Future Delta 2.0
An Experiential Learning Context for a Serious Game about Local Climate Change

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Abstract

In this paper we discuss the theoretical, design and evaluative underpinnings of the *experiential learning context* central to the design processes of the *Future Delta 2.0* serious game. The game is aimed at facilitating understanding and action on local climate change. We begin with a discussion of play as it relates to designing serious games. Then we articulate the *experiential learning context* revealed through three interconnected design strands: meaningful learning objectives – how the learning is structured; situatedness – where the learning takes place, geographically and culturally; learning through action – how learning happens through play. We introduce the *experiential learning context* of *Future Delta 2.0,* a virtual 3D game. The game reaches across art, science and technology to communicate a community-based local vision of climate change challenges and solutions in Delta, British Columbia. Finally, we discuss the design, evaluation methods and analysis of the *Future Delta 2.0 experiential learning context*. Our conclusion is that the *experiential learning context* may contribute theoretically and practically to the research and design of 3D serious games.

Keywords: experiential learning context; climate change educational game; play; game design; serious games

1 Introduction

Global climate change is one of the most urgent and far-reaching environmental issues ever to have affected our socio-ecological health: our actions today determine which world future generations will inhabit. Despite scientists urging for action on climate change, we are still struggling to turn the trends around. Today, most people are aware of the adverse effects of anthropogenic activities on earth, but what we are lacking is a vision of the viable social pathways for action, a vision that links the present with sustainable futures. Given the scale of social change we need to embrace, we recognize that sustainability as a practice involves bringing community-based social processes and a philosophical understanding necessary for behavioural change to the centre of action. These social processes build upon scientific facts to engage communities of practice in imagining and transforming into sustainable societies. The premise that mass media communication of scientific climate change information and facts produces alternative behaviours has not yielded significant changes in human living practices. A problem persists in the gap between scientific facts and viable pathways for action.

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Learning what to do and how to change in response to changing climate conditions involves building new practices and value systems that link knowing, being and doing as a sustainable society.

The *Future Delta 2.0* educational game project emerges as a direct response to increasing recognition that the urgency for understanding and action on local climate change is not reflected within our communities. The design processes and strategies in the development of a serious game position play as a way of practicing change within the safe space of a virtual environment. Play as a change agent may provide an innovative learning strategy framed within a locally situated virtual environment that can be applied to real world situations. The *Future Delta 2.0* educational game project reaches across art, science and technology to communicate a community-based local vision of sustainable solutions for the Corporation of Delta, British Columbia. The educational 3D game provides a space for the experiential learning of multiple futures. The players can explore climate change causes and effects, and choose to explore alternative, locally situated socio-ecological scenarios through play in a safe, virtual game environment. Virtual game worlds are well suited for climate change pedagogy because they enable testing and experimentation with concepts and tools (Mendler de Suarez et al. 2012). Our design employs experiential learning through game play as a change agent for developing understanding and multiple pathways for action on climate change at a local level.

One of our research goals is to create a 3D virtual game environment that may help people feel empowered to work as a community by simulating locally grounded possibilities, solutions and immediate actions in response to climate change. Our premise is that when individuals are empowered and feel that their behaviours can directly influence the wellbeing of the local place and community, they are more likely to actively care and be concerned about the impacts of their real world actions (Sheppard 2012). Framing the virtual game environment as an *experiential learning context* for change directly benefits climate change communication at the local level. The *experiential learning context* is intended to reinforce a sense of urgency about the changing climate, accelerate awareness of the local issues, while building capacity and a sense of agency.

In this paper we discuss design processes and strategies for the *Future Delta 2.0* educational game intended for Delta high school students and aimed at facilitating understanding and action on local climate change challenges and solutions. The *Future Delta 2.0* design process integrates climate change science, locally grounded scenario analysis, artistic multimedia articulation and co-design processes within an *experiential learning context*. First we focus on the theoretical context of experiential learning that is central to our game design. In the next section we define the

relevant background for the development of the *experiential learning context*. In this section we also articulate how our design research and practice uses reflection-in-action (Schön 1983), a process for designing complex interlocking messages that in our project brings together diverse community voices and multiple possible futures into an integrated game environment. In the final section we discuss the *experiential learning context* in terms of the design methods for the *Future Delta 2.0* educational game and introduce preliminary results leading to the next stage of research.

2 Background

Central to identifying the *experiential learning context* as an approach for the development of *Future Delta 2.0* was deepening an understanding that play, at a fundamental level, is a means for learning and change. Within the context of designing an educational game, concepts of experiential learning form a theoretical foundation for developing a virtual 3D environment.

