Serious gaming for port development as a learning tool: a case study of port constructor

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Abstract. Ports play an essential role in nation’s economic growth by fostering trade and development. Making a master plan for port development includes several actions that need to be taken before a final master plan is decided. Implementing such actions in a real situation as a try out for port development will result in time and financial loss, not to mention the effect to the environment and availability of space. Port Constructor is introduced last year as the newest tool to simulate all the planning and development process of a port and see the result of every action in relatively short time. Port Constructor is a serious game, it looks like a game, but it also has a learning objective that needs to be achieved. The primary function of this game is that players can take several actions, undertake tasks, and experience situations which would be impossible to be tried in a real life situation. In addition, Port Constructor allows players to have a position as a port planner and developer, which may not be possible in reality, and experience a real situation within a short period of time. By developing their own port scenario (or real-port scenario) in the Port Constructor, the player will have a real experience as a port planner. This study was conducted to assess the Port Constructor game as a learning tool in port planning and development both for student and more experienced port developers. Furthermore, this study also provides a way of developing scenarios inside the Port Constructor game as well as ensuring that the aim of this game can be achieved by doing a game session together with students and professionals participants. The game sessions were held to prove the playability of the game as a single-player and multi-player game. Resulting in a better outcome when the game played as a multi-player game because players can have a discussion before deciding the next actions that they will take. Examples of several port layouts are provided to prove the flexibility of this game that can be used to accommodate uncertainty of port development when using in the future. In conclusion, developers believe that Port Constructor can be a useful instrument for the learning process of people at the educational level as well as for port developers on their port planning course and project.

1. Introduction
1.1. General Background
During recent years, the expansion of global trade has led to an increase of vessel sizes, and the demand to build new port infrastructure or manage existing facilities that will reflect on growing wealth worldwide. Usually, an extension of a new port only focuses on increasing the capacity of an existing port (Schipper et al., 2015). Planning a port is a multidisciplinary work supported by various fields of expertise, such as oceanographer, safety and logistic, shipping, economic, and nautical engineering.
It does not only consist of planning and building infrastructure but also conflicting stakeholder with different goals. To bridge communication between parties, port planner and designer have to find a way to implement new development in this condition. Therefore, developing a holistic system which reckons technical, social, and economic issues is needed (Bekebrede and Meijer, 2009) which can be found while using simulation game. By using a simulation game, a designer can have more learning experience and try their initial design, before implementing the model in real life (Bekebrede and Mayer, 2006). Thus, the initial plan can be managed and changed without causing a significant loss. Direct experience on what can happen and what can go wrong during development of the port can give a sufficient impact to raise the insight and awareness of the designer (Bekebrede and Mayer, 2006).

In this paper, the game simulation that is going to be used in is the new Port Constructor game. This game can demonstrate on how to plan and manage a port from the early stage using different scenarios on how to develop it. Port Constructor is the newest single player’s computer-based game that is being developed by Port of Rotterdam together with InThere, Delft University of Technology, Shipping and Transport College, and IHE-Delft as a renewal of the SimPort Game.

1.2. Problem Statement and Objective
Considering the fact that developing port is a complex system, a serious game simulation can be applied during the educational stage so it can promote early awareness about port planning and management among the multidisciplinary team (Madani et al. 2017). Game-based learning (GBL) is found to increase soft skills such as critical thinking, creative problem solving, teamwork (Johnson et al. 2008, Madani 2017). In addition to that, it can be used to improve cognitive development, learning retention and social learning (Squire 2013, Van Eck 2006), which is essential for the future port planners and professionals in the port development field.

This paper aims to explain the result of study regarding of the use of Port Constructor as a learning tool for students and for port planners on how to simulate real-life port planning and development scenarios. This research provides an overview of the use of the serious game in port planning and development and its potential to improve cognitive development, professional skills and the learning experience regarding port planning and management.

The following primary questions will be investigated: Can the Port Constructor serious game be a useful tool for education and planning and designing of a port?

The derived sets of specific research questions are proposed to guide to achieve the primary research question:

- How can Port Constructor be used as an education tool for student and port planner?
- What are the learning experiences that can be found after playing this game?
- Comparing single versus multiplayer results, which method has the best outcome for education and port planning?

2. Port Planning and Management
A Seaport is an area where facilities for berthing or anchoring ships and the instrument for transferring of goods from vessel to platform or vice versa present (Alderton, 1999). Branch (1986) defines "a seaport as a terminal and an area within which ships are loaded with and discharged of cargo and includes the usual places where ships wait for their turn or are ordered or obliged to wait for their turn.” Usually, it has an interface with the other forms of a mode of transport, and by doing so, it provides connecting services. Schipper et al., (2015) stated that traditional port was usually built when at some point there was an increasing trade in a local area where can trigger economic flow, with often characterized polluting industry, deficient transports, and little interest in public health, citizen welfare and no awareness for environmental issues. The motivation of port authority to develop existing port is usually because of the economic development in their region. For planning a new development, the location or
public port is restricted by the administrative sector. Thus, the authority of the development has to be decided in advance (Schipper et al., 2015).

Before the planning, a port, port planner, and developer also need to know about the requirement that shipper or ship-owner have to gain their interest. Branch (1986) mentioned that the condition of the market is the one that will decide whether goods will pass a port or not. In regards to that situation, planner also has to put into account the situation of future trends, such as the forecast of the containerization, the concept of the combined transport operation, as well the automatization which happening in this digitalized era. Before making a general master plan for a designated port, there are different features of the seaport that has to be taken into account. Baudelaire (1986) suggested three primary functions: interface, link, and gateway.

A port master plan is the foundation of a port development strategy, gives the outline of the port’s objectives and how to achieve them in the future. It becomes a blueprint for future development. It also incorporates preliminary designs of the main infrastructure works, such as dredging or reclamation works, approach channels and basins, breakwaters, quays, terminal areas and roads (Taneja, 2013). Some criteria need to take into account by port planners in building a master plan based on PIANC (Manap, 2017). Firstly, the flexibility of the port: master plan layout need to be flexible enough to deal with the market uncertainty thus resulting in a smaller loss if a significant change needs to take. Next is that port has to be future proof: master planning should allow some future proofing of the critical parameters such as water depths and the hinterland connections. And lastly, the last is phasing where port which built-in staging steps will provide higher flexibility to adapt the future change in order fulfilling the market demand in the future.

3. Understanding Serious Gaming

3.1. General Overview

Planning and developing public infrastructure in the world today is usually not under control of one party anymore. Thus, the interconnecting of participation and technological possibilities are increasing the complicatedness of the system (Bekebrede et al., 2015). People are in a social sphere present as a complex social system that is huge and dynamic, demonstrating prominent relations within themselves and the environment (Bekebrede et al., 2015). One of the primary function of using serious games is that it can be used to support interpretation, designing, and using such a complex system.

Meanwhile, Guessen (2015) mentions that serious gaming has become a genre of learning and teaching method based on computer-used. It is also suggested that the learning experience should be processed with such a pleasant attitude so that it will gain interest and create positive impact. Sorensen and Meyer (2007) defined a serious game as digital game and tool that has agendas such as to educate, train, and give information despite entertaining the players which can cross a variety of topics, target groups, and contexts. For example, this Port Constructor game will be more efficient to be played by a student who has a background in port development than a student who never learns anything about port planning before.

3.2. Serious Games for Learning Purposes

The computer shows excellent potential in the use of the game in education which has the primary aim to be fun and motivational. This possibility is led by several factors such as the eagerness to renew the educational method, a learning tool that is being easier to find and technology development for creating learning game. One of the positive aspects of using a set of education is to develop a positive attitude to learn in the particular entertaining way and can be applied since the early age (Simkova, 2014). Bekebrede et al. (2015) mentioned that educational and policy games are part of the design science perspective that focuses on a change in learning. Thus the players will have a better understanding after playing the game. This game is usually being used as a research tool during hypothesis testing while doing analytical research.

