems through natural disasters such as forest fires and floods as well as decreasing arable land and melting permafrost (Conley & Newlin, 2021).

According to an article published by NASA in 2022, “Human activities have fundamentally increased the concentration of greenhouse gases in Earth’s atmosphere.” The overabundance of these gases in the atmosphere leads to the greenhouse effect where the gases form an insulating blanket that contains additional heat from the sun causing the earth to warm

(May, 2008). This phenomenon has become a major environmental and economic problem across the world.

As a result of total greenhouse gas emissions, the rate of temperature rise has drastically increased. According to the World Meteorological Organization (2021), since the late 1800s the average global temperature of the world has increased by approximately 1.2 degrees Celsius. If the trend continues, the World Meteorological Organization expects that the temperature will increase another 0.3 degrees Celsius by 2024. Without change, the ultimate results of climate change will negatively affect the ecosystems, economies, and well being of Russia, Germany and the United States.

2.2.1. Impacts on Russian Federation

Russian industry is one the biggest contributors to climate change, as they release the fourth largest amount of greenhouse gases in the world after China, the United States and India per capita (Conley & Newlin, 2021). Another issue is Russia's overreliance on hydrocarbon energy sources which produce greenhouse gases when burned. Despite Russia's massive land mass, less than .1% of Russian energy comes from renewable sources like wind and solar power (Conley & Newlin, 2021). Russia has not focused on converting to renewable energy sources that do not produce greenhouse gases.

Most countries can dissipate heat into the ocean but because Russia is so large, heat is contained within the land (Sinelschikova, 2020). According to the Russian Federal Service for Hydrometeorology and Environmental Monitoring (2020), the average temperature in Russia has been measured to be more than 3.14 degrees Celsius higher than Russia's average temperature

from 1961-1990. Russia has warmed up by almost 2 degrees more than the rest of the world which has had detrimental impacts on the country.

The Russian government has expressed concern for the issues caused by climate change and are working to lower their greenhouse gas emissions. They are one of 184 countries who signed the Paris accords in 2015, pledging to reduce carbon emissions and report their carbon emissions regularly (Kochteeva, 2021). Russia also submitted plans to the United Nations Framework Conventions on Climate Change to reduce their emissions. They are using the year 1990 as a benchmark and are committed to “reduce greenhouse gasses to 75% of their 1990 levels by the year 2020 and 70 % by the year 2030” (UNFCCC, 2015). In 1990 Russia produced over 2.5 billion tons of carbon dioxide and in 2020 they only produced 1.58 billion (Andrew & Peters, 2021). With this data, Russia has already officially met their commitment and could even increase their emissions and still meet their goal for reduction. However, meeting this goal is not a net positive as it represents little meaningful improvement in their current emissions. With 1.58 billion tons of carbon dioxide emitted, Russia is still among the top contributors to carbon dioxide emissions globally (Conley & Newlin, 2022).

The main limiting factor for governments taking a more climate neutral approach is the negative economic impact, especially in Russia. To make Russia climate neutral, the government would have to invest in technology that is both more energy efficient as well as converting more of their energy to renewable sources such as nuclear, wind and solar (Kochteeva, 2021), but this requires substantial up-front capital (Edenhofer et al, 2011). Further, the fossil fuel and gas industries are a very large part of the Russian GDP, and it is estimated that as Russia and the world transition away from fossil fuels it could cost Russia about \$10 billion per year (Kochteeva, 2021). The Russian government has delayed making meaningful progress towards

climate change in order to focus more on “advancing Russia’s domestic and geopolitical interests” (Kochteeva, 2021). Regardless of the governmental response, the harmful impacts of climate change are still being observed all throughout Russia. These impacts emphasize how important it is to teach people about the dangers of climate change so that they recognize its severity and can attempt to mitigate it.

2.2.2. Impacts on Federal Republic of Germany

German industry is commended as one of the most effective combatants of climate change, as it is transitioning from carbon reliant energy to more renewable energy. The current goal of the European Union is to reduce carbon emission by 30% by 2030. Germany has stated that it can reduce its carbon emission by 80% by 2050. Germany plans to surpass the 30% mark by reducing emissions by 40% in 2030, leading all of Europe (Lehr et al., 2008). In order to convert to renewable energy, the German industry has a large investment in the companies needed to make this conversion. The German industry produces a lot of materials for the Renewable Energy System, and because the global demand for renewable energy is increasing, so will the German Economy as they expand to international exports for the RES (Lehr et al., 2008).

In contrast to Russia, the German economy will flourish if more countries switch to renewable energy. Germany is both a local European and global leader in reversing climate change, whereas Russia has been more passive with climate education and regulation, which has caused the Russian economy to depend more heavily on hydrocarbons. Just like Russia and Germany, the United States is at its own position in the prevention and mitigation of climate change.

2.2.3. Impacts on United States of America

The United States is a larger producer of emissions than Russia; it stands as the second highest producer of emissions in the world (Conley & Newlin, 2021). In 2020, according to the Environmental Protection Agency, the USA released 5.2 billion metric tons of carbon dioxide into the atmosphere (EPA, 2021), more than 3 times larger than the amount of greenhouse gasses produced by Russia. The main industries in the US that are causing emissions are transportation, industry, electricity, agriculture and residential use (EPA, 2020). In the USA it is very common for each household to own an automobile that burns petroleum and produces greenhouse gases. This in tandem with the common use of trains, ships, trucks and planes has led to massive amounts of emissions, to the point where 29% of all emissions in the USA are attributed to transportation (EPA, 2020).

The second largest sector in the USA contributing to emissions is electricity production, which makes up 25% of total emissions. This is largely due to the fact that 62% of the electricity generation in the USA comes from burning fossil fuels (EPA, 2020). In 2020 the USA saw a 11% decrease in its emissions from 2019 (EPA, 2020) due to a decrease in driving due to the COVID-19 pandemic and a 14% decrease in emissions from transportation (EPA, 2020). There was also a 10.5% decrease in emissions from the electricity production sector as the USA made shifts away from coal and oil in order to invest in more natural gas and renewable energy sources (EPA, 2020).

Across the 48 states in the mainland of the USA the average rise in temperature is approximately equal to the rest of the world (Climate Central, 2019). However, parts of the USA have observed extreme temperature increases. For example, many cities in the southwest such as

Las Vegas, El Paso, Tucson and Phoenix have all observed at least a 2.4 degree celsius increase. This is a common trend in the states as most cities tend to have had a higher rise in temperature than the more rural areas (Climate Central, 2019). Overall, the rise in temperature in the USA is comparable with the average increase in temperature across the USA being 1.4 degrees celsius since 1970 (Climate Central, 2019).

The USA has been making progress towards climate change as according to the United States Government they have recently set a target aiming to cut emissions in half from the 2005 levels by 2030 (2021). The government is trying to invest in new renewable technology that is less reliant on fossil fuels which produce greenhouse gases (2021). The progress from this plan can already be seen as emissions from the electrical production sector have been cut by 10.5% as a result of investments in new technology (EPA, 2020).

2.3. Comparison of the Russian, American and German Environmental Curricula

American, German and Russian environmental curricula are, in some cases, fairly similar. Just like with the current state of action, there are also varying levels of sentiment towards climate education. While some have made more progress than others, each system has its flaws and need for improvement. In the following section, the educational systems of Russia, Germany, and the United States will be discussed and compared, in the hope of better understanding their level of modern climate compatibility.

2.3.1. Russian Federation Education

Environmental education is not currently required in Russia's compulsory K-12 curriculum (Kudryavtsev, n.d.). In general, there has been much expressed interest in environmental studies in Russia by advisors to the education system, but little work has been put into actually developing the curriculum. Surprisingly, in the unsteady education system in the 1990s, "Environment" was taught in public schools for a brief period and included topics such as ecology and nature conservation (Kasimov et al, 2005). In 1994, higher universities were approved for two strands of environmental education- one on natural and social sciences and another focused on applied environmental engineering (Kasimov et al, 2005, p. 51). However, much of the details from that curriculum are now outdated. In the future with a unified national education plan from the government, climate change and environmental issues may become more public.

2.3.2. United States of America Education

The United States' climate education is similar to Russia's as not all of the states have mandatory climate education. The United States, as a whole, lacks a climate focused education. Currently, only 29 states and the District of Columbia have science standards that require climate education to be part of the educational framework in schools. Only 5 states have social science standards which require climate education to be part of the educational framework (Kwauk & Kane, 2022). Thus, most of the states do not have standards that make climate education compulsory. Therefore, many students are unaware of what climate change is and to what degree it is affecting the world. 12 states have even proposed legislation which interferes with the mandatory teachings of climate change. Many teachers want to change the United States current

climate education and make it more of a priority. A recent study by NPR revealed that around 90 percent of teachers wish climate education was a priority. However, the study revealed that only 45 percent of teachers actually teach it in their classes (NPR, 2019). A different study found that half of science teachers in the United States teach climate change for less than two hours every year (Plutzer et al, 2016). Thus, this education gap surrounding climate change affects people as they do not understand the significance of how climate change affects the environment. These studies show that climate education is not a priority in the United States' educational system.

In this way, the U.S.' educational system regarding climate change is similar to Russia's educational stance on this topic. Both of these countries are lacking necessary environmental education and its this educational gap that is negatively impacting students and the environment.

2.3.3. Federal Republic of Germany Education

Contrary to Russia, Germany has stressed environmental education since the 1960's, and continues to do so today. However, it suffers very similar issues that both the United States and Russia do. A recent study questioned both the recent implementation and effectiveness of the current climate educational system. When investigating the current implementation of Education for Sustainable Development, shortened to ESD, in higher education in Germany, it was said in a recent study that, "...there is at least a slight integration of sustainability and sustainable development, which is particularly noticeable in the recent higher education acts and points to the general task, importance and responsibility of the universities." (Singer-Brodowski, 2018). The same study goes on to state that while many German Federal states mention intent to focus on ESD, only one explicitly states it as a specific goal. (Singer-Brodowski, 2018).

Outside of regulation, there is also evidence that the current attitude of the general public towards the climate in Germany has had an effect on recent education. A study suggested that popular movements with the aim of environmental protection have helped advertise climate education. However, this same study again cites the incomplete integration of ESD in the classrooms of high schools and universities (Bolscho, 2006). In short, while German universities have taken significant steps in the direction of effective and regulated climate education, there are still many more improvements to be made. And unfortunately, it seems as though German climate education suffers from the same issues that plague the Russian and American systems; a lack of universal regulation and effective implementation.

2.3.4. Education's Impact on Climate Change

With background on education, we now can ask if there is evidence that suggests teaching students climate change can lead to an improvement in future climate change actions such as limiting greenhouse gas emissions or pollution. In the US, recent research showed that if 16% of high school students received climate change education, we could see a reduction in carbon dioxide by nearly 19 gigatons by 2050 (Cordero, Centeno & Todd, 2020). In order to educate students on climate change, the method of gamification can be implemented.

2.4. Effectiveness of Gamification in Education and the Workplace

Gamification is defined as “the strategic attempt to enhance systems, services, organizations, and activities, in order to create similar experiences to those experienced when playing games in order to motivate and engage students” (Hamari, 2019). Although games are thought of as being played solely for entertainment, they can also be educational and informative. A great example of the implementation of gamification is the use of Minecraft in

classrooms. A study of the use of Minecraft noted its benefits in helping to reinforce creativity, collaboration, and problem solving skills in a fun and engaging way (Petrov, 2014). When well done, gamification applies the fun and interactive elements of a game and incorporates it into an engaging learning tool.

Gamification can boost students' success by improving engagement with course materials and motivation to learn. Many students need additional motivation to stay focused and engaged in the classroom such as achievements or a way to measure their progress and success. In terms of gamification, these can be points, badges, leaderboards, etc. Every person likes achievements because they serve as a further measure of motivation. In 2017, a Canadian professor at Laurentian University taught their courses with the tool of gamification and created a survey at the end of the course. Over 75% of the students said they enjoyed the aspect of gamification, specifically the leaderboard feature (Langille, 2017). An experiment at the University of Hong Kong in 2015 examined if points, badges, and leaderboards are effective tools in students' learning. In this study, it was reported that gamification tools help increase students' learning by cognitively engaging students. 71.43% of learners in the treatment group were motivated and participated more because of the badges and leaderboard. 95.24% of the students in the treatment group were motivated by points and attempted new tasks to increase their points (Huang & Hew, 2015). These findings show that gamification aids in cognitively engaging students. In this study particularly, the use of points, badges, and leaderboard were instrumental in increasing the students' engagement (Huang & Hew, 2015). Another study in Rio Grande de Sul, Brazil in 2020, showed that gamification tools help increase students' engagement and found the gamified students participated more than the control students. These students had a larger number of logins, points, and badges. The gamified students were more engaged than the control students

due to the fun and interactive elements that gamification provides. It was also found that the gamified students had a higher accuracy of solutions in comparison to the control students (Smiderle et al., 2020).

Gamification has been a reliable medium to get students to engage in learning and is gaining in popularity. Between 2010 and 2014, the number of scholarly papers posted online on Google Scholar alone increased from less than 100 to over 1,500 (Hamari, Koivisto & Sarsa, 2012). This gain in popularity is likely due to the rise of gamification as an essential part of keeping students engaged while retaining the content's educational value. Gamification has proven that it is a great tool for education and many studies have been done on a multitude of businesses to prove this. Two American researchers (Neil Howe & William Strauss) theorize that because of the technological boom, generations such as millennials are more responsive to gamification. Millennials' minds search for any type of reward (Vinichenko et al., 2016). Millennials as well as other generations seek gamification because it gives them rewards for doing well. This theory explains that because the age of technology and screens coincides with millennials' childhood experiences, they relate well to the games because it is part of their lived experience. Millennials value games and rewards, so implementing it into the workplace is a great way to motivate and educate them.

Gamification has shown to be an effective educational tool, and there are explicit factors that contribute to this. Improving student motivation, engagement, and enjoyment are big reasons as to why it is so effective (Hamari, Koivisto & Sarsa, 2012). Keeping students motivated and engaged allows them to learn material and enjoy it while doing so. It is important to understand what the participants look for in a game in order to appeal to these factors. For example, a study done on gamification implementation in a Russian company found that 51.6% of employees

preferred a game with prizes, whereas only 11.9% preferred a game with a virtual tour of some kind. When implementing gamification into the workplace, it is important to understand the preferences of the employees in order to make it most effective. (Vinichenko et al., 2016).

