DRAFT VERSION

Can 3D gamified simulations be valid vocational training tools for persons with intellectual disability? A pilot based on a real-life situation.

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Summary
Objective: To investigate if 3D gamified simulations can be valid vocational training tools for persons with intellectual disability.
Method: A 3D gamified simulation composed by a set of training tasks for cleaning in hostelry was developed in collaboration with professionals of a real hostel and pedagogues of a special needs school. The learning objectives focus on the acquisition of vocabulary skills, work procedures, social abilities and risk prevention. Several accessibility features were developed to make the tasks easy to do from a technological point-of-view. A pilot experiment was conducted to test the pedagogical efficacy of this tool on intellectually disabled workers and students.
Results: User scores in the gamified simulation follow a curve of increasing progression. When confronted with reality, they recognized the scenario and tried to reproduce what they had learned in the simulation. Finally, they were interested in the tool, they showed a strong feeling of immersion and engagement, and they reported having fun.
Conclusions: On the basis of this experiment we believe that 3D gamified simulations can be efficient tools to train social and professional skills of persons with intellectual disabilities contributing thus to foster their social inclusion through work.

Introduction

Persons with Intellectual Disabilities (ID) are one of the social groups with a higher risk of exclusion in Western countries. Having a stable, meaningful employment develops a sense of identity and social status, and it has been stressed as a key factor of social inclusion and psychological wellbeing [1]. Besides, working

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on an equal basis with others has been recognized as a right of persons with ID by the UN Convention on the Rights of Persons with Disabilities [2]. Unfortunately, the employment rate among people with ID is less than a half as for general population [3], and more than a half of persons with ID are out of the labor force – that is neither working nor looking for a job [4].

Intellectual disability involves cognitive impairments such as memory, attention, language and spatial orientation, lowered self-regulation and social development, together with a deficiency of intrinsic motivation and a strong reliance on the other people's reinforcement [5]. However, unemployment of persons with ID is only partially related to the severity of their disability; it is also largely attributable to systemic and social barriers and to inadequate recruitment methods [6]. As a matter of fact, recent studies [7] have shown that hiring persons with ID is not as challenging as expected, it has positive effect in strengthening an inclusive organization culture, and it enhances the corporate image. In addition, employees with ID are dependable, engaged, they have a great attendance, attention to quality and a high productivity. Moreover, their attitude projects positively on other workers motivation [7].

There is a number of evidences that vocational education of individuals with ID can improve their cognitive performance and social behavior, increase their functional independence, and thereby facilitate their integration in a work place and their efficacy at work [8]. Moreover, vocational training has been found to increase motivation and thereby the likelihood of a person with ID to obtain a job [9]. Finally, vocational training can bring evidences of the capacities of persons with ID, contributing to break preconceived concerns of potential employers [9].

The personal accompaniment of students with ID is a key success factor in vocational education, because each individual has particular pedagogic requirements [10]. Moreover, since persons with ID have difficulty in transferring skills, training should ideally take place on the work place. Unfortunately, the amount of resources needed for this personal guidance at the work sites is often unsustainable [10]. Determining strategies for ensuring personalized, easy to transfer training at a reasonable cost is an ongoing subject.

Computer simulations of work procedures can provide unsupervised and personalized learning. Gamified computer simulations add game ingredients such as scoring, awards, timing and attractive graphical designs to these simulations in order to foster engagement [11]. Gamified simulations can incorporate dynamic game balancing strategies to customize feedback mechanisms and levels of difficulty on the basis of player abilities. This feature is particularly suitable to address the diversity of learning rhythms and capabilities [12].

"Serious" educational games are computer games designed with learning as the primary objective. By opposite to gamified computer simulations, they are not aimed at training a specific procedure, but rather at acquiring skills indirectly through game activities. Available pilot research findings have shown that the principal obstacle of using digital games-based learning and gamified simulations with students with ID is related to accessibility problems. Standard computer games and simulations do not meet the special needs of this type of users [13]. In particular, they do not take into account the requirements of lower and adaptive pace, clear and short instructions, use of oral or iconic messages whenever possible [14]. To be effective with persons with ID, they should be either adapted to these requirements or designed specifically for this target.