Based on the research by Khenissi et al. (2015) it is revealed that serious game has a sufficient impact on improving student level of knowledge and inductive reasoning skill. Simkova (2014) also
concluded that while doing a simulation in a game, players can continuously monitor and control their progress so that personal cognitive, motor and spatial skills are developed. Port Constructor seeks to enhance learning about concepts relating to port development and management. The design of this game was build based on the study from the previous game (SimPort MV2). It is developed on knowledge from educators, scientist, and port planners. In the first phase, the game was made in order to facilitate the building conceptual content on port management and development into a digital game. The next stage of the game development is to define the archetypes of port, as well as incidents and dilemmas that might happen during the development of the port.

### 3.3. Serious Games on Port Development

Applying port development planning is very similar to playing a game. It relies on the concept planning, system analysis, and decision science. In addition to that, in simulation games, the participant can become the primary stakeholder while creating the future they want to study and become an active decision maker while designing and analyze the process (Geurts et al., 2007).

Warmerdam et al. (2006) mentioned that it is essential to pay attention to the players feeling while creating the game. Even though a serious game is used as a tool for decision support system, it is widely known that a game supposed to be enjoyable. Visualizing the result of each action that players took, will give more effect and immersion into the game. Thus, a game supposed to be built in such a way that players not only act as a decision maker in a simulation sphere. Because playing a game puts a person in a different mindset than working on a simulation condition in a decision support system.

There are several types of serious games for port planning and development that is being developed before, such as Port of the Future. This game set was developed by Deltares which meant to be used on their port development training. By using Port of the Future game set, the practice has been designed as an introduction to sustainable port or city development with a focus on integrated stakeholder participation in such a pleasant way using game set. This game is more focus on the economic development of the area within the social system, the natural condition and the effect of the sustainable design. It is designed to raise awareness of port authorities, policymakers and other interested parties for sustainable aspects, uncertainties with operations and possible cost savings through reduced maintenance cost on the short to a long term of 20 years (Schipper et al., 2015).

The purpose of this game is to apply a fictional yet based on the reality of the port environment. The central scenario is based on the sustainability pillars of port development which is People Planet and Profit. These three pillars are a set of measures and indicators for safety, economy and the natural environment. The PPP indicators are defined for port development in such a way that the effect and impact of a traditional port can be compared against sustainable port development. The course provides a theoretical background of sustainable development in city, port and coastal area (Deltares, 2017).

The next game is SimMV2. This game was built in late 2004 by Port Of Rotterdam together with Delft University of Technology. This game is designed as a multiplayer game in which, three players as a group build a new port extension for 30 years simulated time. The initial target audience was port experts, but as the trial goes on, a student at Universities also proved to be a right audience to play this game (Warmerdam et al., 2006). The final product of SimMv2 was the so-called SimPort game. As the target group from the previous version is increasing, more features where being requested therefore a new version of the game is needed. This simulation game mimics the real processes of port planning and development including planning, equipping and exploiting the Second Maasvlakte (MV2) in the Port of Rotterdam. This game does not require any specific prior knowledge about seaports or the Maasvlakte. But apparently, player’s interest and willingness to explore this subject area using the simulation game would be helpful (SimPort, 2017).

The SimPort MV2 game has been used in training programs of the Port of Rotterdam, Delft University of Technology, STC, and IHE Delft until today. The SimPort game is limited to the MV2 (second Maasvlakte) scenario and is technically becoming outdated. That is why a consortium of Port of Rotterdam, Delft University of Technology, STC, and IHE Delft have developed with InThere game
company a new game called Port Constructor. Port Constructor designed as a single player game that can be used for all type of port scenario and expansion of existing port. For this research, Port Constructor was tried to be used for both single-player and multi-player game.

4. Research Approach

4.1. Development of Port Constructor

Port Constructor is the newest single player computer-based game that is being developed by Port of Rotterdam together with InThere, Delft University of Technology, Shipping and Transport College, and IHE-Delft as a renewal of the SimPort Game. This game can demonstrate on how to plan and manage a port from the early stage to use different scenarios and to see how decision affect the development. This game is created based on the need for flexibility for every type of port. Thus, the facilitator can create every kind of port and every condition that needs to be implemented in destined port.

As a part of the Smart Port program development, this new game is expected to have the highest flexibility for port planning purposes. Thus, Port Constructor was built in two separate sections. The first part is the Map editor, and the next part is the Game platform. There is no need of particular knowledge beforehand about port planning to play this game. But having a basic understanding of planning and managing a port can be an advantage. Using this game simulates the port planning process, and the learning of port planning is one of the goals of the game.

4.2. Game Validation

Port Constructor started to be developed in 2017 and is expected to be finished in 2018 by InThere game building company. The facilitator works together with the development team consisting of several professionals, who take part in the development of Port Constructor, expertise in port development, organization and management, and computer program and design. Up until now the game still under finalizing phase, where several bugs still found in both game sessions. The final codes for both sessions will be added into the final version of the game later as a list options together with other scenarios from Delft University of Technology, STC and Port of Rotterdam.

4.3. Game session so far

There are two different port scenarios used for the game sessions, Banten port scenario for 1st session and Port of Kuala Tanjung scenario for 2nd session. Both game sessions were held at IHE-Delft. Because of the condition of the players, each scenario was played twice separately the first group is a senior student (Port Development student batch 2016) together with port professionals, and the second group is the junior student (Port Development student batch 2017), to be called game session 1a and 1b respectively. For session 1a, the game was still under development where several bugs appeared and also some functions of the game were not available. Using the same scenario, for the session 1b newer version of the game was being used, but with similar conditions that several bugs were still appearing and some function such as cross-point was not available yet. For the first scenario used in these sessions, the game was built on an easy mode, where there was no incident appear during the development of the port.

Next, for the second port scenario (Port of Kuala Tanjung scenario) the game also played two times separately between the group of senior student & port professionals and a group of junior student, to be called session 2a and 2b respectively. Different with the first session, in this 2nd session the game was already in the final phase of the development. The primary function of the game is ready thus the game can be built with more dilemmas and advanced problems. Taking into account the limitations of the game that the game is still incomplete, this first session (both 1a and 1b) is meant to be a game trial and the second session was tried to be used as real port scenario trial. In addition to that, the scenario built for session 2a and 2b was more complex with additional incidents and dilemmas during the development of the port. Eventually, from both sessions, the game works correctly, and the players can finish the game. But, with the occurrence of bugs and errors during the game session, it delayed the player’s movement.
The 1a game session for the semi-greenfield port was held at IHE-Delft on 15th December 2017. Completed by 9 Student participants and 3 Professional participants. And session 1b was conducted on 30th January 2018 with seven junior student participants. This first session started with a condition where the student participant has no experience and knowledge about the game itself even though, they already use to play serious game types before. And for the professionals, they had some before-information about the game.

The 2nd game session was also held two times. On 23rd February 2018 session 2a was held with 8 total participants, six students, and two port professionals as participants. And the next meeting was held on 2nd of March 2018 with six junior students as participants. This session was conducted using the final version of the game (finalizing minor bugs still in progress). On this session, the condition for both groups is the same where they already aware of the state of the game (they already played it in the previous session).

4.4. Evaluation Approach
After the game session, players filled up a questionnaire regarding the research material about the condition of the game and also direct feedback from the player. The observation is using analysis of questionnaire and game logs files during the meeting. Both trial sessions with the professionals and students are aiming the feedback to improve the game, because of the game itself is still under development. In addition to that, the questionnaires even ask about the ability of the game to be used as an educational tool and also for the planning tool for port professionals.

At the end of the session, there is a short debriefing time, where the game host delivered questionnaires to be filled in by participants consisting of several group questions and also gathering feedback information about the players experience after playing the game. For the first session, due to an incomplete version of the game, the game log cannot be saved automatically thus resulting in extra work for the participants, where they have to screenshot and save their work step by step manually. The results of this game log later will be assessed by the game host to see the best revenue, strategy, best step to developing the port inside this game. The score inside the game is calculated automatically by the computer model based on the player’s decisions.