Climate change is a very tough topic to discuss because of the world ending implications but it is the perfect subject for gamification for that same reason.

Gamification has already been used in many educational settings to successfully educate people about climate change and pro-environmental behaviors (Ouariachi, Li, & Elving, 2020). In 2020, professors at the University of Granada published an article describing how the lack of education surrounding climate change is one of the major reasons that climate change is still an issue today (Ouariachi, Li, & Elving, 2020). This article also discusses how people's behaviors towards the environment can improve if they are better educated about the topic. In this paper, numerous pro-environmental gamification platforms are measured and analyzed to see which ones would be best for this specific educational purpose. The researchers tested 181 platforms against their criteria, which included meaning, ownership, social influence, achievability, challenge, and credibility (Ouariachi, Li, & Elving, 2020). On this basis, the two best platforms were SaveOhno and JouleBug. These platforms were deemed to have the highest potential in engaging their users in pro-environmental behavior change. According to these authors, the elements in their study design are important for designers to consider when striving to incorporate climate change content into a gamification context (Ouariachi, Li, & Elving, 2020). As described in Table 1, the article also discusses that gamification platforms that have the potential to educate people about pro-environmental behavior change through motivational elements, considered to be of utmost importance in maintaining user engagement.

Meaning	Person’s belief that he or she is doing something greater than themselves
Ownership	Feelings of owning or having a strong connection to something they want to improve
Social Influence	Activities inspired by what other people think
Achievability	A goal or something in motion that one wants to achieve; the ability to be brought about or accomplished successfully
Challenge	Something one wants to overcome
Credibility	Something someone can be trusted with

Table 1: User Engagement is increased by these Motivational Core Elements (Authors’

Table based on data from Ouariachi, Li & Elving, 2020)

This table provides us with some important insights on what aspects to focus on when designing a game. As mentioned in the study, these six points are key to making any effort in gamification as successful as possible. By utilizing these elements we can best produce a game that will be both fun and educational.

2.5. Climate Risk Card Game

The Climate Risks card game was created by Radley Yeldar and the Climate Disclosure Standards Board in 2021 from an executive drive to develop a game to educate students on climate change as shown in Figure 1 (CDSB, 2021).



Figure 1. Climate Risks Card Game (CDSM, 2022)

At the beginning of the game the group picks a company card and reads the profile of that company. The group then looks through a set of risk cards each with different potential risks that a company may face due to climate change. They choose 6 risk cards that they feel apply to the company that they have selected. Next, players read through a set of mitigation cards and determine which 6 mitigations would best alleviate these risks. The group then turns over 6 random event cards. Each event has some sort of climate related event and lists the mitigation cards that prevent harm to the company. Players earn points for each mitigation card they have that properly mitigates the event. Our group has taken inspiration from this game and will use it to create an improved game that will appeal to students.

2.6. Conclusion

The prospect of education through gamification provides a promising opportunity for improvement in climate change. The climate situation has been steadily worsening, while both awareness and action have not seen a substantial increase. Both individual educators and institutions have implemented some forms of climate education to varying successes, however there is significant progress to be made. Gamification has become a new area of interest in all forms of education, with recent studies proving its effectiveness. Our project will take these opportunities and establish an effective new tool for climate change education.

3. Methodology

3.1. Introduction

The goal of this project is to create an educational board game focused on man-made climate change aimed at high school and university students interested in finance and business. This board game will introduce and increase these students' knowledge of the current climate crisis and in the long term, promote sustainability and environmental welfare in future business leaders.

In order to accomplish this goal, there are five objectives that we aimed to accomplish. First, we evaluated the best ways for businesses to become more sustainable and climate neutral. Next, we evaluated the level of climate education and areas for development, which gave us an idea of the educational content to include in our game. Then, we administered the original climate game to students and identified structural issues within the current game design and strengths that could be emulated in our own game. The last aspect of the project was to identify promising gamification strategies specific to board and card games.

These objectives were organized into three main groups of game development: content, structure, and strategy. The first and second objectives fall into content; they were the necessary background knowledge to build the content of the game around. The third objective is the structure as it helped us understand the basics of game design, and how and why certain game aspects work and do not work. Lastly, objective four was the basis of our strategy. The concepts and ideas we learned from researching gamification were the main ideas on which we designed the game mechanics and style.

Finally, after developing the content, structure, and strategy of our game we documented the basic framework and layout of the game including how the game is played and the contents of the game. Below is an organizational chart laying out our goals and objectives.

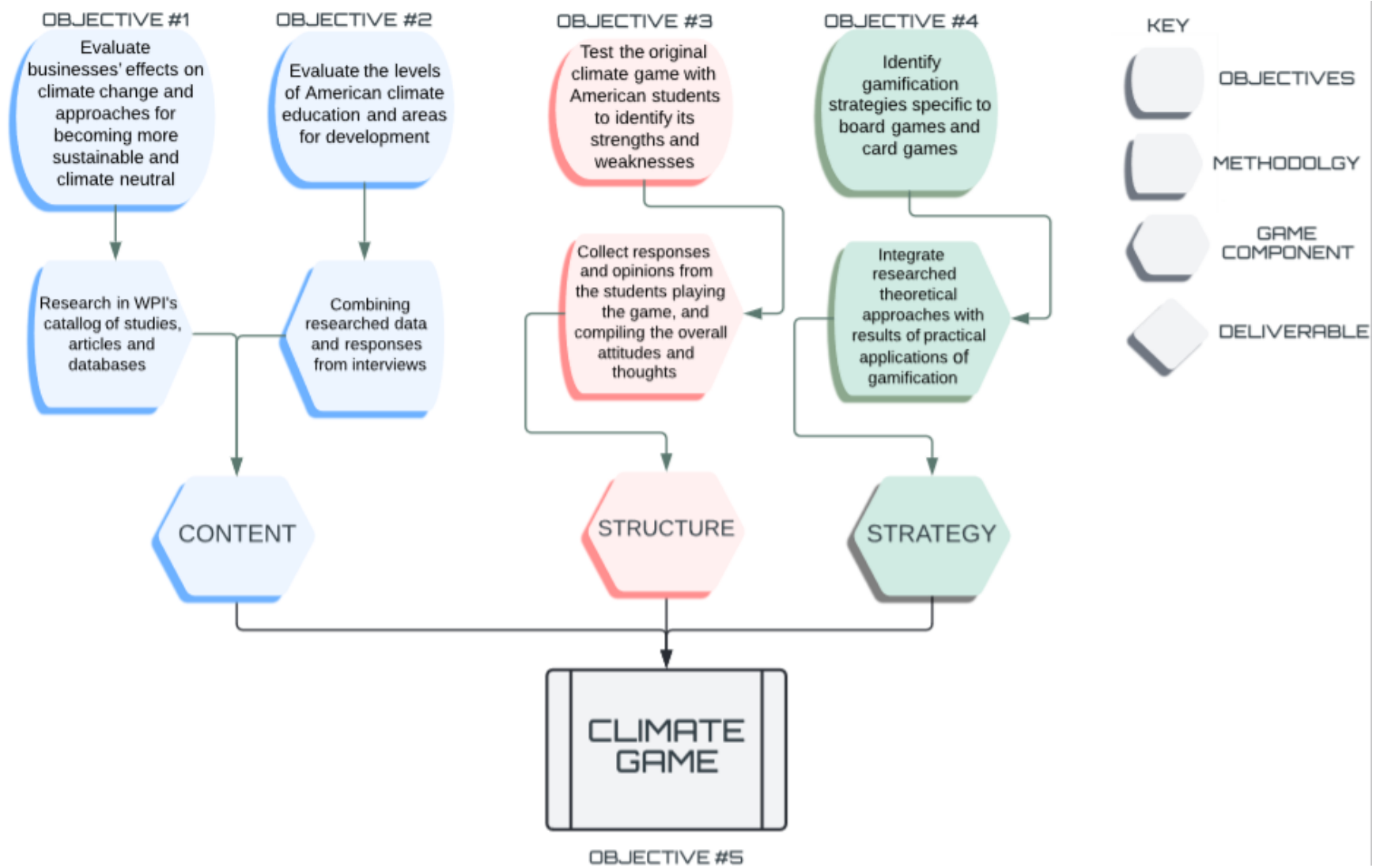


Figure 2: Visualization of Methodology

3.2. Objective 1: Evaluate businesses' effects on climate change and approaches for becoming more sustainable and climate neutral

Our team's first objective was to evaluate approaches for businesses to become more sustainable and climate neutral using foundational research. We identified the major industries that exacerbated climate change. Within each of these industries, we hoped to identify the anthropogenic sources of climate change, as well as risk mitigation approaches that had been attempted. The sources of climate change we researched were primarily recognizable to the average person, such as pollution, greenhouse gas emissions, or any other effect. This was because recognizability would allow the game to be more approachable for the public.

3.2.1. Data Collection: Foundational Research

Our main source for gathering this data was foundational research in Worcester Polytechnic Institute's (WPI) extensive collection of journal articles, databases, and scholarly studies as well as news articles and papers through Google Scholar. Our initial research questions included:

- What are the major climate change industries in the world?
- What are the most harmful practices each industry participates in?
- What are the long-term effects of this practice?
- Where are the effects of this practice felt most harshly?
- What are the best ways for this industry to mitigate this practice?
- What are the expected costs for implementing this mitigation tactic?

For each of these questions we documented our findings from the research in written summaries of the articles. We also categorized the mitigation tactics we found according to various themes, as well as the potential business costs and benefits. By categorizing the tactics, we were able to assign values for use in balancing the game based on the effectiveness of the climate strategy. We used these learnings to develop a standard codebook containing themes and notes to help focus and analyze important aspects of climate change.

3.2.2. Goal for Objective 1

Overall, our goal for the first objective was to develop the content for our game and establish a body of relevant climate change information. It was imperative that this step be conducted thoroughly as it is the most visible part of the game and our project as a whole. Ultimately, we expected that our secondary research and development of a codebook would allow us to curate a table of cross-referenceable risk/solution content ideas for use in developing our game. The organization of our data allowed us to narrow the scope of risks/solutions to provide various strategic situations for players.

3.3. Objective 2: Evaluate the levels of American climate education and areas for development

Our second objective was to evaluate current levels and approaches to climate education and look at the potential areas for development. This objective served as a baseline for our project which determined the extent to which their climate education needs to be improved. We conducted in-depth research to learn how climate education is built into the curriculum of universities and high schools. Interviews were performed to help clarify any gaps in our preliminary research through WPI students.

3.3.1. Data Collection: Interviews

We conducted interviews with WPI students to gain a deeper and more personalized understanding of climate education. To start, we drafted an email introducing ourselves, the project, the logistics of the interviews, and what we were looking for in the interviewees. This was then to different groups of students at WPI, such as IGSD, the wrestling team, and personal friends.

We interviewed several students to gather a spread of data and information for us to find the common themes from the interviews. We set up the interviews and coordinated times and dates via email with the interviewees. The interviews were held on Zoom to allow for more availability. At the start of each interview a consent script was read which can be found in appendix A. Scheduled interviews included at least two team members and one student or individual at a time. This allowed for the individual to be able to voice as many of their opinions as arise. Individual interviews allowed for us to gain a deeper understanding of the interviewee's motivations and interests in climate change. This also allowed for more time to discuss topics in greater detail, and took away the worry that can arise in group dynamics in an interview situation for both the interviewers and participants.

Each team member properly introduced themselves at the beginning of the interview to ensure the interviewee knows who they are talking to. We also confirmed consent at the beginning of the interviews. Prior to the interview, we discussed who is leading the interview. There was one team member directing and asking the interview questions. The other team members were taking detailed notes and asking follow-up questions when it was appropriate. The interviews began with building rapport and a light conversation to put everyone at ease.

Then, we asked open-ended questions to have the interviewee point us in a direction that we want. For this objective in particular, we asked open-ended questions about climate education, allowing for a deeper dive with each participant. Our focus probes related to each subject's educational experience with environmental topics can be found in Appendix B.

3.3.2. Data Analysis: Inductive Coding

Inductive coding was used to analyze the interviews and aided in finding common themes. Coding is the recognition of patterns in a large amount of data, in order to better understand it and easily extract the necessary information. Inductive coding is coding once the data is gathered; a codebook will be created after all of the interviews are completed (Yi, 2018). First, we started out with initial coding to get an overall sense of what the data looks like. Following this is line-by-line coding. This process is more specific as the data is analyzed with a closer eye. Once the line-by-line coding was finished, categories were now formed. The analysis and sorting of data allowed the categories to become apparent. The categorization of the data reflected the themes. The themes then showed us which patterns emerge from these interviews.

3.3.3. Goal for Objective 2

Our interviews with WPI students identified the subject's knowledge of climate change, their knowledge of the implementation of climate education in their curriculum and how it has changed over the years, as well as opinions on how climate education could improve within their university. These interviews gave us a brief understanding of the current level of climate change education of American college students. This was an important insight as it aided us in better comprehending where climate change education is lacking, as well as where we could focus in

our attempt at climate education. We wanted our game to teach students new topics that they are not already familiar with.

3.4. Objective 3: Test the original climate game with American students to identify its strengths and weaknesses

The third objective was to test the original climate game with American students to identify strengths and weaknesses on the structure of the game. The game structure refers to how the game is played, its rules and objectives, and the many possibilities for how we ultimately structure our game. Structure is the foundation for games and is crucial to our project. The different mechanics within our game impact how engaging and enjoyable the game is. It is crucial with educational games to engage the player to lead to a higher retention rate of the information and better help them understand the material presented (Smiderle et al., 2020). The best method for evaluating the engagement level of the original game is getting feedback from students.

3.4.1. Data Collection: Focus Group

In our efforts to define an effective structure, we gathered a focus group of WPI students to receive feedback about the original climate game. We used a screening survey through WPI's Qualtrics survey system which includes basic demographic questions. We were then able to select students for the focus group, and we communicated to them the date, time and location of the focus group.

