

Designing Digital Games to Teach Road Safety: A Study of Graduate Students' Experiences

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Abstract

In this paper, the researchers use an educational technology and instructional design framework to explore key aspects of game design used by educators and university students to teach road safety rules in general. The use of a framework is inspired by the game design literature and graduate students' prior domain experience in their respective fields of teaching. The study also looks at whether student-collaborated game design can lead to more effective learning and/or teaching constructs. Finally, the study explores the steps involved in game design and development, and through student interviews the researchers explain how collaboration plays a major role. To evaluate the proposed framework, a study was conducted with the participation of 6 graduate students using four phases: brainstorming, design, prototyping, and implementation. The students were then interviewed on their goal setting and design methodologies and shared their perspectives on whether these games provided a more creative setting for road safety learning. The study indicated that the proposed framework may simplify the game design process with effective and efficient collaborative design sessions in an educational setting.

Author Keywords

Game design; digital games; road safety; road rules; design experience; iterative design; motivation; planning; education; computer science; software engineering

Introduction

Road crashes are a leading cause of death and serious injury and extract a high cost from society. About 1.2 million road users are killed every year worldwide, resulting in an estimated social cost of over \$500 billion per year (Peden, 2004). Understandably, driver error has been attributed, by some road safety professionals and the general public, to be the biggest (90%-95%) contributor to crashes (Evans, 2004), resulting in constant calls for more training and testing of drivers. On the contrary, the literature on driver training and licensing suggests that many of the existing measures are ineffective in changing driver behaviour or reducing crashes (Senserrick & Haworth, 2005; Tay, 2006, 2008a, 2008b). Most of these studies, however, focused on vehicle handling skills and on-road driver training, and paid little attention to examining the effects of the knowledge test, especially road rules, on driving behaviour, violations and crashes.

Logically, an adequate and updated knowledge of the rules of the road is essential for drivers to drive safely. The conventional method used in Canada, for example, is to acquire this knowledge by reading the driver's handbook published by the provincial government. This approach is not attractive to younger drivers, especially after they have obtained their drivers' license. New methods to help novice drivers learn the road rules and retain this knowledge after passing their driver tests are necessary. Encouraging licensed drivers to update their knowledge will contribute significantly to reducing drivers' violations and crashes. One promising approach in today's digital environment is the use of gaming. "Why read about ancient Rome when I can build it?" This statement, by an elementary student, is the best testament of significant value in terms of digital gaming for learning and training (Moulder, 2004).

Digital games have only made their presence felt in the last decade or so alongside the technological advent of computer peripherals (Friedman & Wyman, 2006). However, there is a substantial increase in the use of video games for the last ten years in the classroom (Simpson, 2005; Squire, 2005a). Video games can be as effective as drills and tutorials for transferring knowledge and providing motivation in a controlled, safe environment (Trollip & Alessi, 2001). In addition, games capture students' attention by providing role play in a particular context, making the learning enjoyable (Squire, 2005a; Squire, 2005b).

A review of the literature on educational video game design (De Aguilera & Mendiz, 2003) indicates that a number of studies that reveal positive effects of cognition development through video games. Skills related to attention, spatial concentration, problem-solving, decision making, and collaborative work are among the noted improvements. It is not surprising then that globally, educators want to integrate digital game based learning into the K-12 curriculum in order to bridge the gap between the manner knowledge is represented and learned by digital natives and how knowledge is imparted and needs to be taught to acquire 21st century skill sets.

However, relatively little is understood about how to apply what educators know about teaching and learning to optimize game-based learning and design. Adoption of digital games in education generally fall into the following three categories: (1) student-built educational games; (2) educators and/or developers built educational games; and (3) incorporation of commercial off-the-shelf (COTS) games (van Eck, 2006). Educational game design typically asks distinct groups of people such as educators, game designers, and/or programmers to work together. These groups have different beliefs that often lead to unsuccessful attempts at creating educational games (Gareau & Guo, 2009; Isbister, Flanagan, & Hash, 2010). Few studies, if any, have explored the idea of designing educational games for general public use. In this case, educational games to teach road rules were designed by people who take the role of educator, learner, and game designer.