In the 1st scenario’s game session, the questionnaire delivered once at the end of the game session. But for the 2nd scenario’s game session, two types of the questionnaire was prepared. The first one, before the game session start (pre-game questionnaire), and the next one similar to the previous session was delivered after the game session (post-game questionnaire). The question asked in both sessions was the same. The pre-game questionnaire consist of several questions about background information of the players regarding the serious game; their ability to play a serious game, simulation game, knowledge about port planning, etc. And also asking about their expectation after playing this game. And for the post-game questionnaire, the main questions were asked regarding the quality of the game, the learning experience that players get after playing the game, also players interaction with the computer-based game. For the post-game questionnaire, the reason questions asked using the same format is in order to get the same approach thus resulting in a comparable result. The process of building scenario and the analysis of the result from the game session will be explained in the next chapter.

5. Port Constructor; how to build your port
Before the game session starts, the players had the opportunity to read the game manual, and brief report explained about the conditions of the port that have been sent several days before the session. When all players gathered at the place where the game session being held, there will be a brief explanation of the game manual by the host before the game session start. This presentation will explain more about the condition how to build your port in the game starting from the beginning, building the master plan based on selected strategy, until running the self-made port for ten rounds. This pre-report will give you more information about the technical part of the game, how the game will look like, and what you should do while playing this game and also how you suppose to build your port based on the prior assessment, if applicable.
The player’s task is simple. The players have to make a port development plan while acting as both port authority and port operator. Building a master plan, implementing the decision, choosing a partner and building infrastructure while maintaining the revenue of the port that will lead to the satisfactory result of the self-made design port over the 10-round period. Furthermore, the players can do proper planning, based on each wish. The players can use their imagination to develop their master plan, or they have an option to build their master plan based on the example of a master plan that was given before on the pre-game report.

How the port will look like, whether to make a sophisticated port or a simple port that they think will give more opportunity to be developed in the future, whether is it possible or not to implement it in real life all of it is based on the player's plan. After the first trial is finished, next experiment is a session for the multi-player will be followed. All the steps are still the same, but the discussion between the team is possible now. For the purpose of this study, each group consists of 2 people with the same background. Development and building strategies need to be discussed among players to reach the best satisfactory result for the team.

Table 1. Main Features of Port Constructor

| Who is playing | The player's group compositions are separated for two-game rounds, the first one as a single player (1 player), and second chapter as multi-players (2 or more player) with one laptop; professionals or students. |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| How to play   | As an individual player, each player needs to work on their computer; there is no interaction and discussion between the players on how to develop their port. They have their own right as a decision maker. As a team, every two players use one laptop to work with. The interaction between players is necessary to provide a good discussion and clear communication for the decision making. Both sessions are played in one classroom with access to the internet. |
| Duration      | 1-3 hours                                                                                                                                                                                     |
| Competition   | The main competition from this game is basically to assess the masterplan and development steps which will result in the best score that they can achieve. However, the game outcomes itself can be used as a comparison with the other players or another team in multi-players session. |
| Passage of time | What time passes in the game is shown by each round. Each round simulates a period of 1-2 years. The time range of the game basically can be changed based on the map editor programmer. It will start in round 1, in which players will start plotting their strategies. The game will steadily continue until it finishes in round 10. The development of the game will take time-based on how the players construct their port. |
| Evaluation    | To evaluate the game performance, questionnaires will be delivered to the players by the game house. To assess the progress of the player's performances, in addition to the surveys there will be an analysis of the result of the game. |
| Briefing and debriefing | Before the game session starts, there will be a brief presentation about the game manual performances. After the game session ended, an evaluation is held through several questionnaires that are given to the player, also a direct comment drawn from the player. |
| Computers     | Overall this game can be used on any smartphone devices of computers. For this study, the game was played using an individual laptop connected |
to the local internet. Game installation and operation equipment are done step by step by the players together with the game facilitator. The game code game that will be used is projected.

**Other equipment** Whiteboard, projector, questionnaires.

### 5.1. Session Limitations

As mentioned before, Port Constructor game is still in the developing phase. The game has been played with a team of students and professionals from Port of Rotterdam; around 20 players already tried this game at IHE-Delft. Port constructor has an objective to achieve the learning experience by working a different type of port planning and also a different kind of port scenario among professionals and students. There is some limitation that makes the result of this research only in preliminary phase by doing a trial and error method. The first one is the condition of the game itself. For the first session, we only use the 4th game version in which not all of the feature is available. The function of the game itself limits the players with the availability of the transportation link, and also some bugs appearance. For the second session, the version used is the so-called final version. With more features added such us connection of infrastructure to the cross point, several bugs still appearing in this version. Thus, the version used in the 2nd session cannot be called final version yet.

Second, is that the evaluation of the session is focusing on the feedback from the student regarding the condition of the game and also the map analysis from players entry data. Regarding the feedback from the player about their learning experience, most of the player feedback for both sessions is mainly about the condition of the game itself. The feedback regarding the state of the game is to improve the function of the game and also to improve the playability of the game while it still under developing. From the first session, we found several bugs and even some malfunction features which can be used to improve the game for the second session. In addition to that, in the map editor, some errors also appear several times which made the building of the scenario takes time longer than necessary. Even though advance features being introduced in the 2nd session, bugs regarding the infrastructure and time development in some functions still appearing which have to be discussed further with the game company.

The third one is about the data generated inside the game log. This research will not examine the feature inside the game program; we only use the game program to run the map model which built inside the map editor and play it in the primary game domain. The examination of the program will be time-consuming and also only be reliable when we have more data from several scenarios and several sessions.

The last one is the server logs and the version that we used. For the first meeting, the game log still cannot be saved automatically. Thus, the players need to keep their map from each round manually. The result from this condition is that the way each player save their works are different from each other. Up until this research is finished, the player still has to save their work manually which is time-consuming. Thus, the result of the game map is not strictly comparable, but the result of the questionnaire is. Despite all of the mentioned limitation, the game works on every computer user, and each player can finish their game without severe disturbance.

### 5.2. Game Session Conditions

In this games, session players play an important role as a port planner. The players are in charge as a virtual port authority and port planner. Which in the beginning will act out as a port planner when planning and designing the master plan based on the play desired on the first step of the game. All coordination, responsibilities, possibilities, and competencies of the design are based on the player’s professional experiences. For this phase, there is no actual competition between players with another, even though in reality, it was found that some players start comparing the result their work with another player. Game session time schedule is divided into several time steps, explained on the Table 2 and Table 3.
Table 2. The 1st Session Schedule

| Briefing                              | Game host present game objective, rules, and task. Present brief explanation of the game manual, on how the game will work. Also, explain about a report that was sent beforehand to the player. |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Chapter 1                             | Single-players game session, where the player plays the game by themselves.                                                                                                                                                      |
| Host evaluation                       | In this first session, student players face severe difficulties. Because this is the first time, they see and play this game. But for port professional, this is not their first time they played the game. Thus they are more familiar with the function of the game. |
| Chapter 2                             | Multi-player game session. Every 2 people performed as a group and played the game using one laptop.                                                                                                                                  |
| Host evaluation                       | After player more aware of each step they take, players getting along with the game in this session.                                                                                                                                  |
| Debriefing                            | Delivering post-game questionnaires                                                                                                                                                                                                    |

Table 3. The 2nd Session Schedule

| Briefing                              | Present brief explanation of the game manual, on how the game will work. Also, explain about a report that was sent beforehand to the player and delivering the pre-game questionnaire. |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Chapter 1                             | Single-players game session. Where player plays the game by themselves.                                                                                                                                                              |
| Host evaluation                       | In this single-player chapter, different with the first session, both player groups already adapted to the game. With a higher level of difficulties on the scenario, players play the game in more patience manner, without causing severe confusion among them. |
| Chapter 2                             | Multi-players game session. Every 2 people performed as a group and played the game using one laptop.                                                                                                                                  |
| Host evaluation                       | After player more aware of each step they take, players getting along with the game in this session.                                                                                                                                  |
| Debriefing                            | Delivering post-game questionnaires                                                                                                                                                                                                    |

5.3. Game Session Scenarios
The scenarios for both game session was made based on the previous study that was done by Manap (2017) for Port of Banten and Prakoso (2017) for Port of Kuala Tanjung. In the next explanation, will be given the general information about respective ports that was sent few days before the game sessions to the player together with a simple game manual to help player adjusting with the game. This brief report is the one that was used as basic information on creating the port situations by facilitator on the Map Editor.

