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► **To cite this version:**

Lahcen Oubahssi, Claudine Piau-Toffolon. A Virtual Learning Environment to Acquire Orientation Skills in the LUSI Class Context. McLaren B., Reilly R., Zvacek S., Uhomobhi J. (eds). Computer Supported Education, Springer, pp.56-76, 2019, Communications in Computer and Information Science, 978-3-030-21150-9. 10.1007/978-3-030-21151-6_4 . hal-02170553

HAL Id: hal-02170553

<https://univ-lemans.hal.science/hal-02170553v1>

Submitted on 22 Feb 2024

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A Virtual Learning Environment to acquire orientation skills in the LUSI Class context

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Keywords: Virtual Learning Environments, Educational Virtual Environment, Pedagogical Scenario, Orientation skills.

Abstract: Virtual Reality (VR) technologies become a promising tool in the context of learning especially for learners with learning disabilities, because of their technological specificities that differentiate them from the traditional learning environments. The development of educational virtual environment is a complex task due to the interdisciplinarity intrinsic to VR and its cognitive aspects. This paper describes a research work whose objective is to propose a solution based on virtual reality to enhance the traditional learning to acquire orientation skills in the LUSI class. This research work identifies some limitations with existing solutions and studies the design and operationalization of learning situations in the form of scenario models. Our aim is providing trainers with an educational toolkit, thus allowing them to recreate virtual reality scenarios and assess the learners' progress for learning orientation skills.

1 Introduction

Virtual Reality (VR) technologies become a promising tool in the context of learning especially for learners with learning disabilities, because of their technological specificities that differentiate them from the traditional learning environments. VR can be described as a set of technological tools that support the creation of synthetic, highly interactive three dimensional (3D) spatial environments that represent real or non-real situations. This description shows that VR can be pedagogically exploited through its unique technological characteristics that can be compiled as follows [32] [33] [34]: creation of 3D spatial representations, namely virtual environments (VE); multisensory channels for user interaction; immersion of the user in the VE and intuitive interaction through natural manipulations in real time.

Mikropoulos, and Natsis [34] define a Virtual Learning Environment (VLE) or Educational Virtual Environment (EVE) as a virtual environment that is based on a certain pedagogical model, incorporates or implies one or more didactic objectives, provides users with experiences they would otherwise not be able to experience in the physical world and redounds specific learning outcomes. Huang & al. [24] refer to Virtual Reality Learning Environments (VLRE) when they speak about environments based on VR used in educational applications.

There are numerous research studies on VR technologies for teaching and learning [14] [23] [31] establishing the advantages of using VR in education. We also note that with the appearance of the virtual reality, the computing allows to offer new experiences to the users thanks to possibilities of interaction and immersion which are even more performing. These possibilities are of great interest in the learning domain because they allow the creation of original and dynamic learning situations detached from the constraints that can exist during real training (danger, cost, uncertainty) and bringing specific advantages (enrichment of situations, replay, etc.) [3] [4] [10] [27] [36]. But Martin-Gutierrez & al. [30] note also some limitations due to the missing of studies on educational designs for a better integration of VR. Existing design-oriented studies are limited [5] but educational design is an integral part of the work all teachers perform [22] and there is a shortage of relevant practical and conceptual tools to support teacher design [37] [5]. Design is a complex task, in particular in the domain of virtual learning environments, due to the interdisciplinarity intrinsic to VR and its cognitive aspects.

We present in this paper a research work whose objective is to propose a solution based on virtual reality to enhance the traditional learning to acquire orientation skills in the LUSI¹ class. This research work took part of the ARVAD project [1]. As part of this research project, we worked with a LUSI class of twelve learners aged 16-18. The major difficulty of this public is managing their stress, which can be caused by several factors, including their own delay or the forgetting of the transport card, the delay of the bus, the noise, and the crowd. Our aim is to provide solutions to this problem of autonomy by using the techniques of virtual reality.

¹ Local Units for School Inclusion

We shall propose in this project solutions to structure the learning situations in formalism understandable for teachings and interpretable by the machine, adaptive and reusable according to the context. The research questions of this study are relative to the activity of design and operationalization of the pedagogical scenarios by the teachers-designers [31] in the target VRLEs. As part of this research, we study the design and operationalization of several learning situations in a virtual reality environment. The initial proposal of this research effort has been discussed in [11] [39] [45].

This paper is structured as follows: the next section will present context and objectives of our project and the main stages of the design of the orientation skills process. We present in section 3 the related research works on virtual reality and instructional design. Our proposal is presented in section 3. A discussion is made in section 4 on results of the pilot study we carried out to verify the usability of the developed environment [38]. We draw a conclusion and present our research perspectives in the last section.