From a phenomenological perspective, play can be understood as a way of being-in-the-world. *Being-in-the-world is* situated within everyday experience and the process of coming to know things and others (Heidegger 1962; Merleau-Ponty 1962). Being-in-the-world describes human encounters with things and others in ways that are open to receive, and embedded within social and cultural environments that move toward continued interaction. Play thus framed, is experiential; it engages the senses, it is immersive and is acted out in a liminal and contingent space (Malaby 2009). As a way of being that is both inside and outside the body, play incorporates physical, psychological, social, and intellectual elements that make up the world of play. Play includes responding to the environment and interactions with others, potentially testing the limits of actions, sensibility and strength. The psychological dimensions of play are characterized by the behaviours associated with the experience, the thoughts, feelings and motivations underlying engagement in the play space. Psychologists often refer to the benefits of play, the immersive quality of experience that leads to a feeling of satisfaction and accomplishment (Baranowski 2009). In terms of social interactions, players negotiate commitment to the process, trust between players and the willingness to participate in the dimensions of play. Social interactions are set within cultural fields that are brought to bear on how processes are played out (Grenfell 2012). As an intellectual element, play engages cognitive functioning, imaginative responses and a rich repertory of problem solving techniques that emerge or build from interactions (Jenkins 2009). More than being a means of supporting or improving learning, play is learning.

Seen through the lens of Performance Studies, play is a responsive action that has evolved out learning in order to survive. The field of Performance Studies amplifies the improvisational and contingent characteristics of play in the context of everyday life. Building on observations made by earlier anthropologists, more recent articulations of play see it as a form of attention, a set of conditions in an interactive environment that instigate creative and generative responses potentially leading to new forms of behaviour (Schechner 2003; Huizinga 1949).

Linked to survival, play assumes the function of an immediate and vital response to environmental conditions. Play evolves behaviours that are necessary biological functions such as finding food and reproducing. Animals learn behaviours through play, first practicing actions within a safe environment before applying skills and strategies in more challenging contexts. Animal play actions such as learning to hunt, while linked to survival, return in human play rituals such as everyday sporting events, as well as religious and aesthetic performances. According to Performance Studies scholar Richard Schechner, in human play there is an "improvisational imposition of order" (Schechner 2003, 104), one that we use as a means to respond and adapt to emerging challenges. Play engages a learning attitude that is open to changing conditions and creates order through concrete immediate experiences.

Experiential learning offers an opportunity to change behaviour through play. Play is not just what humans do as leisure activity; it is also a form of learning. Play as an experience can be seen as a form of problem solving based on a pragmatic model of learning by doing. Experience, which in this case is play experience, is understood as the actions humans do in the world that hold value and are conceptually meaningful (Alexander & Dewey 1987). Educational innovator John Dewey articulated a model of learning that is situated in concrete lived experience – within a context of being involved in a temporal, open-ended physical world. Experiences, situations and nature are understood as continuous and qualitative, beginning and ending in a larger world of immediate experience rather than only in a reflective space. According to Dewey, certain kinds of education, and in particular aesthetic experience allow possible meaning and value to emerge in situations that are relational and contextual. This departs from other forms of learning which assume that objects of inquiry are discrete, quantitative entities to be studied in isolation. These ideas are significant to considering the role of play in an interactive virtual game environment because they clarify and validate ways of framing learning through experience. Dewey articulates the value of gathering empirical knowledge through engaging with phenomena that reveals contextual and situated meaning. He thus brings together ways of knowing through experience that unite art and science rather than keeping them in opposition. Contemporary Western human culture is largely instrumentalist, concerned with quantifying the real in order to predict the possible. Dewey suggests remembering the moral obligation of learning is also to criticize, interpret and evaluate through qualitative *and* quantitative experience. Situated within an ongoing circle of meaning making, learning is contextualized in a larger world of experience that cannot be reduced to simple cause and effect statements based on empirical evidence. Learning through art experiences, allows for meanings to emerge from interaction with media that engages all the senses in "acute [a]esthethic surrender" (Dewey 1934).

Dewey also conducted studies in behavioural psychology that led him to the conclusion that learning by doing involves more than an instinctual response to stimulus. Instead he proposed that learning by doing is the result of a three-part process that includes a layer of conscious interpretation in response to stimuli. Learning by doing is based on an open response to surprises (Darnton 2008). Surprises interrupt spontaneous reactions to situations and initiate a moment of pause, assessment and adaption to new conditions. Surprises introduce challenges or obstacles that call for interpretation before there is a return to the flow of everyday experience. Learning by doing describe situations that integrate immediate reflection in engaging with phenomena, and this process informs subsequent actions.

