A game-based learning approach to road safety: the code of everand

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A Game-Based Learning Approach to Road Safety: The Code of Everand

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ABSTRACT

Game and gamification elements are increasingly seeing use as part of interface designs for applications seeking to engage and retain users whilst transferring information. This paper presents an evaluation of a game-based approach seeking to improve the road safety behaviour amongst children aged 9-15 within the UK, made available outside of a classroom context as an online, browser-based, free-to-play game. The paper reports on data for 99,683 players over 315,882 discrete logins, supplemented by results from a nationally-representative survey of children at UK schools (n=1,108), an incentivized survey of the player-base (n=1,028), and qualitative data obtained through a series of one-to-one interviews aged 9-14 (n=28). Analysis demonstrates the reach of the game to its target demographic, with 88.13% of players within the UK. A 3.94 male/female ratio was observed amongst players surveyed, with an age distribution across the target range of 9-15. Noting mean and median playtimes of 93 and 31 minutes (n=99,683), it is suggested such an approach to user engagement and retention can surpass typical contact times obtained through other forms of web-based content, though must be coupled with a pedagogical design capable of capitalizing on this contact time though a game-based medium.

Author Keywords

Game-based interfaces; road safety; gamification; attitudinal change; e-learning; serious games

ACM Classification Keywords

H.1.2 User/Machine Systems - Human Factors; K.8.0 Personal Computing: General - Games; K.4.1 Computers and Society: Public Policy Issue - Human safety

INTRODUCTION

The number of child pedestrians killed or seriously injured (KSI) on roads is a significant global issue. Statistics released by the World Health Organization place road traffic accidents as one of the leading causes of death worldwide, responsible for 1.26 million fatalities in 2000 [1], and the second leading cause of death amongst those aged 15-29. Hence, whilst this paper focuses on the specific case of the United Kingdom (UK), improving road safety is a significant global challenge [2]. As an emerging form of public e-health intervention, game based learning offers a potential avenue by which to reach demographics which are unresponsive to more formal methods of instruction, with the goal of fostering an attitudinal, and subsequently behavioural, change [3]. This may hold particularly true for the case of children aged 10-15, who present a unique road safety challenge in that their unsafe behaviour is predominantly linked to their failure to apply knowledge of safe practices [4], rather than lacking the knowledge itself.

In recent years it has become apparent that, while the game design community has developed mostly separately from the interaction design community, games can offer highly usable interaction experiences, especially when it comes to learning, motivation, user satisfaction and community formation. In a novel interaction design approach to addressing children's road-safety behaviours through game-based learning, Code of Everand was developed as a massively-multiplayer online (MMO) game for children, embedding abstract and social learning principles as a basis for instigating behavioural change.

In this paper, an analysis is presented of the game's reach to its target demographic, establishing some indicators of impact through self-reported surveys, qualitative interview, and statistics on game usage. The use of a game as not only a subject of research, but also a primary tool for data acquisition is an emerging concept [5], which allows for the analysis in this case of data arising from 99,683 players interacting with the game over a 5-month period. We couple these results to those from a national survey of 1,180 UK children, collected in an electronic format in a classroom-based context, and an online survey of 969 players, and qualitative interviews with a smaller group of participants, towards establishing key considerations for

future interventions. The findings are of relevance not only in terms of the impact of the game on road safety, but also offer some insight into how players approach game-based interventions in general, and the specific case of web-based, open access, multiuser environments.

BACKGROUND

Accidents involving children represented 61% of all deaths and serious injuries on UK roads between 2000-2005 [6], emphasizing the need to promote safer behaviour and awareness amongst younger age groups. Further analyses have investigated the cause and likelihood of accidents within younger age groups: a study of 202 UK police reports and 826 coroner's records [7] analyzed fatal child accidents with the goal of identifying behaviours and groups best targeted by safety interventions. The results demonstrated higher fatality rates amongst males, suggesting that in particular the 11-15 age range represents a high-risk category, with the number killed or seriously injured (KSI) over a 1-year period (2001) four times greater than the 0-5 age range. Reaching this demographic with targeted safety interventions is a demanding task. Knowledge transfer alone has been shown to be inadequate [4]; often children are aware of the principles of safe crossing, but fail to enact them in practice. The causes of this are numerous, though key factors include peer-group pressure and perceived social norms [8], as well as overestimation of ability and underestimation of the likelihood and severity of injury [9]. Furthermore, since safety education programmes are frequently opt-in, they tend to be self-selecting and fail to reach the highest risk groups [10].