Once the focus group was assembled we read them our consent script which can be found in appendix A. Then we gave them initial instructions on what the game is and how

they are supposed to play it. The game was then given out to the participants and they read the directions as well as played through the game on their own. After the playthrough of the game ended they were given a quick survey to fill out.

This survey consisted of questions, described in Appendix C, aimed to assess how engaging the original climate game was. After surveys have been collected we then lead a directed discussion with the focus group. During this discussion we asked them questions targeted at the game's structural strengths and weaknesses, and gave them an opportunity to offer up their own ideas for improvement. This feedback, along with the surveys, was reviewed after the focus group concluded.

3.4.2. Data Analysis

As we reviewed the feedback from the discussion and written answers from the survey we used thematic analysis in order to identify key themes within the comments. We determined all the themes discussed by the participants, and wrote the comments that they made about each theme.

From this analysis we created a table with all the themes discussed during the focus group and all of the opinions of the respondents on the themes. This table provided us an easy way to quickly look at common structural themes that were discussed and clearly see the feedback given on them. All the feedback was examined within our group and incorporated into our game.

3.5. Objective 4: Identify gamification strategies specific to board games and card games

The fourth objective was to develop a strategy for our own game by playing board and card games in order to take note of the similarities and differences between them. Gamification is an essential part of our project. By playing the games coupled with doing research on gamification, we were able to create a game that both appeals to young adults as well as be educational for them.

A great tactic to gain valuable knowledge of gaming strategies is playing a variety of games. Both board games and card games alike gave us insight into game design when we were creating our game. Climate change can be a difficult topic to discuss and learn about, but using gamification allows for a much less overbearing way to learn. Russia has an existing climate change game already, so we used ideas and strategies from it to improve it and made our game more appealing to college students and entrepreneurs.

3.5.1. Data Collection: Game Experience

As a part of our research, we played board games to observe and document certain aspects that add to a game's enjoyment and educational aspect. We created a document detailing what we personally enjoyed about the game, and wrote notes about the educational value when necessary. The notes were compiled and our group discussed them and highlighted similarities between games. We implemented these similarities into our own game and made it as enjoyable and educational as possible.

3.6. Objective 5: Prototype the basic framework and layout of the game including how the game is played and the contents of the game

Finally, with the requisite knowledge gathered in Objectives 1 through 4, we began developing the prototype of the game. Prototyping the game heavily involved playtesting with WPI students. The students' opinions, collected through focus groups, helped in designing an engaging game that will educate people on local and global risks to the climate. This process was completed in three stages: ideation, testing, and revising.

3.6.1. Ideation

We first came up with the general parameters of the game. During the planning term, we brainstormed possible rule sets, boards, outlines, and points systems. During the ideation phase, we incorporated our knowledge of climate change and industrial impact into the game themes and mechanics. We also used many of the notes taken when playing and analyzing games, as we were able to pick out specific gameplay mechanics that we thought worked, or avoided ones we did not like. Once we laid out the initial idea of the game, we created a simple prototype version of the physical game.

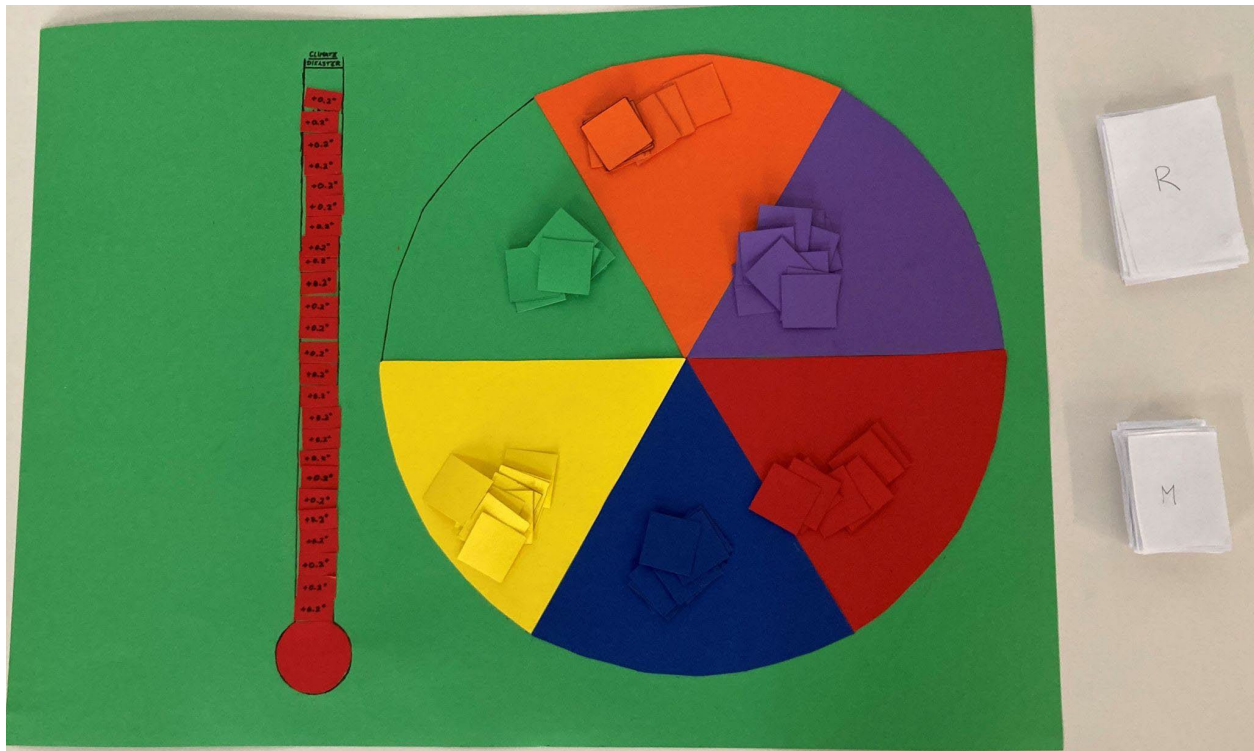


Figure 3: First Prototype of Temperature Rising

This simplistic, and somewhat childish, prototype was used in the internal testing. It was developed in a short period of time and on a small budget, and was perfect in helping us refine and polish the game.

3.6.2. Testing and Design Workshops

Once the prototype and basic rules of the game were developed, the game was initially tested by our group. This testing consisted of playing the game while also discussing the rules, to see how things were balanced and generally assess the quality of play. Once we had gotten to a significant level of development, the game was played by several students from WPI. We conducted focus groups with the same general layout as defined in Objective 3. When testing with other students, we focused on the player's enjoyment of gameplay, the educational quality,

and the players' ease of understanding the rules. The questions asked in the focus group discussed the game and identified the player's feelings and opinions about their experience. Specifically, during the discussion asked about how fun and engaging the game is, as well as if they felt more comfortable or knowledgeable about climate risks. Questions that were asked after the focus group testing can be found in Appendix C.

The focus of our analysis post test was whether the students enjoyed playing the game. The feedback given by the testers was collected and discussed between the group, and improvements and adjustments were consistently made throughout the rest of the development of the game.

3.6.3. Revising the game

Depending on our timeline and how many prototypes we came up with, we may have the same students test the game more than once. If so, we could change or add in questions, to help reflect on progress. For example:

- Compared to the last time, was the game more fun?
- Did you feel that the improved mechanic worked better this time?

Once feedback was collected from the testers, we revisited the ideation stage, and looked specifically at how we could improve the game based on the feedback. The feedback we received and analyzed shortly after, which included changes to the aesthetic, rules, flow of gameplay, and more. We were able to make many changes based on the user feedback, and finished with a product that is very much enjoyable and educational.

After the focus groups were completed, the development of the game was concluded shortly after. During each iteration of revising, comments from the students and the planned changes were documented, alongside photos of any changes to the physical prototype. Since many of the changes included only the rules, and the physical game required very small adjustments, an entire new copy was not necessary. All of the changes that were made were documented or saved, as a way to preserve the development process for future evaluation.

The final prototype was run through the testing phase once more before presentation. The data collected was used to not only judge how the final product holds up to the original goals of the project, but also helped measure the progress the prototype made throughout the process.

3.7. Acknowledgement of Research Limitations

Throughout the term, we faced certain limitations that inhibited and prevented some data collection. The ideas presented here are what we expected to come across as we moved through our methodology during the term.

Throughout the course of this project, many current events have affected and fundamentally altered our goals and available opportunities. The Russian Invasion of Ukraine that began on the 24th of February, 2022, unfortunately made it so that our group could no longer participate in joint efforts with the students from The Financial University under the Russian Federation. Originally, Russia sponsored this project because of the lack of state sponsored combating of climate change compared to the rest of the world, but due to the aforementioned war in Ukraine we were unable to continue working with our counterparts and sponsors.

It was decided that the scope of the project would be altered to fit a more international audience, including and accounting for the education and climate risks in the United States and Germany. Germany was chosen as a place of interest largely due to travel being rescheduled to Berlin. However, there is still the focus on the need for climate education in Russia, as well as the perspective of the business student and future entrepreneur.

4. Results and Discussion

4.1. Findings from Game Content Research

4.1.1. Results of Foundational Climate Change Research

In the early stages of our research we found that the industries causing the most climate change in the world were electricity generation, transportation, manufacturing, commercial and residential emissions, and agriculture (EPA, 2020). We narrowed down the broad industry of manufacturing into mining and oil specifically, since they are among the largest and most well known industries that contribute to climate change. We also researched construction pollution and discovered it was responsible for nearly 11% of global CO2 emissions and replaced commercial emissions with the construction industry (Why the building sector, 2018). With these two stages of research combined, we decided to focus on the following industries for our game: Automotive Manufacturing, Construction, Electricity Generation, Agriculture, Petroleum, and Mining.

We split these industries between our group members and each focused on an industry for further research. Automotive emissions are mostly generated by the use of fossil fuels. These account for about 27% of the US's greenhouse gas emissions (GHG). Electricity generation is mainly in thermal power plants and accounts for about 25% of world GHG emissions (EPA, 2020). Agriculture also has many negative effects on the environment. One of the most pressing is the runoff of pesticides which affect soil, natural ecosystems, and can lead to major water and wildlife destruction (World Wildlife Fund, 2021). Petroleum's negative effects are physical drilling and the pollution due to poor practices. Infamous events such as the Deepwater Horizon

oil spill have dramatically affected the popular opinion on big oil and are great examples of major devastating effects large companies can have on the environment.

Along with these specific company effects, there are also common climate change effects that we researched. For example, the thawing of permafrost in northern climates will cause the destruction of major infrastructures (Melnikov et al., 2022). This will cause roads and pipelines to be broken and worn down which will affect almost all companies. Another major climate change effect is the melting of icecaps and glaciers in the Arctic Ocean leading to major flooding (Conley & Newlin, 2021). In a similar vein, wildfires are also having a drastic effect on the environment. Wildfires cause the temperature in the region to increase and as the trees burn, they release plumes of carbon dioxide into the atmosphere (Hemp, 2005). Wildfires in Russian forests lead to Russia's 2020 emissions to be one third higher than their emissions in 2019 (Conley & Newlin, 2021). Other effects present in our research were smog, construction of infrastructure causing the destruction of ecosystems, increased sea activity, and a global increase in the desire for green products. All of these, along with general knowledge on business, allowed us to come up with about 24 unique risks to companies for our game.

From this point in our research, we looked in-depth at the risks we had laid out and delved into appropriate mitigation strategies for each. We formulated mitigation strategy cards by researching the risk cards and how to mitigate them. For example, smog is an environmental issue that is mainly caused by emissions from vehicles and industries (Britannica, 2019). Thus, the card that mitigates the effects of smog is "limit vehicular emissions." This was the method used to create our mitigation cards.

4.1.2. Results of Interviews with American University Students

We interviewed three Worcester Polytechnic Institute (WPI) students to gauge the level of climate change education present in American curricula. From our interviews, we found that students have a basic understanding of what climate change is and its effects on the environment. The students' knowledge on climate change involved the ecological aspects of climate change; for example, temperatures rise, sea levels rise, and precipitation patterns change. The interviews revealed that WPI students believe there is a limited selection of climate education classes offered at their university. One of the interviewees, Connor Norton, a biochemistry engineering undergraduate, said, "that environmental aspects have not been taken into consideration in his biochemistry coursework thus far." However, he did state that while environmental aspects have not been taken into consideration in his courses, sustainability tactics have been a point of discussion in a few of his classes. Martin Carrau, an industrial engineering undergraduate, also said that sustainability tactics have been frequently discussed in his classes.

The theme of environmental importance was revealed from the inductive coding of these interviews. Connor said, "the topic of climate change is very important to me and it's important to address it to help the future generations." Kenneth Savage, an industrial engineering undergraduate, said, "the topic of climate change is very important to me. I think when people hear the word climate change, they think of rising sea levels and hotter days but it's so much more than that. It is a bigger and broader issue than most people think it is." Martin remarked, "While climate change is of decent importance to me, I still try to be mindfully aware of it like not littering and cutting down on too much plastic. Small little things to keep in mind on a daily basis." These responses show that even though climate change is of varying importance to people, everyone in our sample felt capable of contributing to solutions in a small way.

One of the important pieces of information we wanted to obtain from the interviews was to see if WPI stressed the importance of climate change and its impacts in its course offerings. Kenneth said, “the topic of climate change is shown in freshman year courses like the Great Problems Seminar, but outside of that, not really.” Connor’s view on this question was similar in the way that “they don’t stress it, but they do have a lot of green options on campus like recycling. They don’t go out of their way to stress it more than they need to.” Martin brought up an interesting point, “that while the university shows the impact of climate change through the Green Team and recycling programs, it’s the professors’ pro-environmentalist agendas who stress the importance of climate change.” Martin took an Intro to Philosophy and Religion course and had a professor with a pro-environmentalist agenda who made all of the discussions about the importance of climate change.

These interviews gave us valuable insight in American climate change education even if the sample was limited. The extent of the students’ climate knowledge was dependent on what classes they took and what professors they had. The students that took the AP environmental course or any environmental course had a deeper understanding of climate change than the ones that didn’t. The interviews also highlighted the rigidity of WPI’s engineering tracks and how it deterred the students from taking more environmental courses and electives.