Action researchers, build from systems theories and further propose a double loop model that explicitly accounts for change in a cyclical process of learning (Argyris & Schön 1996; Bateson 1972). Double loop learning develops out of questioning the assumptions of instrumentalist learning that in turn leads to a restructuring of norms. Single loop learning is "paradigm constrained," as well as being first order thinking; it provides an adequate context for testing, analyzing and modifying actions within a specific learning context. Second loop learning is "paradigm breaking" and higher order thinking; it allows inquiry into what constitutes as knowledge and reflects on how actions are informed by "theories in use" within given fields of learning. The learning objectives for addressing complex social and environmental challenges are conceptualized and designed as a learning cycle (Lewin 1951) that introduces learning content through unexpected or surprising interactive experiences that develop the ability to learn by doing (Dewey 1938) and reflect in action (Argyris & Schön 1996). Behaviour change occurs when the unspoken assumptions about the ways things are done are questioned and different ways of operating are enacted.

Bringing these theories into game design, there is a strong case to be made for developing an *experiential learning context* that integrates play as a way of accessing behaviour change. Game designers Katie Salen and Eric Zimmerman articulate the relationship of game play and learning stating that, "[m]eaningful play emerges form the interaction between players and the system of the game, as well as from the context in which the game is played" (Salen & Zimmerman 2003, 33). Within the *Future Delta 2.0* research process, the values articulated through meaningful learning objectives are aligned with the modes of play enacted within the game environment and the feedback mechanisms designed to motivate continued play. Essentially, in order for meaningful game play to occur, the player actions and system outcomes need to be integrated into the context of the game experience as a whole. Interaction design methodologies (McCarthy & Wright 2007; Wakkary 2009), ensure that all designed elements of the game are aligned with the strategic intent of the game - to motivate and support collective behaviour change.

2.1 Serious Games

Games that have a pedagogical intent are often called serious games as a way of distinguishing them from games meant for entertainment or diversion. When social scientist Clark Abt coined the term serious games in 1970, his definition included real time/real world board games, role-playing, simulations and scenarios. According to Abt, serious games "have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement" (Abt 1970). By 2002 the Serious Game Initiative redefined the category using game designer Michael Zyda's definition, to specifically refer to digital media games that provide "a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives" (Zyda 2005). This definition explicitly featured entertainment as the means by which specific learning content could be presented. 2010 Future Lab's literature review defines serious games as "digital games with the intention of teaching specific predefined skills or knowledge" (Ulicsak 2010). What distinguishes this definition from earlier ones is that the idea of play and entertainment is not featured in the description of serious gaming, perhaps reflecting the pedagogical intent of knowledge transfer over entertainment values. There are however serious games for use in diverse applications such as health, education and social change, that can deliver learning content through play in a sophisticated and engaging manner while enhancing knowledge transfer through dynamic modes of representation and innovative game play (Swain 2007; Laamarti 2014).

The cycle of learning defined within the design of *Future Delta 2.0* builds on characteristics of instructional design that have been identified as potentially effective for facilitating knowledge transmission through game-based learning (van Staalduinen & de Freitas 2011; Bellotti 2013). In game-based learning players are encouraged to engage in solving real-world issues, connect existing knowledge to new learning, see how new knowledge is applied in a virtual environment through in-game feedback, and ultimately integrate new critical skills in real world contexts. These characteristics of game-based learning are important for framing and innovating modes of play as pedagogical activities that extend or transform conventional game mechanisms attached to winning and losing, such as fetch quests and levelling up.

Climate change games, situated in the area of games for change or social impact games, are considered a subsection of serious games. They can reach across climate change communication initiatives, future scenario explorations and decision-making simulation games. Climate change communication games are often centered on the issues of carbon footprint and aimed at raising awareness and affecting policy, such as *Green Gang vs. Captain Carbon*[1]. Future scenario explorations and decision-making simulation games enable the players to explore trade-offs, impacts and outcomes of future climate change mitigation and adaptation challenges and solutions. Examples of this approach include games, such as *Climate Challenge*[2], *Climate Interactive*[3], and *My 2050*[4]. *Future Delta 2.0* weaves these different approaches into a locally situated climate change game play. *Future Delta 2.0* is unique in that it is deeply grounded in a real place, linked to scientific information, and co-designed with local community partners who are involved in game development including evaluating the game's effectiveness.

3 The Experiential Learning Context

Designing educational technology through interactive experiences positions learning as a reflection in doing. The designers integrate concrete experience, observation, critical reflection and action as well as framing the learning in the game environment as experiential. The design of a learning experience within a serious game is thus situated within interaction design methodologies (Wakkary 2009).