Entertainment media such as television have often been used to convey safety messages. However, as children's leisure time becomes increasingly fragmented across electronic gaming and social media [11], an emerging need exists for these technologies to be embraced by public health interventions to ensure important messages continue to reach at-risk groups. Furthermore, studies have demonstrated as many as 97% of UK children aged 11-15 play electronic games, and nine in ten UK children aged 5-15 live in a household with a games console [11]. The role, therefore, of HCI experts in understanding how to best utilize game-based media and translate psychological and pedagogical principles to effective digital interventions, is critical in retaining the capacity to reach and impact such audiences.

The project reported by this paper sought to capitalise on the popularity of electronic gaming amongst the target demographic to develop a targeted intervention conveying a road safety message in an intrinsically-motivating fashion. Existing evidence has already shown the efficacy of such games when seeking to induce attitudinal and behavioural change in a young age group, tackling for example topics such as treatment adherence amongst young cancer sufferers [3]. The mechanics, dynamics and aesthetics of a game-based intervention, when designed with pedagogical, psychological and participatory perspectives in the foreground can be effective in achieving the desired intervention outcomes. Similarly, the ability of the medium to reach demographics less responsive to more formal pedagogical approaches has been demonstrated alongside their potential to foster intrinsic motivation [12].

THE CODE OF EVERAND

The initial selection of a game-based medium was driven by the increasing distribution of childrens' time across emerging media, which in turn is reducing the audiences traditional messaging approaches such as television advertising can expect to reach. Whilst other examples of electronic games devised around the concept of road safety have been explored in various forms [13, 14], Code of Everand sought to be unique through its adoption of a massively multiplayer online (MMO) approach. Game-based learning was selected as an appropriate vehicle under the hypothesis that a game-based approach would demonstrate particular attraction to groups with higher risk levels, as identified in the previous section. This research highlighted males aged 11-15 as being at particularly high risk of death or serious injury in pedestrian accidents [6]. The game was developed to complement a wide portfolio of existing road safety interventions, which included approaches such as direct messaging and safety education in schools. As such, rather than seek to replicate these existing interventions, Code of Everand sought to explore a new means for encouraging children to socialize in a safe and positive environment during their leisure time, whilst reflecting upon and rehearsing their safety skills.

A key research question behind this design approach was whether a safety intervention could attract and retain a substantial UK audience when deployed as a free-to-play online serious game. In particular, as the game sought to reach at-risk groups who have limited engagement or exposure to other safety interventions, a concern was whether the "serious" nature of the game would limit its ability to compete for screen-time with leisure game equivalents. Gameplay remained at the forefront of the experience, in line with the view that engagement and entertainment should be foremost in such a context [15]. Towards this goal, storytelling and narrative aspects played a key role in the game's design, with players searching towards the long term goal of uncovering a mythical code, supported by a range of non-player characters with scripted dialogues. Players are provided with both a role to play and a context to play it in, ultimately leading to intervention and the desire to act. In essence this motivational approach is a the process of exposure, in which main protagonists are exposed to a sequence of events, motivating them to act and embark in a narrative journey. This was reinforced through the game's web presence, with short graphic novels and additional materials both adding to the world of Everand, and reinforcing positive safety messages.

Figure 1. The world of Everand, intersected by ley-lines analogous to roads. Players are encouraged to exercise route-planning skills to navigate the land.

Figure 1 shows the world map of Everand, with its various locations and spirit channels. A range of social activities and elements existed within the game, encouraging and rewarding players for collaboration. Players assumed the role of powerful "Pathfinders", tasked with exploring the fantasy land of Everand and safely navigating "spirit channels" populated with a variety of monstrous creatures. As such, an abstract metaphor for road crossing was implemented, with basic road safety principles recreated in the virtual world: pathfinders must carefully select their route, look both ways when crossing a spirit channel, and form peer-groups to enhance their safety and progression. Further images from the game are shown in Figures 2 and 3. Analogical transfer was embedded into the game through a this "crossing" mechanic, built around the spirit channels, with the player required to route-plan, using the map shown in Figure 1, to avoid crossing more dangerous spirit channels, and minimize the required number of crossings to reach their destination. On undertaking a crossing, they are confronted by creatures such as those shown in Figure 3, and must look right and left to defeat them in a turn-based game.

