Engaging Students with Intellectual Disabilities through Games Based Learning and Related Technologies

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Abstract. Studies within our research group have shown that Digital Games Based Learning (DGBL) can have a positive effect on some of the core development needs of people with intellectual disabilities and associated sensory impairments. Of current interest is the expansion of DGBL activities on mobile platforms. The RECALL Project describes the development and evaluation of a novel route learning system for people with disabilities using location based services (on the Android OS). Research has shown that route guidance systems suppress cognitive map development, and for a target audience described as having 'poor spatial skills', systems that develop route learning rather than guidance are required. Two studies are reported here. The first demonstrates that there were less navigational errors made, and less help required, in the more independent usage of the system, than in the earlier training stages. The second focusses on more qualitative evaluation of soft skills and personal development via the use of the system, and of the gamified version of the software. It looks specifically at how a playful approach can aid the understanding of map based representations.

Keywords: route learning, mobile, digital games based learning, disability.

1 Game Based Learning: Effectiveness and Motivation

It is agreed that learning is both an emotional and cognitive process (Piaget, 1951), and when players are engaged in activities that are intrinsically motivating, they are

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more prone to demonstrate deep learning (Habgood et al., 2005). Digital games have been reported to stimulate the students' interest, while motivating them to deploy control, curiosity and imagination (Malone, 1981; Staalduinen, 2011). One of the most important qualities of games is their ability to adapt to user's abilities and time-frames, thus avoiding feelings of anxiety, inadequacy, boredom and stress (Malone, 1980; Sedighian, 1997; Baker et al., 2010; Toprac, 2011). Research has also shown that video games are particularly effective in engaging students with low self efficacy and low motivation (Amon &Campbell, 2008; Brown et al, 2007; Carr & Blanchfield, 2009; Saridaki & Mourlas 2011). Research has also shown that DGBL can have a positive effect on some of the core development needs of people with Intellectual Disabilities and associated sensory impairments. These include improved measures of choice reaction time (Standen et al 2009), decision making (Standen et al, 2009), memory (Brown et al, 2008), and functional skills (Brown et al, 2011a). However until recently, digital games have been predominantly used in the classroom for users with cognitive impairments as a reward and as a tool for external motivation (Fitros, 2005, Saridaki et al 2011).

The aim of the current study was to investigate the potential of using location based services to teach route learning to students with disabilities, and to combine this with a 'playful' approach, to investigate whether this approach is effective in route learning, and in the developing of the underlying key skills required by people with disabilities for their inclusion in society (and especially towards employability).

When developing navigational skills in people with disabilities there are several key issues that should be considered. First, route guidance systems suppress cognitive map development (Oliver and Burnett, 2008). For a group of people who are described as having 'poor spatial skills' route learning should be adopted so as not to further suppress the development of these key navigational skills (Brown et al, 2011b). Second, the importance of developing a full spatial representation cannot be over stated. External frames of reference and map-based strategies allow more efficient representation which enables flexibility, so that alternative routes can be taken, shortcuts can be made and destinations changed, because they encompass a more complete representation of the environment (Golledge et al, 1996; Evett et al, 2009). Third, learning should be combined with fun and use approaches that are motivating to enhance effectiveness (Habgood et al., 2005). Cartwright (2006, p. 33) also states that "We have a need to produce artifacts that provide the stimulus for humans to create a mental map or a synthetic world." Today's mobile devices, like smartphones and PDAs, are often used as gaming instruments. There has been a recent explosion in the number of creative new games that are facilitated by mobile devices in such a way that the game activity evolves according to players' location. Mobile location-based games, are described as compelling for young players as well as adults with or without disabilities (Quinn, & Cartwright, 2011).

Admiraal et al (2009) reported that "mobile games are excellent ways to combine situated, active and constructive learning with fun" (p 302). The mobile games become learning experiences when embedded in places of information such as museums or street settings, since they create an augmented reality setting which helps people to better experience the environment. According to Hinske et al, (2007)) the four main characteristics that contribute both to the mobile game's appeal and to the emotional attachment that players feel are the physical experience, mental challenge, social experience, and immersion. Finally, the feeling of immersion in the game setting provides the main entertainment factor (Ardito et al, 2010).

