

Results of User Interface Evaluation of Serious Games for Students with Intellectual Disability

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Abstract: We have designed and evaluated around 10 serious games under the EU Leonardo Transfer of Innovation Project: Game On Extra Time (GOET) project <http://goet-project.eu/>. The project supports people with learning disabilities and additional sensory impairments in getting and keeping a job by helping them to learn, via games-based learning, skills that will help them in their working day. These games help students to learn how to prepare themselves for work and for dealing with everyday situations at work, including money management, travelling independently, etc. This paper is concerned with the potential of serious games as effective and engaging learning resources for people with intellectual disabilities. In this paper we will address questions related to the design and evaluation of such games and our design solutions to suit the individual learning needs of our target audiences.

Keywords: intellectual disability; serious games; user interface testing

1 Introduction

We have designed and evaluated around 10 serious games under the EU Leonardo Transfer of Innovation Project: Game On Extra Time (GOET) project. The project supports people with learning disabilities and additional sensory impairments in getting and keeping a job by helping them to learn, via games-based learning, skills that will help them in their working day. These games help students to learn how to prepare themselves for work and for dealing with everyday situations at work, including money management, travelling independently etc.

People with intellectual disabilities often face a lack of control and opportunity in their everyday lives, with less than 10% having jobs [1]. People with Intellectual Disabilities experience low levels of employment and face barriers to employment. The UK Valuing People Report [2] and the Learning for Living and Work Report [3] have emphasised the need to promote and develop appropriate training and employment opportunities for this target audience. The Game On Extra Time (GOET) project provides a response to these calls, by the development of engaging and accessible serious games to develop work-based skills in this target audience.

In this paper we will address questions related to the design and evaluation of such games and our design solutions to suit the individual learning needs of our target audiences. It is necessary to design the user interfaces for maximum accessibility and usability. In this way we will minimise the additional cognitive load placed on the user when navigating within the software. In order to achieve these goals we have followed published design guidelines and placed emphasis on using graphics, animations, interactivity, choice and auditory output to promote user engagement and provide alternatives to text. In this paper we will address the pilot testing of the user interface of these serious games.

These games, which are tested in all partner countries (UK, Lithuania and Hungary), include [4]:

- 3D Work Tour: simulating the first days at work in a games ‘mod’ created using the Half Life 2 engine
- Cheese factory: teaching the students using fractions and percentages based on the popular Tetris Game.
- Memobile: trains the student in the important things to do in preparing to leave the house and throughout their working day using mobile phone technology programmed using Flash.
- My Appearance: covering everyday routines such as personal hygiene and getting ready for work-tasks, from getting up until leaving home, using a Flash game.
- VR supermarket: helps to teach students about money management skills within a store environment, developed using Flash.

Five more games were developed, but were not tested in every partner country. These are “Anger management”, “Personal Hygiene”, “Starting Work”, “Stress at work” and “Work Sustainability”.

1.1 What is Usability?

Early conceptualizations of usability were inspired by graphical user interfaces of personal computers that were primarily used for office applications, such as word processing and data-base calculations. In this context, several definitions of usability were introduced, of which the one provided by the international standard ISO 9241-11 [5] has received the greatest acceptance: *Usability is the “extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use”* [5 p. 2]. According to this definition, usability is a construct consisting of three dimensions: effectiveness, efficiency and satisfaction.

Usability research for games is similar to that for productivity software, but it differs in that researchers are trying to both make the game more user-friendly and also more fun. The game’s tools can be usability tested normally, but there are multiple aspects that go in to determining if a game is fun, including pace, challenge, story, game mechanics, art, entertainment, engagement, immersion, and emotional connection [6].

Today, game design also involves a focus on traditional usability such as creating clear terminology as well as non- intrusive, easy-to-use user interfaces [7]. While more than ten principles are under consideration, a preliminary subset of the Game Approachability Principles (GAP), aimed at better engaging casual gamers, is shown below. This specific “shortlist of six” GAP was formulated in keeping with leading learning theories such as [8] Social Learning Theory [9] Self-efficacy, another key concept and term used in education and learning [10].

Game Approachability Principles (GAP) for Improving Game Approachability [11]:

- 1) Observation and Modelling;
- 2) Self Efficacy;
- 3) Game Based Principles (Identity, Manipulation and Perception);
- 4) HELP and PLAY Based Guidelines (such as players not being penalized repetitively for the same failure; varying activities and pacing during the game to minimize fatigue or boredom; etc.);
- 5) Demonstrate Actions and Reinforcement;
- 6) Likeability of the Tutorial

Our questionnaire was focused more or less on GAP 1-5 principles.