By socialising with other players, larger groups could be formed allowing for safer crossings, with players collaborating to overcome creatures and cross safely. In addition to providing an environment which all players simultaneously co-habited, players also had pets ("critters"), which they were encouraged to take responsibility for. Figure 2 demonstrates a social mechanism whereby players were encouraged to compete and collaborate to pay tribute to their own type of critter, with the critter receiving the greatest daily tribute granting a bonus to all players with that critter type. Whilst ethical and safety considerations precluded the implementation of a method for open communication between players, players were able to communicate with one another using a collection of preset dialogue options and actions. This represented one the greatest design challenges, as without direct communication, limitations on socialisation may have impacted retention, as reflected by the results in this paper.

Figure 2. Game elements such as the 'critter court' shown here encourage players to collaborate and compete to gain advantages.

The game was made available from November 2009 to November 2011, accessible through a player embedded within a web page. As such, the interface was constructed to be operated using a mouse on a desktop PC. Prior to launch, it was promoted through online search and display advertising on child-oriented websites. Post launch, two week-long periods of advertising in the UK during children's prime viewing times was coupled with paid search to stimulate uptake.

Figure 3. During a 'crossing', players must select the most appropriate traps and abilities to overcome creatures.

As a novel approach to road safety, multiple underlying pedagogic approaches were explored. It was hypothesized that models for attitudinal change may emerge from social learning [15], in the communities formed by the game, as well as analogical transfer [16] from the game's individual components. The game's design sought to support social aspects of learning through an in-game "buddy list", as well as through supplemental materials such as graphic novels available through the game's website. Impact thus had the potential to occur in social interactions outside of the game, or through further reflection and learning stimulated by, but not transferred through, the game itself. Hence, the method described in the next section sought to establish both the uptake of the game, to assess the viability of this and similar interventions as free-to-play MMO games, as well as providing an examination of the viability of the social

and analogical learning mechanisms through a combination of survey, qualitative interviews, and analysis of the data arising from players' interactions with the game.

METHOD

Four data collection activities were used to gain insight into the efficacy, reach, and audience of Code of Everand: A nationally-representative survey (henceforth referred to as the "national survey"), a survey of the player-base, analysis of data from the game engine, and qualitative interviews with players. The process of analyzing the qualitative interviews was based on an inductive content analysis approach that led to the identification of different experiences when playing Code of Everand. Certain themes were derived from the qualitative analysis focused on transferability of play to real-worlds concepts, learning opportunities in game-based environments, conceptions of game-based content and scaffolding. An ethical review and approval for all components of the study was undertaken by Coventry University, UK.

The national survey was undertaken across 40 UK schools in December 2010. Surveys were completed in an electronic format by schoolchildren, with no incentive for participation in the survey. The total of 1,108 participants was representative of 28±5 participants per site. Participants were equally distributed in terms of gender (0.98 M/F n=1,108), with 43% of children aged 9-11 and 67% aged 12-14. Teachers provided informed consent *in loco parentis*, making clear to children they had the right to refuse to participate or opt-out at any stage, a message repeated in the survey itself. By comparison, the player survey was distributed via email invitation to parents of players, asking them to invite their child to participate, and completed online between February-March 2011. As a result the sample for this survey could be considered to be partly reflective of the user-base for the game (3.94 M/F, n=1,028), with an age distribution as shown in Table 1. Participation in this survey was incentivized with an in-game reward and prize draw.

Analysis of the databases held by the game engine relating to anonymized user behaviour was also undertaken. Informed parental consent was a principal consideration in this study, a consequence of this indirect method used for data capture. Children were required to provide as part of the sign-up process for the game to supply the email of a parent or guardian, who then authenticated their account for play after reviewing an agreement. No further information, which could be used for personal identification, was collected as part of the registration process, and these emails were held separate from the remainder of the data analyzed as personal data under the UK Data Protection Act. Parents of players consented to have this data used for research purposes as part of the sign-up process for the game. The data reported on by this paper represents a complete export of the game's database in May 2010, seven months after the game was made available via the Web. As

the game engine does not facilitate text-chat or other methods for communication between players beyond pre-selected dialogue options, there was no risk personal data could be inadvertently collected through chat logs or similar mechanisms.

