Introducing "The Sustainable Port": a Serious Game to Study Decision-Making in Port-Related Environments

Gianluca Guglielmo
Department of Cognitive Science and Artificial Intelligence
Tilburg University
Netherlands
G.Guglielmo@tilburguniversity.edu

Michal Klincewicz
Department of Cognitive Science and Artificial Intelligence
Tilburg University
Netherlands
M.Klincewicz@tilburguniversity.edu

Elisabeth Huis in 't Veld
Department of Cognitive Science and Artificial Intelligence
Tilburg University
Netherlands
E.M.J.HuisintVeld@tilburguniversity.edu

Pieter Spronck
Department of Cognitive Science and Artificial Intelligence
Tilburg University
Netherlands
P.Spronck@tilburguniversity.edu

2024 IEEE Gaming, Entertainment, and Media Conference (GEM) | 979-8-3503-7453-7/24/$31.00 ©2024 IEEE | DOI: 10.1109/GEM61861.2024.10585733

***Abstract*— In this paper, we report on the development of The Sustainable Port video game, which aims to simulate the complex dynamics and decisions occurring in the present and future development of a port area considering environmental aspects (CO2 emissions) and profit. To evaluate if this game fulfills its purpose, we asked 75 students and 34 employees at the Port of Rotterdam (PoR) to play The Sustainable Port. Our results show that PoR employees score higher than students suggesting a transfer between real-life experience of being an employee in the port and performance in the game. Furthermore, port participants reported that The Sustainable Port can be successfully used to start discussions about the future of the Port of Rotterdam and to raise awareness about the complexity characterizing the decision-making processes occurring in a port environment. Our results, taken together, provide evidence of the effectiveness of The Sustainable Port in simulating dynamics occurring in port development and give us optimism about future applications.**

Keywords—Serious games, Decision-making, Maritime Port, Climate Change, Complexity

I. Introduction

Serious games are an interesting tool that offers the possibility to learn new skills and experience new situations while being in a safe environment with no, or little, real-life consequences. For this reason, it may not be surprising that Serious Games drew the attention of companies such as L'Oreal, IBM [1], or the Port of Rotterdam (PoR) [2]. Such games can be used for recruitment purposes but also to show new business concepts. This point is relevant when considering the environmental effect of big companies and how some of them are trying to reduce their emissions according to new policies such as the European Green Deal. In 2019, the European Commission launched The European Green Deal, a portfolio of policy documents for a range of interconnected industries (finance, transport, energy, agriculture, etc.), which have an impact on climate and are economically important. Its aim is to facilitate a change to climate neutrality for the European Union by 2050. Companies such as the Port of Rotterdam (PoR), which is one of the biggest maritime ports in the world as measured by container TEU (Twenty-foot Equivalent Unit), is a key player in that transition, given its strategic importance, carbon footprint, and connection to other important aspects of the European economy. The PoR plays a strategic public role in the European economy, and it is also a business, with shares owned by public parties.

Given this, the challenges faced by the PoR's decision-makers are multi-faceted, complex, and sometimes opaque to those without their specific decision-making competence. Maritime logistics, including port-side operations, are a truly global business, which affects and is affected by many aspects of the global economy. This makes strategic decisions in the PoR particularly complex. Direct decisional challenges are connected to the size and diversity of the workforce, the number of subsidiaries and facilities involved, and the volume of cargo throughput. These challenges are compounded by factors outside the decision-making process, such as fuel costs, weather conditions, availability of talent, and geopolitical events. These complexities are further complicated by legislative and policy directives at a local, national, and international level, such as The European Green Deal. Such complex aspects may simulated, to a limited extent, using a game.

