Evaluation of the Game Development Process of a Location-Based Mobile Game

Imran Beg, Jan Van Looy, Anissa All
Communications Department, Faculty Political & Social Sciences, iMinds-MICT-Ghent University, Ghent, Belgium
Imran.Beg@UGent.be
J.VanLooy@UGent.be
Anissa.All@UGent.be

Abstract: There is a growing interest of government and NGOs in using (serious) video games in road safety campaigns. Until now, however, little was known on how to set up such a campaign so as to effectively cater to the needs of different stakeholders including the target audience who is often adolescents. This paper aims to address this gap by presenting a mixed method approach for involving stakeholders in the development of a game-based awareness campaign according to user-centred design methodology and assesses its effectiveness in a concrete use case: the development of the location-based mobile game City Jam. The goal was to develop an entertaining yet educational digital game as part of a road safety campaign targeting Flemish adolescents (15 to 18 years old) with the purpose to raise awareness about concrete, realistic traffic situations and influence their attitude in a positive manner. Eight forms of qualitative research were selected and deployed throughout the game development process. Firstly, a literature review was conducted in order to gain an in-depth understanding of learning principles in games, and the media use and road (safety) behaviour of the target audience. Secondly, insights were fine-tuned in collaboration with road safety experts and ideas were gathered and developed into a first game concept. Thirdly, the target audience was involved in order to define game concept that met their preferences and needs. Fourthly, City Jam was tested with the target audience in an iterative fashion so as to assess and optimize game play. Based on the results obtained throughout the game development process it was possible to evaluate the impact of stakeholder involvement on the different stages of the process and the final product. Benefits and challenges of user-centred design methods are discussed and how budget constraints and different desired outcomes of different stakeholders challenge but also enrich the process.

Keywords: location-based games, game design methods, mobile game learning, road safety, user-centred design

1. Introduction

Given that road traffic accidents are still the number one worldwide cause of death among those aged between 15 and 29 years old (World Health Organization, 2013), several studies can be found on how to optimize and evaluate effectiveness of road safety campaigns (RSC) (Hoekstra and Wegman 2011; Phillips et al. 2011). However, given the complexity and contradictory findings on establishing the effectiveness of a traditional RSC, there is a growing need for new approaches towards the design and evaluation of RSC (Hoekstra and Wegman 2011). In the past decades, digital media and information technologies have taken an increasingly central role in everyday life in Western society, particularly for the younger generations who grew up with these technologies. Consequently, questions have been raised on whether traditional teaching methods still meet the needs of these 'digital natives' (Prensky 2003) and whether or not new media, such as digital games, carry the potential of improving education by providing more tailored learning materials and by increasing intrinsic motivation of the learner (Gee 2003). Given the growing interest in games as instructional tools in several areas, such as education, defence, health and wellbeing (Susi et al. 2007), it is hardly a surprise that the interest in the potential of road safety games for educational purposes arose too. For instance, Backlund et al. (2010) assessed the effectiveness of a game-based driving simulator as a learning tool, investigating possible individual learning effects and differences between groupings of participants. Given the positive results, authors concluded that a game-based simulation can be used to enhance driving education. Furthermore, Li and Tay (2014) examined the effect of game-based learning on the improvement of young drivers' knowledge acquisition and retention of knowledge of road safety rules. Post-test results indicated that players' knowledge improved pointing to the potential of using games in this area whilst not providing a convincing benchmark as no control condition was implemented (for a discussion on methodology used in the field, see (All et al. 2014).