Several successful gaming experiences have been carried out in the classrooms to learn general cognitive skills [15, 16] and mathematics [17, 18] to children with ID. In addition to the core skills acquired in these games, through playing, students get familiarized with computer technology, a knowledge which is viewed nowadays as an essential requisite to access to life-enhancing applications.

There is an only limited number of games and simulations addressing specifically vocational training for persons with ID. Most existing solutions address generic behavioral abilities and practical competences but not specific professional skills. For instance, Standen et al. [19, 20] focus on decision making and response time. Various gamified simulations exist to learn routes for public transportation [21-24]. Others address money management through the simulation of shopping activities [25, 26]. Finally, some games are centered in two relevant aspects of independent living: self-care (hygiene and appearance) [27], and healthy alimentary habits [28]. In the frame of the GOET project [29], 10 games to support ID persons in getting and keeping a job were developed, most of them centered in the above mentioned generic skills. Torrente et al. [26] have developed a game oriented at training e-mailing and usage of office equipment for non-severely disabled persons based on a 2D generic scenario. Up to our knowledge, there is no previous experience in developing and analyzing the transfer value of 3D games for vocational training of persons with ID based on the simulation of real-life tasks of actual work sites.

The motivation of our work is to fill this gap. We present IntegraGame a 3D gamified simulation devoted at training persons with ID as room attendants. The aim of this gamified simulation is to bridge the gap between the classroom education and the work-place by providing a virtual training as similar as possible to reality.

Objectives

The main aims of this work are:

- To design and develop a gamified simulation for professional training of cleaning tasks in hostelry based on a real use-case
- To provide accessibility features to the interface in order to facilitate the use of 3D graphics to persons with ID
- To analyze the accomplishment of learning objectives in the simulation
- To evaluate the potential transfer of virtual skills to real skills of a group of test users

Methods

Development

IntegraGame was developed in collaboration with a non-profit organization, Icaria[2] devoted at promoting work integration of persons with disabilities. This organization manages three work places and the special need school Taiga[3]. We selected as reference their hostel, InOut[4] in which 90% of the workers have a

2 http://www.icaria.biz
3 http://www.escolataiga.com

4 http://www.inouthostel.com

disability. The training focuses at forming room attendants. We selected this professional profile because, according to different studies [30], hostelry is one of the economic sectors that can offer better professional opportunities to persons with ID.

The gamified simulation was developed following an agile user-centric methodology, on the basis of the real cleaning procedures of the hostel. It is based on a first-person perspective with users controlling the virtual camera position and orientation. It is adapted to touch screens as well as to mouse interfaces. The 3D environment reproduces faithfully the part of the hostel were most of the cleaning tasks happen (see Figure 1). The graphical model is composed of four different types of space: rooms (S1), cleaning room (S2), corridor (S3) and bathrooms (S4). The cleaning tasks were modeled on the basis of observing and filming the actual procedures of the hostel. The textual description of the task models were first discussed with the hostel managers before their implementation, and they were tested and validated by them after with IntegraGame. Finally, the successive prototypes were tested by 4 actual workers of the hostel with ID and 3 persons of the managing staff without ID. These preliminary tests had a double objective: check the correctness of the task models and validate their usability. The tempos of the tasks and the contents of the messages were composed following the recommendations of real vocational training [31]. The accessibility features provided in IntegraGame are described in Section 3.3.

Figure 1: The 3D virtual environment

Tasks

A recommendation of real vocational training is to break professional activities into simple and short tasks

[30]. Therefore, we divided the daily work simulation into 6 small tasks addressing different situations: preparation of the cleaning cart, entering in a room, checking a room, cleaning it and making the beds. A session is composed of a combination of these tasks in the desired order and number of repetitions. In addition, a familiarization task has been designed to help players to get used to this technology. This task surveys all the interactions that players need to do in the simulation: navigation, camera orientation and object manipulations such as pick, drag, drop and use. For each of these interactions, first an explanation on how it must be undertaken is shown. Then, the player is invited to do it by himself/herself a parameterized number of times. Figure 2 shows a screenshot of some of the tasks. Table 1 describes these tasks: their identifier, learning objectives, generic skills, contents and virtual environment in which it happens.