A key component of usability engineering is setting specific, quantitative usability goals for a product early in the process and then designing to meet those goals [12]. There are typically four different activities that every project engages in during a system development process (Planning, Analysis, Design and Evaluation). Most system development projects include these activities, or at least similar activities that could be easily identified as one of these four.

When the consideration of people with disabilities is included in the design process, it is usual to talk about “Design for all”, “Universal Usability” or “Equitable Use”, implying that the design should be useful and marketable to any group of users [13]. However, Newell and Gregor [14] consider that this ideal may be very difficult if not impossible to achieve. For example, different user groups may provide very conflicting requirements for a product. As an alternative, they propose a “User Sensitive Inclusive Design”, which recognises that inclusivity is more achievable than a universal design. One of their conclusions is that, “User Sensitive Inclusive Design needs to be an attitude of mind rather than simply mechanistically applying a set of ‘design for all’ guidelines.” With this in mind, we employ a methodology for the development of games-based learning which was determined by combining established guidelines on user-centred design eg INUSE [15] and USERfit [16] with contemporary human-computer interaction and product design research.

One of our goals was with the testing, to make clear the tasks for redesigning the games before the pedagogical testing. The usability testing of the developed 10 serious games’ user interface is written in this article.

1.2 Why are Serious Games Appropriate Tools for People with Intellectual Disability?

According to the 2001 Department of Health White Paper [17], people with intellectual disabilities are amongst the most socially excluded and vulnerable groups in Britain, and this is unlikely to differ in other countries. Very few have jobs, live in their own homes or have real choice over who cares for them. Today, the majority no longer live in institutions but in the family home and, although their individual needs will differ, there is an expectation that they will achieve greater independence and greater inclusion in society [17]. The intention of current policy is to enable them to have as much choice and control as possible over their lives, to be involved in their communities and to make a valued contribution to the world at work.

However, in order to achieve these aims, their education needs to equip them with appropriate skills. The Tomlinson Report [18] highlighted the need to provide courses which teach independent living and communication skills, and this need has been reiterated by others [19].

For people with intellectual disabilities, computer-based learning has a huge contribution to make. According to Hawkrigde & Vincent [20], it enables pupils to take charge of their own learning, and they will find stimulation through ‘enjoyable repetition’ and a gradual increase in level of challenge. Blamires [21] argues that enabling technology provides access to educational opportunities and life experiences and facilitates engagement with knowledge and people: “Speech, pictures, words, and animation can be combined in interactive ways to structure concepts to suit the level of understanding of learners and their interests.” [1]. Thus it facilitates alternative methods of supplying information, which may help this group of people grasp more complex concepts. This is of particular importance for learners who may have a poor grasp of language, and its abundance of visual opportunities makes it particularly suitable for those with little or no hearing [1]. Additionally, the use of games-based learning has been promoted for people with Intellectual Disabilities. Originally, the majority of the research on computer games focused on the negative aspects [22]. Pivec [23] makes the point that while it is widely recognised that games have an important role in early learning, as education becomes more formal, games tend to be seen as just an “unserious activity” (p. 387). In a review of both the positive and negative effects of playing videogames, Griffiths [24] describes the role of videogames in cognitive rehabilitation, for example in perceptual disorders, conceptual thinking, attention, concentration and memory in patients with brain damage following stroke or trauma. More recent studies have produced empirical evidence to demonstrate the efficacy of games-based learning in the cognitive rehabilitation of people with intellectual disabilities, to improve choice reaction time [25], independent decision making [26] and working memory [27]. One of the primary advantages of games in learning is their ability to engage the learner voluntarily in sufficient repetitions of the activities to ensure learning takes place [23]. This is what Garris et al [28] termed persistent reengagement, where the player returns to the task unprompted. In short, computer-based instruction, and more importantly games-based learning, can make a very real contribution to teaching essential life and work-based skills to people who struggle to find other ways of learning these skills, and the usability evaluation of such games is essential if we are to make them fit for use by this very specific target audience.

2 Description of the Tested Serious Games

In this section the main design requirements of the tested games, “Cheese factory”, “My Appearance”, “3D Work Tour”, “VR supermarket”, “Memobile”, “Anger management”, “Personal Hygiene”, “Starting Work”, “Stress at work” and “Work Sustainability”, are described.

2.1 Cheese Factory

The Goal of the Cheese Factory Game is to teach percentages, fractions and decimals. Players are challenged to match the falling shape with the shapes distributed along the bottom of the interface to form a whole ‘cheese’. Initially the challenge is one of shape matching by using the arrow keys to position the shapes along the bottom of the interface with the falling shape. This matching challenge addresses the underlying ‘language of fractions’. Later, the challenge of the game is increased, where the falling shapes become amorphous, and players are challenged to match the falling number (without the added benefit of the appropriate shape to indicate value), expressed as either a percentage, fraction or decimal, as we move to fractional notation. This replicates the real world steps when teaching these concepts to students with special educational needs. The game can be played at varying speeds and has increasing levels or challenge to make it scalable for a wide range of abilities.