This study, therefore, takes a unique approach by asking practicing teachers who are also graduate students with knowledge of game design, to create educational games to teach road rules. These participants are either unlicensed trying to learn the road rules or licensed drivers updating their knowledge. In other words, they are learners of the road rules-the content the games aiming to teach. The assumption is that by combining the roles of educator, learner and game designer, educational principles may be better aligned with game mechanics to best meet learner needs.

In this study, we aim to: 1) identify the key aspects of game design used by real time students, using the framework of educational technology and instructional design; and 2) understand student-collaborated game design. The assessment of the games developed is beyond the scope of this paper and is focused elsewhere.

Educational Game Design

Modern educational (computer video) games are thought to be effective tools for teaching hard and complex procedures because they: (1) use action instead of explanation; (2) create personal motivation and satisfaction; (3) accommodate multiple learning styles and skills; (4) reinforce mastery skills; and (5) provide interactive and decision making context (Holland, Jenkins, & Squire, 2003; Sheffield, 2005). There are many different definitions of “games” in the existing literature and there is no universally accepted definition. For example, Abt (1970) defines games as “an activity among two or more independent decision-makers seeking to achieve their objectives in some limiting context” (p.6). Gredler (2004) on the other hand defines games as “competitive exercises in which the objective is to win and players must apply subject matter or other relevant knowledge in an effort to advance in the exercise and win” (Gredler, 2004, p. 571). For the purpose of this paper, we define a game as a free willed digital contextual environment with set rules embodied in the game play where the objective is to reach the goal by playing and learning. It is believed that the same level of engagement and intrinsic motivation of students in digital games can be replicated in a game environment with educational content called digital game based learning (DGBL) (Prensky, 2001). DGBL has gained a lot of interest in recent years. Its benefits include a learning environment that allows numerous means of interpreting instruction and different ways of accomplishing the goal (Simpson, 2009).

Educators have adopted three approaches for integrating games into the classrooms (van Eck (2006). The first approach deals with having students work as designers where they learn the subject matter and new software by making their own games as they learn to problem-solve. For example, Li (2010) conducted a study where elementary students designed and built digital games to teach one another Isaac Newton’s Three Laws of Motion through a visual programming software called ‘Scratch’. Kafai and colleagues’ work propagated the potential for game design as a conducive learning environment for students and teachers to brainstorm and synergize their view points while assimilating mathematic concepts in the real world (Kafai, Franke, Shih, & Ching, 1998).

The second approach involves educators designing educational games, from scratch, for students. Some recent research studies by Barab and colleagues (Barab, Gresalfi, Dodge, & Ingram-Goble 2010; Barab, Gresalfi, & Arici 2009) reflect current undertakings of such efforts. Their work supports the transformational potential of video games that allow students to play real life roles like doctors, lawyers, and scientists. Students can use specific area knowledge particular to their character to answer personally engaging and scenario specific queries (Barab, Gresalfi, Dodge, & Ingram-Goble 2010; Barab, Gresalfi, & Arici 2009). The third approach involves incorporating COTS digital games into classrooms (Eck, 2006). An example is the work done by Squire (2005a) who chose the commercially available digital video game Civilization III to teach

geography and history in middle school. This study coincides with the first approach, where students design and develop educational games to teach road traffic rules.

Collaborative Student-led Design

Due to students' on-going relationship with technology, learning-by-game-building has encouraged researchers to perform empirical studies in the subject areas of mathematics (Kafai, Franke, Ching, & Shih, 1998), computer science (Korte, Anderson, Pain, & Good, 2007) and science (Kafai, Carter Ching, & Marshall, 1997; Li, 2010). In these studies, analyses and interpretations of students' game-building experiences found patterns, processes, and connections between building and learning.