Figure 2: Some tasks

Table 1: Description of the virtual tasks, learning objectives and skills

Id	Learning objectives		Generic skills	Description	Space
T1	LO1.1	Remember which cleaning products and tools are necessary	Cognitive: attention, memory and language	Users have to open the closet containing the products and fill the cart. The cart is located nearby the closet so that navigation is not needed. Users simply rotate the camera to look in one or the other direction.	S2
	LO1.2	Prepare the cleaning cart in a tidy manner			
	LO1.3	Identify all the cleaning products and tools visually and by their name			
T2	LO2.1	Knock at the door before entering	Social: politeness	Users have to knock at the door before entering in a room. Various situations can happen: empty room, room occupied by a guest that leaves the room or that stays inside.	S3
	LO2.2	Wait if there is someone inside	Behavioral: containment		
	LO2.3	Insist if the guest doesn't leave			
T3	LO3.1	Discern if an object is or not valuable	Cognitive: attention and memory	Before cleaning a room, users have to check if there are valuable objects. If so, they call the supervisor with a virtual phone. They need to confirm which objects they have seen, first in a 2D panel and next in the 3D room.	S1
	LO3.2	Do not to touch the valuable personal objects of the rooms			
	LO3.3	Notify the supervisor when needed	Behavioral: decision making		
	LO3.4	Be precise in notifying the situation			
T4	LO4.1	Recognize the trash to throw in the garbage bag	Cognitive: att., memory, exec. functions and spatial orientation	Users have to tidy up and then clean the room, step by step. They open the window to aerate, collect the garbage, and clean the furniture and the floor. At the end, they should remember to close the window and turn off the lights.	S1
	LO4.2	Tidy up the only the guest things that disturb cleaning			
	LO4.3	Follow a routine procedure (the correct tool and the correct order)	Social: ambient awareness		
	LO4.4	Focus on side details such as cleaning all corners of the table			
	LO4.5	Freshen the room. Turn off the lights			
T5	LO5.1	Prepare the beds following the hostel procedure	Cognitive: executive functions and spatial orientation	Users have to change bed linens and make one of the beds of the room according to the hostel procedure.	S1
	LO5.2	Put the dirty sheets in the laundry truck			
T6	LO6.1	Keep the environment tidy and clean even though this is not a specific task	Social: engagement, responsibility and ambient awareness	Users are told to pick an object in the cart at the end of the corridor. In their way to the cart, they must collect all the garbage they find.	S3

Accessibility

There are three main axis of accessibility intervention in IntegraGame: interaction, instructions and pacing. Concerning the interaction, the simulation provides three features: simple click or touch interaction, automatic navigation and restricted selection. User input is based on click or touch interactions. Thus, it can be played with a mouse, based on one-button click and mouse movement or on a touch screen. A click or touch on an object launches the action associated to that object if any. If the object is far from the scope of the user's avatar, an automatic navigation towards it takes place before launching the action. In order to reduce possible errors, selection is restricted at each step of the simulation to the next required action. Thus, when users click on objects not related to the current goal of the task, the corresponding actions are not launched, providing thus an error-free play. In actions where navigation is not required, because all the relevant elements are at the reach of the user, navigation is directly disabled, for instance, in Task 1 and Task 2 where only camera rotation is needed. This avoids users getting puzzled in the environment and trying to repair their errors instead of focusing at the correct way of doing the task. Most of the actions are done instantaneously, but others require a continuous interaction. For instance, cleaning the table requires to keep the button pressed (or touched) and moving on top of it, simulating the gesture of scrubbing, until it is clean enough. Finally, camera rotation is handled either with mouse movements or with touches in a navigation widget that frames the 3D scenario. It is restricted to small angles, in order to avoid users navigating looking at the floor or at the ceiling.