2. Serious game design

It is not uncommon that qualitative research methods, often originating from the field of user-centred design, are deployed throughout the game design process to optimize game play (Pagulayan et al. 2003). However, whereas the goal in traditional usability design is to develop a product in which users can effectively and efficiently reach their goal in a satisfactory way (Nielsen 1994), the goals of a digital game are fundamentally different: i.e. to keep game play as fun and enjoyable as long as possible (Pagulayan et al. 2003). In the field of game design, gradually, more studies on the application of heuristics and usability methods to game design and development arose, developing 'playability' principles for game design (Desurvire et al. 2004). In the field of serious game design, the development of digital games targeted at learning outcomes requires different guidelines given their aim of integrating predefined learning goals into the game and to affect the player's experience. An important challenge is, for example, to integrate learning principles into the game mechanics, without losing its playability or fun factor and thus maintaining its intrinsically motivating qualities (Dondlinger 2007). However, a potential issue in serious game design observed by Vanden Abeele and Van Rompaey (2006) is that user input and feedback are often gathered too far in the development process, limiting, for instance, the potential to optimize the balance between an engaging, entertaining game and its educational dimension. In the field of digital games for RSC, All et al. (2013) addressed this gap by involving stakeholders in co-design sessions for the development of a game design document for a game-based road safety campaign. Thus, whilst initial steps have been taken in developing road safety games and exploring how to involve the target audience in optimizing these games, until now, no study has evaluated the involvement of multiple stakeholders throughout the whole game development process. In this paper we discuss the user-centred design process of a game-based RSC involving multiple stakeholders. Our aim is thereby to provide insights and best practices on how to involve different stakeholders in the design and development process of a game for a RSC.

3. Methodology

Eight forms of qualitative research were selected and deployed over the course of the game development process. To evaluate the outcomes of the stakeholder involvement of City Jam, a systematic outline was chosen: goals, procedures, outcome and evaluation were described for each method. The game development process resulted in several game mechanics, issues and ideas; however, due to practical reasons, the most important and/or challenging were described.

4. Results

4.1 Literature Review

The goals in the first stage were threefold: 1) select the most adequate game application and platform; 2) review learning principles and motivation theories for potential game integration; 3) map road safety issues among adolescents. Firstly, we found that there was a strong trend towards mobile gaming among youngsters related to the growing adoption of smartphones. Secondly, it was observed that, in order to maximize the benefit of using a game-based intervention, it was paramount to focus on motivation and different strategies for achieving enjoyment. Thirdly, we learned that there were different issues regarding road safety among adolescents, categorised in five major risk elements (see table 1). Given the popularity of gaming on mobile devices among adolescents in combination with the mobility aspect of road safety a game format complying with these requirements was chosen: a location-based game on mobile devices. The literature review would also serve as a reference work for the partners, in particular with regard to learning and motivational principles (and suggestions on how to implement them in game design).

<table>
<tr><th>Risk behavior</th><th>Regulations</th><th>Anticipation in traffic</th><th>Lack of experience</th><th>First aid</th></tr>
<tr><td>Alcohol/drugs</td><td rowspan="3">Inconsistency in knowledge on basic rules and traffic signs</td><td rowspan="6">Cyclists and pedestrians are 'vulnerable' road users, erroneously thinking they are ‘invincible’ and ‘privileged’</td><td rowspan="3">Novice versus experienced driver</td><td rowspan="3">Lack of knowledge on first aid</td></tr>
<tr><td>Speed</td></tr>
<tr><td>Fatigue</td></tr>
<tr><td>Distraction</td><td rowspan="4">Consciously disobeying compliance with traffic rules</td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td>Seat belt</td></tr>
<tr><td>Risk assertiveness</td></tr>
<tr><td>Behavior among peers</td></tr>
</table>

Table 1: Five major risk elements and subcategories (obtained from literature review report)

4.2 Road safety expert interviews

To gain insight in how to maximize effective game play, two road safety experts in the field of high school education and experienced with the implementation of RSC for the target audience were interviewed and input was recorded and manually transcribed. It was found that there are no obligations to implement road safety education in the schools’ curriculum (whilst it is put forward as a general goal that should receive attention across different courses). A strategic, cost-effective model was therefore suggested to fit the RSC within the curriculum by making the game session combinable with other school activities (e.g., a museum visit) whereby transportation costs could be shared. Furthermore, to appeal to teachers, we needed to minimize their effort and overhead by offering an easy to use scenario and ready-made

classroom material for debriefing. Hence, we chose for a lending formula; partners will provide devices with the game installed (specified in a later stage). Interviewees also advised to communicate practical information to schools long beforehand by various media channels. Launching the RSC around March/April was considered optimal, as schools select educational activities and projects for the new school year (starting September) before and during the summer break (starting in July). The interviews with the road safety experts proved useful in providing insights in how to integrate the RSC in the school context and how to develop a communication and promotion strategy so as to maximize participation of the target audience whilst also taking into account the needs of intermediaries. In hindsight, it could have been useful to consult more experts and/or other stakeholders such as teachers and/or school principals to verify and optimize the strategic plan.

