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Title: "Sim Greenland" - A Scenario-Based Serious Game for Citizen Involvement

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Abstract:

This master's thesis presents some of the challenges concerning Greenland's future development in terms of large scale projects, and how these can affect the local community. It will then be examined how a serious game can be used to simulate a large-scale project scenario and how such a game can be used to inform the player about possible consequences and problems, as well as collect data regarding choices and priorities for future studies. Subsequently, a description of the development of a "proof-of-concept" prototype of a scenario-based serious game will be presented as well as the testing and test results from test participants. Despite several issues concerning the testing, the results indicate that a scenario-based serious game could be suitably used for citizen involvement in regard to information, feedback retrieval and debate generation, provided a suitable amount of resources are utilized for the development and testing of the game.

Keywords: Serious Games, Scenarios, Simulation, Greenland, Citizen involvement, Public participation

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1 Resumé

"Hvad nu hvis...?" "Hvad sker der, hvis jeg gør én handling, i forhold til en anden?" "Hvad er konsekvenserne af mine handlinger eller mine ikke-handlinger?" "Hvad kunne være sket, hvis jeg havde gjort noget anderledes?" Disse er nogle af de ældste spørgsmål i historien, og nogle af drivkræfterne for menneskeheden siden tidernes morgen. Disse spørgsmål spørger om fremtiden og det ukendte, i forsøget på en eller anden måde at forudsige og forstå, hvad der kommer til at ske, før det sker. Det er naturligvis umuligt at **kende** fremtiden, medmindre du rent faktisk har været der, men at forestille sig mulige fremtider er ikke umuligt, og vi bruger det hver eneste dag for at flytte vores viden om det nuværende, ind i en projektion af en nær sandsynlig fremtid i vores tanker [5].

Et scenario er en sådan kognitiv konstruktion, en planlægning af (eller efter) begivenheder, der endnu ikke er sket, med hensyn til handlinger, reaktioner, interaktioner og/eller konsekvenser. Ved at designe og udvikle scenarier, er det muligt at afbilde resultaterne af ønskede handlinger, baseret på kriterier og udviklingsmodeller som kendes fra observation eller beregning. Scenarier er brugt hver dag, fra de simple aspekter i hverdagens beslutninger f.eks. at krydse en befærdet gade, til de langt mere komplekse vejr scenarier, brugt af meteorologer til at forudsige ændringer i det kommende vejr og ved endnu større skala som et planlægningsværktøj inden for langsigtet virksomheds- og statslige planlægning [10].

Tilfældet af Grønlands fremtidige udvikling, er en situation hvor scenarier har et stort potentiale på grund af usikkerheden omkring de kommende års muligheder. Adskillige grønlandske storskala projekter er i planlægning, såsom "Isua jern minen" [13], "Kvanefjeld mineprojektet" [12] og "Alcoa aluminiumssmelteren" [11] blandt flere, men da det stadig er ukendt, om de rent faktisk realiseres, er kravene til planlægning for de korrekte scenarier høj, konsekvenserne hvis ikke de rigtige problemer håndteres korrekt og belønninger hvis de rigtige valg træffes. For yderligere at komplicere emnet omkring den grønlandske udvikling, er størrelsen af den grønlandske befolkning, da det er ukendt hvilke effekter et nærliggende storskala projekt vil have på et lille grønlandsk samfund og de sociale, økonomiske og økologiske strukturer i området. Et stort antal forskellige scenarier kan således udvikles for grønlands fremtid, på forskellige skalaer.

En måde at teste disse scenarier, er givet ved brug af simuleringer, hvor en række scenarier kan implementeres baseret på deres begyndelses betingelser, modeller for deres sandsynlige fremtidige udvikling kan blive udviklet og tilføjet, og deres indbyrdes påvirkninger af hinanden observeret og testet. Det er da muligt at lave en prognose for forskellige resultater baseret på ændringer i modellerne, ændringer i de givne scenarier og ved at udvælge hvilke scenarier at simulere og hvilke at udelade.

Da borgerinddragelse og socialt engagement i den grønlandske planlægningsproces er vigtige for den demokratiske proces og til at opdage presserende spørgsmål og bekymringer i de lokale befolkninger [14], er det afgørende for processen at borgerne er godt informeret om mulige konsekvenser og fordele ved de forskellige storskala projekter, og at de holdes ajour omkring status og udvikling på projekterne. Desuden er det vigtigt, at tilbagemeldinger fra borgerne indsamles og anvendes i den fortsatte planlægning og udvikling.

Én måde at kombinere simulering af de givne scenarier informering af befolkningen og indsamling af tilbagemeldinger, er ved at udvikle et scenarie-baserede seriøst spil, hvor borgerne kan afprøve og opleve processen med forskellige scenarier, mens de oplyses om forskellige spørgsmål, udfordringer, konsekvenser og belønninger ved de forskellige storskala projekter. Denne tilgang gør det muligt for borgeren at reflektere over hans / hendes prioriteter for den fremtidige udvikling af det lokale område, samt at lære om den løbende udvikling og de mulige udfordringer, uden at det er nødvendigt for vedkommende at kende detaljerne i de forskellige scenarier eller deres underliggende modeller.

Specialets hovedfokus ligger på udviklingen af *"Sim Greenland"*, et scenarie-baseret seriøst spil, baseret på udfordringerne omkring den industrielle udvikling i Grønland, med borgerinddragelse som formål. I *"Sim Greenland"* spiller brugeren som den bestemmende instans for en mindre grønlandsk ø (topografisk baseret på den

grønlandske ø “Sermersût”) og er bedt om at udvikle øen med hensyn til industri, kultur, miljø, turisme og infrastruktur. Det er op til brugeren at opnå en balanceret udvikling og at udvikle det samfund som han eller hun ønsker det. Spillet forløber over 50 år i spil-tid, med mulighed for at øge tidens hastighed, mens der spilles.