Concerning instructions, they are provided always verbally, with a simple and clear style optionally complemented with a written message to reinforce the reading skills of users that have them. The instructions are direct, straightforward and in imperative mode. In addition, in Task 1, in order to reinforce the verbal and written messages, iconic images of the objects to be collected are shown at a side of the screen and objects involved in the next action blink and are highlighted. Finally, in all tasks all actions attempts yield a feedback message, always in positive style. Two levels of difficulty were implemented for all the tasks: in the first level all instructions were posted and in the second level, users had to perform the tasks without step-by-step instructions, only with the initial specification of the goal of the task.

Finally, concerning pacing, users have no limit of time to do each action. The next action is only required when the current one has been done. Since the play mode is error-free, all users finish the simulation having done all the tasks, unless they quit before. The instruction is repeated after a lapse of time of inactivity.

Pilot

The pilot was done two times at 14 months of interval (Iteration 1 in April 2015 and Iteration 2 in June 2016). In the first iteration the simulation had only one level of difficulty which was found insufficient by teachers. Thus, the software was enhanced to include a second level of difficulty which was tested in the second iteration. Each iteration was divided into two steps: training in the classroom with IntegraGame and real-life experiment in order to demonstrate the acquired skills.

For the virtual training, the software was installed in Taiga school and a group of students, each one identified with a unique number played with it during school hours. Teachers supervised them mostly for the familiarization task and less in the other tasks. They played 4 times through a period of 1 month for the first iteration and 4 times (2 per level of difficulty) during 2 weeks for the second iteration. The real-life experiments were done a week after the virtual training finished in the two iterations. In the preliminary tests during the development of IntegraGame, we had seen that although the mouse version was more difficult, it was nevertheless usable. Therefore, since the school did not have touch screen devices, the mouse version was used.

The real-life experiment was carried on at InOut hostel. It put into scene the tasks of the simulation in the real scenario through two exercises: on one hand, T1, and on the other hand, T2, T3 and T4 merged (see Table 2). We did not role-play each task separately because of time restrictions. The first iteration was intended at reproducing level of difficulty 1. Thus, we gave step-by-step instructions and helped users when they asked so. The second iteration reproduced level of difficulty 2, and thus, we let users act without detailed instructions. Table 2 summarizes the contents of these real-life tasks.

Table 2: Description of the exercises of the real-life experiment

Id	Description	Material	Space
E1	Equivalent to task T1. The instructor explains that the user has to open the closet containing the cleaning products and tools and fill the cart located nearby the closet. First, the user fills the cart without guidance, and then the instructor signals the missing objects if any.	Various items of all the objects available in the corresponding virtual task plus some others, also related to cleaning.	The corridor with a cleaning closet
E2	A fusion of tasks T2, T3 and T4. The instructor explains that the user has to check a room. The user carries a garbage bag and a walkie-talkie. He/she has to knock at the door before entering in the room (reference to task T2), then check if there is a valuable object and if so call the supervisor with the walkie-talkie (T3), collect the garbage and turn off the light and close the window before leaving (T4).	• 1 laptop; • 1 wallet with money; • 2 garbage objects on the floor of the room (1 dirty paper, 1 empty can); • 1 guest backpack	The corridor and a room

Participants

Participants of the pilot were selected by Taiga’s teachers among a group of students aged between 15 to 18 and with different ID degreed (between 40% to 65%). One of the participants had, in addition, a visual impairment of 80%. The families were informed of the experiment and gave their permission for the participation and filming. A concern of teachers was to clearly transmit to families that the experiment was not

a selection process, so they talked personally with each family to explain the goals of the pilot.
For the first iteration, 9 participants took the simulation-based training and
10 did the real-life experiment (5 among these 10 had participated in the simulation-based training and 5 had never used IntegraGame). For the second iteration there were 6 students in the virtual training and 13 in the real-life simulation (6 of which had make the virtual training). Table 3 summarizes the composition of the groups.