5.3.1. First scenario – Conditions of Port of Banten
The first scenario is built based on the previous assessment done by Manap (2017) the port of Banten, Indonesia. A lot of simplification was made to fit the assessment into the game. In order to create a simple game for the first session, the scenario was built without severe incident and not using all the research result that was done before. Due to the condition of the game, simplified the previous scenario
need to be done. Thus, resulting in the trial of the adaptive port planning with high abstraction such as the non-technical condition which cannot be assessed in the game is to be removed.

Port of Banten assessment was done by applying Adaptive Port Planning framework by Taneja (2013). The development of this situation will not be part of this research. Ports of Banten in Indonesia presently function as a gateway port which consists of scattered stand-alone facilities with its own infrastructure. There are several sub-ports in this area. For the purpose of this study, Bojonegara Port - which is part of Port of Banten- assessment is the one that is used. Bojonegara is currently under pre-construction, and currently being held because of the market change and political issue in this area. It was initially positioned to be an international hub port to complement the cargo overflow from Tanjung Priok which was forecasted will start to reach its full container handling capacity in 2010 - hence creating the necessity of additional port infrastructure in the region. Manap also mentioned that the area inside the port also included zones for industry and trading as well as container, multipurpose, dry bulk, and liquid bulk terminals.

For the purpose of the first game session as the first trial for port Constructor, not all the assessment done by Manap (2017) will be used. Several conditions such as the type of cargo, the market forecast and also proposed layout will be used. Mentioned companies and function in the game itself was made by the facilitator. For simplicity of this first game session, a proposed breakwater that needs to be built in several phases already built as a whole. There is a small island nearby and also an industrial area in the game scenario. This port of Banten scenario built as a semi-greenfield port. Where players can plan and managed their port in an empty destined area where none of the infrastructures was built. The Port of Banten is proposed to be built in an industrial cluster model. Thus, clustering the industry with the same range will be the best option. During the development, Bojonegara is prepared to have flexibility in handling several types of goods. The masterplan building supposed to be different on each strategy. In the next pictures are shown several master plan as a result of the previous assessment.

5.3.2. Second scenario – Conditions of Port of Kuala Tanjung

The second scenario is built based on the assessment of Port of Kuala Tanjung joint venture together with Port of Rotterdam which was done by Prakoso (2017). Due to the condition of the game, simplified the previous scenario need to be done. Thus, resulting in the trial of the adaptive port planning with high abstraction such as the non-technical condition which cannot be assessed in the game is to be removed. For the condition of the port inside the game, the scenario was built with several additional incidents during the development of the game. This incident was proposed to gain more interaction between players during the discussion. Incidents appeared in several rounds during the development of the port. Prakoso (2017) made the port development scenario by applying Adaptive Port Planning framework by Taneja (2013). The development of this situation will not be part of this research. The first condition that is important to know that Port of Kuala Tanjung is a Greenfield port which planned to be Indonesia’s international port hub along with Port of Bitung in Sulawesi. This project is in the form of Joint Venture project by Pelindo 1, Indonesian state-owned port company, and Port of Rotterdam Authority. All the assessment was done by Prakoso in 2017 will be interpreted to fit in the game.

In the development of PoKT, there are several original conditions mentioned. Based on the assessment, this Joint Venture needs to incorporate stakeholders to achieve the most productive NPV for every scenario and also to provide enormous positive economic and societal impact as added value for the neighbouring environment. The first condition is that in the development, the port will be built in an industrial cluster model. Thus, clustering the industry with the same range will be the best option. In this case, creating the industrial area near port will also give an advantage to the shipping company because it reduces their transportation cost. In addition to that, PoKT will not only rely on one the cargo handling service from the large vessel (one large ship which will transport a tremendous amount of cargo at one time, will result in the massive peak of handling at one moment).

It is also mentioned that in the development of a Green Field port, the technology development inside the port is also crucial. Designing breakwater should be built with some possibility of expansion. For the purpose of this game trial, the client is imaginary will come to the port with an exact condition
which differs from one client to another. From the cargo demand forecast, there are four types of cargo group will come to the port. They are construction and manufacture group (metal base, aggregate, chemicals), food and essential group (primary human needs, feedstock, or finished product), electronic and fashions, and also conventional fuels such as coal or crude oil. From this selected group, each group can have several types of shape, dry bulk, liquid bulk, break bulk, and also a container.

In general assessment, the proposed master plan is dedicated to build two types of seaports, land-based and offshore port development. Continuous monitoring to validate the capability of the master plan is needed. Therefore, a masterplan supposed to be treated as a dynamic goal to achieve ideal port based on the port planner’s perspective. Masterplans can be changed periodically to adapt the market condition.

There are several assumptions made from Prakoso (2017) assessment. There are possibilities to provide multiple sources of electricity, with conditions followed by each type, such as coal is cheap but not environmentally friendly, renewable energy from the sea current can be costly in the building phase, gas field nearby can also be an alternative. While centralized electricity can minimize the maintaining cost, its coverage is small. But when we choose to build scattered plants in each cluster that provide higher reliability but it needs high maintaining cost. Also, sedimentation and other physical condition will not be part of assessment inside the game.

6. Results and Analysis

Taking into account all the limitations mentioned before, after each game session, we evaluate the game by doing a feedback session while handing out a set of questionnaire. Three main conditions are being evaluated: 1. The quality of the game, 2. The experience after the session, 3. The player's interaction by playing the game using a computer. The result of the questionnaire, feedback session and also various maps drawn by the players will be used to provide a preliminary answer to achieve the objective of this research.

Two sessions of the game were held with two different scenarios. This evaluation will be explained and divided based on the number of a game session; session one and session two. In the tables below, the ratings given by participant is illustrated. The player provides a score to each question asked in the questionnaire. Score 1 (fully disagree) to 5 (fully agree) is a given value used in this research which represents player agreement with 5 points as the maximum point. In each session, a senior student played the game together with port professional while the junior student played the game by themselves. There is a very different condition about the game version in both sessions. The first session, the game was not finished yet, while in the second session the game already in the final phase.

7. Port Constructor Game Session Analysis

7.1. The 1st scenario game session

For the first scenario, the game session was held two times with first class consist of 3 port professionals and 9 students and the second class consist of 7 students. What makes the student groups different here is that on the second session the game was held with a new student on the port development class, while on the first session consist of a senior student who gained more understanding of the port planning and development. Below will be explained the result of the questionnaire handed after the game session.

7.1.1. The Game Quality

On this part, we assess the most apparent aspect of the game which is the quality of the game base on the players’ perspective. Playability functions inside the game, players satisfactory and the condition of the program are some of several elements that we asked the player. This kind of question was asked to see how far this game was work and to see whether the objective of the game can be achieved in this preliminary phase.

In both rounds, it is clear that player think the rules of the games are not that clear, the players gave score 2.75 out of 5, this could happen because during this first session, the game was not fully developed yet, where the Port Manager function whose supposed to tell player about the condition of
the port was activated yet. About the playability of the game as well is player excited to play the game, can be seen that for both trials, play alone or as a group, they enjoy playing the game. Thus, can be stated that the function of this serious game as an exciting game is achieved. Even though both student groups prefer to play the game together with the other colleague, professionals, even still in high preferences, prefer to play the game by themselves.