Age	Player Survey		National Survey	
	Male	Female	Male	Female
8 or less	82	17	17	18
9	81	13	71	69
10	103	23	114	117
11	122	26	108	114
12	85	17	128	140
13	65	18	89	81
14	39	12	21	21
15	22	12	0	0
16+	110	33	0	0
Unknown	67	22	0	0

Table 1. Age and gender distribution of player and national survey respondents

The final activity consisted of qualitative research with 31 participants: 28 children aged 10-12, selected on the basis of a single criteria: that they reported walking in the street without adults more than once a week, and 3 players who volunteered to participate in qualitative research following an advertisement on the game's website. These children were interviewed firstly on their pedestrian behaviour, then instructed to sign up to the game and keep a diary for 2-3 weeks. At the end of this period, the group was engaged a second time in a game-focused interview. This was supplemented by interviews with three existing players, who volunteered to participate following a request made by the game's welcome screen as well as on conclusion of the player survey. Each of these participants was also engaged twice, with a first interview focusing upon the game, and a second on their pedestrian behaviour. Interviews took place in the homes of children with a parent or guardian present. Prior to commencement, the aims and objectives of the research were discussed with the parent or guardian who consented to their child's involvement. Though the child was made aware they would be discussing the Code of Everand game, care was taken to avoid explicitly prompting or cueing responses linking the game to road safety, to examine if children made this link automatically.
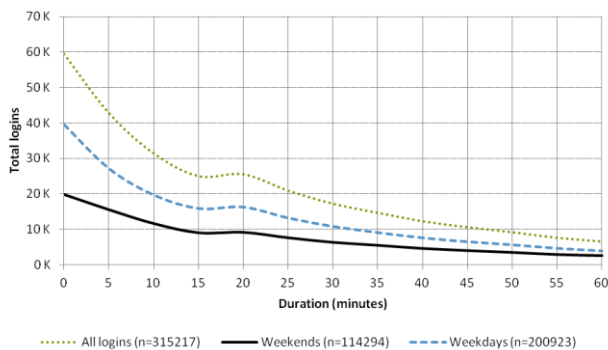
RESULTS

Results are separated into two sub-sections: the first reviews the overall uptake of the game, primarily in quantitative terms as a result of the two surveys and data from the game engine. The second reflects upon the perspectives of players towards the game as explored through qualitative interview and survey.

Uptake and Reach

Over the 7-month period between November 2009 and May 2010, the game attracted 99,608 unique account creations and 315,883 individual play sessions. From the national survey, 16% of participants had heard of Code of Everand, and of these 20% had gone on to play it (n=1,108), figures which, if replicated nationally, would generate a player-base roughly equivalent in size to that observed, assuming the age range recorded by the player survey (Table 1) was reflected in the user base. IP address geolocation showed this audience to be predominantly from the UK (88.1%), Republic of Ireland (3.5%), and US (2.5%), a consequence of the active promotion of the game though two 1-week periods of television advertising and paid search. 29% of players (n=954) reported hearing about the game through this television advertising, 28% from an Internet site, and 21% from friends or school friends.
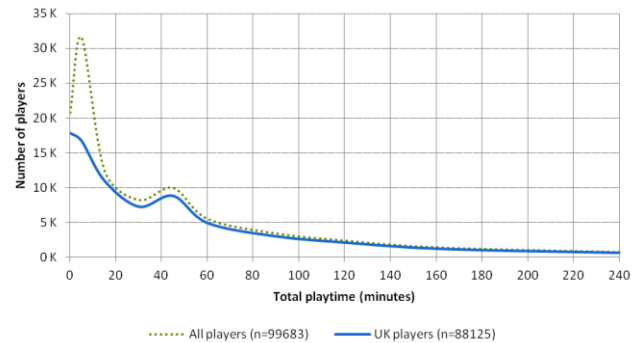

Figure 4. Duration of individual play sessions (n=315,217)

A clear in-game gender bias in avatar selection existed (4.56 M/F, n=99,608); this may have been due to the character creation process defaulting to a male avatar, with a link between time played and gender selection significant at p<0.01, with players with female avatars more likely to play for a longer period. However, a real-world gender bias is represented at a similar level in Table 1 (3.94 M/F, n=969). While this may have some implications of the comparability of the national survey and player survey it does also show that the game was very effective at addressing the target group of children most at risk, which shows a similar gender bias. 68.1% of players for whom data was available (n=969) had an avatar of the same gender as themselves. Notably females were more likely to play male characters than vice versa (70.2% of females played a character of the opposite gender, as opposed to 21.5% of males).