According to Salen (2007), thinking systematically is a requirement for success in the 21st century. She also believes game design supports designer-students in building this skill through an iterative process of meta-reflection when creating these systems. Researchers' (Kafai, 2006; Li, 2010) believed that allowing students to design games puts them in the drivers' seat thereby making learning student centric and engaging.

A study by Pastore and Falvo (2010) revealed that games should be seriously considered as a tool to engage and teach students in schools, and the study concluded that usage of digital games in the classrooms would grow. Due to the generation gap between teachers and students, not only in age but in the manner their brains are wired, video games can open new communication channels between them by bridging this gap and fostering partnering between them (Prensky, 2010). Control needs to be given to students while the harness or facilitator role should be in the hands of the teacher—this is an integral part for the success of the gaming environment (Prensky, 2010).

As discussed above, the Li (2010) study focused on elementary students' learning of math and science through their digital game designing and creation using a Scratch, a free online program out of MIT. The study showcased a majority of students having positive experiences during the process of building digital games. The environment in which these students designed Scratch games supported collaboration by encouraging open-peer feedback through the Scratch portal. Furthermore, students partook in higher level learning, using critical thinking skills and problem solving skills in order to build their games. The researcher concluded that student engagement in the game-building experience can enhance not just the learning of the game design process but also subject matter and generic skills. Thus, the learning-by-building approach can empower students to 'take over the technology' and become creators rather than passive consumers. In a similar vein, Ke (2008) argued that the focus should be on educational computer game design and application in order to enable game-based learning experiences that are both engaging and effective. Kafai (2006) concluded that allowing students to design games puts them in the drivers' seat, which promotes motivation and enthusiasm.

Learner-centered Game Design

The educational technology research community is slowly acknowledging the value of designing educational software in schools that stem from game developers' design methodologies and frameworks (Kirriemuir & Mcfarlane, 2004). However, an increasing number of studies have started to merge the field of educational technology and game studies. Prime visionaries stressed the important correlation between the game design process and game play. They also described general principles for the game design process (Prensky, 2001; Gee, 2003). One important effort was a comprehensive analysis that explored pedagogical foundations of modern educational (computer video) games (Kebritchi & Hirumi, 2008). This study analyzed 50 articles and 55 educational games published between 2000 and 2007. Of the 50 papers, these researchers found that 22 games were designed following specific educational theories. Specifically, the design of the majority of these games contained five key categories of instructional strategies and theories: 1) direct instruction; 2) experiential learning; 3) discovery/inquiry; 4) situated cognition; and 5) the constructivist approaches to teaching and learning. Below is a brief description of these five key groups.

Direct Instruction

The direct instruction approach originated from the behaviorist learning theory that suggests learning occurs through stimulus-response conditioning and generates and sustains motivation through pacing and reinforcement. Many game designers, such as designers of math games, use the design steps of orientation, presentation, structured practice, guided practice and independent practice to develop their educational games and CD ROMs.

Experiential Learning

The experiential learning theory focused on five instructional strategies identified: (a) learning by doing; (b) experiential; (c) guided experiential; (d) case-method teaching; and (e) combination of experiential and inquiry-based learning.

Discovery Learning

The essential idea behind discovery learning is that students are more likely to remember concepts discovered on their own. Researchers have also found that discovery learning is most successful when students have prerequisite knowledge and go through some structured training.

Situated Cognition

The situated cognition theory referred to in this study is rooted in the social development theory of Vygotsky (1978) in which social interaction plays a fundamental role in the development of cognition. Two subcategories within Situated Cognition were also mentioned, which were Situated Learning in Communities of Practice and Cognitive Apprenticeship.

Constructivist Learning

Many games used the constructivist learning approach which allowed the players to build their own game levels. The definition of constructivism was posited by Papert (1991) who suggested that new knowledge could be acquired more effectively if the learners were engaged in

constructing products that were personally meaningful to them. This approach is aligned with constructionism notion suggested by Kafai and Resnick (1996).