2 Recall Project and Route Mate Application: A Playful Approach

The RECALL Project describes the development and evaluation of a novel route learning system for people with disabilities using location based services (on the Android OS) and is the output of a major EU award (504970-LLP-1-2009-1-UK-KA3-KA3MP). Route Mate (the major route learning app of the project) is an accessible location based application developed to help people with Intellectual Disabilities and other sensory and physical disabilities to learn simple routes (Brown et al, 2011b). It provides the user with the option to create a new route through their mobile device or through a desktop console, as well as load and modify an existing route with the help of a parent, caretaker or trainer. There are three modes of RECALL: Plan, Use and Challenge. Plan and Use allow the development of a new route and its practice. This system doesn't guide the user; rather it scaffolds their journey should they make navigational errors (time or geographical divergence) by comparing current progress with their first (ideal) use of a newly planned route. The Challenge Mode provides a range of playful activities to help people with disabilities understand the connection between map-based representations and their corresponding real world locations. The Plan and Challenge Setting mode are available via the 'Console'.

The playful narrative approach takes the form of digital scavenger hunts, by extending the landmark style and interactions in different ways, and using them to scaffold different phases of use of the application. This approach seeks to teach and reinforce the concept of maps and route learning, as well as promoting the connection between the map representation and its real world counterpart.

During the Plan mode and by using different icons that promote narrative, playful storytelling and safety, the facilitator can easily design playful games using many different narratives. For example: Pirates – associated with route planning and creation activities while locating treasure and possible enemies in an urban setting; and Ninjas – a "scavenger hunt" to find as many treasure items as possible, associated with being road cautious and aware of ourselves, of other pedestrians and staying safe and on route while using Route Mate.

3 Evaluating Effectiveness and the Playful Approach

3.1 Effectiveness

In an earlier version of the Route Mate App, the Use Mode was separated into two Modes – Practice (for early stage heavily scaffolded use), and Use (more independent use). It was predicted that the number of error and help events produced by each individual would be lower in the Use Mode than the Practice Mode. If this hypothesis is accepted, it would support the view that with practice participants can use Route Mate to develop increasingly more effective navigational skills and do so more independently.

3.1.1 Methodology

Within subjects mixed methods. Quantitative data was captured using a repeated measures assessment of error and help events. Qualitative data took the form of notes based upon the quantitative measure and other events (Grantham, 2010).

Participants: Eight participants with Intellectual Disabilities (see table 1 - abilities based on ‘P’ levels 1-8 scales are sub-national curriculum, levels 1c-2a go onto National Curriculum levels) were accompanied by an assistant who gave help or explanation when necessary. Testing only took place on days with fine weather conditions as rain could have a detrimental on the device and participant ability. Prior to the creation of the experimental design several preliminary sessions took place so outcomes could be factored into the experimental design and data capture methodology used (Nemeth, 2002). Each participant was given an initial training session.

Task: Each participant was given the task of navigating between the same two start and end points. A number of points called “Road Sign” were created and placed at positions where road name signs were obviously visible. Each user navigated through the route twice, first in the Practice Mode and secondly in the Use Mode. Repeated measures for Error and Help events were recorded on the Data Capture sheet. Qualitative observational notes recorded any utterances, input from the assistant and other miscellaneous observations. As the Practice Mode began the user was pointed in the correct direction, when they reached the first of the Decision Points they were prompted to look at the map (on device) and to make a decision about the direction they should head in. If an incorrect directional decision was made they were asked to re-think their decision and this was classed as one occurrence of requiring ‘Help’. At each Decision Point explanation of navigation decision, more complicated explanations, and failure to properly communicate decisions were recorded

Table 1. Participant’s abilities based on P-Levels

ID	English				Maths		
	Read	**Write**	**Speaking**	**Listening**	**Number**	**U + A**	**SS +M**
1	2B	2C	2A	2A	1C	1	2A
2	1C	1C	P7	P7	2B	1	2C
3	1C	2C	2A	2A	2A	2A	2A
4	1C	P8	1C	1C	P8	1	1C
5	P8	1B	1A	1A	P8	1	P8
6	2A	2C	2B	2B	2C	2	2C
7	1B	1B	1C	1C	1C	P8	2B
8	P6	P7	P8	P8	P6	P8	P7

Once completed in the Practice mode the route was re-run using the Use mode. Observations and any Error or Help occurrences were recorded. As in the Practice phase the participants were left to make their own independent navigation decisions. If the user made an incorrect navigational decision they were asked to reconsider and provide a justification. If they still wanted to make the same navigational decision they were corrected.