The mean time spent playing Code of Everand (Figure 5) was 93 minutes (n=99,608), though the sample was characterized by outliers, with 28% of players experiencing the game for less than 15 minutes, and 14% for more than 2 hours. Hence the median of 31 minutes may be considered to be more representative of a "typical" playtime. With respect to the number of times players returned to the game, 52.4% of players logged in a single time, and for these
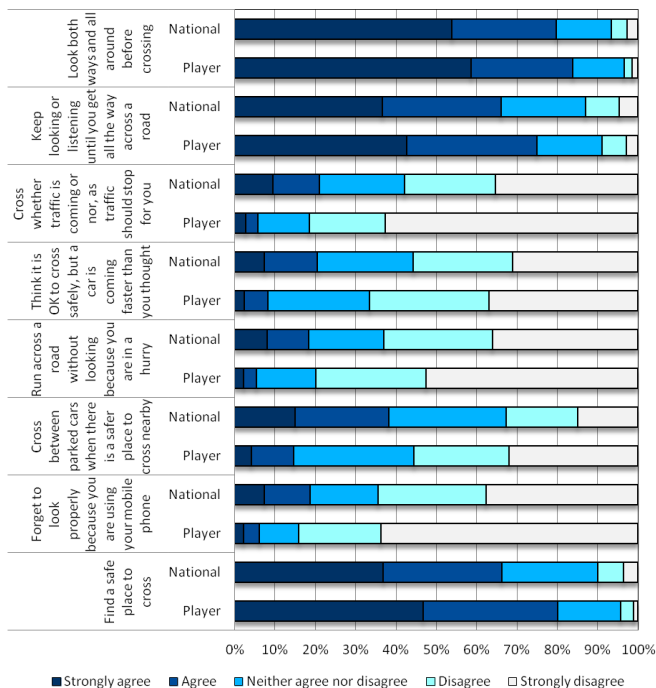
players the mean playtime was 24 minutes. By comparison, 19.8% of players logged in twice, and 9.1% three times. As shown by Figure 4, 36.3% (n=315,883) of play sessions occurred on weekends.

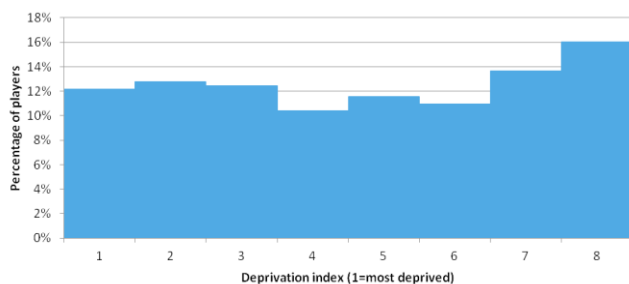**Figure 5. Total time spent playing by individual accounts (n=99,683)**

As the player and national surveys asked identical questions on safety, comparison between individual questions was possible. However, the difference in samples and sampling methods (Table 1), as well as the differing contexts of the two surveys implies a need for caution when attempting to infer underlying causal factors. Figure 6 illustrates Likert responses for both national and player survey respondents for one of three groups of safety questions. Applying a non-parametric test (Mann-Whitney's U) in view of the distribution of the data yielded a range of significant results: Players were more likely to agree that they took the time to find a safe place before crossing (Z=-5.912, p<0.001), keep looking and listening as they crossed (Z=-3.791, p<0.001) and look both ways before crossing (Z=-2.177, p=0.03). Similarly, they reported higher levels of disagreement with negative, risky behaviour, being more likely to disagree that they crossed between parked cars where a safer place was nearby (Z=-11.929, p<0.001), cross regardless of whether traffic was coming (Z=-11.516, p<0.001), or run across the road without looking (Z=-8.339, p<0.001).

Looking more specifically at concrete experiences, players were less likely to agree they had experienced incidences of thinking it was safe to cross, but realizing a car was travelling faster than they thought (Z=-4.595, p<0.001), and the same was true of forgetting to look as a consequence of using a mobile device (Z=-11.163, p<0.001). For questions on self-reported behaviour and experience, the overall weighted results were again in favour of more positive behaviour amongst players, with the only non-significant result at p>0.05 being on knowledge rather than behaviour.

Figure 6. Comparison of Likert scale responses from the national sample (n=1,108) and players (n=814) to questions on frequency of dangerous and safe behaviour.

Whilst these multiple significances are an encouraging finding, possible underlying causes included a potential appeal of the game to an intrinsically safer audience, as well as the differing contexts of the surveys influencing their outcomes. To examine the former, the results for 337 players who had voluntarily supplied postcodes were compared against indices of multiple deprivation [17] to gain some insight into their socio-economic background. Indices of multiple deprivations are used within the UK to rank 32,482 (as of 2007) areas in order based on a range of social and economic metrics. In Figure 7, these are arbitrarily grouped into 8 ranks, each containing 4,060 areas, with the data for players grouped by these ranks. As can be observed, whilst the majority of players were indeed from the least deprived rank, the overall distribution proved broader than might have been expected and therefore it is reasonable to not consider players' social-economic status as a factor in or further analysis.