The most significant finding of this study was that 17 out of 18 games with explicit pedagogical foundations used learner-centered approaches. Only one of these 18 games used the direct instructional method.

Other researchers have tried to juxtapose instructional design theories with game design. For example, in her dissertation Becker (2008) aligned many popular instructional design theories to game elements found in a commercial game and concluded that almost all the educational theories have been embodied in commercial games, one way or another. For example, she matched Gardner's theory of multiple intelligences with game design (Armstrong, 1994). Commercial games using instructional design methodologies like Bloom's taxonomy, Gagne's nine events of instruction and Keller's ARCS motivation model have showcased environments conducive to learning (Becker, 2008). Another study (Fotouhi-Ghazvini, Earnshaw, Robison, and Excell (2009) evaluated four well-documented mobile augmented reality games in educational settings using essential elements and frameworks existing in instructional design, motivational design, and game design. These researchers conclude that some of the essential elements are Bloom's revised taxonomy (Bloom & Krathwohl, 1956), Gagne's nine events of instruction (Gagne, Briggs, & Wager, 1992), and Keller's ARCS motivation model (Keller, 1987).

Gunter and colleagues adapted a different approach, proposing a model to design and evaluate educational games, using motivation, learning theory and instructional design theory (Gunter, Kenny & Vick, 2008).

In addition to focusing on specific instructional design models, Vygotsky's (1978) social development theory - that stresses the importance of social interaction with regard to the development of cognition - has also been explored in relation to game design. It is argued that educational games provide a scenario where rewards and problem settings stimulate the learner, and feedback reinforces the content taught by providing hints related to game play. Furthermore, narration provides a context for interweaving the learning objectives and learner content with the rules of engagement in the game (Dondlinger, 2007). Dickey (2006) is of the opinion that spatial and narrative contexts offer learners this:

A cognitive framework for problem-solving because the narrative storyline in games provides an environment in which players can identify and construct causal patterns which integrates what is known (backstory, environment, rules, etc.) with that which is conjectural yet plausible within the context of the story. (p.2)

In another review study, Dondlinger (2007) examined 35 publications published between 1997 and 2007 related to game design. The analysis of these publications considered the following elements key aspects for effective video game design: motivation, narrative context, goals and rules, interactivity and multisensory cues.

In summary, although increasing number of studies have explored educational games and game design, few, if any have investigated game design by practicing educators (for example, teachers) who are also graduate students familiar with instructional and learning theories.

Research Questions

This study examines experiences of graduate students, who are also educators, when designing games for road safety. The following research questions guided the study:

1. What were the critical design considerations for graduate students when creating a road safety game?
2. What role does collaboration play when graduate students design and develop educational games for road safety?

Methods

Framed in a qualitative, naturalistic research perspective (Creswell, 1998), this research was a case study concentrating on graduate students' thinking and experience of designing games to teach road rules.

Participants

Six (five males and one female, ages 20-40) graduate students in a Canadian university voluntarily participated in this study. Among them, four were graduate students in educational technology and the other two were computer science students.

All participants were avid gamers with rich experience in game playing. These six graduate students were divided into four groups and Table 1 provides details of the teams. Pseudonyms were used in the paper.

Student/Gender	Program	Team	Game designed/created
Alan/M	Educational technology	1	Driven
Mosa/M	Educational technology	2	Splatter
Yoshi/M	Computer science	2	Splatter
Sally/F	Educational technology	3	Invasion
Frank/M	Computer science	3	Invasion
Lawrence/M	Educational technology	4	Will Drive

Table 1: Participants' Demographic Information

In summer, 2010, each team was given the task to create a digital game that would teach drivers, and/or potential drivers, road rules based on the Alberta government's drivers' Handbook. A total of four games were designed and/or created.

Data and Analysis

Five primary sources of data were collected: games created, design documents, interviews, blogs, and the researchers observation notes. Each participant was interviewed either individually or in pairs before, during and after their game creation. Semi-structured interviews were conducted with a list of questions that served as a framework, but often went beyond the initial question to explore teachers' perceptions and experiences.