A tabletop Sustainable Port game was developed by The Barn (https://www.thebarngames.com/) from Delft (Netherlands), in collaboration with a team from the University of Gent (Belgium) and North Sea Port. Such a game aims to reproduce some of the complexity of decision-making in a maritime port like the one mentioned in the previous paragraph. The complexity of the game also reflects some of the key aspects of the decision-making ecosystem of a port. The game design pays special attention to the introduction of new policies and technological advancements that affect that ecosystem. Specifically, it embodies the goals of The European Green Deal of minimizing carbon-dioxide emissions and technological advancements in hydrogen storage and processing for energy, while taking the added value for the business into account. The original tabletop version of the game is a tool that can be effectively used to start a discussion among employees, raising awareness about aspects of the decision-making of the port. The idea is that dialogue would improve the decision-making process, collaboration, and mutual understanding.

In this paper, we report on the status of the development of a digital version of The Sustainable Port, which facilitates behavioural experiments, data collection, analysis, and science-based understanding of the cognitive dimension of decision-making in the Port's decision-making ecosystem.

The game puts the player in charge of a Port making him experience the complexity of its related decisions and how these decisions may impact not only his revenues but also the emission emitted by the Port. Consequently, the player is asked to keep his port fully functioning and in business while reducing carbon-dioxide emissions, making the environmental aspect a salient feature of this game. For this reason, The Sustainable Port, the video game version introduced in this study, may be considered an example of an Ethically Notable Game [3, 4] in the sense that its design "facilitates ethically significant gameplay – defined here to mean in-game actions that provoke moral reflection" [5]. As a consequence, the Sustainable Port invites its players to think strategically and long-term considering the impact that their decisions have on the revenues of the port but also on the environment.

Given the characteristics of this game, the aim of this study is multifaceted. First of all, we want to evaluate if Sustainable Port can be successfully used to simulate mechanics occurring at the Port of Rotterdam. In order to achieve this goal, we asked employees recruited at the Port of Rotterdam and among the student population to play this game. More specifically we want to evaluate if PoR employees used the experience gained at the PoR to play this game, and if such a game can be used to simulate port dynamics and therefore raise awareness about the complexity of decision-making processes in port environments. Second, we want to evaluate if Sustainable Port can be used to start a discussion, among employees, about the future of the Port of Rotterdam. Third, we want to evaluate potential differences in performance obtained in the game by PoR employees and students that may suggest a transfer of knowledge between real-life experience and performance in the game. The results will shed light on the effectiveness of using this game as a tool to simulate the mechanics occurring at the Port of Rotterdam and its future applications.

II. Related Works

A. Ports and Serious Games

Several attempts have been made in the past to create serious games simulating dynamics occurring in port environments. Two notable examples of serious games simulating port environments are Port Constructor [6] and GreenPort Tech [7]. Port Constructor is a game developed in collaboration with the Port of Rotterdam that puts in charge the player as a port planner and port developer designing and experiencing different layouts for his port. Such a game was designed keeping into account the 3 pillars of sustainable development, people, planet, and profit where the development of new infrastructure should be beneficial on an economic, environmental, and human/safety level [6]. Port constructor proposes 2 scenarios based on real ports: the Bantum Port and the Port of Kuala Tanjung. For what concerns the unfolding of the game, the player is asked to define a strategy at the beginning of the game and run his port for 10 rounds [7].

This game was played by a sample of 20 people including both PoR employees and students who suggest that this game may be an effective learning tool to experience port development. However, as the authors of this paper pointed out, the high amount of money provided at the beginning of the game allows the players to build whatever they want, including unnecessary infrastructures, without considering how they spend their money which is a crucial aspect in real life. Furthermore, players seem to focus more on profit neglecting the effects that their port has on people and the planet [6].

Another example of a game recently developed to simulate port dynamics is GreenPort Tech, a 2D roleplay game [7]. Such a game was developed for students to educate them about climate change and develop ideas promoting future sustainability [7]. This game is made of 4 levels aiming to teach the player salient aspects of port environments such as which goods are dangerous and actions specific to coastal activity such as the slowing down of cargo ships [7]. The game asks the player his own name before starting and requires the use of 3 different characters, a pilot, a docker worker, and a custom officer. This game was tested on 35 students and obtained good scores on dimensions such as usability, learning performance, and sense of engagement. Unlike Port Construct, GreenPort Tech has its main goal in climate education targeting the student population. On the other hand, Port Constructor focuses on the different designs that a port may have implementing different strategies where players tend to perceive profit as the main goal [7].