Error and Help Events: A frequency count was used to record the number of instances of help and error events. A help event is where the user asked for help or where it was judged that help was required (e.g., when a user loses their position on the map or is reminded of how to move the map). An error event would be where the participant incorrectly uses Route Mate or the device (e.g., presses the wrong button on the device). An error event may also trigger a help event to occur, for example, if the participant incorrectly used the device or the application and subsequently required help to correct the situation this would be recorded as an error event for the original incorrect use and as a help event for the assistance required in correcting the error. Notes were also recorded on the nature of each help and error event. Spontaneous feedback from the participant and their replies to directed questioning were also recorded (also from assistants).

3.1.2 Results

Quantitative Measures: Table 2 shows the number of help and error events for both the Practice and Use tests. There was a reduction in the mean number of help events from the Practice (mean = 4.5, SD = 2.8) to the Use phase (mean = 3.4, SD = 3.2) but a paired t-test indicated that this did not reach significance. Similarly for errors there was a reduction in the median number of errors from the Practice phase (3.0, range 0 – 5) to the Use phase (median = 1, range = 1 – 8) and a Wilcoxon test (errors non-normally distributed) indicated this reduction did not reach significance either.

Table 2. Number of help and error events for both the Practice and Use tests

ID	Practice		Use	
	Help	Errors	Help	Errors
1	6	3	2	1
2	9	5	11	8
3	3	2	1	1
4	7	4	4	3
5	5	3	2	0
6	3	1	3	1
7	3	0	3	1
8	0	3	1	0

3.2 Playful Approach

3.2.1 Methodology

A Case Study Methodology was adopted via a mixed qualitative and quantitative analysis for a period over two months.

Participants: 43 end users in four different countries, by five different research partners (UK, Greece, Romania and Bulgaria). Participants worked together with their caretakers and parents together with one or two researchers. Gender balance: 55.8% male, 44.2% female. Ages ranged from 8 to 68 years. Ethnicity: 15 were British, 1 Pakistani British, 9 Bulgarian, 7 Romanian and 8 Greek. 45.2% were beginners (referring to technical knowledge), 45.2% were average users and 9.5% (4 out of 43) were described as experienced users. 34.9% experienced learning disabilities, 14% with autism and 4.7% communication problems. Cognitive, physical disabilities and sensory impairment were recorded in almost equal rates ranging from 25.6% to 27.9%.

Evaluation Tools: At this later stage of evaluation (in comparison with 3.1) three phases of evaluation were conducted. First, a Soft Outcome Star measurement tool was used (MacKeith, 2011) to gather and systemize qualitative observations focusing on eight basic areas (Confidence, Engagement, Self-esteem, Concentration, Attendance, Participation and Timekeeping), applied before and after user trials to establish a baseline and to measure the application's impact. The second stage took place in real settings using qualitative methods of analysis. Routes were created with Route Mate in Caretaker or teachers/end user dyads. An observation checklist for six areas of interest (Satisfaction with usability/accessibility features, General attitude towards RouteMate, Verbal and non-Verbal expressions, Caretaker/teacher and end-user interaction and communication, User's progress, Impact/change after use), was used to order to organize the field notes. In depth analysis of selected cases was also included. The third stage used a Likert-scale questionnaire to measure the carers' evaluation of Route Mate, comprising 19 items in three sub-scales. Two supplementary methods took place that are worth mentioning. "Recreating the Route" was a way to test the construction of cognitive maps through the use of mobile assistive technologies. After the end of a journey each group gathered around and with the guidance of the researchers and the help of the caretakers, recreated the trip using markers and a printed Google map copy of the general area. The aim was to recall the entire journey, stop-by-stop and draw them on the map. In this way the researchers could test whether or not the end-users could create a cognitive line of their trip and if Route Mate helped them to do so. The "Where-to-go-next" screen in Route Mate and the playful concept of choosing photos was also evaluated.