The analysis for this paper focused on the interviews and teachers' written work, although other data provided contextual information. Data analysis started with open coding (Corbin & Strauss, 1990) by two researchers, working independently to identify recurring and salient themes. This method enabled us to determine first-level coding and summarize data as a means to create general categories from the full data set. The coded information on each participant was summarized in matrices and then compared to cluster cases. Grouping the data under different codes allowed us to see different patterns and themes emerging. To ensure reliability and accuracy, we employed strategies including the collection of different forms of data for triangulation, analyzing data independently and then cross checks by two researchers, member check, elimination of initial themes based on disconfirming evidence, looking for extreme cases, and paying particular attention to negative evidence (Miles & Huberman, 1994). This paper focuses only on the findings pertaining to the two research questions discussed above.

Context

The process of graduate students' game design and creation were roughly divided into four phases: brainstorming, design, prototyping, and implementation. In the first stage of the project, graduate students were thinking of ideas and techniques to make the content in the handbook fit into the context of an educational game.

The design phase was instrumental in providing a blueprint for the creation and development of educational digital games. Each team developed a plan for mapping the content with various game mechanisms and captures all aspects, features, and components vital to the success of the game. They penned down their initial thoughts, plans, and rationalisation for strategies, in a design document. Various theories including instructional design theories, learning theories and game design principles were used as framework.

In the third stage, each team paper prototyped their design to test their initial ideas. This phase also served as means for graduate students to troubleshoot and collaborate based on their design. It also provided a basis for feedback to check the rationale of the game and determine whether the content would blend in with the game environment. The final stage of the project involved the implementation of the design in digital format.

During each phase of the project, all team members and learning researchers met for regular meetings. Graduate students profited from the group meeting by sharing thoughts and challenges with their peers and researchers. It allowed everyone involved in the project to test currently developed artefacts (e.g. design documents, prototype, partial games) and provide feedback. Collaborative feedback provided during this process propagated new ideas that made the existing games better.

Results

Critical Design Considerations

The first research question focused on the exploration of graduate students' critical considerations when designing the traffic games. The analysis of the data revealed four major themes: 1) iterative design; 2) planning; 3) mapping design to content; and 4) learner motivation.

Iterative Design

The first significant theme that emerged was that graduate students, through this design and development experience, realized the importance of iterative design. Graduate students autonomously implemented this strategy in every stage of the process. They constantly revisited and altered design considerations made earlier along with the dynamic evolution of the game during development. The students' cycle of design and development included all of the essential components: the brainstorming of ideas, the paper prototyping, and the trying out of different solutions to solve problems. Following comments exemplified this:

- “Brainstorming is an important activity that leads to being able to outline and design the objectives, so paper prototyping is a pretty big issue” (Sally, pre-interview)
- “As you plan, there are a lot of things you won't foresee in the program, so you'll have to kind of look ahead and see what problems you may face and be able to look at them and see what you would do if some things came up.” (Frank, pre-interview)

The following description by Yoshi about her teamwork gave a good example of how the design and development process go iteratively:

- “During different stages of design, we are working together and going back and forth. First, we update different components of design during our discussion or during our work and call on different people to have valuable inputs, making it a better story. Second, there is more sophistication especially with the scenarios. The multi-agent and artificially intelligent scenarios are to be implemented. Once again, it does not only include the story level of the operational phase coverage of the traffic but also the construction for the traffic planning phase. The players have to face the scarcity of all these resources to solve problems. It's quite a sophisticated design in the script phase and we are doing trial and error between the script phase and design and implementation of the structural phase of that part.” (Yoshi, mid-interview)

Alan's diagram shared in his blog post provided another example, visually demonstrating iterative design process adapted by all teams.