III. Methods and Materials

A. The Sustainable Port Tabletop Game

The Sustainable Port is played with a deck of event cards, a deck of building cards, a board, and physical tokens (Figure 1). The game is played in 10 rounds in which players need to develop their port towards a certain CO2 target while maintaining a healthy economic added value. During each round the players make decisions of the following types: build a facility, upgrade a facility, close a facility, and demolish a facility. Depending on what they decide, different cards and tokens are added to or removed from the tabletop where the game is played, and the score is changed. Tokens are placed on cards and the board and moved around to indicate information such as: the amount of CO2 that all facilities are emitting, the number of rounds before a facility is built or demolished, the amount of revenue that facilities earn each round, etcetera. Other tokens inform about CO2 emissions and added value that a facility has or rounds left during its construction or demolition. All players make decisions at the same time and start new turns in unison. Importantly, each round begins with the drawing of an event card, which affects the state of the board either now or in future turns. For example, an event card might inform players that in five rounds CO2 emissions must be below a certain threshold, given a new policy, or that a new technology has become available, which means that a new type of facility can be built. Such aspects introduce uncertainty in the game since the players have to revisit their strategy due to new events introduced throughout the game. Four upgrades with limited availability are introduced during the game: process optimization, onsite renewable energy, CO2 capture and storage, and CO2 reuse. These can be used once per facility already built in the port; doing so increases added value or reduces CO2 emissions of that facility.

Fig. 1. Sustainable Port the Tabletop version

The total added value generated by the port determines the amount of money that the player gets at the beginning of a round (half of the added value plus five) which can be used to make decisions such as buying or destroying facilities. Players typically spend all the money they have each round since the remainder does not carry over to the next round. By the end of round 10, each player should reach a CO2 level less than or equal to 10 in order not to outright lose and their score is calculated as total added value minus total CO2 emissions. The player with the highest score wins.

All the participants start with 11 the same facilities in their ports out of 12 spaces available (see fig. 2). The game is designed to have 3 phases in both its board and digital version, an introductory phase, a central phase, and a final phase where the participants can finalize their port. The introductory phase is constituted by round 1 and round 2, during these rounds just one update is introduced, and no new facilities are made available. The central, and crucial, phase of the game, lasting between rounds 3 and 6, introduces 6 new buildings and 1 new update. Finally, the last part of the game (between round 7 and 10) does not introduce any new facility or update in the game.

B. The Sustainable Port Videogame

The digital version of the Sustainable Port was developed by a research team at Tilburg University (Netherlands) in collaboration with The Barn, and a team from the port of Rotterdam. Such a game is implemented in Unity Engine [7] and automatically saves in CSV files the moves performed by the players during the game and the state of the port at the end of each round. Players interact with the mechanics of the game by using a computer mouse to interact with digitally rendered objects on a virtual tabletop. The video game takes up the entire area of a computer monitor, and its playing area is divided into three sections, each with its own distinct in-game purpose, which is meant to represent an important element of the decision-making ecosystem of a port (Figure 2).