Cheese factory teaches the students to use fractions and percentages based on the popular Tetris Game. The user interface of this game is simple too. The instructions are clear, the colours are appropriate, and they are in harmony with the overall interface. The users’ results are shown on the right side of the game, and the next piece of the cheese is also shown. These features support the user in their on-going learning tasks (Fig. 1 and Fig. 2).



Figure 1
Options of the game



Figure 2
Showing the process of the game

2.2 My Appearance

My Appearance teaches the students everyday “morning” tasks, from getting up until leaving home, using a Flash game. The graphic interface of the game is clear and understandable and cartoon-like. It simulates the sequencing of morning tasks in preparation for leaving for work, and the structure of the game is very consistent. For example, after getting up, having a shower, getting dressed (Fig. 3) and eating breakfast (Fig. 4), the user’s avatar is ready to leave for work and its appearance improves.



Figure 3
After getting dressed

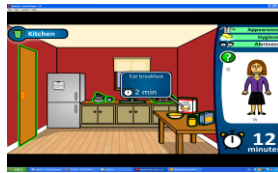


Figure 4
Eating breakfast



Figure 5
Showing the results graphically

At the end of the game the user receives feedback on his/her performance using sound, subtitles or BSL. If the student forgets to wash his/her hands or forgets to have a morning drink, the game doesn't interfere – it lets the student make mistakes and learn from doing so by reflecting on the game responses to their actions (Fig. 5).

2.3 3D Work Tour

3D Work Tour simulates the first days at a workplace in a games 'mod' created using the Half Life 2 engine. After selecting the language there are two possibilities: subtitles and video tour with BSL (British Sign Language) for hearing impaired users. The user interface is very simple and very clearly organised. The VR environment and avatars are realistic and look similar to the work-based environments and people in the real world (Fig. 6 and Fig. 7).

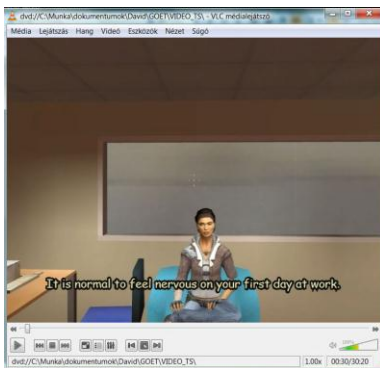


Figure 6
Using subtitles and sound files

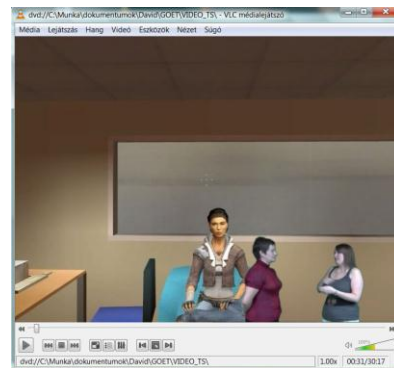


Figure 7
Using BSL

2.4 VR Supermarket

The VR supermarket game helps to teach students about money management skills within a store environment developed using Flash. The player enters the virtual supermarket (Fig. 8) and is given a virtual wallet, shopping list (Fig. 9) and shopping cart. The goods on a given shelf are displayed with their names, prices and images attached to them. To place an item to the shopping cart, the player only has to click on the given item.

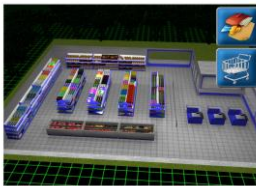


Figure 8
VR supermarket



Figure 9
Shopping list



Figure 10
At the cash register

Before paying, the bar code scanner registers the price of each item in the shopping cart one by one. During this step, both the cashier and the cash register will give feedback to the student (Fig. 10). To pay for the items, the student has to place a sufficient sum of money onto the drop panel by clicking the separate banknotes and coins in the wallet and then hitting the pay button.

2.5 Memobile

The Memobile game trains the student in the important things to do in preparing to leave the house and throughout their working day, using mobile phone technology programmed using Flash (Figs. 11-13).