Der testes hvorvidt et scenarie-baseret seriøst spil som *“Sim Greenland”* kan benyttes til at informere spilleren, indsamle tilbagemeldinger og hjælpe til at skabe debat. På trods af forskellige problemer med testen, indikerer resultaterne at et scenarie-baseret seriøst spil med fordel kan benyttes til borgerinddragelse, med hensyn til oplysning af brugeren, indsamling af brugerens tilbagemeldinger og ønsker, og som debatskabende hjælpeværktøj. Dette er dog forudsat at tilstrækkelige ressourcer delegeres til tilstrækkelig udvikling og testning af spillet.

Til slut beskrives i fremtidige værker, hvordan et spil som *“Sim Greenland”* med fordel kan forbedres og videreudvikles, og hvilke ændringer der i så fald bør gennemføres.

2 Introduction

“What if...?” “What happens if I do one action as opposite to another?” “What are the consequences of my actions or my non-actions?” “What could have happened if I had done something differently?” These are some of the oldest questions in history, and some of the driving forces for mankind since the dawn of time. These questions ask about the future, the unknown and the unknowable, in an attempt to somehow predict and understand what is going to happen, before it does. It is obviously impossible to **know** the future unless you have actually been there, but imagining possible futures is not impossible, and we use this every day, to move our knowledge of the present into a projection of a close probable future in our minds [5].

A scenario is such a cognitive construction, a planning of (or for) events that have not yet happened with regards to actions, reactions, interactions and/or consequences. By designing and developing scenarios, it is possible to depict the outcome of desired actions, based on criteria and development models that are known from observation or calculation. Scenarios are used every day, from the simple aspects of everyday life decisions e.g. when to cross a crowded street, to the much more complex weather scenarios used by meteorologist to forecast changes in the coming weather, and on even larger scale as a planning tools within long-term corporation and governmental planning [10].

The case of Greenland’s future development is a situation where scenarios have great potential, due to the uncertainties of possibilities in the coming years. Several Greenlandic large scale projects are in planning; such as the “Isua Iron Mine” [13], the “Kvanefjeld mining project” [12] and the “Alcoa smelter project” [11] among others, but as it is still unknown whether or not they are actually realized, the demands on planning for the correct scenarios are high, as are the consequences if the right issues are not handled and the rewards if the right choices are made. To complicate the issue of Greenlandic planning even further is the small size of the Greenlandic population, as it is unknown what effects a nearby large scale project will have on a small Greenlandic community and the social, economical and ecological structure in the area. A large number of different scenarios can thus be made for the future of Greenland, at various scales.

A way to test these scenarios, is given by the use of simulations, where a number of scenarios can be implemented based on their current conditions, models for their probable future development devised and added, and their mutual interactions and effects on each other observed and tested. It is then possible to forecast various outcomes, based on changes in the models, changes in the given scenarios and by choosing which scenarios to simulate and which to leave out. As public participation and involvement in the Greenlandic planning process are important for the democratic process, and to discover pressing issues and concerns in the local populations [14], it is vital to the process that the citizens are well informed of the possible consequences and benefits from the various large scale projects and that they are kept up-to-date on the states and developments of the projects. Fur-

thermore, it is important that the feedback given from the citizens are collected and used in the continued planning and development.

One way of combining the simulation of the given scenarios with the act of informing the population and collecting feedback, is by developing a scenario-based serious game, where the citizens can try out and experience the process of various scenarios, while collecting information about the various issues, challenges, consequences and rewards provided by the various large scale projects. This approach allows the citizen to reflect upon his/her priorities for the future development of the local area, as well as to learn about the ongoing development and the possible challenges, without the need to know the details of the various scenarios or their underlying models.

This master's thesis will present some of the challenges concerning Greenland's future development, how scenarios can be used to forecast the development of large scale projects in local communities, and how a scenario-based serious game can be used to inform the user while collecting feedback data from the user. Furthermore, a "proof-of-concept" prototype scenario-based serious game has been developed and tested, and the underlying scenarios and overall functionalities are described, as well as an evaluation of the game design, the testing method and the test results.

3 Developing Greenland

Greenland is an arctic region of 2,166,086 km^2 (410,449 km^2 ice free) with a population of only 56,370 people, of whom approximately 16,000 live in the capital of Nuuk [20,21]. It is a country rich in natural resources (minerals, oil and hydropower potentials) [9] and is the target for several large scale industrial projects currently in planning [1], with "large scale" projects defined as projects where [15]:

1. project construction costs exceed five billion Danish kroner and either
2. project's need for labour in the execution of construction activities exceeds the suitable, available and accessible labour that is available in Greenland, or
3. project requirements for technical and financial capacity of the companies that perform construction activities exceeds the Greenlandic enterprises' capability in technical or economic terms.

As such, the future of Greenland is very uncertain, as it is still unknown whether these large scale projects will be realized or not [1] and the size of the projects in relation to the small population makes the possible benefits and consequences of development hugely significant [1,8], for both the local communities and the country as a whole.

Some of the future challenges facing Greenland if the projects are realized are the issues of changes in demography and culture, pressure on infrastructure, environmental and ecological changes as well as social changes. On the other hand, if the projects are not realized, Greenland will face issues such as a decline in economy, increased emigration and increased urbanisation [1].

For the small communities of Greenland, a local large scale project can have a huge impact on the demography and culture in the area, as they can drastically change the local population composition, due to foreign migrant workers. This can put extra demand on the area infrastructure, such as healthcare and education services, transportation and renovation, as well as police and other services, and possibly make the Greenlandic ethnic group a minority in the community [1,8]. Furthermore, a large scale project has the potential risk of disrupting the local environment in terms of animal migration and pollution, which could affect the hunting and fishing in the area, as well as living conditions. To assess these issues, the project planners are required to perform various impact assessments, such as environmental impact assessments (EIA), social impact assessments (SIA) and to make an impact benefit agreement (IBA) [1,15,22,23]. To prepare for the development of potential large scale projects, there are high demands for planning and development of the Greenlandic infrastructure, which involve improving the amount of qualified skilled labour in Greenland, and reduce emigration [1]. In order to avoid future social

conflicts and issues, it is important that the inhabitants of the communities are consulted and that they are a part of the democratic planning process. It is also important that the planners have discussed problems and challenges properly, to find any issues that could be overlooked. In an effort to involve citizens in local areas, public meetings and hearings are being held and a study was done to help identify some of the biggest challenges and concerns in preparing for large scale projects, after which a workshop was hosted where some of the identified challenges were set up as scenarios [1].