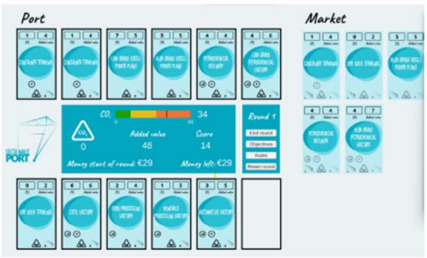

Fig. 2. Sustainable Port video game version

The first and largest area is the "Port." It consists of twelve rectangles, which may or may not be filled with cards that represent facilities, such as a container terminal or a petrochemical refinery. Each card contains information about the facility, such as its cost, the amount of CO2 that it emits, the amount of added value (revenue) that it generates, the number of turns it takes to demolish it, and whether it can be upgraded. During each turn, players can choose to upgrade, begin to demolish or build, close, or do nothing. The second section of the playing area is the "Market", which contains cards representing facilities that may be built in the twelve rectangle spaces of the "Port" area if they are empty. As the game progresses, new cards may be put into or taken away from the market as the result of game-related events or player actions. For example, if the player decides to build a dry bulk terminal, that card will be taken off the market. If an event of a technological breakthrough in biochemical production occurs in the game, an entirely novel facility type may be put into the "Market". However, unlike the board game, the upgrades are not in the "Market", but they are represented as icons on each facility card along with prerequisites for the upgrade. The third section of the playing area is the information hub in the middle. Here are represented the score; obtained by subtracting the CO2 generated by facilities each round from the added value; the amount of money available this round for game-related actions, such as building, upgrading, or destroying facilities; the amount of money that will be made available at the start of the next round; and the round number. This area also contains pushable buttons, which allow the player to end their round, reset the round (reverting the board to its state at the beginning of the current round thus reversing all decisions made so far), and be reminded of objectives and rules of the game with pop-up text. As in the table-top version, the game lasts 10 rounds. But the video game's design focuses on the transparency of game mechanics, since, unlike the tabletop version, it is single-player only. For example, events are not represented by a card-draw at the beginning of the round but appear as objectives each round in a text box. This and similar design choices facilitate data collection about gameplay and player behavior, but also have their downsides. A streamlined single-player video game eliminates discussion among players, perhaps making it more difficult for them to see important aspects of the complex decision-making that goes on in the port. That said, the video game retains key aspects of the decision-making process that the table-top game had. The most important of these is the interplay between added value and carbon emissions of the port. As in the table-top game, this interplay is a part of every in-game decision and constitutes the main measure of player performance.

C. Data collection

A total of 109 (Nmales = 50, Nfemales = 58, Nnd = 1; Mage = 27.27, SD = 11.20) participants were recruited to play the digital version of The Sustainable Port. 75 of them were students (Nmales = 27, Nfemales = 47, Nnd = 1; Mage = 21.2, SD = 3.40) recruited at the Tilburg University while the remaining 34 were employees working at the Port Authority of the PoR (Nmales = 23, Nfemales = 11, Nnd = 0; Mage = 40.67, SD = 10.82) 9 them were Junior employees while 24 of them were Senior employees and 1 was an intern; overall, they had a M = 8.21 (SD = 8.42) years of experience working at the PoR. The participants were recruited from the following departments: HRM department, Strategy department, Finance department, Environmental management, Port Development department, Commercial Department & Policy Department of the Port Harbour Master. Such departments were deemed to be relevant for our purposes since they are involved in strategic decisions concerning the future of the PoR. The

participants were recruited through an anonymous Excel file shared by the researchers' contacts working at the PoR. Given the small sample collected and the direct involvement of the PoR in the participants' recruitment, no specific information about the department the participants worked for was asked. This study was approved by the Ethical Committee of Tilburg University with the code REDC2021.35d. At the beginning of the experiment, participants were asked to read an informed consent form and sign it, if they still agreed to be participants. Before starting the game, participants were asked to provide some demographic information such as their biological sex, age, video games habits, and board games habits on a Likert scale between 1 and 5 (Never, several times a year, several times a month, several times a week, every day) [8]. Such information was later used to evaluate if board and video game habits are significantly associated with the performance obtained in the game. Then, participants were asked to read the instructions for the Sustainable Port video game displayed on a computer screen. Once they read them and communicated their understanding by pressing a virtual button ("start the game"), the Sustainable Port game at Round 1 appeared (Figure 2) on the screen, and game play started. Typically, the experiment lasted approximately 60 minutes. In the end, the participants were informed about their final score (added value minus CO2 emissions) and whether they reached the required CO2 emissions threshold. After having completed the game, both the students and the employees at the PoR were asked to fill in the System Usability Scale (SUS) questionnaire [9], as similarly done in other studies concerning the usability of serious games [10], and were also asked to answer to what degree they agree or disagree (7-point scale from "Strongly Disagree" to "Strongly Agree") with questions related to the experience they had while playing the game, similarly to what was done Port Constructor [6]. For example, they were asked whether they think the game raises awareness about the complexity characterizing a port environment (see question 2 in appendix A) and during which round they started to develop confidence about the game mechanics (in terms of where to click to perform which action; question 1 in Appendix A). The questions asked to all the players (both PoR employees and students) at the end of the game can be found in Appendix A. Additionally, the employees at the PoR were asked further questions about how they experienced the game and the potential use of the game to represent dynamics occurring at the PoR and an open-ended question about if and how this game can be used to start a discussion about the future development of the PoR (see Appendix B: Port dynamics, Port past experience, Discussion purpose). Missing data in the SUS (one single missing answer value in ten questions for one participant) were filled in using an iterative imputer in Python, a method that considers the value of other features to fill in the missing information [11]. For the subjective experience-related questions, only one participant did not fill in the port awareness-related question; such a participant was excluded when reporting the results of this specific question. Before running all the statistical analyses of this work, we controlled for the normal distribution of the residual against a normal distribution using the KS-test [12] and the homogeneity of variance using the Bartlett's test [13].