2 Context of this research work

2.1 The ARVAD project

The ARVAD project was conducted in collaboration with the Technology Enhanced Learning (TEL) Engineering research team of the LIUM² laboratory, the INSH³ laboratory and the Robert Buron High School⁴ in Laval (France). This project is financed by Laval-Agglomeration. The aim of this research project is to propose a solution implemented in virtual reality environment to enhance the traditional learning to acquire orientation skills in the LUSI class. Our goal is to facilitate this learning through digital, and to provide trainers of the LUSI class with an educational toolkit, allowing them to recreate virtual reality scenarios and to assess the learner's progress. We followed a constructivist teaching approach based on problem situations, and a virtual reality environment to develop automation that can be latter exploited in a context of orientation skill acquisition. The challenge of

² <https://lium.univ-lemans.fr/>

³ <https://www.esiea.fr/equipe-insh/>

⁴ <http://reaumur-buron.paysdelaloire.e-lyco.fr/>

this research project relies on the interest of digital technologies in the learning for young people with cognitive disabilities.

2.2 The Local Units for School Inclusion

The Local Units for School Inclusion (LUSI) welcome pupils with cognitive or mental learning disabilities. The main goal of education in LUSI class is the development of autonomy and long-term professional integration in the labor market. LUSI class provides to pupils classroom accommodations and a specific educational program consolidating and developing adapted apprenticeships (general and professional education) with the alternation of collective and individual workshops. Teaching program includes general and specific learning facilitating social integration and autonomy (orientation skills, hygiene, etc.). As lack of skills for independent mobility can be a real barrier in everyday life, orientation activity becomes a daily practice. Different pedagogical learning approaches are taken: from the study of reading a map to real orientation activities in the city.

In LUSI class we distinguish two types of disorders, cognitive [26] and psychosocial [2] [16]. Some characteristic behavior of pupils is to adapt themselves to places; to the people they meet by having the proper attitude. They have no introspection activity and they have major difficulty explaining why they are doing some action. Major cognitive problems are located in four domains: memory, sense of time, reasoning and the space notion. The identified psychosocial problems are located on three domains: attention, motivation and self-esteem.

Several research studies have studied the issues related to the assessment and rehabilitation of these disorders. Sehaba and Hussaan [43] cited some examples based on clinical tests dealing with different cognitive functions, such as working memory [17], attention [28], auditory perception [36], oral and written language [8].

The evolution of computer science has led to the development of several digital solutions for cognitive and linguistic remediation. [7] [9] [15] [40] [42] [43] noted that these kinds of solutions have the advantage of being more flexible and easily accessible. However, most of them do not adapt to the specificities and needs of each user. Research works establish a close relationship between digital environments and teachers' practices and responsibilities in defining new pedagogical strategies within this type of training units. In our work, we address the

issues of designing and operationalizing pedagogical situations enhanced by VR environments in an engineering approach based on scenario models.

3 Learning Scenarios oriented Virtual Reality

3.1 Related work

Design of Virtual Reality learning environments (VRLEs) or Educational Learning Environments (EVEs) is a task that poses new technical difficulties, induced by the interdisciplinary intrinsic to the VR (graphic computer, haptic devices, distribution, etc.) and cognitive aspects (respect of the learned task characteristics, transfer of learning to the real world, etc.) [6] [29] [44]. Research has often focus on technical issues and discussions on how VR can be integrated into curriculum and relate to the learning process. Huang & al 2010 [24] propose a theoretical framework supporting instructional principles to facilitate building novel VRLEs. But they discussed only the pedagogical aspects influencing the learning process when designers apply a new VR technology to educational settings. According to the model of technology integration [35], VRLE's design should combine three sources of knowledge: technology, pedagogy and content. A VRLE includes an educational simulation, which is built around a set of learning objectives. The description of the educational simulations has to take into account the technological environment specificities (structure and dynamics). To fully describe the learning experience, designers of VLREs also need to specify the pedagogical requirements, in order to describe precisely the operationalization and the control of the activities in the environment. Tools by themselves do not teach; appropriate theories and/or models to guide the design and development of this technology are needed [12]. We might consider both didactic situations and scenario model. We analyzed the various research works that studying the question of scenario model design in VR domain.

[10] [4] propose a model based on a centralized and indirect control of an emergent simulation from learning scenario content model. In this model, the environment is populated with autonomous virtual characters and the user is free from his/her actions. Learning scenario design is realized in two steps: dynamic objectives are determined from the

user activity, and then a learning scenario is generated by these objectives and implemented through simulation adjustments.

Trinh & al. [46] provide models for the knowledge explanation for virtual agents populating virtual environments. This knowledge focuses on the structure and dynamics of the environment as well as procedures that teams can perform in this environment. This makes it possible to ensure the different semantic constraints in VR: 1) internal properties of the spatial object, 2) spatial relationships between a set of spatial objects, and 3) semantic of spatial interactions (for example, before and after the state of the spatial tasks).