3.1 Goal of Scenarios

Such scenarios can then be used at public meetings and/or discussion groups, to involve the public in the planning and development process. This kind of public participation allows the average citizen of the local community to gain a better understanding of the processes involved with the planning and development, the possible issues during the development, and the possible positive and negative consequences of the planned project [8]. Furthermore, it allows the host to collect valuable feedback from the participants, regarding their questions, uncertainties, priorities and wishes concerning the planned project and the development in the area, as well as clearing up any misunderstandings.

3.2 Developing Scenarios

The inherit nature of scenarios is that of speculation. As constructs of the mind, they reside in the realm between the plausible and the imagined [4,5]. Nevertheless they provide an invaluable framework which is used every day, at smaller or greater scale [5], from the simple scenario of crossing the street, to the complex scenario of projecting the weather. When developing a scenario, it is possible to try out actions and study outcomes, that would normally not be possible due to various factors e.g. scale, economy or time, and they allow for the study of complex systems, where sudden, unforeseen changes can occur, due to limited knowledge of the system or due to external influences [1].

When developing scenarios, however, it is important to realize that the result is not a prediction of the most plausible future but a projection of several potential futures, each based on driving forces that make them more or less plausible than others, and that the goal is not to find the “right” or “correct” scenario but to gain an understanding of the underlying mechanics and processes that determine the future development [4,1].

When developing the scenarios, several factors are in play:

- Firstly, a clear goal must be set e.g. a specific time frame, area of development or purpose for the scenario.
- Secondly, scenario parameters must be specified, e.g. driving forces, available options, possible consequence and fields of development.
- Thirdly, the scenario must be made uniquely different from the other scenarios, and not just a variation of the same theme and
- Fourthly, the scenario logic, storyline and end result must be devised.

From this, different scenarios can be developed, compared and tested against each other [4].

When looking at Greenland, a variety of different scenarios can be developed, based on the challenges and uncertainties that characterize the current state. These could be, for example, findings of oil, findings of minerals, the transfer of large amounts of foreign workers, lack of education, focusing on tourism or culture instead of industry, stagnant development etc.

One of the ways to test such scenarios is by implementing them into a simulator, where the scenarios can be tested in a controlled environment, without the need for real-life implementation, which can be infeasible due to scope, cost, time or other factors. The various outcomes of the scenarios can then be recorded, providing new

insights and knowledge in the given field of study. While conventional scenario models and simulations have been run by computers, more and more simulations are developed with the goal of using human interaction and creativity to find uncommon solutions to complex problems, not easily found by computers [24,25,26]. Other instances of scenarios and simulations where human interaction is needed have the goal to train, educate or enlighten the user, or to study the users' feedback, reactions, choices, or priorities. For this kind of training or study, serious computer games (see Subsection 3.3) provide a versatile platform, that enables the training or study of multiple users at once, as well as a way of conveying complex information to the user in an easily conceivable form. In the case of the Greenland scenarios, these scenarios can be combined with the notion of serious games (see Subsection 3.3), and a simulation game can be developed which is based on or incorporates different scenarios, which can then be easily tested and processed by a target user group, allowing the user group to play out the scenarios.

3.3 Why So Serious?

Many terms for serious games exists, such as *learning games*, *edutainment*, *serious games* and *game-based learning* among others [2] and several different definitions are found as well. Discussing the various definitions and terms is outside the scope of this paper, and thoroughly done by others [2,3,6,7]. Though many of these terms and definitions are fitting for most serious games, they mainly favour edutainment titles, and thus fall short when confronted with more research-oriented games; thus, this paper will employ the term "serious games" and follow the definition of serious games as *"games that do not have entertainment, enjoyment, or fun as their primary purpose" [6]*.

Though this definition leaves out games with the main focus being entertainment, some of these games can be considered closely related or borderline serious games, as they revolve around serious issues and/or challenges (see Section 3.4).

Serious games cover a wide variety of games, within multiple fields of use, targeted towards various age groups and towards different platforms [7]. This makes serious games a versatile platform for testing or research, as they allow huge user bases with multiple people playing at once [24,25]. Furthermore, the complexities of a given simulation or the specifics of a given scenario can be hidden from the user, allowing the user to use the simulation or scenario without needing to know the details of its design [16,17].

When using serious games for gathering feedback, this can often be done automatically, without disturbing or interrupting the user; e.g. by collecting the data from processes within the game, and sending it anonymously to a server which can then collect and save the data, as well as extract the needed statistical information and forwarding it to the researcher. Another way to gather the feedback data, can be to present the user with a questionnaire while playing, or after the game is finished, or to conduct an interview with the user during or after the game.

3.4 Related Works

In the area of serious games, though hundreds of different games exist, most of these are focussed on education or training, and are targeted towards children or young adults [7]. To our knowledge using a serious game for citizen involvement in regard to planning and development is new; however, the idea of using serious games for research is not. Several research-oriented serious games exists, such as the *The Quantum Computer Game* [24] which deals with building the basic components such as gates for a quantum computer, as well as other physics challenges, or the *EteRNA* [25] and *FoldIt* [26] games, which are concerned with building a synthetic RNA library and protein folding, respectively, to mention a few. Furthermore, several scenario-based games exist among commercial games, and although not serious games by our definition, they can be viewed as borderline serious games as they revolve around areas such as global warming (with the game *Eco Tycoon: Project Green* [16]) and government management (with the games *Democracy* and *Democracy 2* [17]).