4.1.3. Discussion of Game Content Research

Our research on climate change and the main contributing industries has greatly aided in developing the educational content presented in our game. This research provided the necessary information to determine which industries were going to be used in the game as well as which risks and mitigation tactics would be beneficial to teach students about.

Our interviews with American students gave insight into the varying levels of climate change education in the American education system. The students all had a general understanding of climate change and some of its impacts but lacked depth of knowledge in how they could mitigate. The interviews revealed that these students are environmentally conscious and willing to educate themselves more on climate change. The students commented that they would take environmental courses if their schedules were more flexible; environmental courses were not a priority in their academic schedules. However, they still wanted to educate themselves on the topic of climate change, despite the scheduling restraints. This educational board game is a flexible option for students to educate themselves on climate change without interfering with their major courses. This game can be used as a tool that can provide a general overview of climate change to students who have not taken specific climate focused classes. Our fun and interactive board game can educate students outside of the classroom without disrupting their academic schedules.

4.2. Findings from Game Structure Research

4.2.1. Results from Structure Research

As part of our guiding analysis for how to structure our game we conducted a focus group of the original Climate Risks game. This focus group was originally meant to be conducted with six players, as that is the recommended number of players for the game. However, on the day of the focus group three people were unable to make it leaving us with three participants. This ended up being beneficial as we were able to have a more meaningful discussion with the participants. Through our analysis it was found that the focus group participants mainly gave feedback on six different aspects about the game: competitiveness, risk and mitigation cards, companies, game aesthetics, and score. Participants were unsatisfied with the level of

competition within the game and felt that being able to win and improve above others would make it more fun. They also identified some problems with the selection of risk cards, as it was confusing for them to have to pick what risks apply to what company without prior knowledge. They felt that this section of the game required more info and more explanation, which the game did not provide. The majority of the focus group seemed to really enjoy the mitigation card aspect as they identified matching up the mitigation cards to prevent the risks as a fun game component. One participant also thought the mitigation cards could be confusing at times. They explained that this was because there was not much information about how to match up risk and mitigation cards on the actual cards themselves, so they were unsure of the best ones to match up.

The focus group also thought that the companies needed to be adjusted. Their main complaint was that the company profiles were “bland” and could be a lot more in-depth. They also did not like the fact that towards the end of the game the specific company you had chosen had almost no impact on the outcome of the game.

In terms of game aesthetics, the participants recommended adding more pictures and images to the game, and cutting some text on some of the cards. They felt that this would make the game more engaging.

Finally, they were unsatisfied by the scoring dynamic of the game because they felt tallying up points was a little confusing. Also, since the random flipping of event cards was the way points were scored it led to the score being entirely based on chance. Players could choose effective mitigations that applied to their companies and sometimes it would not matter as the points were solely based on a completely random component. This meant that skill and strategy virtually did not factor into the players ability to earn points.

We asked the participants to rank the enjoyment factor of the game on a scale of 1-10 and the average score among them was a 5.33. They did not seem to enjoy the game very much and they identified several ways for the game to improve. They had their own recommendations such as including a game board and adding a natural disaster and wildcard component to the game. They also wanted a game structure that allowed for a more complex strategy and allowed them to outplay one another. The table in Appendix E has specific details on the major comments given by the participants about the Climate Risks game.

Overall the information received from the focus group was very helpful and shared some similarities to our own thoughts on the game. This feedback helped to inspire our game and gave us an idea of how to structure our game in a way students would enjoy.

4.2.2. Discussion of Climate Risks Focus Group Testing

This feedback from our focus groups provided a solid framework for the structure of our game. It became clear that students who played the original climate game were displeased with the lack of competition, as there was no true winner at the end of the game. When creating our game, our group made a conscious decision to make it very competitive, and increase the interactivity to get the participants more engaged. Having a clear win condition, seeing other players progress, and having all players working towards a common goal were game mechanics we incorporated in order to stimulate engagement. We believed this aspect of the game would spur all the players to compete with each other to get to win the game. We also included certain mitigation cards that had the power to affect other players to further increase interaction among players. This was a fun aspect of the game that allows the player to interact with others in a

strategic way. Both of these game mechanics drastically improve the level of competition, interactivity, and engagement of our game.

In terms of handling the confusion surrounding mitigation and risk cards we wanted to streamline the process to make it less confusing. For example, when risk cards are flipped they specify what specific companies they apply to, instead of having the player guess which risks apply to which company. The purpose of the game is to educate the student, so it was confusing for them in the original game when they were asked to determine which risks apply to which companies, information they may not know. Instead the cards in our game clearly tell players what companies are impacted by the risk cards and teach about climate change risks. Another great piece of feedback obtained from the focus group was that mitigation cards should continue to be present in the game as mitigating risks as both groups found the mechanic enjoyable. However, we also found that the cards had to be more clear and include more information to help players understand how they work and how to use them.

In order to improve the overall game aesthetics we determined that an actual game board should be created to track progress. The board is colorful and vibrant and has many game pieces for players to visually display their progress in the game. We also implemented individual boards specific to each player, with lots of graphics and in-game trackers, which contain a more in-depth explanation of each company.

Finally, one of the biggest improvements to the game was creating a more complex game structure that allows for more strategy. The first game was extremely simplistic and the focus groups participants did not seem to enjoy how simple it was. Participants also pointed out that you could not replay the original climate game as you would essentially have the same player

experience each time. In our new game we increased the complexity in order to have a fun game that can be replayed with different strategies and lines of play.

4.3. Findings from Game Strategy Research

4.3.1. Results of Strategy Research

Throughout the timeline of our project, we played several games and had in-depth discussions about the strengths, weaknesses, and designs of each. Each day we would select a game to play that we felt would supplement our data and contribute valuably to creating our own. Our group focused on many aspects of each game, including time length, number of players, interactivity, simplicity, and dependency on luck. Over the timeline we played the following games: *Durak*, *Sushi Go*, *Catan*, *Offshore*, *Secret Hitler*, and *Coup*.

The games we played had varying time lengths, with the longest game lasting about an hour and a half, and the shortest lasting about ten minutes to play through. Card games such as *Durak* and *Sushi Go* both were about ten minutes to complete, but our group was able to play multiple rounds and learn new strategies for each. Games like *Catan* and *Offshore* were both over an hour, and were a bit more complicated than the card games. The time length for these board games did not allow our group to play them more than once, and learning them caused the first few turns to move a bit slowly. A third type of game our group played was a combination of both card and board games. *Coup* and *Secret Hitler* fell into this category and took about 20 minutes to complete depending on the amount of players.

Each game had a range of players, usually around 3-6. The only games that did not have this range were *Secret Hitler* and *Catan*. *Secret Hitler* had a range of 5-10 players and *Catan* had a much narrower range of 3-4 players. Because our group had the minimum number of players to

play *Secret Hitler*, we did not gain access to certain parts of the game as we did not advance as far. When playing *Catan*, one of our members had to sit out because of the narrow player range. Each other game we played we were able to have the correct amount of players and each game ran smoothly because of that.

The next category our group gathered data on was the interactivity of games. The more interactive the game, the more fun we had playing it. When a game is interactive, education can be seamlessly added and instrumental when teaching players. During *Coup*, although players cannot make actions on their turn and advance in the game, they are able to react to other players advancing their game. Throughout the game we found those who paid attention when it wasn't their turn were the most successful. *Catan* involves a trading system, which is extremely interactive and super useful while waiting for your turn. *Sushi Go* forces players to pay attention to others making moves in order to strategize for their gameplan, much like *Coup*. *Secret Hitler* barely had any interaction and is more of a discussion game. Although fun, it lacked the interaction the other games had and certain roles were much less fun depending on the round. When interaction is low, our group found that engagement also was low and the game became uninteresting. In order to avoid this we tried to make our game very interactive so players would feel engaged and learn about climate change. Our group enjoyed games with interaction much more as there was almost never a moment where everyone was not engaged.

Many of these games were very simplistic, with *Durak* and *Coup* being the most straightforward. The longer games like *Catan* and *Offshore* were much more complex, but this could be considered a strength. After playing *Catan* our group wanted to play again and try out different strategies. *Coup* and *Durak* have the advantage of playing multiple games in one sitting,

but players may not be inclined to play them soon after. *Catan* and *Offshore* have the longevity to play multiple days in a row for multiple hours at a time.

Finally, we focused on the aspect of luck in each game we played. If a player loses to luck, it can be discouraging and cause a dislike towards the game. Each game had a certain aspect of luck to each of them, with *Durak* and *Sushi Go* being impacted the most. *Durak* is played with a normal deck of cards, and the game is decided by what cards you draw. This is mitigated by various strategies and how you play with the hand you're dealt. *Durak* takes skill and strategy to dilute how much luck is needed, finding a nice balance. Integrating but balancing luck was an integral part of many of the games we played, except for *Catan* and *Offshore*. *Sushi Go*'s winner depended on what decisions you made with the cards, and *Coup* followed the same idea. *Catan* used a mechanic called Development Cards in order to integrate luck, as you did not know what type of card you would acquire. You also had to roll dice to take your turn in *Catan*, but the board told you which numbers had a statistically higher chance of being rolled. *Offshore* only had one deck of cards, and players were able to see three at a time, decreasing chance and making the same cards available to all players.

The results generated by these games were instrumental in the creation of our game, and we took aspects from each in order to make our Climate Game. Combining what we learned about time length, number of players, interactivity, simplicity, and dependency on luck, our group was able to create a game that took each into close consideration.

4.3.2. Discussion of Strategy Research

When studying the various types of games, we noted the strengths and weaknesses of each, and used this information in our game. To develop our game, we decided on five strategic aspects: time length, number of players, interactivity, simplicity, and dependency on luck

We decided that we wanted our game to take about an hour to play because our group really enjoyed the replayability of *Catan* and *Offshore*. We made sure that our game was balanced with 3-6 players, and that it played the same way each time no matter the amount of people playing it. We came to this decision because we did not want the limitation of players *Catan* has or the functionality issues *Secret Hitler* has when playing with fewer players.

Interactivity of games was a huge factor we considered in our development. Waiting until it is a player's turn with nothing to do is extremely boring and can be the downfall of an otherwise fun and educational board game. We aimed to create a game similar to *Durak* that promotes player engagement the entire time. In our game, players pay attention to other players' turn, because each industry contributes to climate change, and because of this engagement players were able to learn a lot about climate change and its detrimental effects.

We took inspiration from *Catan* for the complexity portion of our game, as it is more rewarding when playing and winning. Each part of our game is connected, from building up a company to mitigating risks that happen in the game. Climate change is a complex topic that is not solved quickly, and our group tried to emulate that in the complexity of our game. Similarly, climate change is not predictable so we tried to implement chance and luck into our game. We did this through the drawing cards through a shuffled deck mechanic. We incorporated several aspects from these games we found enjoyable. We made sure to focus on the shortcomings as well so we did not make the same mistakes. After completing this objective our group had a very good idea of what we wanted our game to be and how we would create it.

4.4. Findings from Game Development

4.4.1. Results of Game Ideation and Creation

With all of the information collected, the initial ideation phase of our game went very quickly and produced many ideas. We focused on brainstorming rules, pieces, mechanics and strategies, and taking detailed notes on all of the concepts considered. This process took place over the span of a week as we went through each person's ideas, discussing each one as a group. There were certain criteria that we aimed to accomplish, such as ease of play, pacing, enjoyability, and educational value.

By the end of this brainstorming period we had a full game idea. Our game, *Temperature Rising*, would focus on a player attempting to build a company while also trying to mitigate their companies against the risks caused by climate change. In *Temperature Rising* there are six companies: agriculture, petroleum, mining, automotive, electrical and construction. Each player plays as a specific company as they attempt to progress through the game by building and upgrading their company's infrastructure. Each turn the infrastructure provides the player with income, but also gives the player emission tokens. Having too many emission tokens triggers the world temperature to rise, which is kept track of with a thermometer on the board, and causes a risk card to be flipped.

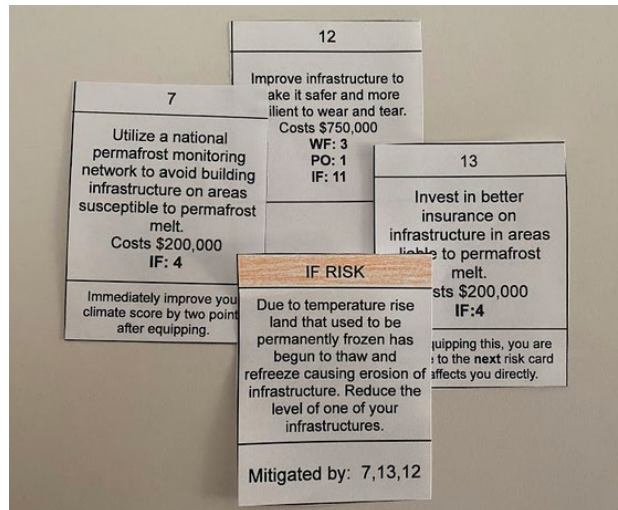


Figure 4. Risk Card and Applicable Mitigation Cards

Each risk card represents a risk associated with climate change and a penalty on the card. Risks can be avoided by playing mitigation cards. The goal of *Temperature Rising* is to upgrade your company infrastructure to the maximum level, while also properly equipping your company with mitigation cards, so that you can manage the climate risks. There is also a mechanic in *Temperature Rising* where if the world temperature rises too high the game ends immediately and whoever has the most environmentally friendly company wins. More detailed rules can be found in Appendix F.