Figure 7. Histogram showing the distribution of players (n=337) by indices of multiple deprivation.

Players' Perspectives

Though the limited sample of 31 participants precludes a meaningful quantitative analysis of interview outcomes, one metric considered was the "top three" pieces of advice a child would give to a friend regarding road safety. Participants were asked this question in the initial and final interviews, and their responses compared to a list of best-practices to examine if their advice had changed and, if so, if it more closely matched desired road safety knowledge which Code of Everand sought to transfer. In initial interviews, four children across the sample identified these items: using zebra crossings, avoiding main roads, crossing in safer places, and avoiding busy junctions. In the follow-up interview after playing the game, this had increased to 13 children, suggesting play did have impact on their knowledge as well as their attitudes as reported in the previous section.

For learning to occur through analogy, a pre-requisite would be that players were capable of recognizing this analogy, and applying the tactics learnt in game to real-world problems. Key to this recognition were the spirit channels and crossing mechanics:

"I think the big ones [spirit channels] are like main roads cause the big blue ones stand out to me more like they are thicker main roads. But the long thin windy roads like this one here to me look like a village, like a little neighborhood or close, or cul de sac. It's a tiny road like just crossing the road." [Female, 12]

Similarly, other participants also recognized the analogy when confronted by the channels:

"The channels are like roads so you have to look left and right and then the monsters are like cars - sort of." [Male, 11]

Quantitative data (Figure 8) supported the assertion that many players had identified the analogy, with 46.8% of players (n=743) agreeing or strongly agreeing that 'I think about road safety' whilst playing. Also noteworthy was the level of disagreement with players to the statement that Code of Everand 'is boring because it is educational', with 61.2% disagreeing or strongly disagreeing, and only 12.8% of players agreeing or strongly agreeing. This suggests the perception of game-based learning amongst the majority of players who responded to the survey was positive, though the potential influence of self-selection bias should be considered. Irrespective, the overall uptake figures support the notion that there is little need to obscure a game's serious intent from players to ensure uptake. Participants who recognized the analogy frequently went on to reflect upon their own behaviour:

"I'm playing it and the next day I'm crossing this really busy road... this massive road... there's no crossing where I go on it. After a week of playing the game I thought: I'm not going to risk it. [...] I thought: cars are going four ways and you never really had time in the middle when the light

switched. You can get injured. I just decided to be safe. The good thing is it influences you to be safe on the roads." [Male, 12]

"Normally, I have to admit, normally if there is a car coming I would wait for it to go past, but every now and again I would run across the road. Every kid does it. You can't say you don't do it, you can't say you will do it, but since playing this game I have taken more care of myself with crossing the roads, actually thought about... a minute ago I basically got run over [i.e. got defeated in Everand]. I have thought more carefully about the way I cross the road." [Female, 11]

"I walk home on my own after school and I've found not to muck around with my friends as much on the way home. Because like for example you can be defeated on here, that could happen in real life." [Male, 11]
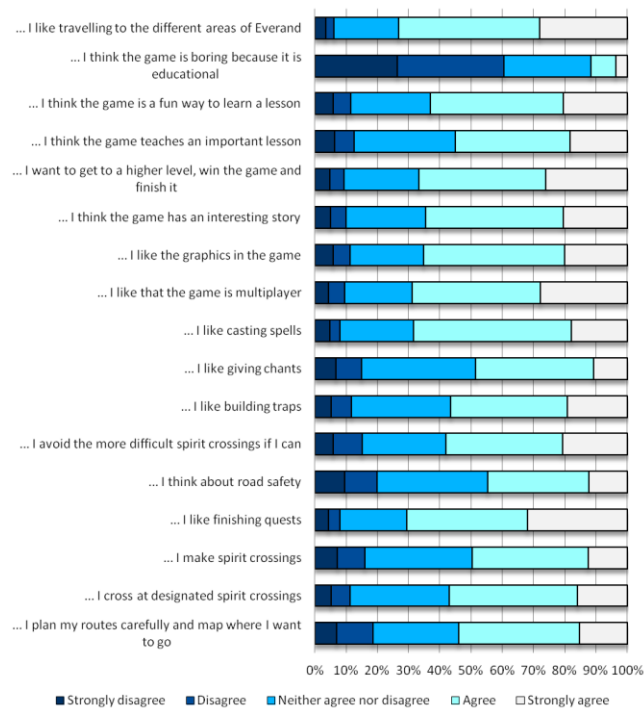

Figure 8. Likert scale responses from players (n=743) when asked about the various aspects of the game.