From the feedback session, it also can be said that they prefer to play the game together with the other colleagues, even though from the map result it differences cannot be seen. From their point of view, it is more fun to play the game with other people. Also, some people mentioned that deciding by yourself is easier thus the game feels so dull. Playing with others makes decision making livelier and feels like in reality. As a conclusion, it also can be said that playing together makes it easier to understand the way the game itself works and also you can discuss it together which help in the decision making for each step taken which results in the best outcome for each choice.

The game degree of immersion is quite good, even though the setting of the game session is not for competition, at the end of each round, some players make a comparison between their result and the other player’s result to see which one of them have a higher score and which one made a better plan. They are also quite excited to play the next chapter of the game session right after the coffee break. The facilitator works as well as a game technician by helping players while facing difficulty regarding some bugs or unexpected game errors. With the help of the presence of professionals from PoR also triggered discussion and interaction between players and also demonstrated the way the game itself works, because facilitator together with professionals from PoR has accomplished more with Port Constructor than the players who see the game for the first time.

From the observation during the session, it can be seen that both student and professionals really enjoy playing the game which is reflected in the last question, shown an average score of 4.42 out of 5. For the other game material regarding the quality of the game such as the rule of the game, the aim and the objective of the game, and the given scenario, the rate is provided by the senior student is sufficiently low hovering in a value of 2. But, all groups agree that this game can be used for port development purposes with an average score of 4.16 (Table 4).

Table 4. Quality of the Game

| Statement                                      | Senior Student | Professionals | Junior Student | Total  |
|------------------------------------------------|----------------|---------------|----------------|--------|
| The rules of the game is clear and straightforward | 2.33           | 3.33          | 3.00           | 2.74   |
| Port Constructor has a clear aim and objective   | 2.56           | 4.33          | 3.71           | 3.26   |
| The aim of the game session is relevant for port development | 3.89           | 4.67          | 4.29           | 4.16   |
| The game is built up in an interesting way       | 4.11           | 4.33          | 3.57           | 3.95   |
| The game materials is understandable and written (game manual) | 3.11           | 3.67          | 2.86           | 3.11   |
| The scenario given is sufficiently detailed      | 3.11           | 4.00          | 3.43           | 3.37   |
| The scenario given is sufficiently realistic    | 2.78           | 3.67          | 3.43           | 3.16   |
| I enjoy playing the game by myself              | 4.33           | 4.67          | 3.29           | 4.00   |
| I enjoy playing the game together with others    | 4.44           | 4.33          | 4.29           | 4.37   |
| Would you like to play the game again sometime  | 4.56           | 5.00          | 4.00           | 4.42   |

7.1.2. The experience through the game

In table below, it is shown the result of the observation based on the player's experiences after playing the game. The question mainly asked about the learning experiences that player achieved. What they gain after playing Port Constructor, how the game can be used in the next future and is the objective of the game as a learning tool for port professional and student can be achieved?
Generally speaking, from the game sessions both students and professionals groups agree that this game can be used as a learning tool in school for students in the port field by giving an average score of 4 and 3.68 points for using this game set for port planners. This likely happens because of the condition of the game which has a very high abstraction. With more knowledge that professionals have, professionals probably expect something more detail in the function of the game before applying the game for real port management. Thus, an excellent experience that professionals have to pay a role in answering the questions regarding using this game in their professional environment which is why the score is slightly lower.

As a correlation with the previous point, from table below, can be seen that both groups agree that this game can be used as both single and multi-player game. One of the research questions is to answer which method that will be suitable for this game based on player perspective. Based on the question asked, it can be concluded that most players prefer to play the game as a team player. In addition to that, all groups also prefer to play this game as a multi-player game. In addition to that, this game also proved its function for port planning and learning different design of the master plan, which showed in high rank given by players, both groups agree that the objective of this game can be achieved.

From all three groups of players, junior student slightly agree that this game can be used to try several ports design, but in reverse, port professional give quite a high value with 4.33 that this game can be used to decide several port designs. In addition to that, with a lowest average score of 3.16 most player seems to doubt that this game can be used as a policy support instrument (Table 5). This case happens because this game in the first place was design to be used as a single player game, thus, while playing this game player unnecessary to do interaction between each other that is why players have a doubt that this game can be used as a policy support tool where in reality a lot of communication needed while developing a policy.

As for the function of the game to support port planner to learn about the development of the port (planning a seaport, learning about strategical and technical inside the port and also observe the long-term growth of a port), players giving an average value of 3.5. It can be said that this score is not a high value. It appeared because of the condition of the game that didn’t provide detail situations and condition inside the port but more about the development of the port as general and the interaction between function inside the port with the surrounded area.

Table 5. The experience through the game

| Statement                                                                 | Senior Student | Professionals | Junior Student | Total     |
|---------------------------------------------------------------------------|----------------|---------------|----------------|-----------|
| I think that port constructor can be used for port planners               | 3.22           | 4.33          | 4.00           | 3.68      |
| I think that port constructor can be used for students in port            | 3.78           | 4.67          | 4.00           | 4.00      |
| I think that port constructor can be used as a multi-player game          | 3.89           | 4.00          | 4.14           | 4.00      |
| I think that port constructor can be used as a single-player game         | 3.78           | 4.67          | 3.86           | 3.95      |
| I think that port constructor can be used as policy support instrument    | 3.11           | 4.00          | 2.86           | 3.16      |
| I think port constructor can be used to learn about different knowledge of port design | 3.89     | 4.33          | 3.43           | 3.79      |
| By participating in this session, I have gained number of insight about planning real port | 3.67    | 3.33          | 3.71           | 3.63      |
| Port constructor provides insight in the technical complexity             | 3.33           | 3.67          | 3.71           | 3.53      |
| Port constructor provides insight in the strategical complexity           | 3.44           | 4.00          | 3.57           | 3.58      |
| Port constructor provides a clear picture on how the given port could be developed in the long term | 3.33 | 4.00 | 3.86 | 3.63 |
7.1.3. Player interaction with computer game simulation

In this section of the questionnaire, the facilitator asked the players about what they feel by playing this game using a computer. As for the primary purpose of this game is supposed to be played in computer and touch-screen gadget such as smartphone and tablet, the playability of this game should be smooth for players to work in every platform environment. For the first session, we are using the unfinished version of the game (version 4th). Even though the game itself works on every laptop, some bugs still appeared in some laptops.

An essential feature of this game is that the game should be enjoyable in the first place. Based on the feedback from the player, this function is achieved because overall players do not have any difficulties playing the game in their laptops and also it is easy to control and interact with the game software (score 4.16, 3.47, 3.63 respectively). On the other hand, the function mapping and setting inside the game receive lower score average of 2.8 (Table 6). This poor rating received most likely because of some features of the game is incomplete such as the infrastructure, and the cross point between infrastructures and also the port manager avatar which supposed to tell the condition of the port development is not available yet. Another thing that needs to be taken into account is the convert time inside the game, even after being told that each round inside the game equal to 1-2 years, in reality, some students still have an unclear view about the time conversion.

| Statement                                         | Senior Student | Professionals | Junior Student | Total |
|---------------------------------------------------|----------------|---------------|----------------|-------|
| It is easy to interact with the game software     | 3.89           | 3.67          | 3.00           | 3.63  |
| (platform)                                       |                |               |                |       |
| I enjoyed using the computer to play the game    | 4.22           | 4.33          | 3.71           | 4.16  |
| I had sufficient control of the interactions     | 3.44           | 3.67          | 4.29           | 3.47  |
| during the game                                  |                |               |                |       |
| The game function menu on screen are             | 3.44           | 3.67          | 3.57           | 3.63  |
| attractive and well-designed                     |                |               |                |       |
| The material mapping in the game were            | 2.56           | 3.33          | 2.86           | 2.79  |
| understandable                                   |                |               |                |       |
| Function navigator throughout the game was       | 3.56           | 3.33          | 3.43           | 3.47  |
| logical and understandable                       |                |               |                |       |
| Each menu on the game is easy to understand and  | 3.22           | 3.33          | 3.43           | 3.16  |
| use                                              |                |               |                |       |
| Each chosen function is easy to implement on     | 3.56           | 4.00          | 3.29           | 3.68  |
| to the game platform                             |                |               |                |       |
| The overall game setting is easy to play and     | 2.78           | 3.33          | 4.29           | 3.00  |
| understandable                                   |                |               |                |       |
| I have a clear feeling of time in the game       | 2.44           | 4.00          | 4.00           | 3.11  |

7.2. The 2nd scenario game session

In this section, the scenario of Port of Kuala Tanjung was also played two times in different settings. The first round consists of 2 port professionals and 8 senior students and the second one consist of 7 junior students. Players were more aware and already adapted to the condition of the game because most of them were the same persons that played the game before. Thus, in this session players already have more understanding of how the game will work. In this second session analysis also consisted of three type of questionnaires, asked after the game.