Within the area of scenarios, large scale project planning and using scenarios, several works including *"Imagining the Future of Greenland"* [1] are concerned with using scenarios for public participation in regard to the planning and development of large scale projects in Greenland; e.g. *"Scenario building: a suitable method for strategic property planning?"* [4] which focuses on the planning, development and execution of scenarios as a planning method, and *"Planning For The Impacts Of Megaprojects"* [8] which focuses on the planning and development of large scale projects in Canada and Greenland.

4 Sim Greenland

The main focus for this master's thesis is on the development of *"Sim Greenland"*, a "proof-of-concept" prototype scenario-based serious game, based on the current issues concerning the industrial development in Greenland, with the purpose of citizen involvement and public participation.

In *"Sim Greenland"* the user plays as the governing body of a small village on a Greenlandic island (topographically based on the Greenlandic island "Sermersût") and is asked to develop the island with regards to industry, culture, environment, infrastructure and tourism. It is then up to the player to acquire a balanced development, and build the society as he/she wishes. The game runs for 50 years in game time, with the ability to speed up or slow down time while playing.

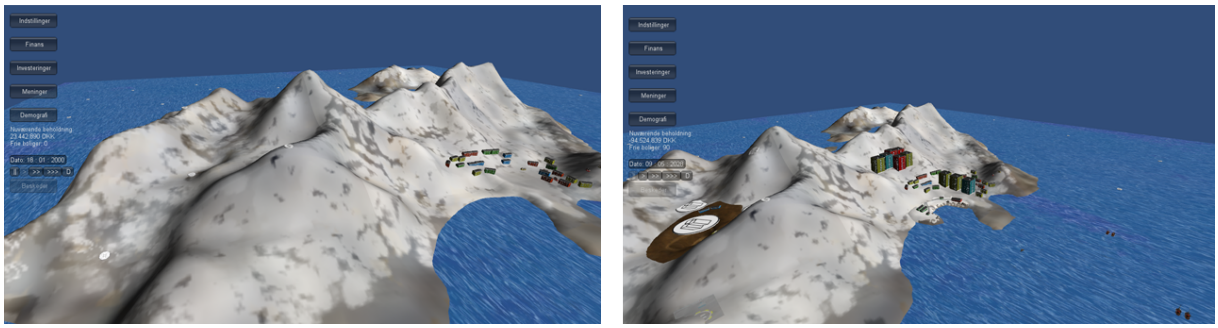

Fig. 1. The main screen of "Sim Greenland", before and after some development. The game is developed using the Unity3D engine and uses 3rd party 3D models and textures [27].

The user plays the game by choosing between different investments available; such as housing, prospecting, cultural or environmental protection, tourism attractions or fishing, among others. The various investments affect the area in different ways, for example investing in small scale fishing benefits the local industry a little and is safe, while investing in large scale fishing benefits the local industry greatly, though also carrying the risk of overfishing and thus removing the fish as a resource in the area, destroying the fishing industry and damaging the environment. These various effects on the area are shown on a feedback screen, where sliders show the user the current state of the different categories (industry, culture, environment and tourism), as well as a written feedback text describing the current state for each category. When the user is done playing, either by exiting the game or by allowing it to play out the 50 years run, an "ending" screen informs the player how his/her collected choices affected the area, and in what way.

"Sim Greenland" is a management game, where the challenge presented to the player is that of managing the island, in regard to development. The win and lose conditions of the game are the same, and happen automatically when the game has been played for 50 years in game time. The game utilizes a Free-3D perspective (see Fig.1), where the user is able to zoom in or out as desired and move the camera freely, within the constraints of the game world.

4.1 The Game Scenario

The game is based on a coarse simulation model of four different scenarios and their mutual interactions:

- Stagnation scenario
  The stagnation scenario is the null-scenario for the other three scenarios, and is carried out by doing nothing in the game.
- Tourism scenario
  The tourism scenario is played out if the user focuses on developing tourism, compared to the other areas. The effect of playing the tourism scenario is an increase of the tourism statistics in the game, and a decrease in the culture and environment statistics in the game.
- Culture and environment scenario
  The culture and environment scenario is played out by investing in culture and environmental protection projects in the game, thus increasing the environment and culture statistics in the game. This limits the available industrial projects in the game, but also increases the tourism statistics.
- Mining and industry scenario
  The mining and industry scenario is played out by focusing on investing in industry projects, such as huge fishing industry, prospecting licenses, mining operations ect. This increases the industry statistics in the game a lot, though decrease the environment, tourism and culture statistics with an equal amount.

Furthermore, several other factors play a role, such as overfishing and sustainability, urbanization and ghettoisation, as well as pollution and demographical composition.

Looking at the three scenarios in regard to the four points for scenario development (see Subsection 3.2), the goal for each scenario is the development in the given time frame, the scenario parameters for each is the fields of development and their consequences, and they differ from each other in the way that they are based on different fields of development. Lastly, their end results are devised, by calculating a combined score in the given field of development.

The goal for the implemented game prototype is to try to inform the user about the current situation in Greenland and to collect feedback data about the users' priorities in regard to the fields of development.

4.2 A Numbers Game

To obtain as realistic a setting as possible, the numbers used for the various investments in the "Sim Greenland" game, e.g. building cost, taxation level, income, living spaces, among others, were obtained from real sources whenever possible, and otherwise estimated based on the available numbers or modified for the sake of game balancing. The numbers where gathered from sources such as "Permagreen Grønland A/S" [28], "Greenland Statistics" [29], "The Greenland Tax Administration" [30], as well as various Greenlandic projects [31,32,33] among others. The effect of the different investments on the local area where calculated based on the current value for each of the relevant feedback categories (industry, environment, culture and tourism) and an effect modifier given to each investment, to ensure that the feedback values never went outside a given threshold, and to balance the effects of investments. This was done by adding the modifier values through a modifier equation (see Equation 1) resulting in the effect graph shown in Fig. 2.

$$newFV = \begin{cases} oldFV + ((100 - oldFV)\,(mV/100)) & \text{if oldFV} \geq 0 \\ oldFV + ((100 + oldFV)\,(mV/100)) & \text{if oldFV} < 0 \end{cases} \tag{1}$$

In the equation, newFV is the new feedback value, oldFV is the old feedback value and mV is the modifier value. The start value of the feedback value is always 0, thus the feedback value can never go above 100 or below

-100, if mV is between -100 and 100. As the added change approaches 0, so do the feedback value approach 100 and -100.