The pragmatic design method we are using to develop the *experiential learning context* for *Future Delta 2.0* is informed by concepts of experiential learning (Dewey 1938) and Schön's (1983) notion of reflection-in-action. The research and practice of design utilizes reflection-in-action processes, which position design as experiential (Wakkary 2009), and therefore encompasses the complex relationship between designer, the lived

[1] http://game.greengang.at/
[2] http://www.gamesforchange.org/play/climate-challenge
[3] https://www.climateinteractive.org/tools/world-climate/
[4] http://my2050.decc.gov.uk/

world, and design actions. The practitioner inquires into the real world design situation and simultaneously integrates reflection, action, and implementation. This concept, also known as experimentation-in-action, shapes the processes and goals though a framing and reframing of the problem setting as a way of working towards the best design solution (Schön 1983). The positioning of the designer as an inquirer in the design situation enables the exploration of multiple and often-contradictory experimental spaces in creativity that allow for imaginary representations of what is and what could be. The design process in turn, is organized around three strands that we have identified as important to both the design process and the subsequent learning in virtual environments: *meaningful learning objectives* – how the learning is structured; *situatedness* – where the learning takes place both geographically and culturally; *learning through action* – how learning happens through play.

Meaningful learning objectives define the choices and actions in the design of the overall game experience. The primary meaningful learning objective for creating a game about climate change centres on how to motivate social change and encourage sustainable thinking and action in local communities through intentional game play. This includes creating a learning context for a positive engagement with climate change, as well as offering positive choices in response to political and social challenges that emerge through game play. Another meaningful learning objective is to bring diverse community voices together within the virtual space and make them accessible to each other, such that citizens can practice influencing environmental policy and implementing climate change solutions. A third meaningful learning objective aims to present a serious and complex topic in a fun, engaging and rewarding way through direct participation with the pedagogical content. Learning change through play can facilitate creative responses to climate change challenges and inspire a sense of community connectedness.

Situatedness embeds the experiential learning cycle within a virtual world of immediate and concrete experiences in recognizable locales and culturally relevant environments. This in turn provides the basis for observation and reflection in formulating an understanding of new choices and actions. Situatedness recognizes that all forms of representation emerge from people with particular values and in cultures that are distinct in time and space (Dulic 2006; Dulic & Hamel 2008). Participatory research experiences contribute social and cultural values embedded in the game, giving players an opportunity to engage in real challenges in a safe space and practice making decisions that have applicability in their immediate real world context.

Learning through action encompasses the complex, interlocking interactive space that uses elements such as spatial design, narrative objects, sound, motion, animation, characters and dialogue to construct the active learning experience. This complex territory of media elements works together to create a sense of embodied experience that work on visceral, behavioural and reflective levels at the same time. In-game feedback mechanisms are thus constructed experientially, combining spatial and environmental feedback with text-based rational explanations of the gameplay choices. The feedback mechanisms also include the collection of objects and swapping in the environment in order for the player to analyze choices and enable new options for play experiences. In learning through doing, players explore, respond and create within the virtual environment. Critical play as a form of learning through action requires attentiveness and provides challenges to overcome. An interactive environment that instigates creative and generative responses can potentially lead to new forms of behaviour. As challenges emerge players are given the opportunity to try out solutions through active experimentation, test their choices, and reflect on experiences. *Future Delta 2.0* is a participatory learning environment where players activate teachable objects in a safe space that can be critically examined before transferring knowledge into real world contexts.

The research and practice of creating the *Future Delta 2.0* game environment provides a rich space for observation and reflective evaluation that can directly benefit educational games, climate change communication, as well as interaction and experience design research. The research project provides a real world context where professional design practice bridges across science, art and technology to create a community learning experience in a game environment. Another one of our research goals is to assimilate our diverse and complex design processes into a theory from which potential actions can be considered. We therefore propose that the design and implementation of the *experiential learning context* be fully realized in a rich and nuanced virtual environment comprised of three core strands: meaningful learning objectives, situatedness and learning through action. These strands encourage enacting, creating new experiences, and imagining multiple possibilities.

4 *Future Delta 2.0*

The game content focuses on climate change challenges and solutions in the Corporation of Delta in British Columbia. The Corporation of Delta is a complex geographic area, positioned on the floodplain of the Fraser River. The forecast for expected climate change impacts to the regional area include sea level rise of 1.2 meters by 2100 (BC Ministry of the Environment 2011) While dikes currently surround much of the Delta floodplain, climate change projections suggest that new designs standards be adopted for coastal land management and flood protection (BC Ministry of Environment 2014). In response to this challenge, communities in Delta are faced with complex decision-making that will involve weighing the trade-offs between social, economic, environmental and political factors.