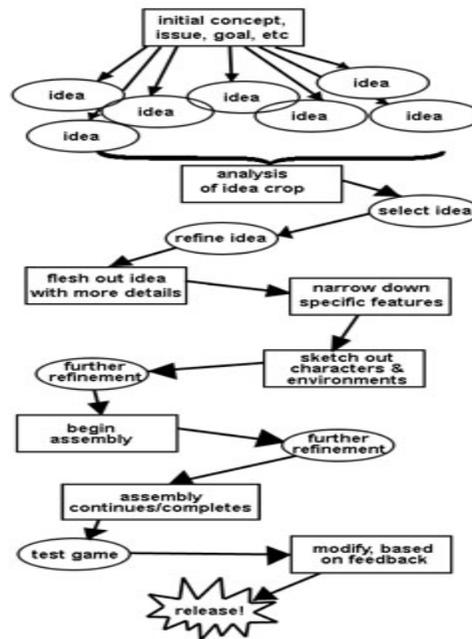


Figure 1: Iterative Design Process

Planning

The analysis of data showed that graduate students considered planning to be vital for the game design and development. Almost all participants discussed how careful and detailed planning could help align educational objectives with game play, but also lay the foundation and make the whole process, particularly the development process, go much smoother. Mosa articulated:

"Planning, planning... and then some more planning. I think the big thing is to get into the problem solving cycle. So, the first thing is to try to figure out what it is that you would like the gamer to accomplish to set up the parameters and the problem and then allow the player enough freedom to explore those areas that the game itself allows you to find the solution that you might not have anticipated but still work to learn the rules and the boundaries that are set...So, planning the subset and then figuring out how the code is going to give those rules so that the players can respond and predict, in a way, so they have the tools they can use". (Mosa, pre-interview)

Examination of the graduate students' planning process confirmed that planning became a determinate element contributing to successful implementation of the game design. Out of the four games, two carefully planned game designs were well developed and the outcomes were high quality games, while the other two with rough and ambiguous plans failed in implementation.

Mapping design to learner and content

When we asked graduate students about their critical consideration of design and development of the games, everyone talked about how game design needed to map to the targeted audiences (i.e. learner) and the content to be taught through the game. The needs of the audiences were believed to be the most important aspect of the game design, as reflected by the following comments made in their pre-interviews:

"You have to know your target audience. So, that is one thing that I am really conscience of that it's going to be 15 or 16 years old who don't really necessarily want to play something that's kind of silly and kiddie. So, you have to just be very conscious that it's got be interesting to them... and make them want to play it."
(Alan, pre-interview)

Students' comments and discussion revealed that they wanted to pitch the game at a level that would make it most effective to the learner by correlating the game with the learners' background or past experience:

"[you] got to speak the language of [your audience] in order to have the sharing of the common ground." (Yoshi, pre-interview)

Besides taking learner needs into consideration, a discussion on the significance of the content for incorporation into the educational game took place. Graduate students discussed that a deep understanding of the content needed to be in place before the designer could start the whole process:

"You can't actually start designing a game until you know your objectives and rules and rationale behind the rules." (Sally, pre interview)

Understanding of the content itself, however, was not enough for a good design. Being a designer also demanded the graduate students to map the content to the design. This exercise made graduate students realize that although they wanted to integrate as much content as possible to the game, it would be difficult, and possibly detrimental to cover everything in the game. They adapted different ways to map the content. Some decided to map each chapter of the handbook to each game level. Others used different puzzles to cover different chapters.

Motivation

How to motivate gamers was a significant issue considered by the graduate students. Although each student had a different outlook or approach on motivation, most of them declared that they did not want to create chocolate-broccoli games. In other words, they all wanted to design games that were intrinsically engaging, fun and relevant to the learners. The following except from the mid interview illustrates this idea:

"I think that it's more important to make an interesting and engaging video game than it is to put in the educational content because if it's boring, no one is going to play it anyways". (Alan, mid-interview)

Analysis of the data showed that different frameworks were adapted by these graduate students to motivate learners, ranging from contextualizing the content, to working on aesthetically appealing products.