The "Ninja Game Route" was an example of a gamified user experience research method. The basic concept was to implement a game narrative structure in the session and create goal-orientated actions. The narrative here was a Ninja scavenger hunt game where participants had to "unlock" and thus collect hidden diamonds. The diamonds were "unlocked" each time a predefined stop was reached and were given to the participant who could recall that stop at the end of the session. All diamonds were placed upon a wooden sword. Incorporating game-like elements, such as this, made the journey not only more fun but also helped the users to concentrate and be more cautious while walking, and could also contribute to spatial map formation.

3.2.2 Results

The data analysis showed a possible link between the level of satisfaction while using Route Mate and previous technological knowledge, while the reliability of the application - defined both as the actual problems that may occur during a test trial and as the negative expectation based on personal experience - seemed to play an important role. Stress levels correlated with user's confidence and in turn became an encouraging/discouraging motivational factor for using Route Mate. During the piloting sessions, as the technical problems started to be resolved, stress levels decreased whilst participants' confidence increased and their intrinsic motivation to use Route Mate motivated them to learn new routes (see Figure 1). The stress levels of the more experienced users are significantly lower. An interesting aspect was that in some cases getting to know and use the technology triggered the desire for self-improvement and learning other skills (independence, learning to read, finding similar programs and information about assistive technologies).

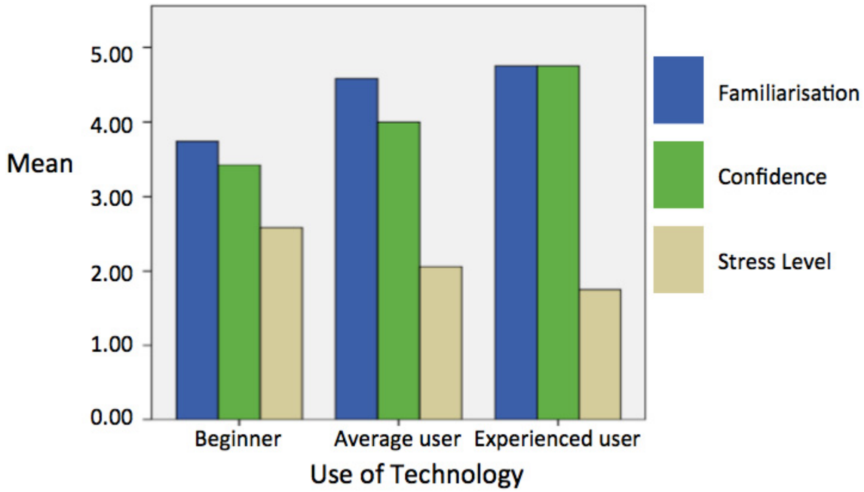

Fig. 1. General means for Outcome Star Scores for participants with varying levels technology experience

The role of Route Mate as an educational tool was evaluated by caretakers and in some cases parents. 83,7% of the responders agreed that Route Mate is a useful tool for training disabled people, while the 79,1% answered that mobile assistive technologies can be a potential educational method. Finally, responses from users with Intellectual Disabilities show no qualitative differences in contrast with individuals with no Intellectual Disabilities (but with other kinds of impairments/disabilities) regarding usability/accessibility, impact and change after use and attitudes to use, providing an important indication that Route Mate can be an equally useful as a learning and assistive tool for both categories. Interestingly, preliminary qualitative results and focus groups at the end of each playful session concluded that users retained information much better when using Route Mate as a scaffolding game than when using it as an assistive route learning application. More research data is required in order to determine that the playful use of Route Mate improved the understanding of map based representations. An increase in self-determination, motivation and memory was also recorded in participants at the gamified piloting sites.

4 Conclusions

The RECALL project has led to the development of a Console – a web based route planning device that can push routes to the Route Mate App. The App itself can be used to plan and practice routes. A series of playful narratives have been created to engage users in independent travel training. In evaluating the route learning modes of App participants require less help and make fewer errors in later stages of route learning than in earlier stages, showing that it is an effective semi-independent route learning system. A qualitative evaluation showed that use of the system can increase measures of self-determination, motivation and memory with high motivational qualities for participants with disabilities and their caretakers. There are also emergent indications that the gamified version promotes the development of better spatial mental models and further evidence to support or refute this finding will be pursed in the future. Future work will also expand the use of the playful narratives and add haptic feedback to the Android interface to allow accessibility by people with visual impairments.

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