Delta, as a region with quite complex sets of issues, has many different communities that are faced with different climate change challenges and solutions. The game environment of *Future Delta 2.0* refers to the larger Delta region within the narrative while the North Delta, Tilbury, Boundary Bay and Ladner areas are

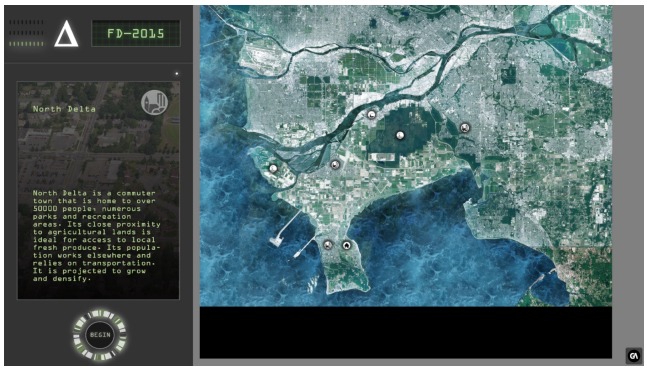

Figure 1 Introduction screen, *Future Delta 2.0*

modeled in detail. The North Delta community is the only one that is not prone to flooding because it is positioned on higher ground. This area has the densest urban development. However, the rest of Delta is on the floodplain and includes areas such as Ladner, Boundary Bay and Tilbury. Ladner is an urban and historical site in Delta, where the Corporation of Delta was first established, and carries large heritage value for the community. Boundary Bay has residential communities in coastal regions as well as a large area designated for agriculture. Tilbury, an industrial area, is located on the south shore of the Fraser River. The game is composed of three acts, beginning in North Delta where the player learns about neighbourhood climate change challenges and solutions. The second act takes place in Tilbury, and focuses on challenges and solutions facing industries in Delta and beyond. The final, third act is situated in Boundary Bay and Ladner, where the player can explore different possible future responses to flooding in Delta.

The *Future Delta 2.0* gameplay learning cycle begins with establishing a single player exploration in a situated, immersive locale. The interaction within the game provides an in-game feedback mechanism that allows for the player's observations, analysis and critical reflection to be tested and practiced within the virtual environment. Through subsequent iterations in response to immediate feedback, this experiential learning cycle enables opportunities for modifications of player behaviour and new choices for experiences. The importance of this process is that the player can repeat elements of the game, make alternative choices, and witness different outcomes.

The *Future Delta 2.0* game research is in the evaluation stage of a five-year interdisciplinary collaboration between the Collaborative for Advanced Landscape Planning (CALP) at the University of British Columbia Vancouver and the Centre for Culture and Technology (CCT) at the University of British Columbia Okanagan, with close community partner, the Delta School District. The team has employed three research associates, one doctoral student, six masters students, and twelve undergraduate students that worked over a four-year period in different stages of game development. The research also included design workshops and consultations with game industry partners, education specialists and scientific experts. The game was produced using the Unity game engine and motion capture tools to create original character animations as well as using off-the-shelf Unity products. *Future Delta 2.0* is divided into three playable acts that are available for download for both Mac and PC (http://futuredelta2.ca/).

The next sections explain how *the experiential learning context* was developed for *Future Delta 2.0* and introduce the preliminary results from high school classroom testing in the Corporation of Delta.

4.1 Meaningful learning objectives – how the learning is structured

The key meaningful learning objective for *Future Delta 2.0* is to motivate and facilitate social change through intentional game play strategies that together build the resources for sustainable thinking and action in local communities. We recognize that it is difficult to measure and evaluate social change. Building on the encouraging results in our previous studies (Schroth et al. 2014; Sheppard 2013), we structured the learning objectives and game design process to further examine the potential of virtual environments for social change.

Future Delta 2.0 creates a context for practicing social change. The game provides an immersive experience for players to reflect on current and potentially new, and more sustainable attitudes and behaviours in a safe environment. Players learn to see the challenges of climate change holistically and examine trade-offs by considering the wider network of interrelated consequences. Learning to see and reflect on in-game choices that have realistically portrayed outcomes allows the player to reconsider their actions, and adjust their choices in order to witness different outcomes. In addition, the game offers multiple solutions for adaptation and mitigation to climate change. Many solutions are not easy because they have not become common practice yet. The game provides a practical framework for learning about sustainable energy ideas and low-carbon lifestyles in a local community context. Different community voices are also brought together within the game space to provide a more complex portrait of how collective decisions need to be made. In *Future Delta 2.0*, learning to change attitudes and behaviours is embedded in dynamic gameplay actions instead of being presented as static information panels. Players are encouraged to uncover information, try out choices and witness how their decisions affect their game play. These are powerful and evocative game mechanisms that support the meaningful learning objectives. When players can see how their choices and actions are part of the challenges of climate change, they can also see how other choices and actions are part of the solutions.

During this phase of the research the main audience has been high school students in the Delta area. By reaching high school students our aim was to also affect parents, and the larger community. The format of a game as an interaction strategy was selected because it is well suited for a generation of students who are very comfortable with learning through interactive media technology. Virtual 3D games contain a language and system of knowledge that is natural for this generation of students. The in-game interaction modes, while borrowing from popular game mechanics, are also practicing and envisioning future change processes. However the game as a stand-alone communication and learning device is not the end product. It is a means by which multiple future scenarios and low-carbon solutions can be communicated back into other community contexts. The scientifically credible solutions featured in the game are meaningful, locally relevant, and feasible. The learning is thus structured to suggest viable pathways for action in real world situations.

