Simulated real worlds: science students creating sustainable cities in the urban simulation computer game SimCity 4

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Abstract
This paper presents an empirical study involving 42 science students playing the urban simulation computer game SimCity 4 with the mission to create sustainable cities. The aim of the study is to empirically explore a science learning context supported by SimCity 4. Focus group interviews and video recordings were used to gather data. The outcome is an analytical description based on the students’ retrospective reflections upon their cities, and the assumptions underlying their design choices. The findings indicate that SimCity 4 did provide a fictitious urban environment where the student could experiment and make use of their scientific knowledge, and experience consequences of their actions, factors that in this paper are referred to as simulated real world problems. The findings also point out that restraints set by the game rules limited the students to accomplish ideas that could not be framed within the game. Instead, these ideas were expressed in other media outside the game (physical models and essays). This observation emphasises the importance of looking at educational use of computer games as an interplay between game, student, context, and teacher.
A simulated real world

"You start by building a small housing area which then begins to grow. You’ll get to see how it evolves and develops a need for other stuff. It’s pretty much that you have to organise, not only rescue services, you have to have a school, you have to have culture and museums and that kind of stuff too. It’s a small picture of reality but it’s still so much better than only to build a model, because then you wouldn’t reflect upon all these things."1

This paper presents an empirical study (still a work-in-progress) involving 42 science students playing the urban simulation computer game SimCity 4 (Maxis, 2003) in an educational setting. The case studied is Future City2 which is a national competition for Swedish students in grade 6-9 (12-15 years old) that take on the role of urban planners with the mission to create sustainable cities. Besides playing SimCity 4, the students also build physical models of the cities, and write essays describing their creations. Previous research bring forth the potentials of urban simulation computer games to facilitate learning about the complex, dynamic, and interrelated nature of urban problems (Adams, 1998; Beckett & Shaffer, 2005). Urban simulation computer games, like SimCity 4, afford fictitious urban environments where students can manipulate variables in the system, and experience consequences of their actions.

Computer games and learning
Research presented in previous literature (c.f. Barab & Dede, 2007; Gee, 2003; Egenfeldt-Nielsen 2006, 2007; Kirriemuir & McFarlan, 2004; Malone, 1981; Shaffer, 2007) point out the learning potentials of computer games, and other digital media with interactive and visually driven learning environments. These types of learning environments are claimed to be challenging the more traditional modes of communication as they are better suited to the contemporary school generation (Gee, 2003; Shaffer, 2008). From a sociocultural point of view a computer game can be described as a carrier of culture with certain affordances and restraints that enables the gamers to do, experience and learn things that they cannot achieve without the tool (Gee, 2003). To learn how to master a computer game and, consequently, to learn how to communicate and act on a higher level, is assumed to carry great motivational potential for learning (ibid.). Previous literature (c.f. De Freitas 2005, Egenfeldt-Nielsen 2006, 2007; Linderoth et al. 2002; Mitchell & Savill-Smith, 2004, Rutter & Bryce, 2006) also state that most of the research results presented so far are based upon theoretical assumptions. If the links between computer games and educational objectives are to be considered, more empirically based studies are required.

Aim of the study
The study presented in this paper aims at contributing to the computer games and learning research field by empirically explore a science learning context supported by SimCity 4 (Maxis, 2003). The topic investigated is if interactions in this gaming environment can provide a context where students are confronted by simulated real world problems, and can contextualise and apply their scientific knowledge.

1 Quote by student about using SimCity 4 to build a sustainable city (by the author translated into English).
2 www.futurecity.nu
Methods

Data gathering method and sample
Focus group interviews were utilised to gather data on the students’ retrospective reflections upon their cities, and the assumptions underlying their design choices. Eleven semi-structured focus group interviews (2-6 students/group) were conducted with 42 14-15 years old students (30 boys, 12 girls) from four schools. The schools were by the research team picked out (based on geographical accessibility) but the participating student groups were selected by the teachers. The gender imbalance among the interviewed students can here only be referred to as coincidental. Each interview took 20-30 minutes, and was performed in separate rooms at the schools. A video projector was used to project the computer cities on the wall, and the students were asked to demonstrate the cities, and motivate their design choices. Video recording were used to document the interviews. Actions within the game during the demonstrations were documented with a screen recording program.