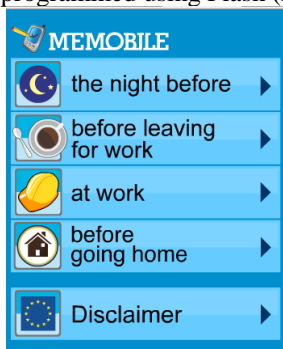


Figure 11
Main menu of the “Memobile”
game



Figure 12
Solving one task



Figure 13
Memory in the “Memobile”
game

2.6 Anger Management (with English BSL)

This set of content uses opposed video sketches that the player must choose between. The topics cover: Discipline, Peer pressure, Bullying, Frustration & stress (Figs. 14-16).



Figure 14
Main menu of “anger management”

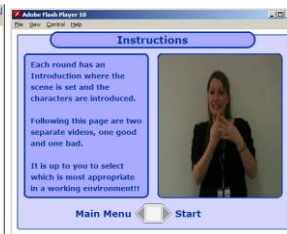


Figure 15
Showing the “Instruction”

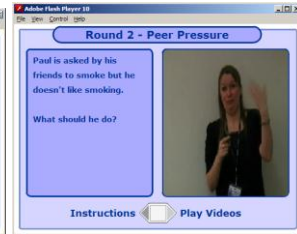


Figure 16
One question in the game

Selection uses the “True” or “False” approach, the player should choose the clip showing the most appropriate behavior.

2.7 Personal Hygiene

This is a very simple set of content. It comprises 7 personal hygiene statements that are answered as “True” or “False”. The play begins with a brief preamble and some simple usage instructions.

Each of the seven statements has a relevant background image. The “True” and “False” locations are randomly assigned. After answering “True” or “False”, a feedback statement is given; a correct answer is associated with a green smiley face, a wrong answer is associated with a red sad face (Figs. 17-19).



Figure 17
Main menu of “Personal Hygiene”

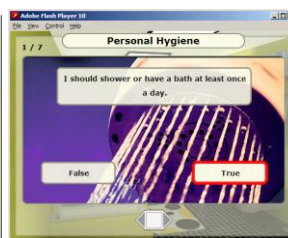


Figure 18
One task in the game

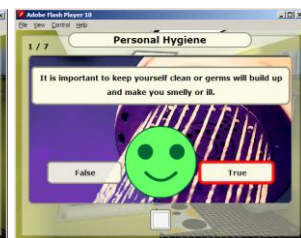


Figure 19
The right answer

2.8 Starting Work

This game simulates the player's home and presents a number of multiple choice questions relating to getting ready to start work, in the appropriate locations around a house. These locations are the bedroom, bathroom, kitchen and living room (Figs. 20-22). When the player chooses to leave the house, they receive a summary of how they performed, plus the option to save a report of their progress as a PDF.



Figure 20
After getting up

Figure 21
One task in the game

Figure 22
The right answer

2.9 Stress at Work (with English BSL)

This game uses animated content (swf files) and the “conveyor” interaction to present two or more optional answers covering issues of stress at work. 8 topics are covered. The game begins with a brief preamble and fairly detailed usage instructions, in text and BSL (Figs. 23-24).

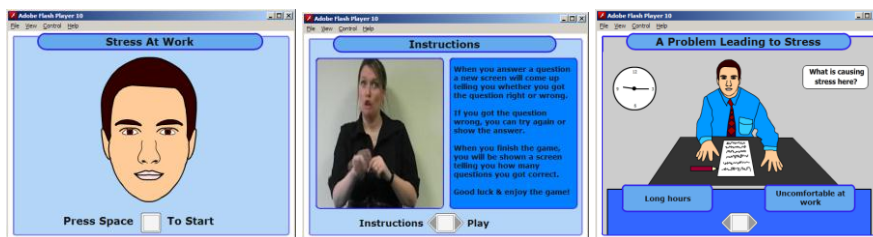


Figure 23
Start the game

Figure 24
One task in the game

Figure 25
The right answer

During the game, the player uses the left or right arrows to move the conveyor at the bottom of the screen and the space bar to select (alternatively, clicking on an un-highlighted answer brings it to the central location and highlights it; clicking again selects it Fig. 25).

Once a response has been chosen, feedback is given. A correct answer is accompanied by a smiley face and the answer associated with that issue. Once all 8 items have been answered, the user reaches the feedback screen again.

2.10 Work Sustainability

This game is “Getting and Keeping a Job”. This has a slightly longer set of content. It comprises 4 sections (Fig. 26), with topic-specific statements that are answered as “True” or “False”. These topics are: Getting a Job (7 statements), Starting Work (9 statements), Getting ready for work (3 statements), Your working day (10 statements). Each of the sections has a relevant background image. The “True” and “False” locations are randomly assigned. After answering “True” or “False”, a feedback statement is given; a correct answer is associated with a green smiley face, a wrong answer with a red sad face.

