Meltdown: A serious game for environmental education on global warming

Yang Chen, Dhiraj Bodicherla, Benjamin H. Scott, and David M. Whittinghill

Purdue University, Department of Computer Graphics Technology,
Knoy Hall of Technology, 401 N Grant St West Lafayette, IN 47907, USA
{yang484,dbodiche,scott90,dmwhittinghill}@purdue.edu

Abstract. With global warming issues getting serious, increasing the awareness and understanding of global warming to the public becomes an increasingly important responsibility for educators, especially with the young generation. In this paper, we discuss environmental education and serious video games through literature, and introduce an example of a serious game called Meltdown. As a project built using the Unity 3D game engine, Meltdown is trying to increase the motivation of the player in understanding the causes, principles and consequences of global warming by providing a simulated global warming game environment. In Meltdown, the player fights against global warming agents to protect the world from melting down via manipulating game props. Global warming knowledge is also presented through its various game features. With Meltdown still in development, we describe the intellectual justification for the project, details of the game system, and future work on user research.

Keywords: Environmental education, Global warming, Serious games

1 Introduction

With the ever increasing development of industry, environmental pollution is drawing more and more attention to society. Problems of environmental instability and worldwide environmental degradation have resulted in a call for a greater emphasis on environmental education for preparing future citizens. From the time environmental education was first defined in greater detail (the mid-1970s) [1], it has evolved from a naive discipline to an academic issue with various research perspectives [2, 3, & 4]. As an increasingly serious phenomenon of environmental issues, global warming is a particular part that cannot ignored. It has been stated in the 2007 IPCC report [5] that the average temperature of the earth will grow from 1.4°C to 5.8°C between 1990 and 2100. The result of rising temperature might include melting of polar ice caps, rapidly rising sea levels, increased strength of typhoons, engulfing of the planet by heat waves, and other disastrous phenomena [6]. Studies have shown that the continued increase in the atmospheric concentration of carbon dioxide and other substances due to anthropogenic emissions is predicted to lead to these significant changes in climate [7]. Increasing motivation among the public,

especially the younger generation, to understand the causes, principles, and consequences of global warming would be helpful for decreasing anthropogenic emissions of hazardous substances. In order for global warming literacy to become more widespread, involving global warming education as an indispensable section of environmental education should be highly considerate.

Cutter-Mackenzie, Edwards, Moore, and Boyd [8] studied children's play and environmental education in their early childhood. They argued that the early development of conceptual knowledge about biodiversity, understanding the importance of sustainability, and avoiding or disrupting the development of biophobic attitudes towards nature are laudable outcomes to achieve in environmental education. As a part of this expansion, serious games for environmental education on global warming for children would be a considerable alternative as an instructional tool for its game playing characters, which are easily associated with children. Though studies have shown that serious games have a positive correlation with learning objectives in courses they are a part of, their role in education is still being explored [9, 10]. While there has been utilization of virtual environments and simulations in education curriculum, such as energy education [11], there is still a need to test the efficacy of an environmental educational game centered on global warming for users.

Meltdown is introduced as a serious game built using the Unity 3D game engine. Its purpose is to increase the motivation of players in understanding the causes, principles and consequences of global warming by providing a simulated global warming game environment. In Meltdown, the player fights against global warming agents to protect the world from melting down via manipulating game props. Global warming knowledge is also presented through its various game features. With Meltdown still in development, we describe the intellectual justification for the project, details of the game system, and future work on user research.

2 Environmental education

A study by Weber and Stern [12] showed a widespread consensus that climate change was occurring among scientists [13], while the awareness of climate change was still far less prevalent among the general public [12, 14] in countries such as the U.S. Given that many policies to mitigate climate change rely on public support and engagement in order to succeed, it is important to understand factors that shape beliefs about climate change among the people [15], especially the children who represent the future.

Studies have been conducted for understanding people's ideas of global warming and environmental education. Chhokar, Dua, Taylor, Boyes, and Stanisstreet [16] conducted a quantitative study based on a questionnaire to determine senior secondary students' views about how useful various specific actions in reducing global warming might be, and their willingness to undertake these various actions. The findings indicated that this cohort of Indian students exhibited high levels of concern about global warming and a willingness to act to reduce it. Individuals' informed lifestyle choices may help reduce global warming, but they do need some understanding of this phenomenon and the factors that contribute to it [16]. Therefore, there is a

significance of showing relative knowledge in an appropriate manner. For understanding how to enhance learning experience of environmental education, feedback from students suggested they prefer live presentation and engagement, among other interactions [17]. A study from Blancher-Cohen and Reilly [2] explored environmental education in high school from the teachers' perspectives with high student diversity. Findings from a series of qualitative methods like focus groups and interviews stated that environmental education demands the inclusion of interactive dialogue. As the development and wide utility of mobile instructional devices, research was conducted for investigating the impact of a mobile guide system on different parameters of environmental literacy in comparison to traditional instruments of environmental education (i.e. brochure, human guide) [18]. Results of this study showed that the computer as a mobile guide lead to an increase in environmental knowledge and user's motivation to engage in environmental education activities.