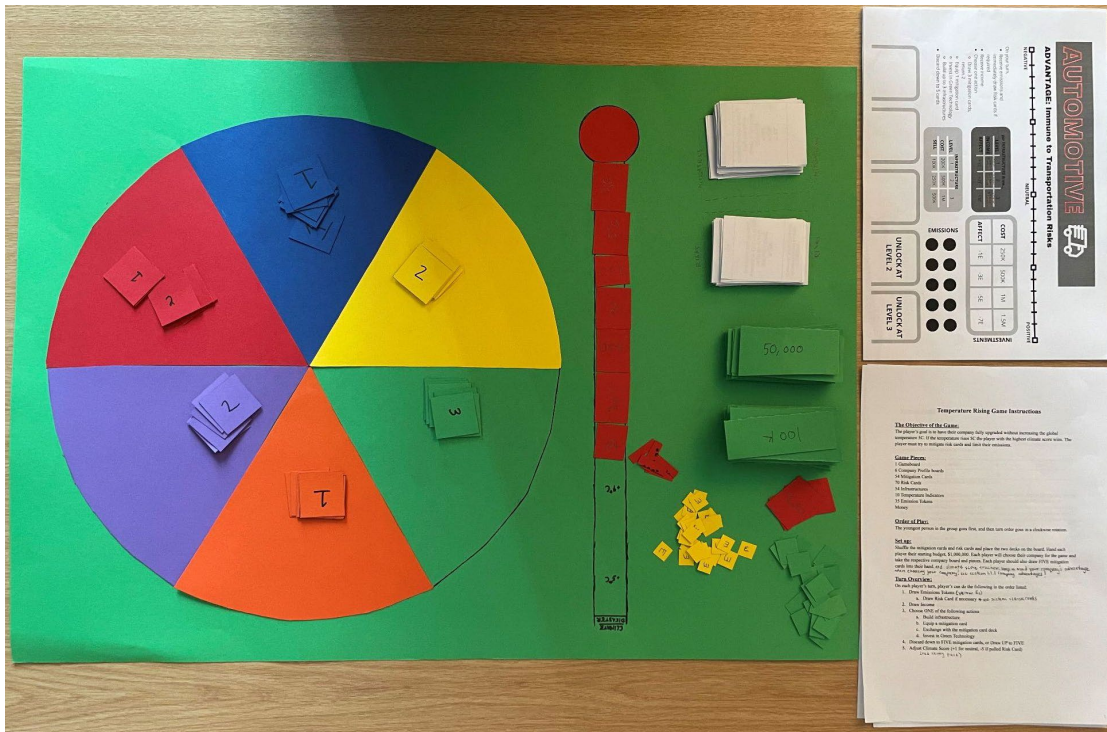


Figure 5: Game Prototype for Focus Groups

We then constructed the physical prototype of the game out of construction paper. We created the game board, company profiles, risk cards, mitigation cards, and other various game pieces as seen in Figure 4.

4.4.2. Results of Playtesting the Game Internally

Once the prototype of the game was developed we were able to begin playtesting internally with our group. There were many changes made very quickly to the rules and gameplay. This process lasted about one week as we went through five cycles of testing and revising the game, each noted as a separate playtest with its own set of notes being taken. Much of what we were doing was game balancing to make sure that players were generating enough money to pay for the costs of infrastructures and mitigation cards. Additionally, we were adjusting emissions per infrastructure and risk card penalties to make sure that the risk cards were punishing, but not game ending. Working with a prototype and analyzing the game as it

was being tested made it much easier to accurately assess certain aspects of the game. One of the aspects of the game that proved extremely challenging to develop was the pace and timing of the game. Only after three or four tests were we able to get it to our goal of around one hour, by making changes to income and how many infrastructures a player has to upgrade to win. After five separate iterations and tests, the game was at a stage where we were ready to test it in the focus groups.

4.4.3. Results of Playtesting the Game Externally

The first two focus group playtests of our game were conducted on April 19th with two groups of 4 and 6 people. During the focus groups participants were given the game rule book and all the game pieces and asked to play the game with no other instruction from the moderators.

One thing immediately apparent throughout both focus groups is a big learning curve to our game. Due to the complexity of the game, reading the rules, setup, and the first round of play took roughly 25 minutes in each focus group. We noticed that for the second round of gameplay both groups were able to get through the round in roughly 10-12 minutes. Towards the end, each turn was going much smoother and the players were able to complete a round rotation in about 6-8 minutes. The long turns were largely due to confusion with the game mechanics. However, as demonstrated by the much quicker game rounds at the end, the players were able to catch onto the rules and understand the game much better. Many players commented towards the halfway mark that they had a solid understanding of the game by that point. During the playing of the game it was also pointed out that a few revisions or clarifications to the rulebook need to be made that would perhaps help players understand the game earlier. Some specific examples of

this were the selling of infrastructure, the equipping of mitigation cards, and a forewarning that disregarding the environment would heavily impact your company's growth.

When prompted with what was enjoyable about the game the participants had a multitude of answers. The most common answer to what was enjoyable was the temperature rise mechanic. They enjoyed the logical flow of how having more company infrastructure leads to more emissions, which then cause the world temperature to rise, and then that triggers a risk card. They thought that this in-game mechanic was interesting as it accurately represents how climate change is caused in the real world. The second most common answer to what was enjoyable was the building of your company. People enjoyed being able to invest in infrastructure and upgrade and improve their companies as well as the benefits of having a bigger company. People also enjoyed the deep strategy in the game and having to balance investing in infrastructure while also investing in mitigation cards and green technology.

After discussing aspects participants liked we wanted to find what participants thought was confusing and what they would change or improve. The main complaint was that the rules were too confusing and the turns were taking too long. Some players felt like the game was too hard to understand and there was too much going on. Another common issue was the mitigation cards had text that needed further explanation. People also thought that it was hard to see the benefit in buying mitigation cards because it was hard to understand what they actually did without seeing it firsthand.

Overall, people found the game enjoyable after learning how to play. When asked how enjoyable the game was on a scale from 1-10 the average answer was a 6.9, which shows improvement from the enjoyability of the original climate game. Many of the participants also

pointed out that since the game is complex and has a lot of strategy to it, it might be a lot more fun on a second playthrough.

After the first two focus groups it was clear changes needed to be made to the game to improve the clarity. Lots of changes and further specifications were added to the rule book, as well as reordering the rule book in order to have more important parts of the rules at the beginning instead of buried at the end.

A third and final focus group was conducted with the game on 4/22. This focus group consisted of 4 participants, but one of the participants was a returning player who was in the first focus group. The returning player managed to retain almost all the rules from their first playthrough and was able to greatly assist the other new players in learning the game. This combined with the improvements and further clarifications we made to the rules drastically improved the players' comprehension of the game. This focus group went at the quickest pace as the players were able to learn all the rules and complete the first round in just 13 minutes, almost half the time of the first focus groups.

It was also clear that this group enjoyed the game more giving an average enjoyment rating of 7.25, which is .35 points higher than the last focus groups rating. Interestingly the returning player found this focus playthrough much more enjoyable and rated the game two points higher than they did the first time. They explained that there was much less confusion in this game and they were able to play fast paced while also using a lot of strategy.

As far as the education aspects of *Temperature Rising*, focus group participants noted that after playing, they were more aware of their company's impacts on the climate. Participants felt they could have delved more into the specifics but the length of the game and variety of options limited their experience.

While the group did enjoy the game they also had some good comments and suggestions for improving the game and making it more balanced. Some of these included changing risk card prices to make them more fair, adjusting mitigation cards to make some less powerful, and making mitigation cards more clear. They also suggested creating a QR code for players to download rules on their phones and including a game discussion section at the end of the game for players to summarize what they learned and reflect on their playstyle. All of these changes have been incorporated into the game.

4.4.4. Discussion of Game Development

The information we collected and analyzed prior to the beginning of development greatly simplified and shortened the ideation phase. By playing a large collection of games and laying out certain aspects and ideas that we saw work, we supplied ourselves with a guide to potential game aspects. There are three aspects of our game that we found to be imperative to properly designing the game; interaction between players and the consequences of actions, risk and mitigation cards, and variety of actions and illusion of choice. These aspects lie in the realm of what we believe will make our game effective and thus, educational to students. Likewise, by having climate change education as our focus it was relatively easy to get down the outline of the game.

When transitioning into the testing and revising phase of the game's development, we fully realized the time that this process would require. Not only did our internal playtesting sessions last hours and usually took up a large portion of the work day, documenting changes and keeping the prototype up to date also proved to be time consuming. The largest portion of the time spent during internal playtesting was brainstorming changes to the rules and mechanics. The problems we found throughout the game did not have one clear answer. Many of these

problems, such as too little income in the early game, too many emissions being distributed, or too few risk cards being pulled, could be solved in multiple ways. As a group, we had to find and agree on the best way to solve the current problem, while also trying to not overcorrect or break the game in the process.

Game development was not a process our group had experience with before the beginning of the project. research and preplanning before any development began created a very narrow timetable to fully develop the prototypes for ourselves. One of the biggest struggles that we faced towards the end of D term was the lack of availability of fellow students to participate in focus groups. This unfortunately limited the scope of our results and analysis of the final state of the game. This was partially brought upon by the uncertainty of our target testing audience; with the original plan of the Russian students changing to the possibility of German students, and finally to our classmates. This also made planning ahead in any significant amount difficult, as we were constantly unsure what opportunities would be available to us.

5. Recommendations

The goal of our project was to develop an educational board game focused on teaching high school and university students about the current climate crisis and to promote long term environmental sustainability in future business leaders. To expand the potential and impact of the game in the future, *Temperature Rising* should be developed in numerous ways. This is not to say our project did not meet its goal but rather that there are several opportunities for future projects to improve on our work.

One potential opportunity for a future project is to test *Temperature Rising* with international students. This was a stretch goal for our group but the development of international conflict in Ukraine made it near impossible. With a full term to collaborate with another international university, future project teams could test the effectiveness of our game and discuss potential aspects that may demand focus. As well as international students, *Temperature Rising* should be tested with high school students in order to assess the effectiveness of the game at various education levels. By expanding the target audience we can hope to educate more students earlier in their schooling, which should improve retention and internalization of climate change information.

Another avenue for future development of *Temperature Rising* is key improvements to the physical game. Thorough designs of game pieces and the board proved to be too time consuming for our project but are essential if *Temperature Rising* is to be used in a commercial setting. The designs we used were elementary and were more focused on practicality for testing the game mechanics. Developing our models into more mature designs may also decrease some

confusion for players as well as increasing the desire to play the game. These physical aspects would become less important if *Temperature Rising* was digitized.

One of the key ideas present at the beginning of our development was planning for an online video game version of our game. Many aspects of our game that were seen as confusing to focus group participants would be eliminated by digitizing the game, such as turn order and keeping track of income. Numerous trackers included on each company's individual board would be automated, allowing for the game to be played in a quicker fashion. Comments had been made in the focus groups that there were too many options for a beginner player. By digitizing the game, many options would not be available until later in the game and options could be easily suggested to players.

The most appealing aspect to digitizing *Temperature Rising* would be the increase in availability to students around the world. In the hopes of manufacturing the game for popular use, the game would become costly due to the materials involved and the cost of manufacturing. This cost would not be realistic for students and certainly not for teachers attempting to have several games going in their classroom at the same time. If a video game version of our game was developed, there would be no physical pieces or manufacturing needed. In a similar vein, digitization of *Temperature Rising* would make translation and localization for international students much easier. In theory, a small team, such as a group of five students from the Financial University, would be able to do this once the groundwork for the video game was created. This would allow for increased accessibility as any student with access to a computer could play this game. This increase in availability would improve the knowledge of the information provided and hopefully fulfill our main goal- educating students on the consequences of climate change and promoting sustainable practices in future business leaders.

6. Impacts

Ideally, our game will be seen as a useful educational tool for educators at high schools and universities, and will be implemented into their curriculums. *Temperature Rising* has the potential to help educate students who are unfamiliar or unconnected to the current state of the climate. However, the educational value of the game is limited somewhat by the content of the game; it does specifically mention the history and specifics of climate change, as well as what certain actions cause emissions or other damage to the climate.

The message that we want players to walk away from *Temperature Rising* with is that actions taken with regards to the climate have large scale impacts on both individuals and the world. We want to support the idea that climate inaction is not only harmful but detrimental to the current situation. Players learned while playing *Temperature Rising* that ignoring implementation of mitigation cards and investment in green technology results in the temperature rising to a critical level. *Temperature Rising* will hopefully help many students learn about how to mitigate climate change and lead to a more sustainable world in the future.

References

- Andrew, R. M., & Peters, G. P. (2021). The Global Carbon Project's fossil CO₂ emissions dataset [Data set]. *Zenodo*. <https://doi.org/10.5281/zenodo.5569235>.
- Bolscho, D., & Hauenschild, K. (2006). From environmental education to education for Sustainable Development in Germany. *Environmental Education Research*, 12(1), 7–18. <https://doi.org/10.1080/13504620500526297>
- CDSB. (2021). *Climate risk game*. Climate Disclosure Standards Board. Retrieved February 28, 2022, from <https://www.cdsb.net/climate-risk-game>
- Climate Central. (2019, April 17). *American warming: The fastest-warming cities and states in the U.S.* Retrieved April 8, 2022, from <https://www.climatecentral.org/news/report-american-warming-us-heats-up-earth-day>
- Cordero EC, Centeno D & Todd AM (2020). The role of climate change education on individual lifetime carbon emissions. *PLoS ONE* 15(2): e0206266. <https://doi.org/10.1371/journal.pone.0206266>
- Conley, H., & Newlin, C. (2021). *Climate change will reshape Russia*. Center for Strategic and International Studies. Retrieved January 31, 2022, from <https://www.csis.org/analysis/climate-change-will-reshape-russia>
- Druzhinin P., Potasheva, O. (2020). Evaluation of the Impact of Climatic Changes on the Development of Agriculture of European North Russia. *IOP Conference Series. Earth*

and Environmental Science, 459(6), 62054–. <https://doi.org/10.1088/1755-1315/459/6/062054>

Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Seyboth, K., Kadner, S., Zwickel, T., Eickemeier, P., Hansen, G., Schlömer, S., & von Stechow, C. (2011). *Renewable Energy Sources and Climate Change Mitigation : Special Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.
<http://www.cambridge.org/9781107607101>

Encyclopædia Britannica, inc. (n.d.). *Smog*. Encyclopædia Britannica. Retrieved April 20, 2022, from <https://www.britannica.com/science/smog>

Environmental Protection Agency. (2021). *Inventory of US Greenhouse Gas Emissions and Sinks*. [https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks#:~:text=In%202020%2C%20U.S.%20greenhouse%20gas,sequestration%20from%20the%20land%20sector\).](https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks#:~:text=In%202020%2C%20U.S.%20greenhouse%20gas,sequestration%20from%20the%20land%20sector).)