In order to contextualize the content, some teams developed engaging and intricate storylines and narrations. For example, Alan's game was "a mystery game; like a dark and gritty graphic novel detective kind of story." The third team developed a game based on the story of alien abduction.

Believing that problem solving should be the focus of learning, other teams took a different approach by setting the whole game as a problem solving scenario. Team #2 designed a game that was a world of 'Splatter' where slug like creatures travelled through a space from place to place:

"[Splatters] travel using ...roads in the game and the splats are cars. They still explode most graciously whenever they touch one another. The game is a problem-solving based game where they use the Alberta Transportation rules of the road and traffic laws to solve splats' transportation problems and progress to various levels". (Mosa, mid-interview)

Team #1 and #3 used mini games to set up different problem solving cases. All teams had considered the importance of the game appeal: a key element each team articulated about their design was the development of aesthetically appealing and graphically engaging backgrounds and auditory attractive sound system. For example, Team #3 described their design rationale to emphasize the importance of aesthetic appeal of the game's environment. Such description exemplified graduate students consideration of this aspect:

"A canvas was used to build the alien universe and then transferred onto the computer...people react positively to an aesthetically appealing environment". (Sally & Frank, design document)

The team further clarified their game storyline involved unique game characters: "These characters are custom made and are mostly serving the function of rewarding the gamer and giving instructions to the next level of gameplay in a more visually appealing way than sterile instructions on the screen." (Sally & Frank, design document)

In short, strategies for user engagement play a pivotal role in graduate students' design of the traffic games which propagates interactivity between the learner and game. All digital games strive to bring about this state of total immersion. In this case, linking educational content to a game system brought about a means of communication between learners and technology.

Collaboration

The second research question examined what role collaboration played when graduate students design and develop educational games for road safety. The analysis of data demonstrated that collaboration played a significant role in the game design process, occurring through both structured and unstructured interactions. Specifically, the data showed graduate students collaborated in 3 different ways: 1) small team; 2) large group; and 3) online interaction. For the

graduate students who chose to work in teams, they discussed how the design and development experience helped them to work collaboratively. All graduate students who worked in small teams described how team members' skills complemented one another to help them accomplish tasks effectively. A couple of them enthusiastically explained that the highlight of the experience was the project's affordance to allow them to work in teams and practice collaboration skills. Frank's following comment best demonstrated this:

"A highlight [of the process] is TEAMWORK! I would say collaborative skills! It wasn't a one person job and it was fun, but we had different ideas to where we wanted to go...so we compromised or we used both ideas...I love collaborative imagination, collaborative problem solving!" (Frank, final interview)

Regular large group meetings encouraged collaboration because it provided a common ground for team work and a place to present and view peers' ideas. Graduate students not only shared games, but also thoughts, feelings, and strategies, allowing them to refine their games with inputs from all involved in the project. Graduate students, including those who chose to work individually, highlighted distributed cognition expertise helped them solve problems. For example, some students had artistic skills while others were musically inclined. Exchanging artistic works with musical pieces and helping each other on different aspects of games became a common practice. Alan drew art pieces for Mosa, Mosa made musical pieces for Alan and Team #3. When they encountered technical difficulties, some asked colleagues while others sought assistance from different online communities. Lawrence said: "I actually had to contact people in India to help in the programming part of this game."

Peer interaction through online communication such as blog sharing also facilitated collaboration. A common repository was created on Blackboard for all students to access and contribute information. Web links provided access to flash and action script tutorials and road rules practice tests that benefited all the students. Interacting asynchronously on blogs provided the means to stay connected and brought about a sense of togetherness on the project by sharing their on-line journals, thoughts, and ideas. Blogs by individual students provided up-to-date status reports on their projects and allowed peers to exchange comments and feedback. Some unexpected collaboration also occurred through these kinds of interaction. For example, Alan came up with the name of his game "The Driven" from Sally as explained by their following online dialogue:

Alan: "I have been working on my design but am finding it difficult to come up with a name for my game. Sally I like your blog name with which you write your posts."