In search for novel methodologies to improve environmental education, researchers have become aware of the high interest in new technologies. Consequently, studies based on virtual environments of different degrees of immersion and simulations are becoming the new trend in environmental education [18].

3 Serious Games

The motivating features behind digital games are that they might provide a useful and attractive new method of learning [19]. Suggestions that game players might actually be developing useful skills from playing these games led to this belief. From the perspective of video game playing, serious games were defined as "a pedagogical tool with a purpose, moving beyond entertainment to deliver engaging interactive media to support learning in its broadest sense" by De Freitas [20].

Serious games offer immersive and virtual environments that provide learners a realistic opportunity to practice and develop a variety of different competencies [21, 22] such as problem-solving, decision-making, inquiry, multitasking, collaboration and creativity. It has been shown that high levels of interest are necessary to trigger and maintain a strong intrinsic motivation for learning [23], while the influence on learning motivation of serious games are widely studied. Konetes [24] has analyzed the applications of learning simulations and games through the lens of the intrinsic and extrinsic motivational factors. The intrinsic motivational factors were found out to be created by serious game interactions. An assessment study of serious game players' motivation was conducted by Derbali and Frasson [25] using a questionnaire and electroencephalography (EEG). Thirty-three voluntary subjects were placed in front of two computers: one for playing and the other for answering the questionnaires. The result showed that the EEG wave's patterns correlate with the increase of motivation during certain parts of serious game play.

Despite the long-standing presence of serious games in fields such as aeronautics, nuclear testing, military war and even health care education [26], studies over serious games concerning environmental education are still limited and deserve more attention. Bodzin [27] has created a course curriculum based on serious games to

enhance energy education. It assisted in helping students analyze the environmental characteristics of a region before making a decision on producing a new power plant. Within global warming education, serious games are able to provide severe global warming situations that could eventually occur as well as global warming knowledge by the simulation environment enhancing immersion and learning motivation.

4 The Meltdown Game

4.1 Background

The name Meltdown was chosen as it is the most common phenomenon of global warming. The game is programmed in JavaScript and C# using the Unity game engine. The game uses 2D assets and is played from an overlooking perspective (see Fig. 1). As of this publication Meltdown is still under development, but the framework of entire game is built, game levels are set, main game props and global warming agents are designed (more game images are under development), and game mechanics are decided. In its final release Meltdown will be distributed on PC and Mac as an open source program and may even have a web-based deployment.

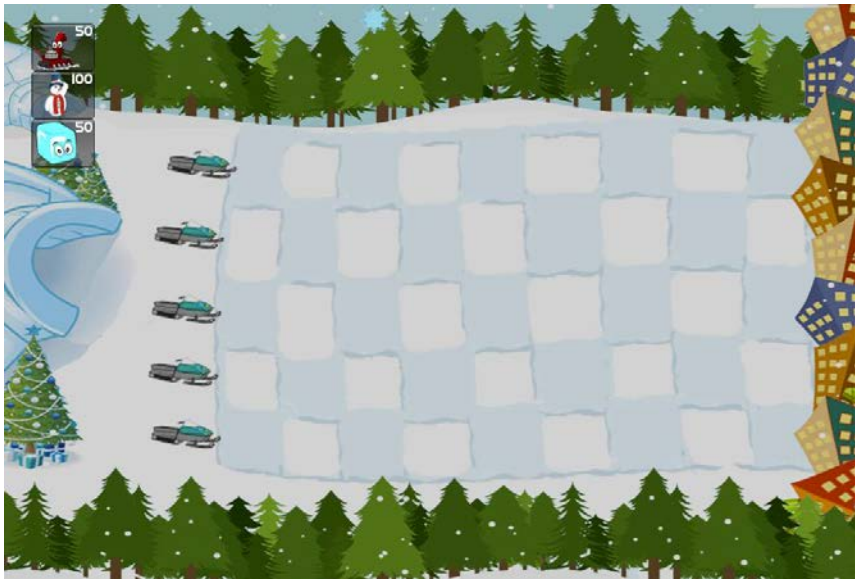

Fig. 1. Prototype of the game scene from the player's perspective.