Table 3: Characteristics of the users groups

	Iteration 1			Iteration 2		
	Virtual Training (4 times)	Real-life experiment		Virtual Training (2 times level 1, 2 times level 2)	Real-life experiment	
		PLAYER GROUP	CONTROL GROUP		PLAYER GROUP	CONTROL GROUP
women	5	2	0	2	2	2
men	4	3	5	4	4	5
Total users	9	5	5	6	6	7

Evaluation

For the evaluation, the whole description of the user play was recorded click after click, the virtual distance traveled by the user‘s avatar and the time per action, were computed. Furthermore, the following values were computed:

- Correct actions: actions that the player is requested to do and that he/she has done.
- Related actions: auxiliary actions needed to perform the correct ones such as navigation, and opening and closing doors.
- Incorrect actions: actions that the user has incorrectly intended to do but that have not happened in error-free mode.

For the real-life experiment, the evaluation was necessarily more subjective. There were two non-teacher evaluators per experiment who counted times, correct and incorrect actions and need of help. On the basis of these observations, a mark was assigned to every subject. The marks were compared and discussed with teachers.

Tables 4 and 5 summarize the metrics used to evaluate each of the learning objectives and the acceptance criteria that are measured in terms of number of wrong actions (n) and elapsed time needed to perform the action (t) in comparison to the time needed by a user without disabilities at low pace (reference time). Some of the learning objectives of the virtual training could not be evaluated in the real-life experiment, as explained above, because not all the tasks were role-played due to time restrictions.

Table 4: Assessment criteria of the learning objectives in the virtual training (tref=reference time, n=number of actions, nref=reference number of actions)

LO	Metrics	Acceptance criteria
LO1.1	Time to prepare the cleaning trolley in T1	t < 2*tref
LO1.3	Wrong actions between the instruction to pick an object and the action to grab this object in T1	n < 4*nref
LO2.1	Wrong actions on the door before the knocking action in T2	n = 0
LO2.2	Wrong actions between the voice answer of the guest and the next instruction in T2	n = 0
LO2.3	Time and wrong actions between the second instruction and the knock again action in T2	t < 2*tref and n = 0
LO3.2	Wrong actions on a valuable object in T3	n = 0
LO3.3	Time between the instruction and the call to the supervisor in T3	t < 2*tref
LO3.4	Objects selected in the 2D interface when the OK button is pressed in T3	only the correct object
LO4.1	Wrong actions between the instruction to throw the first object to the garbage and the action to throw the last one in T4	n = 0
LO4.2	Wrong actions between the instruction and the action to tidy up the last object in T4	n = 0
LO4.3	Time to do the whole T4	t < 4*tref
LO4.4	Time between grabbing the cleaning cloth to clean the table and the completing the action in T4	t < 2*tref
LO4.5	Wrong actions between the instruction and the correct action in T4 for: opening the window, closing the window and turning off the lights	n = 0
LO5.1	Time to do the whole T5	t < 2*tref
LO5.2	Wrong actions between the instruction to remove the sheets and the correct action in T5	n = 0
LO6.1	Wrong actions on the toilet paper before throwing all the garbage in T6	n = 0

Table 5: Assessment criteria of the learning objectives in the virtual training

LO	Metrics	Acceptance criteria
LO1.1	Percentage of objects put on the cleaning trolley in E1	100% (iteration 1) 80% (iteration 2)
LO1.2	The manner to put the objects on the cleaning trolley in E1	Balanced distribution of objects
LO2.1	To knock or not before opening the door in E2	Door knocked
LO2.2	To open the door or not between the answer of the guest and the next action in E2	Not to open the door
LO2.3	Time between the answer of the guest and knocking at the door again in E2	$t < 12$
LO3.1	The type of object reported by the user to the supervisor in E2	All notified objects are valuable
LO3.2	Number of valuable objects touched by the user in E2	No valuable objects touched
LO3.3	To remember or not to use the walkie-talkie without the help of the instructor in E2	Walkie-talkie used without help
LO3.4	Number of valuable objects notified to the supervisor in E2	At least one valuable object
LO4.1	Objects picked up and thrown into the garbage bag in E2	At least one garbage object
LO4.5	To remember or not to close the window and lights at the end without the help of the instructor in E2	At least one action

Results

The results of the virtual training are shown in Table 6 that indicates, for every learning objective, the percentage of users who passed the acceptance criteria. Only the first and last time the users did the simulation is represented. A per task analysis of the evolution of the results of the first iteration can be found in [32].