4.3 Road safety experts focus group

A first goal was to verify and elaborate on road safety issues among the target audience. The second goal was to concretize the findings concerning road safety issues among adolescents and gather input for translating road safety elements into the game concept. Therefore, a focus group was organized with four road safety experts and data was transcribed and analysed. The findings confirmed and strengthened most of the previous findings on traffic behaviour and skill set of the target audience. Road safety experts provided additional information on punishment strategies. For instance, short term consequences to disobeying traffic rules and/or risk behaviour are more effective for adolescents: punishments such as fines or time investment (e.g., following a state road safety course) will be more likely to impact adolescents than pointing them to the potential longer term consequences of an accident. The focus group with the road safety experts proved to be of value for the verification and validation of previous road safety issue findings and served as input for the punishment mechanics for game design.

4.4 Co-design sessions

The main goal was to explore the interest and preferences of the ‘co-designers’ (target audience) on game theme, game mechanics, mobile phone application and locations in the city to play mini games (for a detailed description, see All et al. 2013). Five co-design sessions were held with the target audience to gather input and data was analysed manually. A total of 39 game concepts were created and based on preferences the game theme ‘music band on tour’ was chosen. To take gender preferences into account, it was proposed to design a competitive (preferred by boys) game based on gathering items (preferred by girls). It was suggested, for example, that ‘levelling up’ could be linked to gaining a higher social status (i.e. starting out as a poor music band without transport and ending as a popular wealthy music band having a limousine). In hindsight, it could have been interesting to involve road safety experts in the co-design sessions to emphasize the theme of road safety, since only a few co-design groups integrated it into their game concepts.

4.5 Game design document

The game design document (GDD) contains the description of the game design for a digital game, and is used as a guide throughout the game development process. It was our goal to send a GDD out as a tender to several Flemish game developers, describing the game scenario including the entertaining and learning dimensions (written in collaboration with a game developer). Two game developers responded to the tender and a game developer specialized in location-based games was selected as the best partner for the actual game development. Due to financial and practical reasons, an adjusted GDD was proposed by the game developer, deviating from the original GDD. It caused some problematic issues since several educational related elements were adjusted and/or removed without alternative suggestions for replacement (e.g., mini game with augmented reality to emphasize the mobility aspect was not adopted in

the adjusted GDD). It might have been more efficient to focus even more attention on the pre-production stage, so that the final GDD could be used as a faithful outline for the final game as changes are cheaper and schedules less tight than in the production stages. One possible solution could have been to define stricter requirements in terms of budget, desired outcomes and practical implementation for the final product at the beginning of the GDD stage.

4.6 Concept design focus group

A focus group with the target audience was organized to test several concept designs and styles for the game so as to gather feedback among the target audience (see also All et al. 2013). A game designer was also present (as confidant of the social scientist to prevent socially desirable behaviour) for support. Different designs for the scoring system, game characters, and the virtual game environment were discussed and participants received a 'creative assignment' in which they were given the instruction to create game characters, draw their own scoring design, illustrate the game environment and present 'wild ideas'. Several proposed designs by the game developer were received as too childish and it was suggested that they could be made more funny and ludic. The concept of taking a picture on the tablet in the beginning of the game to personalize the game received positive feedback. Although the focus group was initially not planned, it was useful for exposing target audience preferences regarding design styles and game mechanics. Due to the extra focus group, the game developer saved time and money by focusing on certain features which they knew would appeal to the target audience and design new styles based on the input (see figure 1).