Environmental Protection Agency. (2020). *Sources of Greenhouse Gas Emissions*. <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#:~:text=Human%20activities%20are%20responsible%20for,over%20the%201ast%20150%20years.&text=The%20largest%20source%20of%20greenhouse,electricity%2C%20heat%2C%20and%20transportation.>

Financial University. (2020). *Mission and Vision*. Retrieved February 9, 2022, from <https://en.fa.ru/>

- Fronzel, M., Simora, M., & Sommer, S. (2017). Risk perception of climate change: Empirical evidence for Germany. *Ecological Economics*, *137*, 173–183.
<https://doi.org/10.1016/j.ecolecon.2017.02.019>
- Hamari, J. (2019). Gamification. *Blackwell Pub*, In *The Blackwell Encyclopedia of Sociology*, Malden. Pp. 1-3, <https://doi.org/10.1002/9781405165518.wbeos1321>
- Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work? -- A literature review of empirical studies on Gamification. *2014 47th Hawaii International Conference on System Sciences*. <https://doi.org/10.1109/hicss.2014.377>
- Hemp. (2005). Climate change-driven forest fires marginalize the impact of ice cap wasting on Kilimanjaro. *Global Change Biology*, *11*(7), 1013–1023. <https://doi.org/10.1111/j.1365-2486.2005.00968.x>
- Huang, B. & Hew, K. (2015). Do points, badges and leaderboard increase learning and activity: A quasi-experiment on the effects of gamification. Pp. 275-280, from https://www.researchgate.net/publication/286001811_Do_points_badges_and_leaderboard_increase_learning_and_activity_A_quasi-experiment_on_the_effects_of_gamification
- Kamenetz, A. (2019, April 22). *Most teachers don't teach climate change; 4 in 5 parents wish they did*. NPR. Retrieved April 11, 2022, from <https://www.npr.org/2019/04/22/714262267/most-teachers-dont-teach-climate-change-4-in-5-parents-wish-they-did?t=1649667866048>

- Kasimov N. S., Malkhazova S. M. & Romanova E. P. (2005). Environmental Education for Sustainable Development in Russia, *Journal of Geography in Higher Education*, 29:1, 49-59, <https://doi.org/10.1080/03098260500030363>
- Kirabaev, N., Hugh-Jones, S., Calhoun, C., & Yakunin, V. I. (2011). Education for an Innovative Russia. In P. Dutkiewicz & D. Trenin (Eds.), *Russia: The Challenges of Transformation* (pp. 225–244). NYU Press. <http://www.jstor.org/stable/j.ctt9qfd2q.14>
- Kireeva, A., & Digges, C. (2021). *Permafrost melt caused by climate change could cost Russia billions, environmental minister says*. Bellona.org. Retrieved February 21, 2022, from <https://bellona.org/news/arctic/2021-06-permafrost-melt-caused-by-climate-change-could-cost-russia-billions-environmental-minister-says>
- Kochteeva. (2021). Foreign Policy, National Interests, and Environmental Positioning: Russia's Post Paris Climate Change Actions, Discourse, and Engagement. *Problems of Post-Communism*, 1–13. <https://doi.org/10.1080/10758216.2021.1968912>
- Kudryavtsev, A. (n.d.). *Russia*. Russia | Global Environmental Education Partnership (GEEP). Retrieved February 7, 2022, from <https://thegeep.org/learn/countries/russia>
- Kwauk, C., & Kane, J. (2022, March 9). *Empowering the US global change research program to further climate education and training*. Brookings. Retrieved March 28, 2022, from <https://www.brookings.edu/research/empowering-the-us-global-change-research-program-to-further-climate-education-and-training/>
- Kwauk, C., & Winthrop, R. (2021). *Unleashing the creativity of teachers and students to combat climate change: An opportunity for global leadership*. Brookings. Retrieved February 14,

2022, from <https://www.brookings.edu/research/unleashing-the-creativity-of-teachers-and-students-to-combat-climate-change-an-opportunity-for-global-leadership/>

Landers, R. N. (2019). Gamification Misunderstood: How Badly Executed and Rhetorical Gamification Obscures Its Transformative Potential. *Journal of Management Inquiry*, 28(2), 137–140. <https://doi.org/10.1177/1056492618790913>

Langille, A. (2017). *How gamification can boost student success*. The Conversation. Retrieved February 7, 2022, from <https://theconversation.com/how-gamification-can-boost-student-success-81666>

Lehr, U., Nitsch, J., Kratzat, M., Lutz, C., & Edler, D. (2008). Renewable energy and employment in Germany. *Energy Policy*, 36(1), 108–117. <https://doi.org/10.1016/j.enpol.2007.09.004>

May, R. (2008). *Climate Change*. (1st ed.). Encyclopedia Britannica, Incorporated.

Melnikov, V. P., Osipov, V. I., Brouchkov, A. V., Falaleeva, A. A., Badina, S. V., Zheleznyak, M. N., Sadurtdinov, M. R., Ostrakov, N. A., Drozdov, D. S., Osokin, A. B., Sergeev, D. O., Dubrovin, V. A., & Fedorov, R. Y. (2022). Climate warming and permafrost thaw in the Russian Arctic: Potential economic impacts on public infrastructure by 2050. *Natural Hazards*. <https://doi.org/10.1007/s11069-021-05179-6>

Moscow Institute of Physics and Technology. (2022). *Fees & Scholarships*. Fees & Scholarships - Moscow Institute of Physics and Technology. Retrieved February 21, 2022, from <https://mipt.ru/english/edu/finance.php>

- Nyumba, T., Wilson, K., Derrick, C. J., Mukherjee, N., & Geneletti, D. (2018). The use of focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and Evolution*, 9(1), 20–32. <https://doi.org/10.1111/2041-210X.12860>
- Ouariachi, T., Li, C.-Y., & Elving, W. J. L. (2020). Gamification Approaches for Education and Engagement on Pro-Environmental Behaviors: Searching for Best Practices. *Sustainability*, 12(11), 4565. <https://doi.org/10.3390/su12114565>
- Petrov, A. (2014). Using Minecraft in education: A qualitative study on benefits and challenges of game-based education. *University of Toronto*. <https://hdl.handle.net/1807/67048>
- Plutzer, E., McCaffrey, M., Hannah, A., Rosenau, J., Berbeco, M., & Reid, A. (2016). Climate confusion among U.S. teachers. *Science*. 351. 664-665. [10.1126/science.aab3907](https://doi.org/10.1126/science.aab3907).
- Russian Federal Service for Hydrometeorology and Environmental Monitoring. (2020). *A Report on Climate Features on the Territory of the Russian Federation in 2019*. <https://cc.voeikovmgo.ru/images/dokumenty/2020/o-klimat-rf-2019.pdf>
- Zandalinas, S. I., Fritschi, F. B. Mittler, R. (2021). Global Warming, Climate Change, and Environmental Pollution: Recipe for a Multifactorial Stress Combination Disaster, *Trends in Plant Science*, Volume 26, Issue 6, Pages 588-599. <https://doi.org/10.1016/j.tplants.2021.02.011>.

- Sinelschikova, Y. (2020). *Why is Siberia warming faster than anywhere else on the planet?* Russia Beyond. Retrieved February 28, 2022, from <https://www.rbth.com/science-and-tech/332456-siberia-warm-climate>
- Singer-Brodowski, M., Brock, A., Eitzkorn, N., & Otte, I. (2018). Monitoring of Education for sustainable development in Germany – insights from Early Childhood Education, school and Higher Education. *Environmental Education Research*, 25(4), 492–507. <https://doi.org/10.1080/13504622.2018.1440380>
- Smiderle, R., Rigo, S.J., Marques, L.B. *et al.* (2020) The impact of gamification on students' learning, engagement and behavior based on their personality traits. *Smart Learn. Environ.* 7 (3) . <https://doi.org/10.1186/s40561-019-0098-x>
- Strunz, S., Gawel, E., & Lehmann, P. (2016). The political economy of renewable energy policies in Germany and the EU. *Utilities Policy*, 42, 33–41. <https://doi.org/10.1016/j.jup.2016.04.005>
- The United States Government. (2021, April 22). *Fact sheet: President Biden sets 2030 greenhouse gas pollution reduction target aimed at creating good-paying union jobs and securing U.S. leadership on Clean Energy Technologies*. The White House. Retrieved April 9, 2022, from <https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/>

UNFCCC. (2015). *Russia Submits Its Climate Action Plan Ahead of 2015 Paris Agreement*.

UNFCCC. Accessed January 27, 2019. <https://unfccc.int/news/russiasubmits-its-climate-action-plan-ahead-of-2015-paris-agreement>.

Vick, J. (2021). *The education system in Russia*. Expatica. Retrieved February 14, 2022, from

[https://www.expatica.com/ru/education/children-education/the-education-system-in-russia-](https://www.expatica.com/ru/education/children-education/the-education-system-in-russia-104072/#:~:text=Primary%20education%20begins%20at%20the,training%20college%20for%20that%20period)

[104072/#:~:text=Primary%20education%20begins%20at%20the,training%20college%20for%20that%20period](https://www.expatica.com/ru/education/children-education/the-education-system-in-russia-104072/#:~:text=Primary%20education%20begins%20at%20the,training%20college%20for%20that%20period)

Vinichenko, M. V., K. Ridho, T., Karacsony, P., Li, N. P., S. Narrainen, G., & L. Chulanova, O.

(2019). The feasibility and expediency of Gamification Activities in higher education.

International Journal of Education and Practice, 7(4), 459–468.

<https://doi.org/10.18488/journal.61.2019.74.459.468>

Vinichenko, M. V., Melnichuk, A. V., Kirillov, A. V., Makushkin, S. A., & Melnichuk, Y. A.

(n.d.). Modern Views on the Gamification of Business. *The Journal of Internet Banking*

and Commerce. <https://www.icommercecentral.com/open-access/modern-views-on-the-gamification-of-business.php?aid=71902>

Why the building sector? Architecture 2030. (2018). Retrieved April 20, 2022, from

<https://architecture2030.org/why-the-building-sector/>

World Meteorological Organization. (2021). *2020 was one of three warmest years on record*.

<https://public.wmo.int/en/media/press-release/2020-was-one-of-three-warmest-years-record>

World Wildlife Fund. (2021). *Impact of sustainable agriculture and farming practices*. WWF.

Retrieved April 20, 2022, from <https://www.worldwildlife.org/industries/sustainable-agriculture>

Yi, E. (2018). *Themes don't just emerge - coding the qualitative data*. Medium. Retrieved April 20, 2022, from

<https://medium.com/@projectux/themes-dont-just-emerge-coding-the-qualitative-data-95aff874fdce>

Appendices

A. Consent Scripts:

a. Interview Script

Hello, we are a group of undergraduate students from Worcester Polytechnic Institute in Massachusetts, working in collaboration with the Financial University under the Government of the Russian Federation to create an educational board game aimed at high school and university students interested in finance and business. This board game will introduce and increase these students' knowledge of the current climate crisis and in the long term, promote sustainability and environmental welfare in future business leaders. We are interested in hearing about your experience as part of the Financial University and your thoughts on the climate curriculum within the university. Your participation in this interview is voluntary and you may withdraw at any time. If you do wish to proceed, may we record this interview to help with our research and analysis? Additionally, please let us know if you would like to remain anonymous or if we are allowed to quote you. We will provide you with the opportunity and option to review our results before publication.

b. Focus Group Script

Hello, we are a group of undergraduate students from Worcester Polytechnic Institute in Massachusetts, working in collaboration with the Financial University under the Government of the Russian Federation to create an educational board game aimed at high school and university students interested in finance and business. This board game will introduce and increase these students' knowledge of the current climate crisis and in the

long term, promote sustainability and environmental welfare in future business leaders. We are interested in your participation in a focus where you will play a previous version of a “climate risk card game” developed by the Climate Disclosure Standard Board and Radley Yeldar. After you have finished playing the game we will ask you to fill out a survey and participate in a group discussion led by us. The discussion will be recorded with both audio and video purely for analytical purposes. Your participation in this focus group is voluntary and you may withdraw at any time. Additionally, please let us know if you would like to remain anonymous or if we are allowed to quote you in our final report. We will provide you with the opportunity and option to review our results before publication.

B. Sample Interview Questions

- a. Objective 2: Evaluate the level of Russian climate education and areas for development
 - i. What do you know about climate change?

Justification: We want to see what knowledge the subject has on climate change, if any.

- ii. How much information/knowledge have you learned about climate change in your education thus far?

Justification: We want to see if climate change has been stressed in any of the classes the subjects’ have taken thus far.

- iii. What environmental classes, or specifically climate change classes, are offered at your school, if any?

Justification: We want to see if climate change has been implemented into the subjects' curriculum.

- iv. How important is the topic of climate change to you?

Justification: We want to understand if climate change is important to the subjects and if it is, to evaluate how important it is to them.

- v. If your university offered any environmental elective courses, would you take any?

Justification: This question will reveal if the subject has any interest in the environment, especially since this topic might be outside of the subjects' majors.

- vi. Do you think your university stresses the importances of climate change and its impacts on the country?

Justification: We want to see the subject's thoughts on how important climate change is to the Financial University.

C. Questions and Discussions for Focus Groups

- a. On a scale from 1 to 10 (with one being no fun and ten being the most fun you have ever had) how enjoyable was this game?

Justification: This question will give us a baseline on how enjoyable people find the game and can be used as a way to quantitatively compare this game to the game we will eventually create once people have tested and rated our game.

b. What parts of this game were fun and enjoyable?

Justification: We want to be able to figure out what structural aspects of this game are enjoyable so we can emulate them in our own game.

c. What parts of this game were boring and uninteresting?

Justification: We want to determine structural aspects of this game that people did not like so we can avoid them.

d. What parts of the game were confusing?

Justification: A confusing game will only detract from its educational value so we want to eliminate structural aspects that are hard to follow.