Attempting to create models for learning through analogy can be particularly challenging in a game-based environment, given the potential for players to seek to defeat a game as efficiently as possible, rather than take the route intended by designers. Consider, for example, the following child's perspective of their avatar - this player had learnt that, situationally, dying in game could be used to his advantage to save time on travel:

"He [my avatar] would be probably very very annoying. He'd be doing stupid things like killing himself. [...] I wouldn't do really stupid things, but if I was like him in this

game and I knew if I died I just could come back, I would just keep on trying things." [Male, 11]

Qualitative work demonstrated that usability within Code of Everand, though with some areas for improvement, was not a barrier to players' entry, a finding again reinforced by broadly positive responses to questions of the enjoyment of various game elements (Figure 8). A significant observation here related to the expectations of children with respect to how game-based content is conveyed. A tendency was observed to avoid reading text, and very few children in qualitative observation (n=31) referred to the substantive game manual, reflected in approaches which either built on trial-and-error or more-able partners:

"I just like to find out for myself because then I get used to the controls earlier" [Male, 11]

"It's better to play with someone [...]. Well it was a bit worrying at the start and [another male player, 10] told me what I had to do... he explained it first. That was ages and ages ago when we first got it." [Male, 10]

Entertainment games largely embrace spoken dialogue, and particularly with a young audience whose literacy skills may not yet be fully developed, text-heavy game content may easily be overlooked. If learning outcomes are similarly embedded, it is equally possible they may be overlooked. Code of Everand avoids this in-part though its implementation of analogical problem-solving though a predominantly visual approach, though to play and understand the game fully some appreciation of its depth is required whilst in turn implies reference to the manual. Some interviewees overlooked elements of gameplay such as using the correct trap types to match monsters, or the world map, as they were not sufficiently transparent.

DISCUSSION

Taken as a whole, the results show significant usage within the UK, supported by positive attitudes of players towards game based learning. Evidence suggests that though the audience was predominantly male, females did make up around one in five players. Though playtimes and return visits preclude the ability to assert that social learning was occurring on a large scale over a long-term within the game, qualitative and survey data illustrate that in the shorter term, players were recognizing and reflecting upon the analogy to real world safety. It is again worth noting that as proven methods already existed for transferring the fundamental knowledge of safe crossing, Code of Everand focused upon encouraging children to apply this knowledge in practice, rather than reiterating the direct messaging aims of other methods of safety education. As such, whilst the ultimate impact of this recognition and reflection is hard to quantify, evidence suggests the game did achieve the objective of reaching a large UK audience for a significant contact time, and encouraged a proportion of this audience to reflect upon their existing safety knowledge in the context of the game.

A key benefit of the game based approach when compared to other interventions was its ability to attract a young audience for a period averaging 93 minutes, a notable achievement considering children were playing the game outside of a classroom context without extrinsic motivation. Similarly, that 16% of the nationally-representative sample had heard of the game (n=1,108), and that of these one in five had gone on to play it, demonstrates the appeal serious games can hold for this audience. Interest amongst the target audience was evident for game-based approaches to learning, with the majority of those surveyed disagreeing that the game's educational premise made it 'boring'. Evidence did emerge to support impact in the short-term on players of the game, and indeed there was no pre-requisite on minimum exposure time under the models of analogical transfer and scaffolded reflection built into the game. Qualitative interviews and larger scale statistics outlined in the previous section demonstrated recognition of the game's serious purpose and analogy, in many cases leading to reflection and self-reporting of attitudinal change by interviewees. Comparison of the player survey to the national survey also showed significantly safer behaviour amongst players, though a more rigorous control study approach would be required to demonstrate this conclusively, and would itself by limited due to the difficulty in obtaining concrete metrics of safer behaviour over the long term amongst participants within a practical sample size.