Figure 1: Participants during the creative assignment (top) and concept designs after input (bottom)

4.7 Heuristic evaluation

To identify potential usability and playability problems in the early stages of game development, a heuristic evaluation was performed on the pre-alpha version of City Jam by a social scientist. To identify usability problems for the interface and playability issues in an early stage, the Heuristic Evaluation for Playability (HEP) checklist of Desurvire et al. (2004) was used in combination with the traditional heuristic checklist of Nielsen (1994). The game developer created paper mock ups of the game structure (i.e. print screens) and the scenarios. The material was examined with a specific focus on the game interface design (i.e.,

menu, instruction screens, visual design) and the learning aspects (i.e., textual and/or visual feedback). In a second stage, pre-alpha game aspects were tested on the tablet to assess game play. One major, three intermediate and seven minor issues were found. Feedback on actions and events (e.g., picking up virtual items and how it is displayed in the inventory) were found to be unclear and/or inconsistent. Furthermore, mismatches were found between the user mental model and the game model (e.g., game instructions were provided behind the clock icon, instead of the question mark icon). A major issue was the practicalities given the game format. Since the game is played outside in the city centre, it was important that players are provided with information in case of technical crashes or moving outside the game area. Looking back on the development process, it would have been profitable if heuristic evaluations were performed more than once, since it is quick and cheap method to identify potential problems and can therefore save time and budget costs.

4.8 Field testing

To test the game mechanics and experience of the target audience, City Jam was tested in an iterative fashion in the city centre of Ghent, Belgium (see figure 2). Four field tests were conducted over four months, in which a total of 41 adolescents from eight schools participated in three field tests and an extra field test was organized for road safety experts (see table 2). Each field test consisted of two parts: the game test itself (approximately 90 minutes) and a focus group held directly afterwards (approximately 45 minutes). A Go Pro camera with head mount was used to capture game play behaviour (in test three, two head mounted cameras were used). Game experience was recorded in the focus group (maximum of 12 participants per group) and data was collected using questionnaires. Each test resulted in a research report containing findings and recommendations for improvement which were communicated to the project partners. After field test one, it was decided that a Likert scale questionnaire was insufficient in capturing the game experience and attitude of the target audience (i.e., game mechanics were implemented in the game step by step, making the interpretations sensitive to errors). Instead, game testers wrote down three positive and three negative aspects after game play.

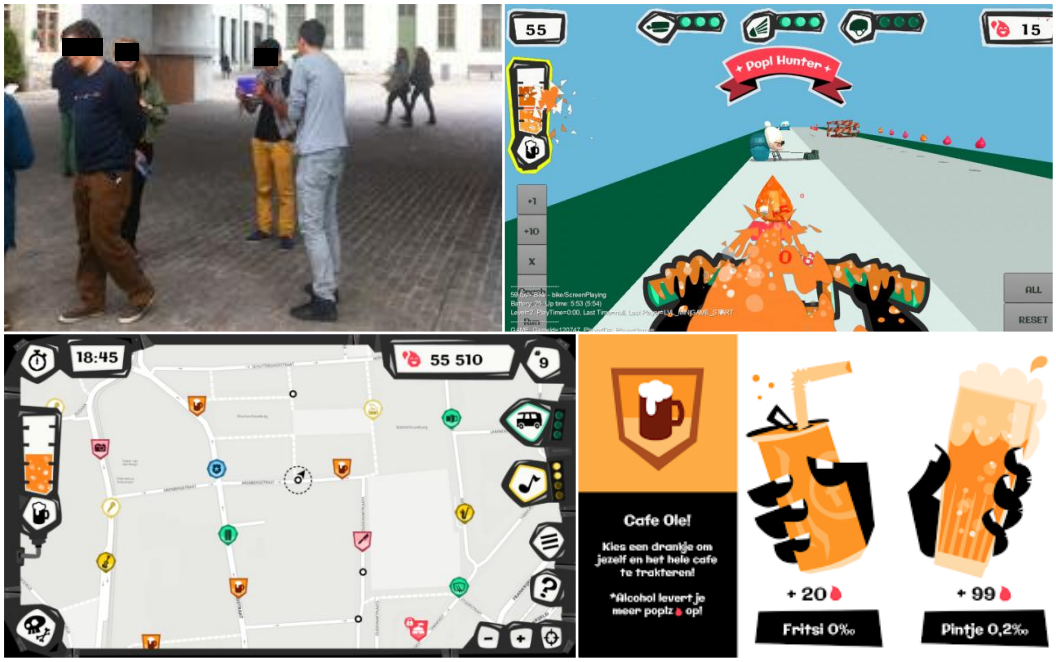

Figure 2: Participants playing a mini game (top left and right), digital map and menu on tablet (bottom left) and a decision screen when a virtual item is picked up (bottom right)