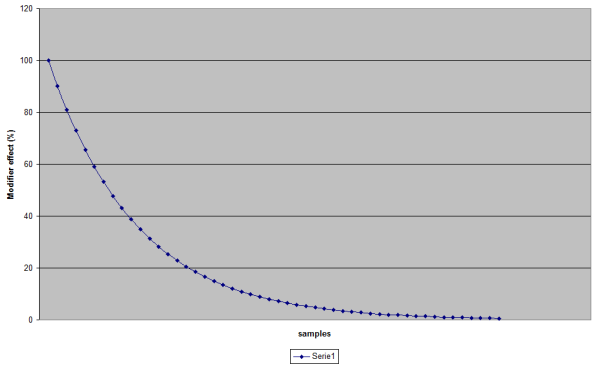

Fig. 2. The effect of the modifier on the feedback value in %, depending on modifier size and current feedback value. Y-Axis: effect of the modifier value in %. X-Axis: Number of times modifier value added to feedback value. Start value of feedback = 0, modifier value used = 10.

As can be seen by the graph, the higher the value of the current feedback value is, the less impact the modifier value provide. This was done to keep the number within the limits, but also to convey that the same investment has different impact on the area, depending on circumstances, e.g. adding the pollution from a fishing boat to the environment does not make as big a difference if the area is already heavily polluted, as if the area have no pollution at all, or adding a new tourist attraction to an area with heavily tourism does not make as big a difference, as adding it to an area with no or little tourism.

For each investment, the following modifiers were used:

- Expenses
  - Construction cost - Everything was given a construction cost, which was then spread out to be paid during the construction period of the investment. The construction cost was estimated based on numbers from [28].
  - Running cost - When the investment was constructed, a given running cost was used instead, which was then paid annually during the lifetime of the investment. The running cost was estimated based on the Greenlandic median salary obtained from [29] and modified for game balance.
- Incomes - The investment income was implemented in two parts as with the expenses, though during construction the income was always set to 0, as the investment was not yet operational.
- Workforce - The number of workers (free living spaces) required for the investment. During the construction phase, population units are added to the area demographic, based on the workforce needed for the investment. This include the number of workers, as well as the worker nationality and their spoken language, based on [33] and [21].
- Feedback modifiers - A positive or negative modifier value was given for each affected category depending on the nature of the effect. E.g. a metal mine would have a positive modifier value for the industry category, but a negative value for the environment category. This modifier value was then added to the category feedback value when the investment was constructed, by using the equation (see Equation 1).
- Needed requirements - in addition to the workforce, most investments required a natural resource and/or the construction of another investment to be constructed, or function properly, depending on the size of the investment. E.g. a large fishing investment would require a harbour investment, as well as a suitable amount of room for workers and a large enough fishing resource to continue functioning after construction.

Table 1 shows the implemented investments in *"Sim Greenland"*:

Investment (size)	Category	Expenses / Incomes				Requirements		Modifiers				Other
		Con.	Run.	Inc.	FLS	Res.	Inv.	I	E	T	C	
Housing (1)	Inf	6.25	0.8	0.81	-	-	-	-	-	-	-	+16 FLS
Housing (2)	Inf	40	4.2	4.28	-	-	-	-	-1	-	-1	+84 FLS
Harbour	Inf	50	1.4	0	5	-	-	3	-2	2	-	Unlocks Sea
Helipad	Inf	10	1.4	0	5	-	-	1	-	3	-	
Tourist office	T	1	1	0	5	-	-	-	-	15	-	Unlocks Tourism
Souvenir store	T	1	1	1.27	5	-	-	-	-	5	3	
Restaurant	T	2.5	4.64	5.27	25	-	-	-	-	5	4	
Whale watching	T	0.175	1.9	2.36	10	Whale	T, Ha	-	1	5	2	
Tourist flights	T	2	1	0	5	-	T, He	-	-	3	-	
Coastal sailing	T	1	0.1	0	-	-	Ha	1	-	1	-	
Coastal cruise	T	1	0.1	0	-	-	T, Ha	-	-	3	-	
Deep-sea fishing	T	0.175	1.9	2.36	10	Fish	T, Ha	-	-	4	-	
Nature park	E	0.28	0.28	0	-	Nature	-	-	10	5	5	Locks Area
Preservation of land area	E	0.28	0.28	0	-	Nature	-	-	15	2	5	Locks Area
Museum	C	X	1.8	0	10	-	-	-	-	2	10	
Protect cultural remains (area)	C	0	0.28	0	-	Culture	-	-	-	-	10	Locks Area
Prospecting license (1)	I	0.78	-	-	5	-	-	1	-	-	-	Shows Resources
Prospecting license (2)	I	1.5	-	-	10	-	-	1	-	-	-	Shows Resources
Prospecting license (3)	I	2.29	-	-	15	-	-	1	-	-	-	Shows Resources
Prospecting license (4)	I	3	-	-	20	-	-	1	-	-	-	Shows Resources
Prospecting license (5)	I	3.79	-	-	25	-	-	1	-	-	-	Shows Resources
Exploration License (Metal)	I	-	-	**	X	Metal	-	2*	-	-	-	Shows R. Value
Exploration License (Diamond)	I	-	-	**	X	Diamond	-	2*	-	-	-	Shows R. Value
Exploration License (Uranium)	I	-	-	**	X	Uranium	-	2*	-	-	-	Shows R. Value
Mine (Metal)	I	0	0	***	500	Metal (5)	-	8*	-5*	-4*	-	
Mine (Diamond)	I	0	0	***	500	Diamond (5)	-	8*	-4*	-3*	-	
Mine (Uranium)	I	0	0	***	500	Uranium (5)	-	8*	-6*	-5*	-	
Fishing vessel(s)(1)	I	0.04	1.6	****	10	Fish	Ha	2	-1	-	1	
Fishing vessel(s)(2)	I	0.09	3.1	****	20	Fish	Ha	4	-2	-	1	
Fishing vessel(s)(3)	I	0.13	4.62	****	30	Fish	Ha	6	-3	-	1	
Fishing vessel(s)(4)	I	0.18	7.64	****	50	Fish	Ha	8	-4	-	1	
Fishing vessel(s)(5)	I	0.22	15.18	****	100	Fish	Ha	10	-5	-	1	