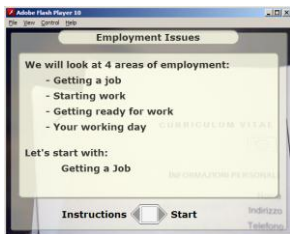


Figure 26

Four sections of the game

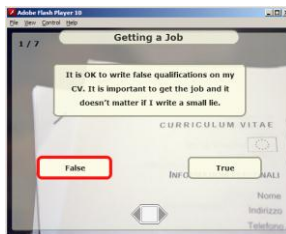


Figure 27

One task in the game

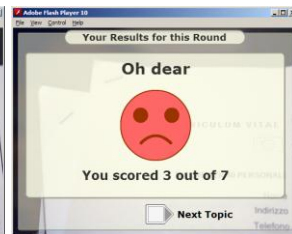


Figure 28

The wrong answer

3 Evaluation of the User Interface

There are objective and subjective evaluation methods, for example Heart Rate Variable-based method [29]. We used subjective method based on questionnaire.

We have developed a 5 point Likert Scale close-ended questionnaire for testing the user interface of the newly developed serious games.

Likert Scales: Likert scales are scales on which the participants register their agreement or disagreement with the statement. “_Strongly Disagree (1), _Disagree (2), _Neither Agree nor Disagree (3), _Agree (4), _Strongly Agree (5)” on a five-point scale.

This questionnaire contains 29 questions arranged in 4 themes.

- To what degree are the games enjoyable? (6 questions)
- Questions concerning the usability of the software (4 questions)
- Questions concerning the software’s manageability: (9 questions)
- Questions concerning the graphics (10 questions)

If the sentence has a negative meaning, for example, “The noises or music used in the games were disturbing.”, we converted the user’s answer. Because if the user answer is “Strongly Agree (5)”, the answer has negative content, it should not get the best 5 points, only the minimum 1 point.

The negative meaning questions are:

- Using the software was tiring (Table 1).
- Playing with the software was boring (Table 3).
- The noises or music used in the games were disturbing (Table 14).
- Failures were typically results of disorientation (Table 16).
- Failures were typically results of not being able to recognise pictures (Table 26).
- Failures were typically results of not understanding instructions (Table 27).

The questionnaires were filled in by 8-15 specialists of psychology, teachers, spec. pedagogy, and IT administrators from Lithuania, Hungary and the United Kingdom.

The specialist scored the games. The mean and standard deviation (STD) of these scores are written in the table 1-29 in the following section.

The scores are between 1.57 and 4.86. The smallest score is 1.57 (Table 1-2) with $STD=0.53$ and $STD=1.57$. The highest score is 4.86 (Table 17-18) with low $STD=0.36$.

3.1 To What Degree are The Games Enjoyable? (6 Questions)

How engaging are the games?

Table 1
Using the software was tiring

game	mean	STD
Cheese factory	1.57	1.16
My Appearance	3.21	1.76
3D Work Tour	3.08	0.51
VR Supermarket	2.43	1.79
Memobile	3.07	1.20
Anger Management	3.80	0.63
Personal Hygiene	4.0	1.41
Starting Work	2.71	0.99
Stress at work	4.56	0.53
Work Sustainability	3.63	0.52

Table 2
The content of the software was engaging

game	mean	STD
Cheese factory	1.57	0.53
My Appearance	3.21	0.85
3D Work Tour	3.08	1.19
VR Supermarket	2.42	1.49
Memobile	3.07	0.47
Anger Management	3.80	0.63
Personal Hygiene	4.00	1.69
Starting Work	2.71	0.61
Stress at work	4.55	0.93
Work Sustainability	3.63	0.52

Table 3
Playing with the software was boring

game	mean	STD
Cheese factory	3.50	1.22
My Appearance	2.71	1.38
3D Work Tour	2.42	1.31
VR Supermarket	2.36	1.50
Memobile	3.86	1.10
Anger Management	3.50	0.71
Personal Hygiene	4.23	0.93
Starting Work	2.86	0.66
Stress at work	3.33	0.50
Work Sustainability	2.38	0.52

Table 4
The games were easy to play

game	mean	STD
Cheese factory	4.85	0.36
My Appearance	4.57	0.65
3D Work Tour	3.42	0.67
VR Supermarket	4.50	0.94
Memobile	3.43	1.16
Anger Management	3.90	0.86
Personal Hygiene	3.92	1.55
Starting Work	3.57	0.94
Stress at work	3.78	0.83
Work Sustainability	4.00	0.00