Table 6: Results of the virtual training. Percentage of users that passed the acceptance criteria for every learning objective

	Iteration 1		Iteration 2			
			Level 1		Level 2	
LO	First game	Last game	First game	Last game	First game	Last game
LO1.1	44	67	33	83	50	67
LO1.3	33	67	50	67	50	50
LO2.1	44	44	83	67	67	100
LO2.2	67	67	83	83	67	67
LO2.3	78	89	83	83	33	67
LO3.2	67	78	33	67	100	100
LO3.3	56	89	0	33	50	83
LO3.4	11	0	33	50	50	67
LO4.1	50	88	17	67	83	67
LO4.2	50	88	17	67	33	50
LO4.3	88	100	67	67	33	67
LO4.4	75	88	83	100	100	83
LO4.5	63	75	33	83	67	83
LO5.1	67	100	33	83	50	50
LO5.2	89	100	67	83	67	100
LO6.1	25	75	50	67	83	100

The results of the real-life experiments are shown in Table 7 and 8. Table 7 shows the marks obtained in the real-life experiment in a scale of 1 to 10 (minimum, maximum, mean and standard deviation values among the group of users) for users having done the virtual training (player group) and users that have not do it (control group). Table 8 shows the percentage of users that passed the acceptance criterion for every assessed learning objective.

Table 7: Results of the real-life experiment: marks obtained by the users in a range of 0 to 10, for the two exercises E1 and E2 and global result with equal weight of the two exercises.

		Iteration 1		Iteration 2	
		PLAYER GROUP (5 users)	CONTROL GROUP (5 users)	PLAYER GROUP (6 users)	CONTROL GROUP (7 users)
E1	min	4,00	3,00	3,75	0,63
	max	10,00	8,00	9,88	7,50
	mean	7,20	5,80	7,95	3,30
	SD	2,59	2,17	2,35	2,25
E2	min	7,50	6,25	1,00	1,00
	max	8,75	8,75	9,00	8,00
	mean	8,25	8,00	5,33	4,43
	SD	0,68	1,12	2,66	2,57
TOTAL	min	5,75	5,75	2,38	0,81
	max	9,38	7,88	9,44	6,25
	mean	7,73	6,90	6,64	3,87
	SD	1,62	1,11	2,46	2,15

Table 8: Results of the real-life experiment: percentages of users that had passed the acceptance criteria for every learning objective.

	Iteration 1		Iteration 2	
LO	PLAYER GROUP (5 users)	CONTROL GROUP (5 users)	PLAYER GROUP (6 users)	CONTROL GROUP (7 users)
LO1.1	100	100	83	14
LO1.2	80	40	83	57
LO2.1	100	80	50	57
LO2.2	80	100	50	57
LO2.3	40	40	50	57
LO3.1	80	60	50	43
LO3.2	100	100	17	14
LO3.3	80	60	50	43
LO3.4	80	60	50	43
LO4.1	100	100	83	71
LO4.5	100	20	67	29

Discussion

Concerning the virtual training, the results confirm that all students could use the gamified simulation and most of them passed the acceptance criterion at the last game (Table 6). The differences in the results of the two iterations for level of difficulty 1 can be explained by the fact that the groups were small and the individual skills of the users play an important role in the results. However, in both cases there is a clear progression in the results of the last game in comparison to the first one, which indicates that students have learned. This observation is also true for the second level of difficulty. An exception is LO3.4 for the first iteration in which users did it worse at the last game. This learning objective consists of identifying the valuable object in the 2D interface. In general, it has the worse scores. This may be due to the fact the change of context from 3D to 2D was puzzling for the users. In addition, the recognition of valuable objects is difficult, because the concept of value depends on cultural reasons that vary among persons. Comparing the levels of difficulty in the second iteration, the score of the first game of the second level of difficulty is in general lower than the score of the last game of the first level. This is expectable, because increasing the level of difficulty requires an adaption. However, the results of the last game of level 2 are comparable and sometimes better that those of level 1, which can also be seen as a sign of successful learnship.