In addition to that, for this session, the facilitator added a pre-game questionnaire which mostly asked about the condition of the player itself. In session 2 there was 4 female, and 10 male participants where 2 of them were a participant from Port of Rotterdam, and the rest are IHE student. More than half
of them rarely play the game or only play a couple times a year. And only 4 out of 10 play an internet-based game more often roughly 1 each month or weekly period. All of the participants actually ever played a simulation game before. 11 people played the game more than 3 times before, including 4 of them that already played more than 8 times. Most of the player stated that they are relatively skilled on using a computer and more than half stated that they are relatively familiar with port planning, with 2 of them explained that they are very familiar with the port planning.

In general, more than half of the player prefers to have a project class rather than have a formal lecture or learning from the textbook. In addition to that, they agree that learning by doing a project such as simulation can improve their ability to work together with others, and also really useful in the education field. It is also clear that all players expect to gain more knowledge about the long-term development of port planning by playing this game. This also includes the learning experience about the technical and strategical complexity of port planning. They also want to get a better understanding of their decision on people profit planet which is the 3-primary factor in the development of the sustainable port.

7.2.1. The Game Quality
It is known now that the player’s feedback regarding the quality of the game play an important role. They are the first groups that experience this game before this game officially launched. The question asked in this session are the same as the previous session. The overall result showed that the second session has an average of score higher than the previous session. After gaining more experience from the previous session, all groups now seem to be confident enough to play the game alone even though they still slightly prefer to play the game together as a group. In addition to that, they can discuss each step of the development, having colleagues to play this game is also more fun. Moreover, after gaining experience, they stated that the rule of the game and also the objective of the game is clearer in this session. Comparing the previous session score 2.75 in this session player give an average score of 3.57 out of 5 which is a good sign of improvement (Table 7).

The players’ degree of immersion in this session is also improving, even though the set of the game session is not for a competition, players keep comparing their result score to one another. And discussion among players happened naturally. Table below illustrated the score given by the player. In this second session, there is no score under 3.5 out of 5 which meant that most of the player agrees with the statement mentioned in the questionnaire which reflecting that most of the players give more positive responses toward the overall quality of the game compared with the first session. From the observation during the session, it can be seen that both student and professionals really enjoy playing the game which is also reflected in the last question, showed an average score of 4.36 out of 5. From both session, first and second, it can be concluded that this game is attractive resulting in a statement that player want to play the game again later. In this session also all groups agree that this game can be used for port development purposes with an average score of 4.21 slightly higher than the previous session.

### Table 7. Quality of the Game of 2nd Session

| Statement                                    | Senior Student | Professionals | Junior Student | Total  |
|----------------------------------------------|----------------|---------------|----------------|--------|
|                                              | n = 6          | n = 2         | n = 6          | n = 14 |
| The rules of the game is clear and straightforward | 3.33           | 4.00          | 3.67           | 3.57   |
| Port Constructor has a clear aim and objective | 3.83           | 4.50          | 4.00           | 4.00   |
| The aim of the game session is relevant for port development | 3.83           | 5.00          | 4.33           | 4.21   |
| The game is built up in an interesting way | 4.33           | 5.00          | 4.17           | 4.36   |
| The game materials is understandable and written (game manual) | 3.67           | 4.00          | 3.67           | 3.71   |
| The scenario given is sufficiently detailed | 3.17           | 4.00          | 4.00           | 3.64   |
| The scenario given is sufficiently realistic | 3.33           | 4.00          | 3.83           | 3.64   |
| I enjoy playing the game by myself | 3.83           | 5.00          | 4.33           | 4.21   |
| I enjoy playing the game together with others | 4.33           | 5.00          | 4.33           | 4.43   |
| Would you like to play the game again sometime | 4.50           | 5.00          | 4.00           | 4.36   |
7.2.2. The experience through the game

In table below the result of the observation based on the player's experiences. The questions asked is the same as the previous session such as; What they gain after playing Port Constructor, how the game can be used in the next future and is the objective of the game as a learning tool for port professional and student can be achieved?

Generally speaking, both groups agree that this game can be used as a learning tool, for a student in the port field with an average score of 4.43 and 4.1 points for using this game set for port planners. The reason why this score happened is similar to the previous session where professionals have more experience. Thus, they expect something more detail in the function of the game, the more excellent expertise that professionals have to plays a big role in answering the questions. Overall, the result from this session also shown a high improvement. All the given score by players are higher than 3.5 out of 5. In addition to that, for both method using the game as single and multi-player, players give the highest score of 4.43 and 4.5 respectively to reflect that this game really suitable for them (Table 8).

As for the function of the game to support port planner to learn about the development of the port (planning a seaport, learning about strategic and technical inside the port and also observe the long-term growth of a port), players give an average value of 3.5. Despite that, this game has a high score to be used for port planning and learning different design of the master plan, which showed high rank with an average total score of 4.3. It can also be concluded that both students and professionals agree that the objective of this game as a learning tool for students and port planners can be achieved.

Table 8. The Player experience after playing the game 2nd session

| Statement                                                                 | Senior Student | Professionals | Junior Student | Total   |
|---------------------------------------------------------------------------|----------------|---------------|----------------|---------|
| I think that port constructor can be used for port planners               | 4.00           | 4.50          | 4.00           | 4.07    |
| I think that port constructor can be used for students in port field      | 4.50           | 5.00          | 4.17           | 4.43    |
| I think that port constructor can be used as a multi-player game          | 4.67           | 4.50          | 4.33           | 4.50    |
| I think that port constructor can be used as a single-player game         | 4.50           | 5.00          | 4.17           | 4.43    |
| I think that port constructor can be use as policy support instrument     | 4.00           | 4.50          | 3.50           | 3.86    |
| I think port constructor can be used to learn about different knowledge of port design | 4.17 | 5.00 | 4.17 | 4.29 |
| By participating in this session, I have gained number of insight about planning real port | 3.50 | 4.00 | 3.83 | 3.71 |
| Port constructor provides insight in the technical complexity              | 3.17           | 4.50          | 3.67           | 3.57    |
| Port constructor provides insight in the strategical complexity           | 3.67           | 4.50          | 3.83           | 3.86    |
| Port constructor provides a clear picture on how the given port could be developed in the long term | 3.33 | 4.00 | 3.83 | 3.64 |

7.2.3. Player interaction with computer game simulation

Players used their individual computer to play this game. The primary purpose of this game is supposed to be played on computer and touch-screen gadget such as smartphone and tablet. Thus the playability of this game should be smooth for a player to work in every platform environment. It also takes into account the condition of the game that was still having some bugs appearance which causes difficulties for players to control their moves in the game.

Based on the feedback from the player, this function is achieved because overall players do not have any difficulties playing the game in their laptops and also it is easy to control and interact with the game software (score 4.3, 4.1, 4.1 respectively). Overall, the score given by players are quite high, more than 3.5 except the player material mapping inside the game and also the time passed in each round. The score 3.3 was given by player for the time passed because of player still not really sure how
long each round is reflecting the real life-time (Table 9). Even though facilitator already gave them an explanation that each round is reflecting 1-2 years in real life.