4.2 Game story

As a serious game that aims to enhance learning motivation on environmental knowledge, Meltdown specifies its game/educational scope in global warming. The game involves an igloo town protecting itself from melting due to increased effects of global warming caused by the cities. The main game scene takes place outside an igloo and the losing scene happens inside the igloo, in which the town has melted away to nothing. The player assumes the role of a responsible citizen of the igloo town fighting against global warming agents coming from an industrial society.

Inventory consists of a very primitive and innovative set of items and weapons for players to select. The inventory currently includes ice cubes, snowmen, and snow blowers (see Figure 2). They are the igloo warriors and they fight against the enemies. Players need to pay to use these items. The currency, snowflakes, is generated from the game system automatically and can also be made by snow blowers. Electric bulbs, lighters and hair dryers are the global warming agents that are currently in this game. They move from the society side of the game scene and invade toward the igloo side.

Fig. 2. Current game inventory.

4.3 Scenarios and simulation

Players are presented with the scenario that global warming agents are invading the igloo town by uniform movement from a building block, which represents the industrial society. The global warming agents (enemies) are all common daily necessities that use electricity or batteries to run and perform their regular actions. When these enemies move close to snow warriors, they attack igloo warriors by melting them down. The igloo warriors have different specialties in fighting against these enemies, such as the snowman throwing snow balls, ice cubes being able to resist more attacks but cannot attack themselves (see figure 3), and snow blowers produce snowflakes which are used as game currency to enlarge inventory and purchase more igloo warriors. These gameplay mechanics works in a similar way with the famous entertainment game, Plant vs. Zombies, by Popcap Game Company. Besides that, when the enemies are attacking igloo warriors, there are "CO_2" patterns

growing up consistently from the enemies' surroundings and disappear a couple seconds later. The future game HUDs (head-up display) will show how much watt electricity is costing; a progress bar will show the severity of global warming, and a thermometer will show the temperature constantly. With continuous enemy attacks and accumulating carbon dioxide emissions, the severity of global warming gets worse and the temperature rises. Eventually, the game will be over when a specific number is reached, which means the world is destroyed by the global warming. To protect the igloo and save the world, players have to strategically place their army to stop the attack. During game play, the causes (mainly carbon dioxide), principles (the usage of electricity), results (destroyed world) and good contribution (decrease the carbon dioxide emissions) are presented to players in an immersive game environment.

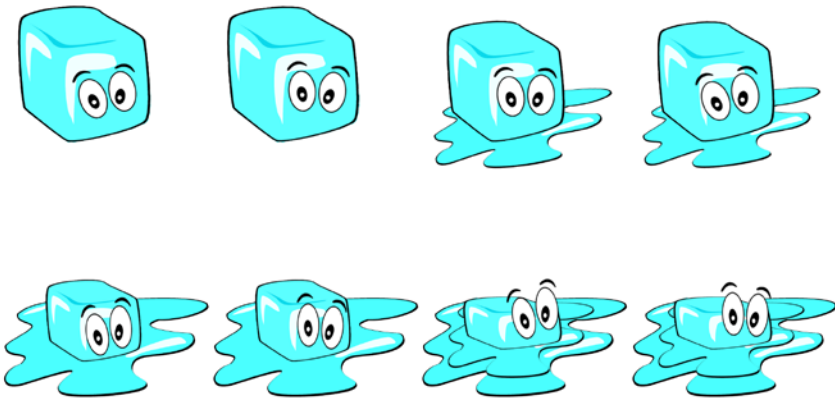

Fig. 3. A sprite sheet animation of ice cube melting down.

In order to properly simulate real world scenarios, Meltdown features a day/night cycle for two different levels for now. For future designs, Meltdown will optimally feature the diversity of global warming agents and igloo warriors. In addition, the integration of other relative global warming knowledge would provide players with a broader perspective on learning.

5 Conclusion and future work

We are creating Meltdown with the goal of providing a serious game for enhancing learning motivation on global warming. In Meltdown, global warming knowledge is presented during gameplay. In the future, after fully developing the game, user research would be conducted for examining its effect on enhancement of learning motivation in relation to global warming. Two groups of primary school students will be selected as participants for an experiment with an experimental group and control

group. Hopefully, the study results will benefit further serious game development for environmental education, specifically on global warming.