4.2 Situatedness – where the learning takes place

Future Delta 2.0 is unique in its commitment to creating the situatedness of climate change by realistically portraying the local, visual and connected aspects of Delta communities. Four recognizable locales were developed from maps, and GIS data, combined with model generating programs, to create a believable environment for the game play. In addition, the environments are populated with multimodal details such as realistic audio and visual representations of local vegetation, birds and a diversity of NPCs (non-player characters). The connections to the everyday lives of Delta residents are made through narrative elements that reflect local challenges and solutions with the intention of evoking empowerment through an emotional identification with the place (Dulic et al. 2011). The design processes also involved multiple

Figure 2 Boundary Bay CIMA Vision, Act 3 in *Future Delta 2.0*

cycles of community engagement. Before game development began there was an extended community-based research process with workshop sessions in Delta to visualize future scenarios in response to sea-level rise (Barron et al. 2012; Sheppard et al. 2011). The workshops brought climate change science and modeling to the community scale and engaged multiple stakeholders, policy makers, government officials and community members of Delta in envisioning local future solutions.

Another aspect of situatedness has been grounded in an ongoing collaboration with the Delta School District. This collaboration has included focus groups, design co-design workshops, and classroom testing with students and teachers in participating Delta high schools. The co-design process has allowed for community participation in many stages of the research from strategy development right throughout the game design processes and evaluation. Workshops were conducted to determine how the game form and content aligned with the curriculum, interests and concerns of the school community. It also provided an opportunity to involve students in modeling objects and characters as well as collecting data on local knowledge and opinions on climate change. The role of the teachers in the game design was to see if the game could be integrated into the high school curriculum, while the role of the students was to make sure that game play strategies and interaction design reflected their day-to-day reality, culture and values. These participatory co-design workshops were an integral part of the design inquiry and provided interim results in the iterative process. Students and teachers shared valuable contextual knowledge about well-known local families as well as specific iconic signage for public spaces. These community-based design experiences contributed social and cultural values and unique visual identifiers that are embedded in the game, giving players an opportunity to engage in relevant challenges in their immediate recognizable world context.

4.3 Learning through action – how learning happens through play

Future Delta 2.0 presents a serious and complex topic in a fun, engaging, and rewarding way. The learning environment and GUI (game user interface) were designed for positive engagement with climate change challenges and solutions. An important design question was deciding which characteristics of game play were particularly effective in facilitating a positive experience of sustainable thinking and doing. We chose to design educational technology that encourages direct participation with pedagogical content through the exploration of the space, objects and interactions with NPCs. In addition, the game situates community mobilization strategies within the game space and simulates complex decision-making through active choices. The three main learning tools, CIMA Vision (CIMA Vis), Carbon Vision (C-Vis), and Future Vision (Future Vis) allow players to move through the acts and locales using familiar video game actions such as collecting, swapping, obstacles and puzzles.

The CIMA Vis tool allows a player to identify, categorize and tag objects that are causes, impacts, mitigation, and adaptation solutions in the virtual 3D game environment. This tool is based on a conceptual model designed to explain the interconnected relationship between climate change (C)auses, and (I)mpacts to (M)itigation and (A)daptation solutions, and has been used with participants invited to identify CIMA examples in aerial photographs of their neighbourhoods (Sheppard 2012). These workshops provided the basis for the game activity within the 3D virtual environment, where the CIMA objects are teachable elements, offering the player the opportunity to learn how to see climate change at the neighbourhood scale. In the process of categorizing objects in terms of the contribution to causes, impacts, mitigation and adaptation, the player is able to analyze the neighbourhood environment within a more holistic understanding of climate change.

C-Vis is a visual tool that allows players to see the amount of carbon emitted in the environment by colour coding carbon producing objects and buildings. As the player encounters different glowing coloured objects, the amount of emissions is measured and relayed to the player. The player is then given the option to swap high carbon producing objects with lower carbon objects and see the resulting colour change.

Future Vision (Future Vis) presents possible imaginary spaces and allows the player to learn about how different solutions for sea level rise could play out in a specific community. Future Vis offers the player the chance to engage with four different alternatives to sea level rise in the Delta region. The scenarios were developed from an extensive research process involving citizens, planners and policy makers in the Delta Regional Adaptation Collaborative Study (Barron et al 2012). This foundational research comprised of community-based workshops where 3D visual images of sea level rise were created for future scenarios. In the *Future Delta 2.0* game, each future allows the player to assess the trade-offs for each solution and experience future worlds that have either adapted or mitigated the effects of climate change. Players can practice influencing environmental policy and experience climate change solutions in situations where diverse community voices are brought together other.