Table 5
Activities in game play were predictable

game	mean	STD
Cheese factory	2.71	1.20
My Appearance	3.00	0.96
3D Work Tour	3.25	0.45
VR Supermarket	3.71	1.20
Memobile	1.64	1.08
Anger Management	3.00	0.47
Personal Hygiene	2.15	1.41
Starting Work	3.21	0.80
Stress at work	3.00	0.00
Work Sustainability	2.00	1.07

Table 6
I used the software willingly

game	mean	STD
Cheese factory	4.71	0.61
My Appearance	3.71	1.07
3D Work Tour	2.33	1.30
VR Supermarket	4.42	1.02
Memobile	3.36	1.45
Anger Management	3.60	0.52
Personal Hygiene	3.46	0.78
Starting Work	2.85	0.77
Stress at work	3.33	0.50
Work Sustainability	3.00	0.00

3.2 Questions Concerning the Usability of the Software (4 Questions)

Questions regarding the usability of the software:

Table 7
The software displays realistic situations

game	mean	STD
Cheese factory	3.14	0.86
My Appearance	4.00	0.68
3D Work Tour	3.83	0.72
VR Supermarket	3.86	0.77
Memobile	3.36	1.00
Anger Management	4.00	0.00
Personal Hygiene	4.15	0.99
Starting Work	3.79	0.43
Stress at work	3.89	0.33
Work Sustainability	4.00	0.00

Table 8
The presented situations were relevant and important

game	mean	STD
Cheese factory	3.71	0.61
My Appearance	4.14	0.66
3D Work Tour	3.67	0.65
VR Supermarket	3.64	0.74
Memobile	3.43	0.76
Anger Management	4.30	0.48
Personal Hygiene	4.30	0.63
Starting Work	3.79	0.43
Stress at work	4.00	0.00
Work Sustainability	4.00	0.00

Table 9

Are you satisfied with the quantity and diversity of the questions used?

game	mean	STD
Cheese factory	3.36	0.63
My Appearance	3.29	1.14
3D Work Tour	3.27	0.65
VR Supermarket	3.36	1.00
Memobile	3.07	0.73
Anger Management	3.40	0.52
Personal Hygiene	3.62	1.45
Starting Work	2.64	0.63
Stress at work	2.78	0.67
Work Sustainability	3.38	0.52

Table 10

Using the software was easy

game	mean	STD
Cheese factory	4.57	0.65
My Appearance	3.86	0.95
3D Work Tour	3.50	0.67
VR Supermarket	4.21	0.58
Memobile	3.50	1.51
Anger Management	4.10	0.57
Personal Hygiene	3.92	1.19
Starting Work	3.50	0.85
Stress at work	4.00	0.87
Work Sustainability	4.00	0.53

3.3 Questions Concerning the Software’s Manageability: (9 Questions)

Questions regarding the software’s manageability:

Table 11

There is sufficient opportunity to correct or revisit responses given in the game

game	mean	STD
Cheese factory	3.71	0.83
My Appearance	3.64	1.08
3D Work Tour	3.58	0.90
VR Supermarket	4.07	0.47
Memobile	3.36	1.08
Anger Management	3.90	0.32
Personal Hygiene	3.77	1.09
Starting Work	3.64	0.63
Stress at work	4.00	0.00
Work Sustainability	4.00	0.00

Table 12

The content areas between levels are distinct

game	mean	STD
Cheese factory	3.86	0.36
My Appearance	3.29	1.07
3D Work Tour	3.58	0.90
VR Supermarket	3.43	0.85
Memobile	3.36	0.84
Anger Management	3.10	0.32
Personal Hygiene	3.69	1.18
Starting Work	3.21	0.80
Stress at work	3.11	0.33
Work Sustainability	3.00	0.00

Table 13

It was easy to follow the activities in the game

game	mean	STD
Cheese factory	4.07	0.73
My Appearance	4.00	0.88
3D Work Tour	3.67	0.89
VR Supermarket	4.21	0.43
Memobile	3.50	0.85
Anger Management	3.90	0.32
Personal Hygiene	3.00	1.47
Starting Work	3.57	0.85
Stress at work	4.00	0.50
Work Sustainability	1.41	1.07

Table 14

The noises or music used in the games were disturbing

game	mean	STD
Cheese factory	4.64	0.74
My Appearance	3.90	0.99
3D Work Tour	4.36	0.92
VR Supermarket	3.57	1.28
Memobile	4.00	1.05
Anger Management	4.00	1.05
Personal Hygiene	2.44	1.13
Starting Work	4.00	1.05
Stress at work	4.11	1.05
Work Sustainability	4.25	1.03