Table 1. Categories: Inf = Infrastructure, T = Tourism, E = Environment, C = Culture, I = Industry. Expenses/Incomes: Con. = Construction cost, Run. = Running cost, Inc. = Income, All values are in million Dkk. Required investments: Ha = Harbour, T = Tourist office, He = Helipad. FLS = Free Living Spaces. X = Missing. * = Number multiplied with investment size.

Some of the investments shown in Table 1 have varying income, depending on different circumstances, which are detailed hereafter:

Exploration license incomes The exploration license is a special investment, as it is not an actual investment, but rather an approval of the application to explore an area, by an interested party, e.g. a domestic or foreign company. As such it does not have a construction or running cost, but it also does not provide a direct income. The exploration licenses are implemented following the legal rules for exploration licenses in Greenland [34], by which the exploring party is required to invest a specific amount of money in the area every year, e.g. by buying supplies, machines ect., depending on licensing year. This is illustrated in the game as the income and is thus subject to change several times. The income amount is calculated in Equation 2.

$$Income = \begin{cases} (100,000Dkk + (1,000Dkk * explorationSize * 10)) * taxationPercentage & \text{Year 1 - 2} \\ (200,000Dkk + (5,000Dkk * explorationSize * 10)) * taxationPercentage & \text{Year 3 - 5} \\ (400,000Dkk + (10,000Dkk * explorationSize * 10)) * taxationPercentage & \text{Year 6 - 10} \end{cases} \quad (2)$$

No standard exists for licenses longer then 10 years, as these are individually negotiated between *The Bureau of Minerals and Petroleum* and the licensee.

Mining investment income As with the exploration license, the mining investment is not an actual investment, but an approval of transforming an exploration license into an exploitation license, bearing a mining operation. Unlike the exploration license, no standards exists for the exploitation license in regard to minimum investments in the area, though negotiations of royalties are done on a case by case basis. Thus the income from the mine in the game is covered by the increase in population tax income from the required workforce.

Fishing investment income The income from the different fishing investments are calculated based on the available fish resources in the affected area. This is done by calculating the values of the fish resources in the affected area, where the affected area is dependent on the size of the fishing investment, and the fish resource value is dependent on the resource size and whether or not it is utilized sustainably. The calculation follow the formula in Listing 1.

```
collectedFishValue = 0
Foreach fishResource in affectedArea
 collectedFishValue = collectedFishValue + fishResourceValue
If (collectedFishValue - investmentSize <= 0)
 InvestmentIncome = 0
Else
 InvestmentIncome = (medianIncome * workers) * (collectedFishValue - investmentSize)
```

Listing 1. Fishing income

The value of the fish resources are altered depending on whether or not they are utilized sustainably, as overfishing of the fish resources will cause their values to drop. A fishing investment distributes its weight (equal to size) equally across the available fishing resources in its area of effect. E.g. a size 3 fishing investment with 2 fishing resources in its area of effect, will place an equal weight of 1.5 on each fishing resource. If the combined weight of the affecting fishing investments of a fishing resource is higher then its value, the value of the fishing resource will start to drop. If the collected weight on the fishing resource is greater then 1 above the fish resource value, the weight above the fish resource value is subtracted from the fish resource value. For example, if two fishing resources have a value of 2 and is within the area of effect of a size 3 fishing investment and a size 4 fishing investment, the fishing resources will each be affected by a combined weight of 3.5 from the two fishing investments. This is more then 1 above their value, and thus they will each drop to a value of 1.5. As the overfishing continues, the values of the fishing resources will continue to drop, until the value reaches 0, after which the resources are removed and the environment feedback value is modified with -2 for each of the two resource, through the modifier equation (see Equation 1). If a fishing investment is overfishing, the *collectedFishValue* in listing 1 will drop for the given fishing investment, and its *investmentIncome* will go towards 0. If all fishing resources in the area of effect of a given fishing investment are gone, the fishing investment will close and be removed from the game.

Yearly updates The *"Sim Greenland"* game is event driven, in the way that the game is based on dates and the progression of time, and all in-game objects receive an event update once a day. Once a year, every resource is updated with a sustainability check, and over-exploited resources, e.g. fishing resources, are updated with a new value where applicable. Furthermore, the area finance is updated in regard to income and expenses from investments, and the taxation income is calculated based on the number of inhabitants in the area, the median income in Greenland [29] and the taxation percentage [30].

5 Testing

In this section the design of the test will be presented, as well as a pre-evaluation of the expected results and the final results of the testing.

5.1 Test Design

To make sure the test of the prototype game provides as usable and relevant data as possible, the test was designed for a test group of individuals, sitting by their own computers and with access to the Internet. The test group was then asked to download the game from an open link, play through the game once to several times depending on preferences and when they had finished the game, answered a short online questionnaire. The choice to use a downloadable game and online questionnaire was due to the ability to reach more test participants simultaneously, and thus a larger data base within a limited period of time. The disadvantage of this type of test is the bias on quantitative data compared to the qualitative data obtained by e.g. a structured interview with the test participants, within the controlled environment of a test setting. Apart from the questionnaire which focused on the understanding and playability of the game, as well as how information was conveyed and understood, the game itself collected data from the user while playing, thus recording the users' choices from within the game.