Though playtimes (duration) were in excess of what might be expected from a visit to a static, informational website [22, 23], they were not indicative of the long-term retention often demonstrated by commercial massively-multiplayer online games. One factor behind this may have been the difficulty in realizing social aspects in the absence of the ability for players to directly communicate. When surveyed, 68% of players (n=618) purported to play the game alone, 9% with friends they met online, and 23% with parents, siblings, or friends from school. However, the in game 'buddy' list, which allowed players to record and track their friends, was used by only 14% (n=99,608) of players, and of the 59,479 social ties formed, only 2,685 were reciprocal. Within the smaller qualitative sample, the players who had made friends with other players tended to do so without any real sense of social connection. Either a player had approaches them, asked them to be friends, and they had said yes, or participants initiated the friendship; yet the entire encounter carried the same weight as acknowledging someone in the street: a clear example of social interaction, but not of meaningful social connection. Considering design methodologies for MMO worlds which emphasize the role of socializers in creating sustainable communities [19], this likely had a significant impact on user retention. More encouraging in this respect was the fact that 21% of players (n=969) signed up to Code of Everand after hearing about it from a friend or school

friend, suggesting the game was discussed amongst children beyond the confines of its online environment.

An open question in the national survey showed the most played game in the 9-15 age range was the PEGI-18 rated *Call of Duty* series (53% of boys and 12% of girls, n=1,108), demonstrating that this age group are widely engaging with adult gaming titles, compared to lower usage rates for child-oriented games such as *Club Penguin* (12% of boys and 13% of girls). Whilst Code of Everand was not intrinsically 'childish' in its design, this does demonstrate that appealing to such an audience in their leisure time requires interventions to compete with games aimed at a mature audience.

Taken in a wider context, this has implications for all interventions which seek to capitalize on social networking or other technology-facilitated social interactions, since interventions limited by policy preventing open communication amongst under-16s are likely to struggle when placed in competition with the adult-oriented sites and technologies which this audience reported to be widely using. Furthermore, when asked by open question what they felt were the greatest dangers affecting children their age, 16% of players (n=111) reported Internet-related threats; this was no doubt a consequence of the online nature of the survey, but nonetheless reflects a degree of wariness towards online social interactions amongst children who are frequently informed of the dangers they may pose. The specific chosen game-based interaction approach has a very clear appeal to the target audience of children aged 9-15, with a gender bias towards male players. An important part of this appeal is that the mechanics, dynamics and aesthetics of the game is deliberately not designed to be "childish", and focuses foremost on being fun and challenging. Even with this young age group some reflection can be expected and the scaffold pedagogical approach is suitable, provided that the analogy is not too difficult to spot.

CONCLUSION

A critique common to evaluations of digital games for learning is that evidence of high usage is not adequately supported by evidence of impact or reach to a target demographic. This is a particularly complex issue in the case of public health as digital games are typically deployed to enhance rather than replace other interventions, and therefore comparisons with existing methods of teaching or training can be of limited value. Similarly, in the specific context of road safety, differences between self-reported and actual behaviour makes survey or interview alone a limited tool for assessing behavioural changes. Hence, whilst the evaluation of Code of Everand presented in this paper cannot claim to conclusively demonstrate long-term change, the analysis of reach as well as impact presented a compelling case for the future consideration of game-based approaches to changing attitudes and behaviour in young audiences. Such approaches must capitalize on the findings

of this study to anticipate exposure time at the early stages of design and develop and implement models for learning transfer accordingly.

If, as evidence suggests, the limited exposure times of players to the world of Everand were strongly influenced by difficulty in communicating and forming meaningful social ties, a need exists for careful review of reflection upon policy and its underlying ethical implications when creating social online environments for young audiences. If enabling direct communication is not viable, then as this study demonstrates, the resulting environment faces a challenge in engaging an audience widely interacting using social media and online games for which similar restrictions are not in place.

Despite these challenges, growing evidence, including that provided by this paper, suggests that the large-scale deployment of digital games for learning can attract and retain a sizable audience for a period likely to exceed that possible through more static web-based intervention [22, 23], or other media such as television advertising. By relying on players' ability to recognize and reflect on underlying road safety principles, Code of Everand followed widely accepted best practice approaches for serious games by putting gameplay elements before educational content [18]. It also demonstrates the need for careful and structured pedagogical design reflecting upon the typical playtimes of users; a factor which can be difficult to anticipate prior to launch due to the absence of similar large-scale studies. Certainly for the 9-15 audience, developers must be aware of the high level of competition for children's screen time as well as the games with which children currently engage, the majority of which may not necessarily be titles explicitly designed for a young audience. A model of analogical transfer requires considerable time investment of the part of the player, and it may be the case that alternative methods or mechanisms could prove more effective in delivering rapid outcomes. Developing these approaches and translating them to game design principles through careful reference to established pedagogies must by a key goal for future work.

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