Table 15

The speech used was clear and understandable

game	mean	STD
Cheese factory	3.29	0.61
My Appearance	3.25	0.75
3D Work Tour	3.58	0.90
VR Supermarket	3.43	1.16
Memobile	3.00	0.00
Anger Management	2.80	0.42
Personal Hygiene	3.22	0.67
Starting Work	3.00	0.00
Stress at work	3.00	0.50
Work Sustainability	3.00	0.00

Table 16

Failures were typically results of disorientation

game	mean	STD
Cheese factory	4.21	0.89
My Appearance	3.64	0.93
3D Work Tour	3.58	0.51
VR Supermarket	3.43	0.94
Memobile	3.36	0.84
Anger Management	3.40	0.97
Personal Hygiene	3.54	0.88
Starting Work	3.14	1.03
Stress at work	3.78	0.67
Work Sustainability	3.75	0.71

Table 17

Starting the software was an easy process

game	mean	STD
Cheese factory	4.86	0.36
My Appearance	4.43	1.09
3D Work Tour	4.25	1.14
VR Supermarket	4.36	0.63
Memobile	3.79	1.42
Anger Management	4.10	1.19
Personal Hygiene	4.08	0.76
Starting Work	4.08	1.14
Stress at work	4.11	1.27
Work Sustainability	3.88	1.25

Table 18

Closing the software/Quitting at the end of the game was easy

game	mean	STD
Cheese factory	4.86	0.36
My Appearance	4.36	0.63
3D Work Tour	4.08	0.67
VR Supermarket	4.21	0.80
Memobile	4.07	1.27
Anger Management	4.00	0.47
Personal Hygiene	4.46	0.66
Starting Work	4.00	0.68
Stress at work	4.00	0.50
Work Sustainability	4.13	0.64

Table 19
Closing the software/Quitting at the end of the game was easy

game	mean	STD
Cheese factory	4.36	1.15
My Appearance	3.29	1.54
3D Work Tour	2.08	0.79
VR Supermarket	3.00	1.71
Memobile	2.07	1.49
Anger Management	2.20	0.79
Personal Hygiene	3.08	1.38
Starting Work	2.14	1.46
Stress at work	2.11	0.78
Work Sustainability	1.38	0.74

3.4 Questions Concerning the Graphics (10 Questions)

Questions regarding the graphics:

Table 20
The software's look is realistic

game	mean	STD
Cheese factory	3.29	0.61
My Appearance	2.21	1.37
3D Work Tour	2.25	1.54
VR Supermarket	3.69	0.48
Memobile	3.07	0.99
Anger Management	3.70	1.06
Personal Hygiene	2.77	1.09
Starting Work	2.36	1.28
Stress at work	3.67	1.12
Work Sustainability	1.88	1.46

Table 21
The software's look is likeable

game	mean	STD
Cheese factory	4.07	0.73
My Appearance	2.79	1.63
3D Work Tour	2.25	1.36
VR Supermarket	3.85	0.89
Memobile	4.00	0.88
Anger Management	3.30	1.25
Personal Hygiene	2.54	1.13
Starting Work	3.21	1.12
Stress at work	3.22	1.09
Work Sustainability	1.75	1.39

Table 22
The software's look was appropriate to its aim

game	mean	STD
Cheese factory	3.92	1.21
My Appearance	3.86	0.53
3D Work Tour	3.83	0.58
VR Supermarket	3.93	1.14
Memobile	3.50	0.76
Anger Management	4.10	0.32
Personal Hygiene	3.15	0.69
Starting Work	3.64	0.74
Stress at work	3.78	0.44
Work Sustainability	3.88	0.35

Table 23
The pictures used were easy to recognize

game	mean	STD
Cheese factory	3.57	0.85
My Appearance	4.21	0.58
3D Work Tour	3.92	0.51
VR Supermarket	3.79	1.48
Memobile	3.93	0.62
Anger Management	4.20	0.42
Personal Hygiene	3.77	0.44
Starting Work	3.86	0.53
Stress at work	3.89	0.33
Work Sustainability	4.00	0.00

Table 24

The illustrations and backgrounds used were helpful

game	mean	STD
Cheese factory	3.50	0.65
My Appearance	3.79	0.97
3D Work Tour	3.00	0.00
VR Supermarket	3.00	1.30
Memobile	3.79	0.80
Anger Management	3.80	0.42
Personal Hygiene	2.00	1.35
Starting Work	3.07	0.47
Stress at work	3.11	0.33
Work Sustainability	3.00	0.00

Table 26

Failures were typically results of not being able to recognise pictures

game	mean	STD
Cheese factory	2.79	0.97
My Appearance	2.43	0.85
3D Work Tour	2.75	0.45
VR Supermarket	2.93	1.27
Memobile	2.36	0.74
Anger Management	3.20	0.42
Personal Hygiene	2.15	0.89
Starting Work	2.86	0.77
Stress at work	3.11	0.33
Work Sustainability	2.50	0.76