5.2 Pre-evaluation

Some of the big questions when evaluating the data were *"1. Are these results based on the actual wishes and preferences of the users?"* This is an important question, as it is possible that the user made the given choice just to try out various options in the game, wanting to play the game as entertainment and thus wanting to see what would happen, and not as was intended, to make the choices based on his/her personal preferences for the future development of Greenland. Another question was *"2. Did the game succeed in its intended purpose?"* Being to inform the user about the current situation in Greenland and collect the wishes and preferences of the user. And *"3. Did the users understand their choices?"*, leading to the final question *"4. How are the in-game choices usable?"* If the user did not understand the game and what effect the different choices had on the outcome of the game, the choices provided by the user are not usable, and thus care must be taken in future works to make sure the user understands the effect of his/her choices.

To answer these questions, the following approach was conducted:

1. To ensure that the collected data actually represents the preferences of the user towards the future development of Greenland, the game asks the user whether or not she/he is happy with the choices made during the game. The resulting data is then tagged, to reflect the user's answer. If the user is unhappy with the choices, the user can play again.
2. To answer whether or not the game informed the user and collected data, the questionnaire given to the users asks if the user has gained knowledge about the situation in Greenland and about the advantages and disadvantages of large scale projects, and the data collection was tested during development.

3. To help ensure that the user understands the choices that he/she makes in the game, and the consequences of these choices, the possible choices in the game have a description, explaining what it does and the consequences of the given choice. Furthermore, several feedback messages explain the current state of the game.
4. Provided that the user understood his/her choices in the game, the user was happy with his/her choices and that the user gained knowledge and/or information from the game, the user choices from the game are usable, as they indicate that a serious game can be used to collect data from the user, inform the user about the Greenlandic situation and large scale projects (and their pro's and con's). Furthermore, the data indicate the preferences of development for the user, based on the given scenarios.

5.3 Results

Due to time constraints only one test was held with eight test participants. Table 2 shows the results gathered from the game during the testing, and Table 3 shows the results from the questionnaire.

Investment	Category	Invested by % of participants (hits)
Housing	Inf	100 % (67) (*)
Harbour	Inf	100 % (8)
Helipad	Inf	100 % (8)
Tourist office	T	87.5 % (7)
Souvenir store	T	87.5 % (7)
Restaurant	T	62.5 % (5)
Whale Watching	T	100 % (17) (*)
Tourist flight	T	75 % (6)
Coastal sailing	T	87.5 % (7)
Coastal cruise	T	87.5 % (7)
Deep Sea Fishing	T	62.5 % (5)
Natural Park	E	100 % (8) (*)
Protect the area (country)	E	62.5 % (5) (*)(**)
Museum	C	100 % (8)
Protect cultural remains (area)	C	50 % (4) (*)(**)
Prospecting license	I	100 % (21) (*)(**)
Exploration license (metal)	I	50 % (4) (*)
Exploration license (Diamond)	I	0 % (0) (*)
Exploration license (Uranium)	I	0 % (0) (*)
Mine (Metal)	I	0 % (0)
Fishing vessels	I	100 % (22) (*)

Table 2. Categories: Inf = Infrastructure, T = Tourism, E = Environment, C = Culture, I = Industry. (*) = These investments could be constructed more than once, and should be seen in relation to the rest of their category. (**) = An error occurred in recording, corrupting the results from the Danish game version and these data are omitted.

Due to a corruption of the recorded data, the final results (investment summary) of the individual games where not obtained, though the collected data indicates that most of the participants focused on developing the tourism in the game, and while the test participants invested in the prospecting license, only four exploration licenses where invested and no mines. Combining the data collected from the game with the questionnaire, show an indication that the test participants preference of investments was tourism as the first choice, environment as the second, culture as the third and industry lastly, with the only real investments in industry being fishing.

Summary questions	Summary of Answers
Did the user understand the game?	86.6 % understood the game.
What was the reason for your choices?	50 % personal preferences.
Did the user gain new knowledge?	27.5 % gained a small amount of new knowledge(*).
Could a game like *"Sim Greenland"* be used to generate debate?	50 % answered "Yes", 12.5 % answered "No".

Table 3. The participants where given four questions participating to understanding the game and eight questions participating to their knowledge before and after they played the *"Sim Greenland"* game. (*) Averaged over the number of answers.

6 Discussion

In this section the test and game is evaluated and discussed.

6.1 The Test

Finding any test participants of Greenlandic origin within the time frame proved unobtainable, and as such test participants of Danish origin were used instead. Eight test participants were used, between the age of 16 and 30, and all played the game once.

Test Model The test model used was based on quantitative data collection, within a short time frame, and as such the game was distributed online, with the users downloading and playing the game, while the game recorded data automatically, followed by answering a questionnaire. This method proved useful for gathering quantitative data quickly, though did not allow for the gathering of qualitative data as could be obtained with a structured interview, nor did the method allow for clarifications or elaborations for the test participants.

Test Results Though no statistically significance can be shown by the collected data, the questions asked in Section 5.2 can still be answered.

1. *"1. Are these results based on the actual wishes and preferences of the users?"*
   based on the answers to the questionnaire and the collected data from the game, the data indicates that the results are the preferences of the users.
2. *"2. Did the game succeed in its intended purpose?"*
   The intended purpose of the game was to:
   A Inform the user.
   B Collect feedback data from the user.
   C Be used to generate debate about the current state of Greenland, the future development of Greenland, and large scale projects in Greenland

   A: Looking at the results from the questionnaire, 27.5 percent of the participants believed they gained a small amount of knowledge from the game. As this number is fairly low, and the participant who believed they gained knowledge, only thought they gained a small amount of knowledge, this result is believed biased positively, by asking the participants about their knowledge before and after having played the game. A better way to test this, could have been by supplying the participants with a questionnaire before playing the game, as well as after playing the game, with specific questions regarding large scale projects or the development of Greenland. Thus in the view of this group, the game did not succeed in informing the user.
   B: As the game collected data from the users while playing, although not all data was collected as intended, due to data corruption, it is the view of this group that the game succeeded in collecting feedback from the

user.