Sally: "Glad you like my blog name! Why don't you use the name for your game? 'The Driven' has a nice ring to it?"

Alan: "Actually yes, that would really sound good for the game. Are you sure I can use it for my game?"

Sally: "Absolutely!"

Creativity and collaboration occurred naturally through the design and development process, enabling and even forcing teachers to think innovatively. Distributed cognition and expertise also contributed to successful game building. Furthermore, the process allowed and encouraged systemic collaboration not only among peers but also to the broader communities at large.

Conclusions

This study has explored graduate students' experiences of designing and developing educational games for road safety. This empirical investigation adds significantly to the research of digital game based learning by focusing on educational game design for road safety—a traditionally under-researched field, and by examining people taking on the roles of game designer, learner, and educator at the same time. It contributes to the ongoing research of how to harness the power of digital games for educational purposes. By providing insights into graduate students' thinking and experiences, this study enhances our understanding of best practices of game design for teaching traffic rules that could improve road safety in general.

This study of graduates' students experiences of designing and developing educational games for road safety demonstrates that they followed an iterative process: planning, design, development, field test, that is typical to educational game design (Klopfer & Squire, 2008). The results suggest that iterative design, planning, mapping design to content and learner motivation are the four critical aspects. Although iterative design was not emphasized beforehand, it was automatically employed in the process. This illustrates that the design has to be constantly revisited, as the initial blueprints constantly evolve. This is consistent with the key concepts identified by professional game designers (Isbister et al., 2010).

Several factors contribute to this constant change. First, getting feedback from users through various approaches such as prototyping and play testing would bring out new perspectives and fresh ideas. Second, when implementing the plans, graduate students encountered various problems and therefore have to improvise and come up with new approaches to solve the problems. Third, graduate students, while viewing prototypes of their peers, get fresh ideas for use in their games. They may also get inspired by games or strategies used by their peers or other people. The adaptation of the iterative design strategy significantly improved the quality of the games.

Planning plays a significant role in graduate students' design and development process. A plan is the fundamental structure integral to the game. Careful planning helps designers to balance the educational content with engaging gaming elements. Graduate students claimed that they cannot "emphasise enough on the importance of planning." Just as the old cliché 'If you fail to plan, you plan to fail,' we claim that a good plan provides the impetus for the successful completion of the project. Students with carefully crafted plans have positive experiences as their game development process becomes a smooth one.

Graduate students provided detailed design documents in the first stage. This stage provided the initial means to communicate designers' visions and plan various plausible solutions to the problem. The iterative design process allowed designers' to reinvent and refine their initial plans

which resulted in well-tuned outcomes. An implication to future educational game design, particularly by amateur designers like graduate students, is that it is vital to plan details including storyboarding, sketching level maps, and creating detailed conversation scripts before actual creation of anything. This would allow the game implementation come together quicker, smoother, and identify problems easier.

Another critical consideration of graduate students as designers' is how to map content and learner needs to game design in order to maximize the educational value of such games. Learner age and background along with educational content to be included, are important aspects for the graduate students to contemplate. This is in accordance with previous research (Backlund, Engstrom, Johannesson, & Lebram, 2010) that game based simulations which incorporate pedagogical goals in the game design may alter game components to reach the desired effect and enhance learning in driver education.

In this study, during this design process graduate students collaborated through various means, some were intentionally built into the initial project but others were unexpected. For example, distributed cognition as an exercise was exemplified by their exchange of music and art pieces; they were not requirements of the collaboration by design. This self-inspired collaboration brought out graduate students special qualities shared in terms of goodwill and invariably promoted the quality of their games.

Parallel to professional game designers' thinking (Dondlinger, 2007; Isbister et al., 2010), graduate students consider motivation to play an important role when designing and developing games. The games created are intrinsically engaging, fun, and relevant to the learners. Graduate students adapted different frameworks to motivate learners. For example, students contextualized content by developed engaging, intricate storylines with narrations. In addition, all teams believed that problem solving should be the focus of learning to keep the learner constantly engaged.

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