Table 28

The software was rich in (visual and audio) stimuli

game	mean	STD
Cheese factory	3.29	0.73
My Appearance	3.36	0.84
3D Work Tour	3.08	0.51
VR Supermarket	3.79	1.48
Memobile	3.07	0.62
Anger Management	4.00	0.47
Personal Hygiene	1.92	1.32
Starting Work	2.86	0.53
Stress at work	3.78	0.44
Work Sustainability	3.00	0.00

Table 25

The connection between the pictures and the actions rendered to them were unambiguous

game	mean	STD
Cheese factory	3.29	0.83
My Appearance	3.71	0.91
3D Work Tour	3.25	0.62
VR Supermarket	3.07	0.62
Memobile	3.50	0.65
Anger Management	3.10	0.56
Personal Hygiene	3.15	0.55
Starting Work	3.36	0.63
Stress at work	3.11	0.60
Work Sustainability	3.13	0.35

Table 27

Failures were typically results of not understanding instructions

game	mean	STD
Cheese factory	3.07	0.73
My Appearance	2.79	1.05
3D Work Tour	3.17	0.58
VR Supermarket	3.71	0.91
Memobile	2.79	0.97
Anger Management	3.20	0.63
Personal Hygiene	4.00	1.47
Starting Work	3.14	0.95
Stress at work	3.22	0.67
Work Sustainability	3.13	0.83

Table 29

The screens of the software were detailed

game	mean	STD
Cheese factory	3.93	0.73
My Appearance	3.21	0.97
3D Work Tour	3.18	0.60
VR Supermarket	3.79	0.69
Memobile	3.07	0.62
Anger Management	3.40	0.69
Personal Hygiene	3.69	0.75
Starting Work	2.93	0.79
Stress at work	3.22	0.44
Work Sustainability	3.00	0.00

After every question there is a “If you wish comment, why you have selected the given answer” open ended question to supplement the response given. At the end of the test there is a “30th question” - a half page for further notes, comments and remarks.

3.5 Score of User Interface

Table 30 contains the mean of the scores written in Tables 1-29. All the scores are above 3.2 and $0.487 < \text{STD} < 0.803$.

Table 30
Mean and standard deviation of the games’ total points

game	mean	STD
Cheese factory	3.754	0.752
My Appearance	3.522	0.593
3D Work Tour	3.255	0.638
VR Supermarket	3.644	0.547
Memobile	3.318	0.570
Anger Management	3.614	0.487
Personal Hygiene	3.360	0.736
Starting Work	3.232	0.504
Stress at work	3.521	0.525
Work Sustainability	3.203	0.803

In conclusion the scores show (>3.2); all the games’ user interfaces are user friendly and suitable for the target group, students with intellectual disability.

3.6 Design Principles

We tested the following serious games: : “Cheese factory”, “My Appearance”, “3D Work Tour”, ”VR supermarket”, “Memobile”, “Anger management”, “Personal Hygiene”, “Starting Work”, “Stress at work” and “Work Sustainability” software. Our testing process is based on a 5-point Likert Scale. The test results show that we developed very “easy to use” and user friendly games. Based on the evaluation results, we iterated our own design guidelines for serious games for use by people with intellectual and additional sensory impairments, which can currently be summarised as [4], [30]:

- Ensure presentation at appropriate speed
- Allow users to go back
- Allow User Control
- Make any text plain text
- Never convey information by colour alone

- Ensure sufficient contrast
- Help users navigate
- Make clear Maintain organisation
- Use unique and informative text descriptions for any hyperlinks (never click here!)
- Use accessibility features
- Design simply in simple layouts
- Use fallbacks
- Make systems consistent and error free
- Aim for compatibility with assistive technologies
- Allow keyboard access
- Do not include elements that are known to cause seizures

Conclusions

In this paper we have discussed the design and evaluation of 10 serious games and their user interfaces. These serious games were developed for students with intellectual disabilities to help them in activities of daily living, their working life and specifically in managing a budget. We have demonstrated the test process of the user interface design of the serious games and our solutions for any identified problems for students with intellectual disabilities. The detailed pedagogical tests finished in September 2010. The detailed pedagogical test and case studies will be written in a later paper.

While many new technologies have become available for research and education, many fundamental problems remain to be addressed via informatics research. We hope that the number of investigations conducted in the field of serious games and Virtual Reality for special needs education will grow. Computer graphics are better now and the 3D rendering techniques are becoming more mature, thus contributing to the reality of the simulated environments [31].

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