Field test	Game testers (N=47)	Number of teams	Age range (years)	Gender	
				M	F
1	18	4	14-18	15	3
2	7	3	14-17	6	1
3	6	4	n/a	4	2
4	16	5	15-17	8	8

Table 2: Demographics of game testers in the iterative testing stage

In the first field test, competitiveness (e.g., sabotaging other teams with virtual 'bombs') and the game concept (e.g., outside, discovering the city while playing) were considered positive aspects of the game. However, it was found that the game was seen as an individual rather than a cooperative game: i.e. discussing about strategy, explaining game features to each other was mixed from team to team. Furthermore, game testers addressed that they were not always involved in the game play, given the restrictive game play on one tablet per team (i.e., the tablet size, visibility and constantly walking made cooperation more difficult). To optimize cooperation physical maps with information on items and scores for non-tablet holders were implemented as to improve cooperation. In the second field test, however, it was found that teams forgot the maps or did not find them useful for the game play. Evaluating other cooperative elements, such as promo actions (e.g., taking group pictures with virtual fans) and traffic questions (not present in test one) were considered as mildly interactive as it stimulated negotiation and decision making. Field test three was organized with road safety experts and there was consensus on risk behaviour during game play (especially player with the tablet): the touch with reality (i.e., paying attention to the traffic whilst playing) is lost because of the attention required for playing on the tablet. However, several experts remarked in the focus group that, although it is dangerous, it is a good example of the reality (traffic participants do not think of traffic in terms of a process, rather, in terms of going from point A to point B). It was suggested that after having played the game, a debrief session should be held (e.g., by the educator) as to reflect on the game. Moreover, the road safety experts evaluated that the game was strong in the sense that it provided the players with choices and therefore increased the chance of reflecting on road safety issues and/or risk behaviour. For instance, although there are police patrols, players can try to avoid them whilst being virtually 'drunk', or be sober and if they are checked by the police men they can receive positive feedback (without a fee). Either way, it was proposed that both induce reflective thinking. In field test four, new game mechanics were integrated and introduced to the game testers so as to improve cooperation and safety while playing. The role of bodyguard was implemented to engage non-tablet holders in the game and to enhance traffic awareness during game play. The role of map reader was introduced as to enhance cooperation and strategic planning between tablet holder and non-tablet holder. Results showed that the bodyguard role was confusing and was not seen as a game element. Secondly, usage of the map was not increased compared to the previous tests. Another issue in previous tests was whether or not game testers understood implemented game strategies. For instance, a game dynamic for educational purposes integrated in the game was to make teams aware of the consequences of choices concerning virtual alcohol consumption and (not) picking up of virtual road safety items. If a team consumed too much alcohol (i.e., going to the virtual pub) and/or did not pick up any road safety items (e.g., helmets, bicycle lights) this could consequently influence the amount of fee received by the police when encountered during game play and the amount of points earned in the mini games. Result suggests that, due to the adjustments made based on previous findings in the field tests, these game dynamics were understood and discovered during game play. In hindsight, the testing stage followed a tight schedule and the game developer was under pressure in delivering a final version of the game: new game mechanics were not always finished in time whilst at the same time

adjustments had to be made based on the findings in the field tests. Moreover, the timing of field test two was found to be unfortunate since it was planned during the exam period, resulting in a small test group. A final field test for the target audience could have strengthened the findings obtained in field test four, when all the game mechanics were integrated, but due to budget and time constraints this was not possible.