C: Even though the game failed in informing the users, half of the test participants believed that a game such as *"Sim Greenland"* could be used for generating debate about the future of Greenland and large scale projects, while only one of the participants did not believe so. It is the view of this group that simply playing a game concerning the issue of the future development of Greenland, might help raise awareness of the issues, and if a game is developed that succeed in informing the user, this will be usable for generating debate. Thus it is the view of this group that the game succeeded, at least partially, in being able to be used to generate debate about the future of Greenland and large scale projects.

3. *"3. Did the users understand their choices?"*
   Based on the questionnaire, the users did understand their choices within the game, as well as the consequences of these choices.
4. *"4. How are the in-game choices usable?"*
   Based on the collected data, the users did understand the choices and consequences within the game and the users choices were based upon the personal preferences of the users. Thus the users' in-game choices indicate that a serious game can be used to collect data from the user and that these data indicate the user's preferences in regard to the future development of Greenland.

6.2 The Game

The game prototype was planned to be a, as realistic as possible, scenario-based serious game, simulating the development of a small Greenlandic village, including numerous options for development within tourism, culture, industry, environmental protection and infrastructure, and showing accurate calculations of social, demographic, economic and environmental changes throughout the game span. Unfortunately this proved overly ambitious and undoable within the time frame and with the allocated resources. The final game version developed contained several development options within the tourism and industry categories, but only a few options within the culture, environment and infrastructure categories. Furthermore, while using realistic numbers for taxation and construction costs for most investments, due to the limited number of infrastructure options and expenses, the game economic was hugely unbalanced resulting in a never-ending stream of money while playing, with only minor setbacks while constructing new investments. While the demographic changes was implemented, based on the needed workforce when developing new investments, the resulting social changes were never fully implemented, and as such did not affect the outcome of the game.

Game Interaction While the perspective of the game was fitting, several issues were found with the user interaction in the game. While moving around the map could be done with the keyboard, looking around could not, and should have been implemented with key bindings, e.g. "Q" and "E". Furthermore, zooming into or away from the map was only implemented for keyboard, and should have been implemented for mouse, e.g. with the mouse wheel. When placing the various investments on the map, if was different whether or not they needed to be placed on the map or if they where placed automatically, which should have been implemented more consistently. Furthermore, the right mouse button was used both for when looking around and for cancelling the chosen investment, resulting in the user needing to chose the investment again, if having to look around. This should have been kept separate.

Feedback The user was given feedback when placing investments, in that the placed investment became see-through when placed, and then became gradually more solid when constructed, and when clicking on the investment, a building percentage indicator would show how far the investment were in its construction. Furthermore,

investments that needed a specific resource would show an effect area, indicating the area of effect for that investment. For the feedback in regard to the effects of the various investments, the description of the given investment showed what effect they would have on the various categories, and the commutative effect could be seen on the feedback screen, together with a feedback text, describing the current situation. The feedback could have been improved, however, by implementing different building models for development, so new investments showed a partially constructed building, leading to the finished building upon completion, as seen in most commercial real-time strategy games, and by showing a small building percentage counter on the main screen. Furthermore, the feedback of the game economy was lacking, as the user had to click the finance screen, and would not get a warning when entering a negative bank balance. This could be improved with a yearly finance report as seen in games such as *"Open Transport Tycoon Deluxe"*, as well as pop-up warnings. In regard to the investment effect feedback, this could be improved by instead of showing the numbers and text as used, a graph could show the changes in value for the various categories over time, using indicators on the graph to show what investments provided which effect.

7 Conclusion

The greatest issues with the game was found to originate in the fact that the game and underlying scenarios were developed simultaneously, and thus the underlying models were not yet set when development on the game began. This further affected the design decisions for the game, and should have been avoided. Having the scenarios planed out and completed before development of the game began, would have helped the game development and made game design decisions easier, as it would then have been clear what functionalities would be needed, and how they would affect each other, before development began, saving time and resources during development.

While a test was conducted, several issues arose during the test phase of the project, which were not corrected due to lack of resources. Continued development on the game to resolve the various issues as well as better balancing, could lead to a test on a larger scale with participants of Greenlandic origin, which in turn could provide better results.

Based on the collected data and the answers to the questions in Section 5.2, it is concluded that a scenario-based serious game can be used to inform, gather feedback and generate debate, provided a sufficient amount of resources is used on its planning, development and testing.

8 Future Works

For future works the *"Sim Greenland"* game should be revised and continuously developed to improve its usability and functionality in regard to providing information to the user, to expand upon the implemented scenarios in regard to detail, driving forces, effects and interaction between the scenarios, as well as allow for implementation of more scenarios. Furthermore, the resource part of the game should be revised, to allow for more diverse resource options in a more consistent manner, and the game world should be revised to allow for multiple other investments options and types of resources. The social, demographic and economic sections of the game should be revised, to allow for more detail and consistency, e.g. in regard to unemployment, education, age and gender. To allow for these changes, better underlying models are needed, that simulate the demographic, social and economic mechanisms and changes in detail, in order to simulate the underlying structures of a real society.

The user interface of the game should be improved as discussed in Subsection 6.2, and usability tests should be conducted to ensure easy interaction with the game by the target group, which can consist of a mixture of several different age groups as well as a mixture of technical experience and educational backgrounds.

A future large scale test should be done with participants of Greenlandic origin, using the examined methods for quantitative data collection, as well as qualitative methods, such as structured interviews.

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