According to the teachers observations in the classroom, students understood the environment, the interaction rules and the aim of the training. They did not report having difficulties in using the mouse for navigation, although in the validation tests held during the development of the project, it was clear that the touch device was easier for them. The feeling of immersion was strong, some students answering orally to the character inside the room or knocking directly on the screen at the virtual door in Task 2. All students felt attracted by the software and wanted to play. They were concentrated while playing. The global feeling of teachers was that IntegraGame was a useful tool that could complement effectively their work, and that it could be used not only for that particular vocational training, but also as a complementary exercise of the current curriculum, which they have actually done. The major flaw that found in the first iteration was the fact there was only one level of difficulty. This drawback was corrected in the second iteration. They valuated as an achievement the fact that in the second level of difficulty users could do the tasks without per-action instructions. Concerning the results, they confirmed that they were expectable taking into account the capacities and skills of each individual, which are seen as the major factor of success.

Concerning the real-life experiment, several factors should be taken into account aside from the fact that the users had trained or not: the specific intellectual capabilities of the subjects and their emotions. The fact that the environment was new for them, that they were filmed (in the first iteration), and that they were the center of attention somewhat conditioned their behavior. Nevertheless, the global impression of the mediators was positive: trained students immediately recognized the situation and in general resolved it better than the others. It can be seen in Table 7 that the trained group has higher better marks than the control group in the two exercises and the two iterations. The results of iteration 2 are in general worse than those of iteration 1, because the level of difficulty was higher, with less guidance. However, the difference between the trained group and the control group is higher with the highest level of difficulty. When analyzing the learning objectives separately (Table 8), the same observations can be done: in general the player group outperforms the control group. An exception is LO 2.1 to LO2.3 related to knocking at the door (see Table 1) which are slightly lower in the second iteration. This result seems to indicate that social abilities may be more difficult to acquire and retain than procedural ones.

Table 8 also shows better results in the first iteration (easier) than in the second (more difficult). This is particularly visible in the learning objectives LO3.1 to LO3.4, where the intervention of the instructors were key to help users remember to identify the valuable objects. The difficulty of these learning objectives is consistent with the observations of the virtual training. The major difference between the player group and the control group corresponds to LO1.2 and LO4.5. In LO1.2, 80% of the trained subjects put all objects and all of them in the same order and place than in the simulation, in comparison to 40% on on-players (83% to 57% in the second experiment). In LO4.5 100% of the players remembered at least one of the two objectives (close the door and turning off the light), in comparison to 20% of the non-players (67% to 29% in the second iteration).

Conclusions

Vocational training is essential to promote the integration of persons with ID in the work force. It is however demanding in terms of personal and time resources. The hypothesis of this paper is that 3D gamified simulations can complement vocational training by providing self-contented instructional materials that can be played ubiquitously, as often as needed. The efficacy of serious games and simulations depends on one hand on their accessibility to users with ID, and on the other hand on the similarity of the virtual tasks to real ones. We have conducted a pilot study that has involved students and workers with ID, educators and employers in the design a gamified simulation based on a real-life use-case. The validations results on the simulation have shown that the technology is usable and attractive to students. The next step in the development of this technology is to implement more levels of difficulty in the simulation, to increase the number of situations and add more challenge through the inclusion of virtual rewards.

In order to measure the transfer value of the simulation, we have set up an experiment comparing the real-life skills of trained students and non-trained students. The evaluation is complex, subject to a diversity of factors such as the level of disability of the person, his/her motivation for the task and mostly contingencies of the experiment itself such as the fact of filming, time restriction, and the presence of educators and school mates. However, in spite of its limitation and the reduced number of subjects, the pilot showed us that there was a noticeable difference between trained and non-trained students. In addition, educators and employers considered it useful, and educators have integrated it as curricular activity.

Broadening the scope of application of the simulation to other daily-life environments and procedures is relatively easy and cheap, because the structure of the software is modular and allows re-using the objects and actions. Moreover, we believe that gamified simulations like IntegraGame can help companies to systematize and document their work procedures, which can be beneficial also for non disabled persons.

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