Data sets
The video data analysed consist of two parts, recorded at the same occasion with same audio but different visuals: 1) eleven video recordings of the students demonstrating the cities (260:45 minutes) and, 2) eleven screen recordings of the cities (267:05 minutes). Additionally, essays were read and a selection of the physical models viewed in order to get a richer picture of the students’ creations.

Data analysis
The analytical stance towards the empirical data gathered assumes a qualitative approach, which indicates an ambition to “study things in their natural setting, attempting to make sense of, or interpret phenomena in terms of the meaning people bring to them” (Denzin & Lincoln, 2005, p. 3). The analysis performed is of a descriptive nature, and an abductive analysis approach applied. The gathered video data was analysed in a two phase analysis (Patton, 2002), without any predetermined categories. A number of emerging trends were identified, categories for coding developed, and critical incidents identified and transcribed in detail.

The situation: Future City
Future City is a competition organised by some twenty organisations within the building trade. The participating students play the role of urban planners, building cities and handling matters such as the infrastructure, building constructions, transport system, power sources etc. The goal is to create a future city that is a part of a sustainable development. According to the organisers the aims of the competition are to create an interest for and knowledge about technology, science, engineering, sustainable development; to increase the understanding for the complexity of urban planning; and be a forum for exchange between teachers, students, engineers and architects.

The tool: SimCity 4
SimCity 4 (Maxis, 2003) is an urban simulation computer game where the gamer takes the role of a mayor with the aim to build a flourishing city populated by content citizens. The gamer starts by laying the groundwork by creating a region of land. Next step is to place zones for residential, commercial or industrial development. To

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create the best possible conditions for a successful city different kinds of public services have to be installed. Not only basic utilities, like power sources (available alternatives are coal power plant, natural gas power plant, oil power plant, windmills), water plants, transport systems that connects the different zones, but also services to the citizens including health, education, safety, parks and leisure. Improper funding to services can lead to strikes. The key to create a successful city is to maintain balance between various factors such as a growing population, urban and economic development, environmental disturbances, and quality of life for its citizens. As the city matures and grows new possibilities, services and functions that can be implemented appear. The city gradually turns into a more complex system with many different parameters that determine the progression of the city.

Findings

As previously pointed out, the aim of this study is to explore SimCity 4 as a potential science learning environment for students to be confronted by simulated real world problems, and contextualise and apply their scientific knowledge. The outcome is an analytical description based on the students’ retrospectively reflections upon their cities, and the assumptions underlying their design choices. Two main categories and a number of sub-categories emerged from the gathered data.

A visual summary

The illustration presents a visual summary of the categories further described in the written description below.

Figure 3: The visual summary. The black dots indicate groupings of student reflections/utterances linked to the sub-categories.
Written description
This first main category treats how students were referring to 1) Science and socio-scientific issues with a focus on: 1a) Process, 1b) Concepts, and 1c) Concepts in context.

1a) Process (choosing power sources)
Since the citizens and industries require power to develop power plants have to be installed. A variety of alternatives is offered, more or less environmental friendly, costly, and efficient. A distinct steering factor frequently referred to by the students when choosing which power system to install, was the relationship between cost, amount of power generated, and environmental damage. The students were also referring to what requirements (size of population, number of high-tech jobs etc) had to be fulfilled before the most advantageous power plants could be implemented in the city. These build-in restraints in the game resulted in two observed strategies, and a “meta-strategy” applied by the students when determining which power system to install.

The first strategy consisted of implementing the most environmental friendly alternative from the start by choosing renewable sources of energy, e.g. windmills that generated a relatively small amount of power to a high costs. This strategy resulted in a slower industrial development of the city, slower expansion of population, less income from taxes, and a low level of pollutions. When the city budget allowed it more efficient, but still environmental friendly power plants were installed, e.g. solar power plants.

The second strategy consisted of implementing more efficient, but less environmental friendly power plants (e.g. natural gas, or coal power plants) that generated power to a low cost, but also resulted in a higher level of pollutions. This strategy resulted in a quicker industrial development with lots of citizens moving in. High income from taxes was rather early in the game generated which quicker made it possible to invest in better alternatives from an environmental point of view, e.g. solar power plants. As soon as the city budget allowed it the “forerunners”, e.g. the coal power plants were torn down and replaced by less environmental unfriendly alternatives.