IV. Results

A. System Usability Scale

Overall, the game obtained a marginal usability score of M = 59.00 (SD = 19.39). Employees at the PoR (M = 67.87, SD = 13.90) gave higher scores to the game compared to students (M = 54.97, SD = 20.17). Such difference in score resulted to be statistically significant applying a Welch t-test, after having controlled for the normality of the residuals and the non-homogeneity of variance, $t(89.03) = 3.83$, $p < .001$.

B. Confidence in Rounds Mechanics

Overall, 13 participants did not develop confidence in the mechanics of the game (9 students and 4 PoR employees; see question 1 in Appendix A). The remaining players developed confidence in the game mechanics during the central phase of the game around round 4 (M = 4.07 SD = 1.86). PoR employees (M =3.63, SD = 1.98) seemed to develop confidence in the game mechanics earlier than students (M = 4.07, SD = 1.76). However, this result, applying an independent t-test (after having controlled for the normality of the residuals and the homogeneity of variance), was not statistically significant ($t(94) = -1.57$, $p = .12$).

C. CO2 Target and Raw Score

96 players reached the CO2 target needed not to lose the game while 6 students and 7 PoR employees did not reach the CO2 target required not to lose the game. Overall, considering the scores obtained without looking at the understanding of the game mechanics and the reaching of the CO2 requirements, the PoR employees obtained a mean score of 35.24 (SD = 12.95) while students obtained a mean score of 28.97 (SD = 17.05). 9 students and none of the PoR employees scored 0 on the game.

D. CO2 Target and Raw Score Distribution

After having illustrated the scores and their distributions for PoR employees and students, we used a multiple linear regression model to evaluate if the PoR employees performed better in the game than the students after having controlled for their Biological Sex, Age, Video games habits, and Board games habits. Such questions were asked before the players played the game and independently from the post-game SUS assessment. For this analysis, we kept into account only the players who reached the carbon dioxide target required by the game (CO2 <= 10) and understood the game mechanics. Finally, we excluded the participant who did not declare their sex obtaining a final sample of 86 participants, 61 students (Mean score = 30.82, SD = 16.37) and 25 PoR employees (Mean score = 37.56, SD = 13.03). Given the unknown nature of the interval of the Video games habits and the Board games habits (since they were defined with a 5- points Likert scale), before adding them to the multiple linear regression model, we evaluated if they could be treated as continuous variables by using the Likelihood-Ratio Test (LR-test) [14]. The LR-test confirmed the viability of using such variables as continuous in our model. All the variables included in the model had a variance inflation factor smaller than 5 [15] suggesting the lack of multicollinearity. Finally, the model implemented explained 24 % of the variance of the final score obtained by the players ($F(5,80) = 5.19$, $p < .001$). However, the results show that the only significant predictors were Video games habits and which group of participants the player belongs to (see Table 1).