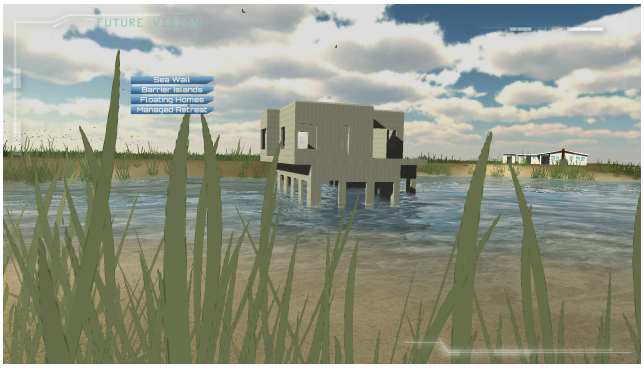

Figure 3 Managed Retreat Future Scenario, Act 3 in *Future Delta 2.0*

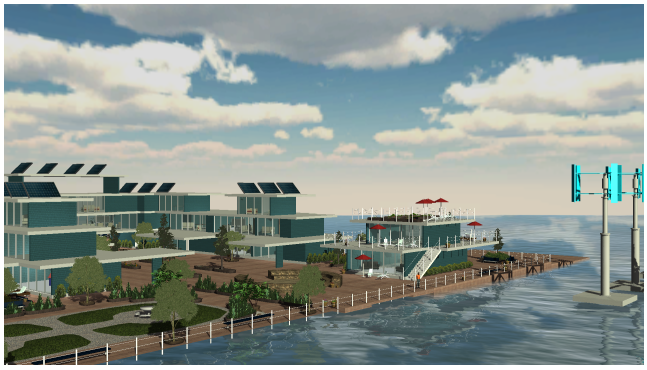

Figure 4 Floating Homes Future Scenario, Act 3 in *Future Delta 2.0*

In-game community mobilization simulates complex decision-making processes where the player is tasked with identifying the diverse needs and values of communities. Critical skills and reflective practices are introduced, applied and assessed within the *experiential learning context* of *Future Delta 2.0* through active game play that enacts the learning objectives and can potentially transform behaviours in real world contexts.

5 Evaluation methods and analysis

The evaluation methods of the *experiential learning context* for *Future Delta 2.0* were structured as part of the iterative design inquiry. Seen through the lens of interactive design practice, the reflective practitioners use quantitative and qualitative methods, such as questionnaires, focus groups, workshops, classroom discussion and close observation of play sessions as a means of gathering experiential material and data in order to integrate results throughout the research process into the final design of a game product (Schön 1983; Wakkary 2009). As such, the evaluation is not singularly based on testing *Future Delta 2.0* in a classroom setting, but is rather an accumulation of understanding the ways in which the design strands are reflected and implemented throughout the development of the game and embedded in a playable game product. *Future Delta 2.0* was brought into a classroom learning context for game testing, with intention of creating a final game product that can be used to supplement climate change curriculum in Delta high schools.

Recalling Schön's (1983) notion of reflection-in-action, the analysis of the *Future Delta 2.0* game necessarily addresses the complex relationship between game designers, the lived world of intended game players, and design actions. The practitioner inquires into the real world design situation of creating *Future Delta 2.0* through methods such as the co-design process, as well as qualitative and quantitative evaluations in order to simultaneously integrate analysis, design and implementation in the game. This iterative process frames and reframes the problem context to create a fun and engaging serious game about climate change and is an important way of moving towards the best design solution (Schön 1983).

Many of the design actions for *Future Delta 2.0* came out the research evaluation of the *Future Delta* prototype (Dulic 2011). The quantitative and qualitative results of the first playable iteration of the game helped shape the *experiential learning context* of the next research phase. According to the study, the game prototype helped players link the complexity of climate change on a global scale with local impacts in a real place (Schroth et al. 2014). These prototype results strengthened the design focus of the next research phase - motivating positive action, in a clearly situated virtual environment with realistic and scientifically credible game content.

The co-design process of the *Future Delta 2.0* research in the spring of 2014 involved approximately thirty Delta high school students and six teachers who gave feedback on game content and form. The design team analyzed the findings from this process, suggestions for improvement were integrated into the game, and the learning context for the game testing was designed based on the teacher/collaborator feedback. The co-design process thus ensured that the game continued to reflect meaningful learning objectives relevant to the school curriculum and student interests, situated in the lives of the participants who were actively engaged in learning through play.

The next stage involved game testing in five classrooms in two Delta high schools during the 2014-2015 school year. The game testing was designed to be part of an educational unit on climate change, such that before playing, the students filled out pre survey questions about their level of familiarity with video games and knowledge of climate change. At the end of the three sessions, students filled out a post survey so that the research team would be able to compare results from before and after the game play experience.