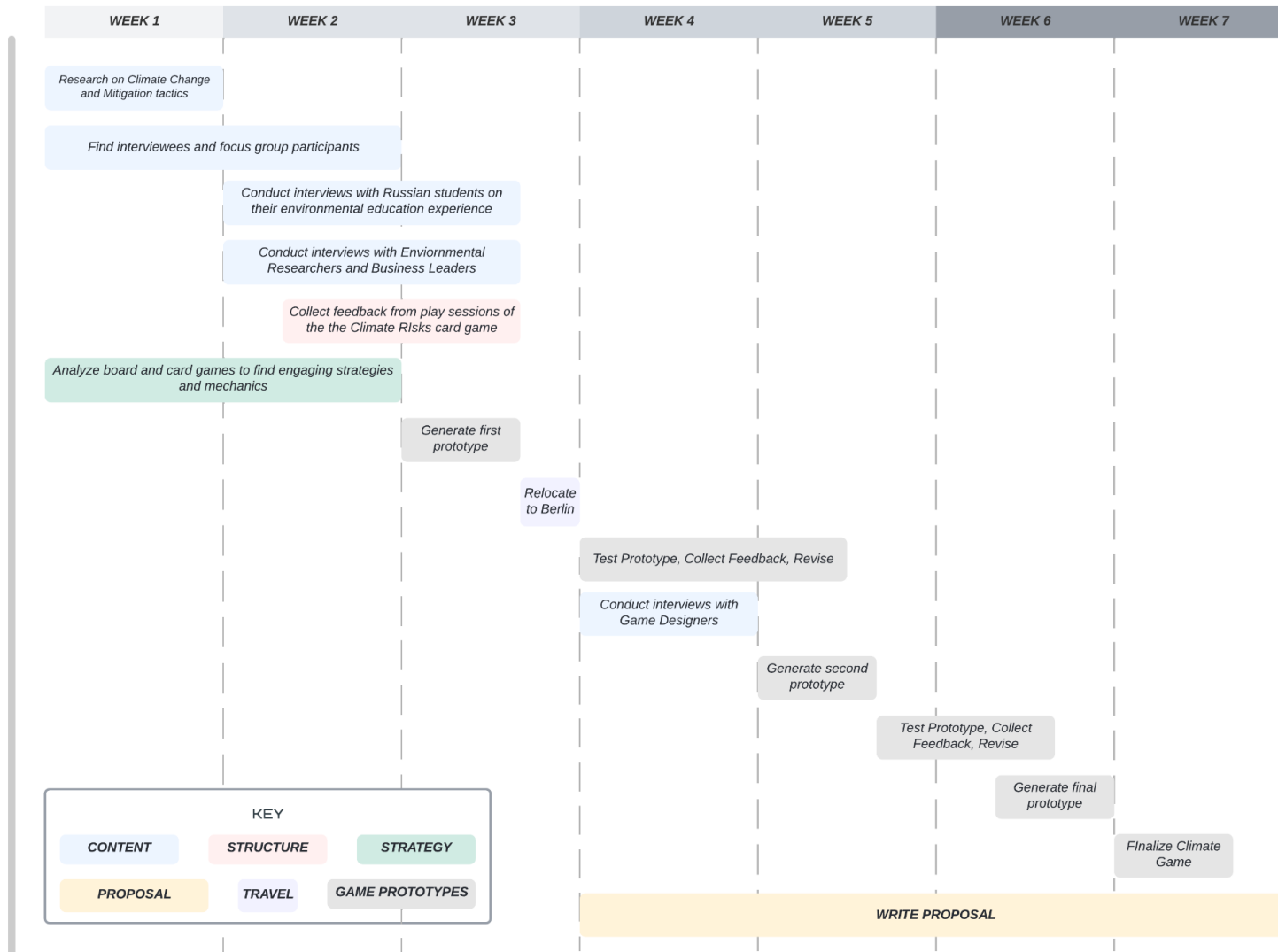
e. What suggestions do you have to improve the structure of this game while keeping the content the same?

Justification: This question is good because we will still be in the brainstorming phase of our own game at this stage so any and all suggestions will be welcomed.

f. What are some enjoyable Russian board games that you might model a new climate game off of?

Justification: The game we are designing is for Russian students so it might be more engaging for them if it emulates games that they played while they were growing up.

D. Schedule for D Term



E. Thematic Analysis of Original Climate Game Focus Group

Theme	Comments
Competitiveness	<p>“It would be better if we competed against another team”</p> <p>Identified “getting points” as fun and enjoyable</p>
Risk cards	<p>“Choosing risk cards was hard to follow and had to be clarified a few times”</p> <p>Identified “prioritizing risks” as confusing</p> <p>Identified “not knowing which risks to prioritize” as boring and uninteresting</p> <p>“Maybe add natural disaster component”</p> <p>“Clearing up the risk choosing section in the directions would be helpful”</p>
Mitigation cards	<p>Identified “trying to match up the actions” as fun and enjoyable</p> <p>“Have more action cards and have a wildcard slot to add another action card which covers multiple risks”</p> <p>Identified “determining how to mitigate those risks” as fun and enjoyable</p> <p>Identified “choosing how to mitigate risks” as confusing</p> <p>“because we weren’t familiar with the subject or company to an extent”</p> <p>Identified “matching up the cards to try to have some semblance of risk management” as fun and enjoyable</p>
Companies	<p>“Company profile was a bit bland”</p> <p>“Weren’t familiar with the subject or the company to an extent”</p> <p>“More in-depth company backgrounds maybe”</p> <p>“Company profile was essentially irrelevant after risks were</p>

	chosen”
Game aesthetics	“Too much text, more pictures and less description would make it less boring” Recommended “making descriptions more concise and adding images”
Scoring	“Scoring was a bit confusing” “Largely based on chance”

F. Temperature Rising Game Instructions

The Objective of the Game:

The player's goal is to have their company fully upgraded without increasing the global temperature 5C. If the temperature rises 5C the player with the highest climate score wins. The player must try to mitigate risk cards and limit their emissions.

Game Pieces:

1 Gameboard
6 Company Profile boards
54 Mitigation Cards
70 Risk Cards
54 Infrastructures
10 Temperature Indicators
35 Emission Tokens
Money

Order of Play:

The youngest person in the group goes first, and then turn order goes in a clockwise rotation.

Set up:

Shuffle the mitigation cards and risk cards and place the two decks on the board. Hand each player their starting budget, \$1,000,000. Each player will choose their company for the game and take the respective company board and pieces. Each player should also draw FIVE mitigation cards into their hand.

Turn Overview:

On each player's turn, player's can do the following in the order listed:

1. Draw Emissions Tokens

- a. Draw Risk Card if necessary
- 2. Draw Income
- 3. Choose ONE of the following actions
 - a. Build infrastructure
 - b. Equip a mitigation card
 - c. Exchange with the mitigation card deck
 - d. Invest in Green Technology
- 4. Discard down to FIVE mitigation cards, or Draw UP to FIVE
- 5. Adjust Climate Score (+1 for neutral, -5 if pulled Risk Card)

Turns in Detail

1. Emissions:

To start each player's turn, the player will tally up their emissions. Each infrastructure generates a specified amount of emissions per turn, and green technology (if upgraded) counteracts a portion of them. A player should draw the total amount of emissions from the supply. Emissions are generated per infrastructure as follows:

Infrastructure Level	Level 1	Level 2	Level 3
Emissions Generated	+1E	+2E	+3E

*See Green Technology Investments for Counteracts

If a player has at least five emissions: they must pull a risk card. Their emissions get set back -5, and they read the risk card. The company places a temperature tracking piece on the thermometer, increasing the temperature by 0.5 degrees. The specified companies may mitigate the risk, or they may be unable to. If the player is unable to mitigate the risk card **they cannot take an action this turn.** They receive income unless otherwise specified and subtract five from their climate score. Then the turn is over.

1.1. Risk Cards

When a player reaches at least five emissions, they will draw the top card from the risk card deck. Most risk cards can be mitigated with specific mitigation cards, as written on the risk card. A mitigation card must be **already equipped in order to mitigate a risk card**. If a mitigation card is in the player's hand, it has no effect on the risk card.

Risk cards can vary from universal effects (affecting every player), to multiple effects (affecting two players), or even individual effects (affecting one company). If a risk card has a universal or multiple effect, the affected players each must mitigate the risk card on their own.

Risk cards effects are immediate. After dealing with the effects, the player who drew the card should also decrease their climate score by -5 and increase the global temperature by 0.5 degrees.

If the player who flipped the risk card cannot mitigate it, they lose their action for the turn. The player still collects income, and then their turn ends. If a player mitigates the risk, they proceed with their turn as normal.

1.1.1. Company Advantages

Each company has an advantage described on their company board. They are each immune to a certain type of risk card, meaning if a risk card is flipped and the company is targeted by it, they don't need the mitigation card for it to not affect them.

Electrical is not fully immune to any risk card, but takes half of the effect of both transportation and political risk cards.

2. Income:

After a player has taken their emissions and dealt with any risk cards, they draw their income from the supply. Each infrastructure generates a specific amount of income per turn **on top of the \$100,000 passive income**. Income is generated per infrastructure as follows:

Infrastructure Level	Level 1	Level 2	Level 3
Income Generated	\$100,000	\$200,000	\$300,000

3. Take an Action

3.1. Building Infrastructure

A player can choose to build infrastructure during their turn. Infrastructure generates income as well as emissions in a company's turn. There are three levels of infrastructure. A player can build as much infrastructure as they choose in a given turn, and are only limited by the amount of money they have and the current level they are on. A player must build all three infrastructures in a level in order to upgrade to the next level of infrastructure. A player cannot build infrastructures of different levels in the same turn. A company cannot go below zero in its income, and therefore players may need to sell their infrastructure to get back to a positive cash amount. The table represents each infrastructure and its cost to build as well as its price to sell.

Cost	Level 1	Level 2	Level 3
Build Infrastructure	\$200,000	\$500,000	\$1,000,000
Sell Infrastructure	\$100,000	\$250,000	\$500,000

The amount of income and emissions generated by each infrastructure is as follows:

Per infrastructure	Level 1	Level 2	Level 3
Income	\$100,000	\$200,000	\$300,000
Emissions	1	2	3

3.2. Equipping a Mitigation Card:

A player can choose to pay to equip a mitigation card by paying the cost listed on the card. Mitigation cards are strategies that are able to *mitigate* risk cards so they do not have an impact on your company. A player may only equip one mitigation card a turn, only on their turn. A player can only have a specific amount of mitigation cards per level, but should always have 5 in their hand unequipped.

Player Level	Level 1	Level 2	Level 3
# of Equipped Mitigation Cards	3	4	5

A mitigation card may also have a ‘passive effect’ written on it. As soon as the mitigation card is equipped the passive effect takes place.

For example, if a mitigation card reads ‘half emissions next turn’, when tallying up emissions on your next turn, you should reduce them by half of what they are. If a mitigation reads ‘get out of risk card free’, even if the risk card doesn’t affect you the passive effect is used and goes away.

Mitigation cards stay equipped for the entire game, **even when they mitigate a risk card**. Because a company is limited to a certain number of mitigation cards per level, if you move to equip more than the amount allowed, a company will need to swap the newly equipped card with another already equipped. When this occurs, the card being replaced is put at the bottom of the deck.

Trading of mitigation cards is allowed, but it can only occur on a company's turn, after they have taken income.

3.3. Exchanging with the Mitigation Card Deck:

When exchanging mitigation cards with the deck, a player takes the top three cards from the mitigation card deck and looks at them. They may take only one mitigation card to exchange with a mitigation card in their hand. The two remaining cards are put at the bottom of the deck.

3.4. Investing in Green Technology:

A player can invest in green technology to lower their emissions every turn. Below is a table to show the costs and advantages of investing in green technology:

Green Technology	Level 1	Level 2	Level 3	Level 4
Cost	\$250,000	\$500,000	\$1,000,000	\$1,500,000
Emissions	-1	-3	-5	-7

Certain mitigation cards have a passive effect that forces another company to upgrade green technology. The company selected must upgrade their green technology immediately and pay double the specified price. They purchase it as soon as the mitigation card is equipped, no matter the turn. This may cause a company to reach negative money, forcing them to sell off infrastructure on their next turn.

4. Climate Score

The climate score for each company represents how well a company reduces its emissions. To start the game each company's climate score is zero, and each turn a company does not flip a risk card, their climate score goes up by one. If a company flips a risk card, their climate score decreases by -5. If the thermometer fills up before a player can upgrade their company fully, the company with the highest climate score wins.

End Game and Winning

The end of the game can be triggered by two events.

1. Temperature Reaches 5C
 - a. If the global temperature reaches 5C, the game ends. The winner is the person with the highest climate score.
2. Company Reaches Full Upgrades
 - a. If a player upgrades all three of their infrastructures to level three, they have played their last turn and every other player gets one more turn. The winner is the company that has reached maximum upgrades. In the result of a tie (two or more companies have maximum upgrades), the climate score decides the winner. If there is still a tie, the winner is decided by which of those companies has the most income.

G. Risk Cards

PR RISK	PR RISK	PR RISK	PR RISK
Building your company infrastructure leads to the destruction of a local ecosystem. Public outrage ensues. Pay \$100,000.	Building your company infrastructure leads to the destruction of a local ecosystem. Public outrage ensues. Pay \$100,000.	Building your company infrastructure leads to the destruction of a local ecosystem. Public outrage ensues. Pay \$1,000,000.	The construction site for your new infrastructure causes the destruction of a local ecosystem. Public outrage ensues. Both you and the construction company must pay \$400,000.
Mitigated by: 6	Mitigated by: 6	Mitigated by: 6	Mitigated by: 6
PR RISK	PR RISK	PR RISK	PR RISK
A popular newsletter is published explaining how fossil fuels are the number one cause of global warming. Public outrage ensues. Both you and the petroleum company must pay \$400,000.	A small local newspaper publishes a story about how your company is contributing to the climate change epidemic. Public outrage ensues. Pay \$100,000.	An online blogger determined to stop climate change gains a following and convinces people that large companies that use fossil fuels are harming the world. Public outrage ensues. Both you and the petroleum company must pay \$400,000.	TikTok star Charlie D'Amelio posts a dance video calling your company out for high emissions. Public outrage ensues. Pay \$100,000.