TABLE I. THE RESULTS OF THE MULTIPLE LINEAR REGRESSION MODEL

	B	SD	U	L	t	p
Age	-0.30	0.23	0.16	-0.77	-1.29	.20
Biological sex (Ref. Male)	-6.90	3.52	0.10	-13.91	-1.96	.053
Digital Games Habits	4.14	1.50	7.12	1.17	2.77	.007
Board Games Habits	3.33	2.76	0.23	-2.15	1.21	.23
Participants (ref. students)	13.33	5.41	24.10	2.56	2.46	.016

To further investigate the relationship between the two significant predictors and the score obtained in the game, we plot the score obtained by the players in the 2 groups and their video games habits (see Figure 3).

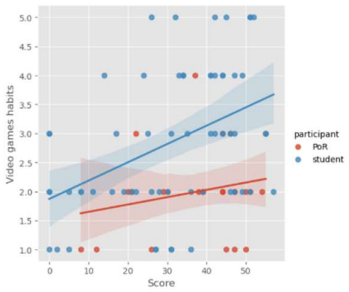

Fig. 3. A scatterplot, with the best fitting line, showing the relationship between video games habits and the scores obtained in the game for the 2 groups.

The plot suggests that PoR employees seem to score higher than students independently from their video game habits. This is further supported by a correlation analysis showing a significant Pearson's r coefficient ($r = 0.42$, $p < .001$) in the students' group between score and game play habit but not in the PoR participants ($r = 0.22$, $p = .30$).

E. Port Awareness

After having investigated the differences in scores in the two groups, we looked at the results of question 1 of Appendix A, about Port awareness. Most of the participants agree (80.73%, N= 88), to some extent (strongly agree, agree, somewhat agree) that the game increases awareness about the port-related decision-making processes. More specifically, 91.18% (N = 31) of the PoR employees and 76% (N = 57) of the students agreed with question 2 in Appendix A.

F. PoR Employees Specific Questions

Port Dynamics: To further evaluate if the game proposed in this study manages to capture some of the dynamics occurring in a port (port dynamics) we asked if PoR participants agree to question 1 in Appendix B. As a result, most of the PoR employees (88.23 %, N = 30) agree to a certain extend (strongly agree, agree, somewhat agree) with this specific question.

Port Past Experience: Given the aim of the game to model certain aspects occurring in real life, we asked PoR employees if they used the experience they gained working at the PoR to play the game (See question 2 Appendix B). 24 PoR employees (72.73%) agree to a certain extent (Strongly agree, agree, somewhat disagree) with the question related to the use of their past experience to play the game.

Discussion purpose: Overall, most of the players suggested that The Sustainable Port can be used to start a discussion about the future development of the Port of Rotterdam. For example, some of the PoR participants suggested that the game will help take sustainability more seriously whereas one participant suggested that this game "*might be mandatory for everyone to play at least once to understand the transition our Port is aiming for!*". Another participant suggested that this game can used to introduce stakeholders and new employees to the dynamics occurring at the Port of Rotterdam. A few examples of feedback given by the PoR employees can be found in question 3 of Appendix B

V. DISCUSSIONS

The results obtained in this study seem to suggest that The Sustainable Port fulfilled the aims proposed at the beginning of this study. First of all, our participants suggested that the game effectively simulates dynamics occurring in a port environment. Given this, it may not be surprising that our participants also suggested that this game may be used to raise awareness about the complex dynamics characterizing port environments. Second, the results obtained in the game by the PoR employees, and their affirming they used the experience they obtained in real life to play this game, seems to suggest that performance in The Sustainable Port may be influenced by skills learned in real-life. Last but not least, PoR employees suggested that this game can be used to start a discussion about the future of the Port of Rotterdam providing, for example, a tool conveying a big picture of the activities occurring in different departments. Altogether, these results suggest that Sustainable Port may be an effective tool to simulate situations occurring in a port environment and that this game, and its future versions, can be used for several purposes such as a recruitment tool [1] or to convey a new business concept [2].