Regarding the material mapping inside the game, this poor rating received most likely because of some features of the game is incomplete such as the infrastructure which resulting some confusions because there are a troubles caused by bugs and also because players might need to play the game several times, before really understanding the composition and location of the material inside the game.

| Statement                                                                 | Senior Student | Professionals | Junior Student | Total   |
|---------------------------------------------------------------------------|----------------|---------------|----------------|---------|
| n = 6                                                                     | n = 2          | n = 6         | n = 14         |
| It is easy to interact with the game software (platform)                  | 4.17           | 4.50          | 4.00           | 4.14    |
| I enjoyed using the computer to play the game                             | 4.17           | 5.00          | 4.17           | 4.29    |
| I had sufficient control of the interactions during the game              | 4.00           | 4.50          | 4.00           | 4.07    |
| The game function menu on screen are attractive and well-designed         | 4.00           | 5.00          | 3.67           | 4.00    |
| The material mapping in the game were understandable                      | 3.33           | 4.50          | 3.17           | 3.43    |
| Function navigator throughout the game was logical and understandable     | 3.83           | 4.50          | 3.67           | 3.86    |
| Each menu on the game is easy to understand and use                       | 4.00           | 4.50          | 3.67           | 3.93    |
| Each chosen function is easy to implement on to the game platform         | 3.67           | 4.50          | 3.67           | 3.79    |
| The overall game setting is easy to play and understandable               | 3.67           | 5.00          | 3.50           | 3.79    |
| I have a clear feeling of time in the game                                | 2.50           | 4.50          | 3.67           | 3.29    |

8. Layout Design Analysis

As mentioned before, because of the game’s limitations players had to save their work manually in all game sessions. When the game version is finalized, every institute will have their platform to keep the game log thus it will be easier to analyse players action and the result of it.

In the very first trial for the 1st scenario, because the game was not fully developed, the game setting was made in an easy mode. Thus, players can have a better understanding of the game, without additional issues which can lead to confusion. On the other hand, for the second scenario, more options, dilemmas inside the game was given to the players, to create a port’s condition as similar as possible with the real-life port scenario. In this study, we are not going to assess every step that player take and the effect of their action to the port development, but instead giving more understanding about how the game can work for port planning and development. Even though the differences between playing this game alone or playing with other colleagues could not be seen clearly in the result below, but based on player feedback, they have a better understanding and determining each action more carefully when played as a team.

8.1. The 1st scenario - session 1a

In the pictures below show an example of the work from the first group. Session 1a consists of senior student, and port professional as the participant and the condition of the game was not fully developed yet. In the first picture, it is shown the master plan chosen based on the proposed strategy, here is a container based terminal strategy. In this version, the Port Manager Function was not working yet. Therefore, the player can see the demand for the port based on the graphic shown when the Manager’s avatar is clicked. In this example below is a result of the game that was played by two senior students, as a team. They built the master plan first. And following the development of each round, players have a tendency to build their port based on the master plan that they made, but some changes during the development were also made. Initial available cash for this game is 40millions which affecting players...
action where they can choose every function that they want to build without much thinking about the available finance. Therefore, for the next game session with a junior student, the initial money is reduced so that players can think more carefully about every decision made.

Figure 1. Example of the master plan from 1st scenario session 1a

In the Figure 1, it is shown the first round action and Figure 2 picture shown the last round of it. The score differences here is caused by the achievement that players made. In the map editor, facilitator determines the condition of this achievement. For this game, if the player’s revenue for Profit is closer to the value of 15million, they will get a higher score. Even though from this example it is clear that the income is far from 15millions. In addition to that, the score also derived with an accumulation of another unit such as People and Planet. But in this session, players not fully aware of the condition of people and profit that’s is why their score could not reach high value. But in case of fulfilling the demand of the port, based on players result, it is clear that the capacity in the port can handle the demand.

8.2. The 1st scenario - session 1b
This session consists of a junior student in port development. Pictures shown below is an example of one individual player. Here, the student chooses container dominated terminal as their plan. During the development of their port, most of the players tend to build their port following the allocation area in their master plan. In this version of the game, there was a bug in the infrastructure when a player wants to cancel their action to build their road or railway, all the existing road and rail disappeared. This infrastructure is indeed crucial because every function type that players create need to be connected to the infrastructure so that function can be activated. For example, in the picture from round 5 below we can see that the liquid bulk terminal (purple colour) is enabled it means that this function can operate and increase the capacity of the port.
Comparing score from round 5 and round 10, it can be said that player has a relatively average score, as there was overcapacity in the port. In the last round, when port demand is 280 throughput unit, the capacity that the port had is 600 which is double. This can lead to a lower score. Because in this game, the player also needs to pay attention to balance their port capacity and the demand of the port. If their port sufficiently handles the demand since round 5, for example, the player does not need to keep building because they will keep getting revenue from their existing facilities and they do not have to spend their money for unused “facilities” because the capacity is already fulfilled.

8.3. The 2nd scenario - session 2a

For the second scenario, the game session was held with a better version of the game. Cross point function is introduced, which need to be determined first in the map editor. This cross point works as a hub for the infrastructure line from the port area to the hinterland area. In this version, the Port Manager avatar is also working. She explained about every situation that happens in the port, such as the condition of demand and capacity of the port, the new facilities built in the port including the incident that might appear and lastly giving news regarding the infrastructure connection between facilities.

In this session, there was a bug on one of the liquid functions when players played the single-game code. When players build this facility, it suddenly gave the player a massive amount of unit which led to not only over capacity but also huge revenue. The condition of this facility is already explained by the Port Contractor avatar. If players pay attention to the contract of this facility, they should not choose this function because it will give an over-capacity condition to the port. Not all players choose this facility, but when players choose this function, this issue will be shown.

In the case below, when players decided to build this facility, players will get a massive amount of revenue that can lead to a condition where players can build any “unnecessary” infrastructures and facilities without worrying their financial condition. In the pictures below, it is an example of how players built their port with high revenue because of the error. When they have available money since the beginning, players can quickly fill up their port with all kind facilities in the first round. Which also results in high score since the beginning. Unfortunately, this score remains constant until 9th round because of the overcapacity condition. Even though players got high revenue, it did not mean that their score will be higher as well. The equilibrium condition of the port needs to be achieved in order to get a better score for the next round. They also need to pay attention to the “People and Planet” condition not only from “Profit” point of view.

In addition to that, when players have sufficient money to build every facility that they can, they tend to not look on the port’s state. Some of them keep building facilities even though the capacity in the port already fulfilling the demand. Generally speaking, based on this result, we cannot use this kind of result to assess action-effect relation for real port development. But this kind of issues can be used as a learning experience for the scenario developers when they built their scenario and also for players while they play the game players need to read the contract condition and choose every single facility carefully.
8.4. The 2nd scenario - session 2b

This session was held using the latest version of the game. It can be said that all functions are working normally instead of the Infrastructure where there was still a problem when the player tried to cancel their contract. The pictures below is an example of the team player result. The player chooses Dry Bulk Dominated port as the strategy.
During the development of the port, in the first place, players decide to fulfill the demand for container and dry bulk cargo. Since early stage, they decide to build the extension breakwater which is necessary before building the container terminal.

As the development continues, the player decides to fulfill the demand of the port by adding more facilities one by one. As a result, the capacity in the port is also increasing which lead to a higher score compared to the first round. However, because of the early investment on the breakwater where no direct income is coming, the revenue for these few rounds is really small.

On the last round, the capacity of the port can fulfill almost every type of goods that came to the port. As a result, their score is getting higher, and the revenue is also getting bigger. It also can be seen that, during the development of this port, players stick to follow their master plan. There was a small change when they build the general cargo terminal (blue tiles with boxes inside) in an empty area where they prepare as allocation area if master plan needs to be improvised.