The third strategy observed and here referred to as a “meta-strategy” consisted of outwitting the game dynamics, finding loopholes to gain money and quicker obtain a city budget that allowed investment in more environmental friendly alternatives. This meta-strategy can in some sense be referred to as cheating, but it can also be seen as a creative skill and competence consisting of being able to penetrate a dynamic system and make the most out of it in order to fulfil the purpose of the activity.

1b) Concepts
When demonstrating their cities the students expressed conceptions, and/or misconceptions of scientific phenomena occurring in the game world. The conceptions described by the students were both on a scientific, more theoretical level, and a more practical level explaining technological constructions appearing in the game.
Three main types of utterances were observed, which were the usage of a scientific concept:
- without any further elaboration on the meaning of it,
- accompanied by a correct explanation of it,
- accompanied by an incorrect explanation of it.

1c) Concepts in context
This sub-category treat the students’ lifestyle related reflections, and conceptions of what a sustainable development might be, and how it can be achieved. Two directions of utterances were observed.

The first direction of utterances dealt with how to create fundamental conditions for sustainable development (besides power related issues mentioned in sub-category 1a), e.g. by implementing parks, recreation centres for the citizens to enjoy, or by placing the industrial zones or airports far from residential zones. The students were not only the emphasising the ecological aspects of sustainable development, but also social aspects and the importance of health and education.

The other direction dealt with how to create conditions for action, i.e. conditions for citizens to act accordingly to that the students considered to be a sustainable lifestyle. This was expressed by putting an effort into installing systems for public transportation, recycling centres for waste disposal, building spaces for recreation, and setting up proper educational systems.

![Figures 4 & 5: Examples of future cities, to the right, solar power plants. (© Electronic Arts 2003)](image)

The second main category treats the by the students pointed out 2) Limitations of SimCity 4 to support science learning in the Future City context. The limitations concerned the game rules, and the gaming environment as such. The students’ comments on this are divided into two sub-categories: 2a) In-game-restrictions, and the constructive 2b) Out-of-game-compensations.

2a) In-game-restrictions
When demonstrating the cities the students were commenting on the weaknesses within the game world such a lack of futurist features, to few options offered, or that the rule system in the game is based upon a US (or Western) value system. These factors obviously limited the students to accomplish ideas that could not be framed within the game.
2b) Out-of-game-compensations
In order to accomplish ideas which were not possible to carry through within the frame of game, the students stepped out of the game and implemented the ideas in the physical models, or in the essays. As previously explained, building physical models, and writing essays were also parts of the competition. In the physical models and the essays the students could elaborate on ideas and concepts that were not possible to explore in the game due to limitations set by the game rules.

Concluding comments
The first round of analysis in this work-in-progress (still) indicates that SimCity 4 did provide a fictitious urban environment where the student could experiment, make use of their scientific knowledge, and see relationships between occurrences. When reflecting upon their cities the students applied (correctly, or incorrectly) scientific concepts, and discussed scientific phenomena that appeared in the game. Also, processes of reasoning and balancing were observed, e.g. when laying down the different city zones, or when choosing power sources. When deciding which power plant to install the students considered relationships between cost, amount of power generated, and environmental damage. They got to experience consequences of their actions and how they influenced the development of the city, e.g. citizens moving in or out, level of pollution, budget and tax problems, factors that in this paper are referred to as simulated real world problems.

The build-in restraints set by the game rules limited the students to pursue some of their ideas of what a future city could be, which was also commented on by the students. However, since the Future City competition also included building physical models and writing essays the students were offered other media where they could express these ideas. This observation is a clear example of the significance of the setting that a game is being played within, and that the educational use of computer games ought to be seen as interplay between game, student, context, and teacher.

The next phase in the analysis is to look more closely into how the students’ perceptions of sustainability are actually manifested in their cities. One interesting and up-lifting remark to conclude with is that it was observed that the students were not only emphasising the ecological aspects of sustainable development, but also the social aspects and the importance of health and education, which indicates a holistic view on urban development.
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References


Barab, Sasha & Dede, Chris (2007). Games and Immersive Participatory Simulations for Science Education: An Emerging Type of Curricula. *Journal of Science Education and Technology*, 16(1), 1-3.