Interestingly, considering the results of our multiple linear regression, video games habits seem to be a significant predictor of the score obtained in the game; however, given the results of our correlation analysis, this seems to be specifically true for the student group. Nevertheless, such results may provide the base to hypothesize that students and PoR employees adopt different strategies in this game and that such differences may also emerge when comparing proficient players in the student group with the PoR employees. Given the possibility of extracting the decisions performed in the game, future studies may focus on finding the decision-making profiles of students and PoR employees and evaluate how their potential differences. Another aspect that seems to differentiate PoR employees from students is their perceived usability of the game in terms of SUS. As we have seen, our game, in its current state, has an overall marginal usability where students scored the game lower than PoR employees. Even in this case, this score may be due to the effect of the previous experience that PoR employees obtained in real life possibly working at the Port of Rotterdam. Future studies may further investigate this aspect looking into other factors, such as age, influencing the score obtained in the SUS.

The game introduced in this work, similarly to what was done in previous studies [6] was tested on a heterogenous sample of students and employees working for a port authority. Our game presents some similarities but also differences with the previously mentioned games aiming to simulate port environments [6, 7]. For example, Port Constructor provides the players with a high amount of money in the beginning [6] making them able to build all the facilities they want. On the contrary, in The Sustainable Port, the player has always limited resources from the beginning of the game. Such an aspect forces the player to ponder each decision made in the game making it more similar to real life situations where resources are limited. Other differences can be found when comparing Sustainable Port to GreenPort Tech. Unlike GreenPort Tech, our game requires the player to keep the profit into account and not just the environmental aspects [7]. Furthermore, The Sustainable Port, unlike Port Constructor, forces the player to keep into account environmental aspects (CO2 emissions) from the beginning since this is a relevant feature to keep into account not to lose the game. Given this specific attention to environment-aware decision-making, The Sustainable Port may be considered an Ethically Notable Game and used to investigate ethical decision-making as well [3, 4]. To sum up, Sustainable Port combines crucial aspects of the Port Constructor and GreenPort Tech where the player has to keep into account both the profit (the added value) and the environment (the CO2 emissions) to win and perform well in the game. However, our game presents also limitations that do not affect the previously mentioned games. For example, GreenPort Tech presents personalization that may increase the engagement of the player [7]; while port Constructor allows the player to play the game multiple times to experience different port designs [6]. Up to date, our game lacks these two aspects that may enrich the game and its dynamics. Future versions of The Sustainable Port should include these aspects and evaluate if they enrich the gaming experience.

ACKNOWLEDGMENT

This research is founded by the MasterMinds project, part of the RegionDeal Mid- and West-Brabant, and it is co-founded by the Ministry of Economic Affairs and Municipality of Tilburg

REFERENCES

[1] O. Allal-Chérif and M. Bidan, “Collaborative open training with serious games: Relations, culture, knowledge, innovation, and desire,” Journal of Innovation & Knowledge, vol. 2, no. 1, pp. 31–38, Jan. 2017, doi: https://doi.org/10.1016/j.jik.2016.06.003.

[2] E. F. T. Buiel et al., “Synchro Mania - Design and evaluation of a serious game creating a mind shift in transport planning,” 46th International Simulation and Games Association Conference, ISAGA 2015, Kyoto, Japan (18-25 juli, 2015), p. 1, 2015, Accessed: Sep. 19, 2023. [Online]. Available: https://repository.tno.nl/islandora/object/uuid%3A3c49819d-839e-4786-97db-c1ca02f606f3

[3] M. Sicart, “Values between Systems: Designing Ethical Gameplay,” www.igi-global.com, 2010. https://www.igi-global.com/chapter/ethics-game-design/41308 (accessed Sep. 19, 2023).

[4] Z. J. P, “Ethically Notable Videogames: Moral Dilemmas and Gameplay,” 2009, Available: http://www.digra.org/digital-library/publications/ethically-notable-videogames-moral-dilemmas-and-gameplay/

[5] D. Staines, M. Consalvo, A. Stangeby, and S. Pedraça, “State of play: Video games and moral engagement,” Journal of Games & Virtual Worlds, vol. 11, no. 3, pp. 271–288, Oct. 2019, doi: https://doi.org/10.1386/jgvw.11.3.271_1.