PR RISK	PR RISK	PR RISK	PR RISK
Mitigated by: 1, 6	Mitigated by: 1, 6	Mitigated by: 1, 6	Mitigated by: 1, 6

WF RISK	WF RISK	WF RISK	WF RISK
Due to temperature rise workers experience heat exhaustion at work. Some of them decide to go on strike. Pay \$100,000.	Due to temperature rise workers experience heat exhaustion at work. Many of them decide to go on strike. Pay \$400,000.	Due to temperature rise workers experience heat exhaustion at work. All of them decide to go on strike. Pay \$1,000,000.	The heavy machinery in your factories combined with the temperature rise have led to unhealthy factory conditions. Many workers decide to go on strike. Both you and the automotive company must pay \$400,000.
Mitigated by: 15,16	Mitigated by: 15,16	Mitigated by: 15,16	Mitigated by: 12, 15,16
WF RISK	WF RISK	WF RISK	WF RISK
The universal outcry for more climate change regulations has not been answered. Many workers decide to go on strike to protest. Everyone must pay \$400,000.	Increased rain leads to pesticide runoff on farms causing a food shortage. Workers get hungry on the job and lose productivity. Both you and the agriculture company must pay \$400,000.	Increased rain leads to pesticide runoff on farms causing a food shortage. Workers get hungry on the job and lose productivity. Pay \$400,000.	Increased emissions have generated some smog in the surrounding area. Workers begin to develop respiratory diseases decreasing productivity. Pay \$100,000.

Mitigated by: 1, 5, 6, 16	Mitigated by: 12,16	Mitigated by: 12,16	Mitigated by: 4, 5, 6, 8
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PR RISK	PR RISK	PR RISK	WF RISK
A large study is published about how large companies that produce high amounts of emissions are the driving factor behind the increasing global temperature. Public outrage ensues. Everyone must pay \$400,000.	In response to the impacts felt by climate change consumers start to seek out products made by sustainable companies. Pay \$400,000.	In response to the global impacts felt by climate change consumers start to seek out products made by sustainable companies. Everyone must pay \$1,000,000.	Increased emissions have generated lots of smog in the surrounding area. Workers begin to develop respiratory diseases decreasing productivity. Pay \$400,000.
Mitigated by: 1, 6	Mitigated by: 4, 5	Mitigated by: 4, 5	Mitigated by: 4, 5, 6, 8
WF RISK	WF RISK	PO RISK	PO RISK

<p>Increased emissions, especially from electricity generation, have generated lots of smog in the surrounding area. Workers begin to develop respiratory diseases decreasing productivity. Both you and the electrical company must pay \$400,000.</p>	<p>Increased emissions have generated lots of smog across the world. Workers begin to develop respiratory diseases decreasing productivity. Everyone must pay \$400,000.</p>	<p>Pollution from your company leads to an increase in cancer and heart disease in nearby neighborhoods. Lawsuit ensues. Pay \$100,000.</p>	<p>The EPA finds your company to be in violation of the Clean Air act. Lawsuit ensues. Pay \$1,000,000.</p>
<p>Mitigated by: 4, 5, 6, 8</p>	<p>Mitigated by: 4, 5, 6, 8</p>	<p>Mitigated by: 1, 12</p>	<p>Mitigated by: 1, 11</p>

PO RISK	PO RISK	PO RISK	PO RISK
<p>You pursue litigation against a rival company due to the fact that they are producing more emissions into the air than they are allowed to. Choose a company and they pay \$100,000.</p>	<p>You pursue litigation against a rival company due to the fact that they are producing more emissions into the air than they are allowed to. Choose a company and they pay \$100,000.</p>	<p>As a result of the Paris Accords your country has decided to reduce country wide emissions. However, since a reduction has not taken place the government decides to sue all the companies still in violation. Everyone pays \$400,000.</p>	<p>The government begins spreading awareness about bad practices common in companies. Pay \$100,000.</p>

Mitigated by: 1, 11	Mitigated by: 1, 11	Mitigated by: 1, 11	Mitigated by: 11
PO RISK	PO RISK	PO RISK	PO RISK
The government begins spreading awareness about bad practices common in companies. Pay \$400,000.	The government begins spreading awareness about bad practices common in companies. Everyone must pay \$100,000.	A young politician takes issue with your company and pressures you to pursue climate action more aggressively. Pay \$400,000.	Bad public reputation has caused additional emission regulations to be placed on your company. Pay \$400,000.
Mitigated by: 11	Mitigated by: 11	Mitigated by: 1	Mitigated by: 1,11
PO RISK	PO RISK	PO RISK	PO RISK

<p>The government needs to reach its goals for decreased emissions. They identify your company as an issue and impose small emission regulations. Pay \$100,000.</p>	<p>The government needs to reach its goals for decreased emissions. They identify your company as an issue and impose large emission regulations. Pay \$1,000,000.</p>	<p>The government needs to reach its goals for decreased emissions. They impose new emission regulations for the country. Everyone must pay \$400,000.</p>	<p>As part of a new countrywide policy every company must provide updated and accurate emissions data to the government. Failure to do so results in a fine. Everyone must pay \$400,000.</p>
<p>Mitigated by: 2,4,5</p>	<p>Mitigated by: 2,4,5</p>	<p>Mitigated by: 2,4,5</p>	<p>Mitigated by: 2,4,5</p>
<p>PO RISK</p>	<p>PO RISK</p>	<p>TR RISK</p>	<p>TR RISK</p>
<p>The government demands your company present its most recent emission data or incur a fine. Pay \$400,000.</p>	<p>The government demands your company present its most recent emission data or incur a hefty fine. Pay \$1,000,000.</p>	<p>Due to increased rain the water level in transport canals is too high to travel in. Pay \$400,000.</p>	<p>Due to increased dryness the water level in canals is too low to transport in. This affects mining especially. Both you and the mining company must pay \$400,000.</p>
<p>Mitigated by: 2,4,5</p>	<p>Mitigated by: 2,4,5</p>	<p>Mitigated by: 3,9,10</p>	<p>Mitigated by: 3,9,10</p>

TR RISK	TR RISK	TR RISK	TR RISK
Due to flooding of streets trucks are unable to get gas. Pay \$100,000.	Due to flooding of streets trucks are unable to get gas. Pay \$400,000.	Due to flooding of streets trucks are unable to get gas. This is especially detrimental to the automobile company. Both you and the agriculture industry must pay \$400,000	Due to flooding materials are unable to transport through certain regions. Pay \$400,000.
Mitigated by: 3,9,10	Mitigated by: 3,9,10	Mitigated by: 3,9,10	Mitigated by: 3,9,10
TR RISK	TR RISK	TR RISK	TR RISK
Due to flooding materials are unable to transport through certain regions. Pay \$1,000,000.	Due to massive floods materials are unable to make it through transport paths. Everyone must pay \$400,000.	Increasing temperature leads to more frequent hurricanes. Seaports are destroyed. Everyone must pay \$1,000,000.	Due to smog in your area, transportation vehicles are unable to travel. Pay \$100,000.

Mitigated by: 3,9,10	Mitigated by: 3,9,10	Mitigated by: 3,12	Mitigated by: 4,6,8
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TR RISK	IF RISK	IF RISK	IF RISK
Due to heavy smog, transportation vehicles are unable to travel. Everyone must pay \$400,000.	Increased global temperature has caused heavy rainfall in certain areas. As a result your company infrastructure floods. Reduce the level of one of your infrastructures.	Increased global temperature has caused heavy rainfall in certain areas. As a result your company infrastructure floods. Reduce the level of one of your infrastructures.	Increased global temperature has caused heavy rainfall in certain areas. As a result your company infrastructure floods, underground mines are particularly susceptible. Both you and the mining company must reduce the level of one of your infrastructures.
Mitigated by: 4,6,8	Mitigated by: 9,14,12	Mitigated by: 9,14,12	Mitigated by: 9,14,12
IF RISK	IF RISK	IF RISK	IF RISK

<p>Increased global temperature has caused heavy rainfall in certain areas. As a result your company infrastructure floods, crop fields are particularly susceptible. Reduce the level of one of your infrastructures.</p>	<p>Temperature rise has caused the melting of glaciers and polar ice caps leading to lots of floods that damage infrastructure. Everyone must reduce the level of one of their infrastructures.</p>	<p>Due to temperature rise land that used to be permanently frozen has begun to thaw and refreeze causing erosion of infrastructure. Reduce the level of one of your infrastructures.</p>	<p>Due to temperature rise land that used to be permanently frozen has begun to thaw and refreeze causing erosion of infrastructure. Reduce the level of one of your infrastructures.</p>
<p>Mitigated by: 9,14,12</p>	<p>Mitigated by: 9,14,12</p>	<p>Mitigated by: 7,13,12</p>	<p>Mitigated by: 7,13,12</p>

IF RISK	IF RISK	IF RISK	IF RISK
<p>Due to temperature rise land that used to be permanently frozen has completely thawed out causing the collapse of infrastructure. Reduce the level of two of your infrastructures.</p>	<p>Due to temperature rise land that used to be permanently frozen has begun to thaw and refreeze causing erosion of infrastructure. Everyone must reduce the level of one of their infrastructures.</p>	<p>A large storm caused by the rising temperature damages your infrastructure. Reduce the level of one of your infrastructures.</p>	<p>A large hurricane caused by the rising temperature completely destroys your infrastructure. Reduce the level of two of your infrastructures.</p>
<p>Mitigated by: 7,13,12</p>	<p>Mitigated by: 7,13,12</p>	<p>Mitigated by: 12,14</p>	<p>Mitigated by: 12,14</p>

EC RISK	EC RISK	EC RISK	EC RISK
The increased temperature has caused a drought. Crop yield falls heavily. The agricultural industry can not collect income on their next turn.	A heat wave causes manufacturing equipment to overheat. The automobile company can not collect income next turn.	The rising sea level causes flooding of mines. The mining company can not collect income next turn.	A construction project gets delayed due to heavy storms. The construction company can not collect income next turn.
Unmitigatable	Unmitigatable	Unmitigatable	Unmitigatable

EC RISK	EC RISK	TEMP RISES	TEMP RISES
Large hurricane causes power outages across a large area. Electrical company can not collect income next turn.	Storm at sea causes a large oil spill. Petroleum company can not collect income next turn.	Increased dryness in wooded areas causes a forest fire. The temperature immediately gets raised again and you lose your turn.	Increased dryness in wooded areas causes a forest fire. The temperature immediately gets raised again and you lose your turn.

Unmitigatable	Unmitigatable	Unmitigatable	Unmitigatable
TEMP RISES	TEMP RISES		
Increased dryness in wooded areas causes a forest fire. The temperature immediately gets raised again and you lose your turn.	Increased dryness in wooded areas causes a forest fire. The temperature immediately gets raised again and you lose your turn.		
Unmitigatable	Unmitigatable		

H. Mitigation Cards

1	2	3	4
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<p>Hire a public relations specialist to help manage reputation. Costs \$600,000</p> <p>PR: 5/11 PO: 7/16</p>	<p>Hire an analyst to track greenhouse gas emissions. Costs \$300,000</p> <p>PO: 6/16</p>	<p>Invest in different means of material transportation within your company i.e. trucks, freight trains, planes, ships etc. Costs \$450,000</p> <p>TR: 9/11</p>	<p>Reduce transportation needs in your company to limit vehicular emissions within your company. Costs \$600,000</p> <p>PR: 2/11 WF: 4/11 PO: 6/16</p>
	<p>Next turn, reduce emissions by half.</p>		
<p>5</p>	<p>6</p>	<p>7</p>	<p>8</p>
<p>Limit use of fuel and electricity by reducing power use in your company. Costs \$650,000</p> <p>PR: 2/11 WF: 4/11 PO: 6/16</p>	<p>Plant a field of trees in order to offset emissions. Costs \$650,000</p> <p>PR:9/11 WF:4/11 TR:2/11</p>	<p>Utilize a national permafrost monitoring network to avoid building infrastructure on areas susceptible to permafrost melt. Costs \$200,000</p> <p>IF: 4/11</p>	<p>Limit the use of coal as fuel. Costs \$300,000</p> <p>WF: 4/11 TR: 2/11</p>
		<p>Immediately improve your climate score by two points after equipping.</p>	<p>Next turn, reduce emissions by half.</p>

9	10	11	12
<p>Build flood barriers in your infrastructure to limit the effects of flooding. Costs \$650,000 TR: 8/11 IF: 5/11</p>	<p>Have alternative suppliers for materials in case they are unable to make deliveries. Costs \$400,000 TR: 8/11</p>	<p>Hire a climate specialist lawyer on retainer. Costs \$450,000 PO: 8/16</p>	<p>Improve infrastructure to make it safer and more resilient to wear and tear. Costs \$750,000 WF: 3/11 PO: 1/16 IF: 11/11</p>
		<p>Immediately improve climate score by one point after equipping.</p>	
13	14	15	16
<p>Invest in better insurance on infrastructure in areas liable to permafrost melt. Costs \$200,000 IF:4/11</p>	<p>Invest in better insurance on infrastructure in areas liable to storm and flooding. Costs \$350,000 IF:7/11</p>	<p>Provide free water and AC to workers to prevent heat exhaustion. Costs \$300,000 WF: 4/11</p>	<p>Invest in insurance to protect your production process i.e. strike insurance, crop insurance etc. Costs \$350,000 WF:7/11</p>

After equipping this, you are immune to the next risk card that affects you directly.	After equipping this, you are immune to the next risk card that affects you directly.	Increase in worker productivity improves passive income by \$50,000	After equipping this, you are immune to the next risk card that affects you directly.
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17	17	17
Force another company to make green investments at double the price. Can not be played against a company that has already invested in level two green technology.	Force another company to make green investments at double the price. Can not be played against a company that has already invested in level two green technology.	Force another company to make green investments at double the price. Can not be played against a company that has already invested in level two green technology.
17	17	17
Force another company to make green investments at double the price. Can not be played against a company that has already	Force another company to make green investments at double the price. Can not be played against a company that has already	Force another company to make green investments at double the price. Can not be played against a company that has already

invested in level two green technology.	invested in level two green technology.	invested in level two green technology.