9. Port Constructor and SimPort analysis
In this section, the analysis of the comparison of usability of the serious game between Port Constructor and Simport will be explained. As so-called renewal version of Simport, this section focus on explaining about the result condition on each game in order to see the ability of Port Constructor whether or not it can be used as port planner tools in reality. As known before, Simport is a game that used to support the analysis of expansion Maasvlakte 2. It mimics the real live process inside the port planning. One of the objectives of this game is to gain better insight into any unforeseen and unintentional effect of the
Maasvlakte2 development within 10-30 years. This game played in a way that all players act as a board of director of the MV2 project. The game played by 4-6 players with 3 different roles can be chosen; general director, building director and commercial director (Bekebrede and Meijer, 2009). Player also have to have an active discussion on set about their strategies on how to build the MV2.

In their research in 2006, Bekebrede and Mayer focused on using this game to learn about the building of a seaport in the game and learn about the complex system within it. Even though the aim for both Port Constructor session and SimPort are different, the approach being used for both games is similar. Thus in this part, the writer wants to emphasize the analysis of a general overview of both games as a serious game in the port development field. To build this analysis, the data used for SimPort assessment are based on the research held by Bekebrede and Mayer in 2006. In their research, the game session mainly aims to be used the SimPort for building a real port inside a game and also to learn about the complex system using SimPortMV2. The questionnaire asked in this session also divided into 3 parts, assessing the quality of the game, the interaction with the computer and lastly the learning experience which mainly focus on the complexities of the project. (The result of their research is shown in the Appendix C.)

Based on their research, it is stated that the players really enjoyed playing the game. In addition to that, player’s degree of immersion is relatively good and the discussion between students and 2 professional from PoR improving the quality of players performances. Out of 28 players, they gave an average score 4.4 on a 5-point scale for the game session performance by playing the game with other, compared to Port constructor game session with 19 players they give score 4.37. It can be concluded that both games have a high score for appreciation from the players with more than 80 percent for both games stated that they would like to play the game again.

Both of this game using computer device as a tool to play it. Even though for Port Constructor it can be played not only on the computer but also on the table and any other smartphone devices. The result from both sessions is comparable in order to see how far Port Constructor as a renewal of SimPort has been improved. The other comparison that can be made is the interaction of the player with the computer. In SimPort game session, the research also held on several version of the game, which results in the better result when players played the game in the newer version. It was stated, “Players have more sense of and control over the simulated time and improving the user interfaces.” This loose of sense for a time also happening in the Port Constructor game where the player gave a relatively low score for this condition. But overall, both game sessions have positive feedback regarding playing the game using computer software, and also players enjoy using a computer to play the simulation game.

It is clearly stated that SimPort MV2 provided a learning experience regarding the strategical technical and commercial complexities of the project. In this case, Port Constructor could not provide all this technical approach because of the condition of the game itself. Port Constructor have higher abstraction compared to SimPort MV2 and also because of the first approach of the game is to be used as a single-player game with no necessary to play the game in a group discussion environment. On the other hand, if compared the use of the game to learn different type and design of port, Port Constructor fulfilled its objective. Port Constructor have more flexibility because facilitator can build their own scenario, compared to SimPort MV2 where only provide 1 type of port which is Maasvlakte 2 scenario.

10. Experiences and Conclusions

10.1. Facilitator and scenario developer experiences

All the analysis mentioned before was based on the player’s feedback and result analysis. In this section, facilitator’s experience will be explained. The first thing that the facilitator did is to build a scenario based on the existing assessment. Because of the condition of the game, simplification of a real port scenario is needed thus in the process of the scenario’s development facilitator created the virtual scenario in Microsoft Excel. Building the scenario inside map editor takes the longest time. Firstly, based on the available data a simplification was made by transferring the real data to fit into the game. From 3 main elements (Group, Function type, and Function) Function takes longer time than the others to be created. Inside this Function part, the scenario developers needs to provide the detail of the
condition for each type which is inserted with wrong values the result in the game will be unbalanced. They need to create every single element inside these function such as the size of the facility, the prices to build it, the maximum unit of this facility, etc. This kind of explanation was built based on the developer’s understanding with some help from port professionals because such data could not be obtained easily for public use. Thus, in order to create a function which reflects the real-life condition, several trials had to be made until the best value for each element inside this feature is found. In addition to that, to see whether this value is good enough to be used, it has to be tested in the trial game. After some correction was made, it needs to be tested again until facilitator found the best value for every facility.

While building this scenario, facilitator also found some elements and conditions that might not work or is not suitable in the previous game sessions yet. One of this element is Strategy. In the early explanation about the condition of the game, Strategy supposed to act as a strategic plan for the game. But from these sessions, facilitator found that it did not give any significant contribution to the derived score or revenue while playing the game. In addition to that, for the second session, facilitator adding what is called Incident, where the demand and capacity of the port can be manipulated in some rounds. But from the previous game session, this feature was not really visible to the player. This feature supposed to improve group discussion before taking action for the next steps in developing the port. But from the session held, players most likely not really aware of this situation. If applicable, the news about the happening incident supposed to be more noticeable to the player in order this function can be fully worked.

There is another condition that was not fully working from last sessions, it was the “People, Profit, and Planet” condition. This game is developed in such a way that the score is derived from the People Profit and Planet condition during each round. But from last game sessions, players was not fully aware about this situation. During the briefing on each game session, this condition was mentioned and it also appeared in the option when player choose each facilities that they want to build. But from facilitator point of view, it can be said that players were not fully aware, or not really care about the situation of each unit (People Profit and Planet). Players usually choose each facilities based only from Profit condition but not taking into account the other conditions.

As facilitator and scenario developer’s comment, even though one of the advantages of this game that it can be built with high flexibility, some function boundaries are necessary. For example, during the development of the port, a player tends to create their port following the higher factorize value, even though in reality such action may be impossible to be implemented. Such as, when the player decided to build a Container terminal, sometimes the value near the waterfront will be lower than the value inland which is not the case in reality. A recommendation for scenario developer, it is important to pay attention to the value of the dependencies. Because based on this study, even though a relatively high value was implemented on the dependencies while playing the game, those values could not be achieved as it is.

10.2. Conclusions
Based on the result analysis on the previous chapter, this section will provide the conclusion by answering proposed research questioned in the 1st chapter;
1. How can Port Constructor be used as an education tool for student and port planner?
By doing a game session, in the first-hand facilitator need to build the scenario in map editor then leave the development plan and action to the player. In this case, if the facilitator is the port planner and the game session was held for students in the port development, both parties will gain a learning experience not in planning a port, but also operating and taking action on developing a port.
2. What are the learning experiences that can be found after playing this game?
Because of the flexibility of the game, this game can be used to try for several designs of the port. For example, if a big group of student divided into several small groups and each group has to build their own port scenario and hold game sessions using each other scenario after that. Students will learn not only building and planning port scenario inside the game but also tried several designs of the port. It is
also applicable for port planner if they have to build several types of port with a different condition. But because of the condition of the game, if this game going to be used for real live port planning with a lot of complication surround it, a lot of improvement will be needed based on the condition of each port. Moreover, during the game session, players will have a chance to have a discussion with each other. Including action plan, preventive plan, they can have a sharing session based on their background experience in developing a port.

3. Comparing single versus multiplayer results, which method has the best outcome for education and port planning?

This game was meant to be used as a single player game. In order to see more about the capability of the game, facilitator tried to use the game as a multiplayer game. Base on the result of this study, it is clear that this game is also suitable as a group game. Moreover, player prefer to play this game as a multi-player game, because they can have more discussion and the game session feel more lively and realistic in that way. Based on the game session, using this game as a multi-player game has a better outcome because the player can have an open discussion, about decision making during the port development in each round.

Based on the several research question mentioned above, the primary question can be answered; Can the Port Constructor serious game be a useful tool for education and planning and designing of a port? Based on this study, the answer is yes. Port Constructor can be used as a learning tool for the student (in the port field) and also suitable for port professional by applying the mentioned method in this study, but for trying the design of a real port, improvement will be needed.

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