[6] A. D. Ningrum and M. Van Schuylenburg, “Serious gaming for port development as a learning tool: a case study of port constructor,” *IOP Conference Series: Earth and Environmental Science*, vol. 530, no. 1, p. 012005, Jul. 2020, doi: https://doi.org/10.1088/1755-1315/530/1/012005.

[7] L.Ying-Ru, S. Chen, and W. Wang. "Gaming for Green Port Management as a Learning Tool: a Case Study of Green PorTech." *IFSPA 2022 IFSPA 2022* (2022): 237.

[8] N. Sevcenko, M. Ninaus, F. Wortha, K. Moeller, and P. Gerjets, “Measuring Cognitive Load Using In-Game Metrics of a Serious Simulation Game,” Frontiers in Psychology, vol. 12, Mar. 2021, doi: https://doi.org/10.3389/fpsyg.2021.572437.

[9] J. Brooke, “SUS -A quick and dirty usability scale,” 1986. Available: https://hell.meiert.org/core/pdf/sus.pdf

[10] G.P Tolentino, et al. "Usability of serious games for health." *2011 Third International Conference on Games and Virtual Worlds for Serious Applications*. IEEE, 2011.

[11] K. M. Fouad, M. M. Ismail, A. T. Azar, and M. M. Arafa, “Advanced methods for missing values imputation based on similarity learning,” PeerJ Computer Science, vol. 7, p. e619, Jul. 2021, doi: https://doi.org/10.7717/peerj-cs.619.

[12] A. Gupta, P. Mishra, C. Pandey, U. Singh, C. Sahu, and A. Keshri, “Descriptive Statistics and Normality Tests for Statistical Data,” Annals of Cardiac Anaesthesia, vol. 22, no. 1, pp. 67–72, 2019, doi: https://doi.org/10.4103%2Faca.ACA_157_18.

[13] C. Viwatwongkasem, T. Vorapongsathorn, and S. Taejaroenkul, “A comparison of type I error and power of Bartlett’s test, Levene’s test and Cochran’s test under violation of assumptions,” undefined, 2004, Available: https://www.semanticscholar.org/paper/A-comparison-of-type-I-error-and-power-of-test%2Cand-Viwatwongkasem-Vorapongsathorn/4f5e6fda40d12eb458ae11687dc4554ef765795c

[14] R. A. Williams, “Ordinal Independent Variables,” SAGE Research Methods Foundations, 2020, doi: https://doi.org/10.4135/9781526421036938055.

[15] M. O. Akinwande, H. G. Dikko, and A. Samson, “Variance Inflation Factor: As a Condition for the Inclusion of Suppressor Variable(s) in Regression Analysis,” Open Journal of Statistics, vol. 05, no. 07, pp. 754–767, 2015, doi: https://doi.org/10.4236/ojs.2015.57075

APPENDIX A

Question 1 - Round when confidence in the game mechanics: “During which round did you develop confidence in the game mechanics? (for example: which button or option is associated to specific actions)”

Question 2 - Port-related awareness: “The game raised awareness about the complex decisions characterizing a port's development.”

APPENDIX B

Question 1 – Port dynamics: “The game can be used to represent dynamics occurring during actual port-related decision-making processes.”

Question 2 – Port past experience: “I based my decisions on the experience gained working at the PoR

Question 3 – Discussion purposes: “Do you think this game may be an effective tool to start a discussion about future decisions concerning the Port of Rotterdam's development? In which way?”

Example of answers for question 3

Participant 1: Yes. I think the Port of Rotterdam needs to be taking sustainability more serious. even if that means less profit can be made. we need to take a statement in that so our reputation towards society improves.

Participant 2: Yes, making people more aware what options, trade-offs and challenges there are

Participant 3: Definetly, might be mandatory for everyone to play atleast once to understand the transition our Port is aiming for!

Participant 4: definitely interesting for the decisionmakers here at POR

Participant 5: Not in details but certainly on a conceptual level, or as to introduce new staff or stakeholders to the complex decision processes that PoR is in.