An analysis of preliminary results from pre and post survey of two classrooms with a total of 65 students suggest that the *experiential learning context* of *Future Delta 2.0* enables students to think holistically about climate change as a complex problem. Pre and post survey results from the question regarding student concern about the effects of climate change point to an overall increase in concern after game play. It also reveals an increased understanding of the correlation between local and global climate change effects.

The question on how knowledgeable students feel about the effects of climate change in their local area again reveals a more complex approach to understanding climate change. After playing the game, overall student knowledge increased while the number of students who were certain of their knowledge decreased. The correlation between increased knowledge and the uncertainty of that knowledge points to a deeper understanding of the complexity of local climate change challenges and solutions. These preliminary results are significant to us because it shows how experiential learning is an effective strategy for a holistic understanding of complex problems.

In particular, 52.2% of students responding to a post survey question said that playing *Future Delta 2.0* made them think differently about climate change, whereas 29.9% said it didn't change their thinking, and 18.8% were not sure. This points to over half the respondents having experienced climate change in a new way through gameplay. In addition teachers involved in the classroom game testing appeared enthusiastic about the game's ability to hold the attention of students and stimulate discussion about climate change.

Researchers found that students were excited to play the game, preferred the format in comparison to conventional book learning and they retained some important concepts about climate change causes and impacts as well as possible solutions. In an initial exploration of the observation notes from three classrooms in Delta Secondary, there are dominant themes that have emerged from the observation of the students playing Act 3 of *Future Delta 2.0*. The first theme is the importance of relating to the game

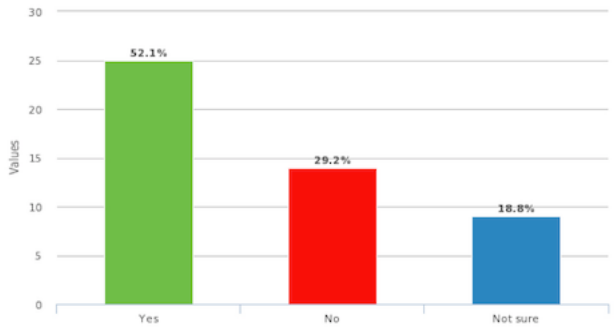

Figure 5 Post Survey Response: Has playing the video game made you think differently about climate change?

space as home. When students can identify and recognize places and character types in the game environment, they are more engaged and willing to learn through play. The second theme is there is a tension that needs to be maintained between providing the students with dynamic action and inserting obstacles that encourage reflective thinking in the game space. Students enjoyed moving quickly through their exploration of the third act, however when they were required to slow down in order to accomplish tasks, they moved into a mode of play that more closely resembles thinking-in-action. These initial findings support the value of setting up an intentional *experiential learning context* for game-based climate change education.

5.1 Further evaluation and developments

The qualitative understanding of student/game interactions in the classroom is only at a preliminary stage of analysis. Further evaluation will look through the experiential material for more evidence of the above-mentioned relevant themes for integrating serious games in climate change curriculum.

Much of the recent literature on serious games and educational technology is concerned with developing systematic and transferable methods of assessing the effectiveness of game-based learning (Seebauer 2014; Bellotti 2013). This research is essential for ensuring the credibility and applicability of serious games in educational contexts. Design inquiry focused on *experiential learning contexts* is well placed to incorporate the latest strategies for moving toward the best design solution in motivating community engagement in climate change.

Future Delta 2.0, as a tool for learning climate change intended for wide distribution, would benefit from engaging with in-game assessment metrics (Bellotti 2013; Seebauer 2013), and contextualizing game-based learning in relation to other types of experiential learning. In-game analytics of learning in relation to play mechanisms would provide quantitative data that could be used to further develop strategies for engaging students in place-based virtual environments. In addition using serious games in conjunction with other experiential climate change tools has not been fully investigated. The development of *Future Delta 2.0* as one of many climate change educational tools available to teachers and students is promising.

6 Conclusion

This paper discusses the design processes and strategies for the *Future Delta 2.0,* a virtual 3D game environment. Considering the uncertainty and unpredictability of so many elements of climate change, the game supports the idea that play is a vital approach for experiencing challenges, solutions and futures.

Future Delta 2.0 provides students with immersive and interactive climate change experiences through virtual game play - a medium that is relevant for 21st century ways of knowing. Digital technology allows for navigation between real and game world experiences in ways that can build understanding and skills for more resilient responses to future challenges.

Our early research reflections indicate that design inquiry fully engaged with communities in a rich *experiential learning context*, weaves together meaningful learning objectives, situatedness and learning through action, and yields a serious game product that can be used in a potentially transformational way in educational contexts. Further evaluation of the experiential materials and game-testing documentation will allow for a comprehensive and critical assessment of these claims. It is however important to discuss interaction design processes at this stage because the holistic discussion of the *Future Delta 2.0 experiential learning context* may be immediately beneficial for improving the effectiveness of serious games in education.

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