4.9 Final brainstorm sessions

The name City Jam was chosen by the partners after a brain storm session and ten names, ranked online by adolescents, served as input. Another goal was to select and adjust questions that cover the five major road safety problems among adolescents as found in the pre-production stages. Selecting and editing of road safety questions took place in the final months of the game development process and input was provided by the Flemish department of mobility. A brainstorm session with the partners was held to discuss and select multiple choice questions (e.g., driving and using a mobile phone, which traffic participant has priority in several traffic situations, alcohol consumption and traffic behaviour). It was found in field test three that, although received positively as part of the game, the majority of game testers commented that they did not interact that much with the road safety questions because they were found to be too easy or not well integrated in the game scenario. Therefore, it would have been more profitable if the brainstorm session took place in the pre-production stage.

5. Discussion

This paper aimed to evaluate different user-centred design methods for involving different stakeholders, (i.e., road safety experts, game designers, social scientists and the target audience) in the development of City Jam, a game-based RSC. Desired outcomes of the project partners were taken into account and collaboration resulted in an end product that was attuned to the needs and preferences of the target audience.

Based on the findings in the literature review performed by social scientists, a location-based game format was chosen given the popularity of mobile devices and the mobility aspect of the RSC. Expert interviews with road safety experts were held given their experience with campaign design for schools and to find a strategic plan to maximize the reach to the target audience. Valuable input was gathered on promotion, distribution, game location (i.e., selection of cities) and the type of cost-effective formula that would work best for schools and intermediaries. A focus group with road safety experts was organized to redefine and validate road safety elements detected in the literature review and gather input on game mechanics for the educational dimension (e.g., a punishment strategy was proposed and later developed, tested and redefined). To create a game that matches the target audience, co-design sessions were deployed so as to discover and unravel the needs and preferences of adolescents on storyline, location, game mechanics and mobile phone features. It was found that becoming popular is an important theme, mixed with competitive elements and collecting items, to level up throughout game play. In collaboration with a professional game designer, the findings on the educational dimension (i.e., road safety elements) and the entertaining dimension (game dynamics, elements and mechanics) were formulated in a game design document for the game developer. Before actual game development the game developer requested to gather feedback on game design styles and elements. A focus group was organized with the target group and provided the game developer insights in their preferences, which saved time and money in the game development stages (i.e., target audience perceived the game style as too childish and amateur like). During the actual game development, a heuristic evaluation was performed so as to assess general usability and playability issues and investigate the translation of road safety issues in game mechanics/elements. An often used method to improve game usability and enjoyment is usability testing (Pagulayan et al. 2003) in a laboratory setting with predefined tasks to be performed by target users (Nielsen 1994). However, given the location-based game format and the multiplayer aspect this was not

optional and it was therefore chosen to test the game in an iterative fashion followed by debrief sessions. A great advantage of testing was to re-test game mechanics and elements. For instance, the ideal balance between winning (collecting items and perform actions) and losing points (i.e., receiving fines or sabotaging other teams) was assessed. A potential problem however, was that game mechanics were only fully integrated in the final test, limiting the assessment of game enjoyment and experience of educational elements in previous tests.

In retrospect, there was room for improvement in pursuing an efficient, cost-effective and satisfactory collaboration between project partners; milestones, planning and the description of game elements in the GDD were found to be too vague in the latter stages of the game development process. For example, road safety questions were not explicitly adopted in the GDD which led to insufficient testing. By foreseeing this, consequences such as extra costs and testing (accompanied by time pressure) could have been prevented. Moreover, budget and time constraints mediated the project outcome; improving and/or replacing game mechanics due to testing was not always feasible. Furthermore, the project could have been enriched with additional stakeholder involvement of school representatives, such as teachers and principals, to strengthen the strategic plan (i.e., fitting City Jam in the school's educational curriculum on road safety) and instructional designers so as to provide feedback on the translation of learning principles into game design.

A next step could be to investigate methodologies in a more systematic fashion so as to assess their added value and outcomes. Furthermore, in a follow up, a study will be conducted into the effectiveness of City Jam using a quasi-experimental research design to assess changes in cognitive and affective outcomes.

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