References

1. Padua, S.M.: Primate conservation: integrating communities through environmental education programs. American journal of primatology, 72(5), 450--453 (2010)
2. Blanchet-Cohen, N., Reilly, R.C.: Teachers' perspectives on environmental education in multicultural contexts: Towards culturally-responsive environmental education. Teaching and Teacher Education, 36, 12--22 (2013)
3. Van Velsor, S.W.: A qualitative investigation of the urban minority adolescent experience with wildlife. PhD thesis, University of Missouri (2004)
4. Ramasundaram, V., Grunwald, S., Mangeot, A., Comerford, N.B., Bliss, C.M.: Development of an environmental virtual field laboratory. Computers & Education, 45(1), 21--34 (2005)
5. Intergovernmental Panel on Climate Change. IPCC Fourth Assessment Report (2007) http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf, (2010/7/5 retrieved)
6. Chang, C.Y., Lai, S.L.: Applied Situated Learning Theory to Investigate Effect of Global Warming Awareness Education in College--Quantitative Case Study with Experimental Design. Advanced Materials Research. Vols. 524-527, pp. 2490-2495. Trans Tech Publications, Switzerland (2012)
7. Cox, P.M., Betts, R.A., Jones, C.D., Spall, S.A., Totterdell, I. J.: Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. Nature, 408(6809), 184-187 (2000)
8. Cutter-Mackenzie, A., Edwards, S., Moore, D., Boyd. W.: Young Children's Play and Environmental Education in Early Childhood Education. Springer Verlag (2014)
9. Darling, J., Drew, B., Joiner, R., Iacovides, I., Gavin, C.: Game Based Learning in Engineering Education. In: International Conference on Innovation, Good Practice and Research in Engineering Education, Vol. 70, pp. 2008. Loughborough University, England (2008)
10. Chen, Y., Oxenrider, M., Whittinghill, D.: How the Social Element in Game-based Learning Can Interfere with Learning Outcomes: An Examination of the Research Literature. In: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, vol. 2013, No. 1, pp. 1820--1830 (2013)
11. Nataraja, K., Whittinghill, D.: MAEGUS: A Sustainable Energy Simulation to Promote Energy Literacy. In World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, vol. 2013, No. 1, pp. 2474--2479 (2013)
12. Weber, E.U., Stern, P.C.: Public understanding of climate change in the United States. American Psychologist, 66, 315--328 (2011)
13. Doran, P.T., Zimmerman, M.K.: Examining the scientific consensus on climate change. Examining the Scientific Consensus on Climate Change, 90, 22 (2009)
14. Leiserowitz, A., Maibach, E., Roser-Renouf, C., Feinberg, G., Howe, P.: Climate change in the American mind: Americans' global warming beliefs and attitudes in January, 2010. Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change (2010)
15. Drummond, A., Palmer, M.A.: Heart rate change and attitudes to global warming: A conceptual replication of the visceral fit mechanism. Journal of Environmental Psychology, 38, 10--16 (2014)

16.Chhokar, K., Dua, S., Taylor, N., Boyes, E., Stanisstreet, M.: Senior secondary Indian students' views about global warming, and their implications for education. Science Education International, 23(2), 133--149 (2012)
17.Mazzatenta, C.: Can GLOBAL WARMING heat up environmental education. The American Biology Teacher, 70(6), 342--344 (2008)
18.Ruchter, M., Klar, B., Geiger, W.: Comparing the effects of mobile computers and traditional approaches in environmental education. Computers & Education, 54(4), 1054--1067 (2010)
19.Connolly, T.M., Boyle, E.A., MacArthur, E., Hainey, T., Boyle, J.M.: A systematic literature review of empirical evidence on computer games and serious games. Computers & Education, 59(2), 661--686 (2012)
20.De Freitas, S.: Learning in immersive worlds. Joint Information Systems Committee (JISC), London (2006)
21.Adams, S.A.: Use of “serious health games” in health care: a review. Studies in Health Technology and Informatics, 157, 160--166 (2010)
22.Blakely, G., Skirton, H., Cooper, S., Allum, P., Nelmes, P.: Educational gaming in the health sciences: systematic review. Journal of Advanced Nursing, 65, 259--269 (2008)
23.Hidi, S.: An interest researcher's perspective: The effect of intrinsic and extrinsic factors on motivation. In: C. Sansone & J.M. Harackiewicz (Eds.), Intrinsic and extrinsic motivation: The search for optimal motivation and performance, pp. 309-339. San Diego, CA: Academic Press (2000)
24.Konetes, G.D.: The function of intrinsic and extrinsic motivation in educational virtual games and simulations. Journal of Emerging Technologies in Web Intelligence, vol. 2, no. 1, pp. 23--26 (2010)
25.Derbali, L., Frasson, C.: Players’ motivation and EEG waves patterns in a serious game environment. Intelligent Tutoring Systems, vol. 6095, no. 2, pp. 297--299 (2010)
26.Petit dit Dariel, O.J., Raby, T., Ravaut, F., Rothan-Tondeur, M.: Developing the Serious Games potential in nursing education. Nurse education today, 33(12), 1569--1575 (2013).
27.Bodzin, A., Cirucci, L., Kulo, V., Dempsey, C., Anastasio, D., Sahagian, D.: Teaching and Learning about Energy Resources with Web GIS (2012)