Sehaba and Hussaan [43] propose a serious adaptive game for the evaluation and rehabilitation of cognitive disorders; their system makes it possible to personalize the course of games to each patient according to their capacities and competences. The architecture of the system organizes the knowledge in three layers: domain concepts, pedagogical resources and game resources. The main objective of this work is to reuse this architecture in different fields of applications and different serious games.

Fahim & al. [19] ensured that the generic side of the POSVET pedagogical scenario model through the use of the MASCARET meta-model, allows to reuse pedagogical scenarios on different platforms. The main advantage of POSVET is to allow the adaptation of educational activities and to offer to learners a control on their learning. This work aims at adapting the educational scenario to the learners' needs but doesn't offer solutions for assisting the teachers in their design process.

Marion & al. [29] propose a learning scenario model that describes machine-readable educational activities in a virtual environment, in a generic way in terms of learning domain, type of task to carry out and learning strategy. The author uses a virtual environment meta-model that provides an abstract representation of virtual environments to allow its model to be both generic and machine-readable.

Chen & al. [14] propose an analysis that focuses on the improvement of a pedagogical design model of virtual environments using formative research. They propose a theoretical framework which identify four principles of pedagogical scenarios' realizations: 1) the conceptual principle that guides the learner towards the information he must consider; 2) the principle of metacognition that explains to the learner how to think during learning; 3) the procedural principle that indicates how

to use the information available in the VRLEs; 4) the "strategic" principle that allows the learner to analyze the learning task or problem to be solved.

3.2 Lessons learned and issues from existing works

These research works overcome some limits identified in [10] that are related to the limited reactivity of the system or pedagogical control of the adaptation approaches. The models proposed improve the way to explicit knowledge [5] [46] or the pedagogical design of virtual environment [14] or permit the personalization of the course [43]. To overcome the lack of dynamic of the pedagogical scenario design, some works [10] [46] embed virtual agents in the virtual environment. But these works still limit the use of the virtual environment to predefined knowledge and learning activities. In [10], experts can enter their own model in a graphical editor that relies on a formal representation directly interpretable by computer systems. The meta-model approach developed by [29] also permits to experts to generate their virtual environment. But, despite these interesting approaches, they do not address in particular, the problem of the definition and adaptation of scenario models directly by the trainers according to the pedagogical situations they might encounter and the technical VR environment. Trainers/Teachers can still not adapt by themselves the pedagogical scenario according to the learner profiles and enable a gradual learning process. Our main concern is to propose solutions to trainers to help representing scenario according to their own pedagogical needs in new environments such as those dedicated to virtual reality. As part of this research, we study the design and operationalization of several learning situations in a virtual reality environment. We are particularly interested in learning design activities by means of scenarios models, by the teachers themselves, to enable them to design learning situations in virtual reality environments to ensure the achievement of their educational objectives. Last but not least, it is important to take note that the implementation of these scenarios always requires an extra effort in order to meet different technical, pedagogical and content constraints required by this type of environment [35].

4 Our contributions

As stated by [30] younger students have always lived surrounded with technologies and are digital natives [41] but relationships between technology and learning are not evident and virtual technologies are not an exception to this. But an investigation by [33] found that students had a favorable attitude towards these technologies in the educational process. Studies in the scientific literature linking virtual technologies with improvements in particular in students' social and collaborative skills [25] and students' psychomotor and cognitive skills [20] allowed us to suppose that the use of tablets, smartphones or video games in their daily life, and the attraction they show for all these devices suggest that virtual technologies can be beneficial for both learning and autonomy development.

In order to achieve our objectives, we adopt an iterative and participative approach involving a representative teacher [44]. Design occurred before, during and after prototype's implementation. Participants (teacher and researchers) to the design process developed their design using a broad-to-specific pattern in iterations [5]. In a first time we analyze and model existing learning situations, develop a functional demonstrator and test the usability and relevance of the demonstrator in real situations. During the analysis phase, we tested the technical acceptance of virtual reality environments through the manipulation by the LUSI class learners of two well-known 3D video games based on displacement situations using a joystick. This test proved that learners were very comfortable with these environments and associated peripherals. In order to define the practices and put them into perspective with the theories and methods of learning adapted to the target audience, we observed for a period of three months in the LUSI class the different pedagogical situations. Based on this study, we proposed pedagogical models to be implemented in the future virtual environment. These models may offer the possibility to trainers to define their own scenarios according to the learner's profile and the pedagogical situation.

4.1 Example of a Learning Scenario oriented LUSI class

The LUSI class learners were asked to carry out various educational activities related to orientation skills so that they could develop more autonomy in their personal and professional lives. We observed these

activities, depending of two categories of pedagogical situations (High School category and City category) and synthesized them in Table 1. The activities being carried out can be characterized with different variables and parameters in accordance with the needs of the teaching staff of the LUSI class. For instance, an activity “*work stress management*” can be adjusted with the variation of the level of stress by adding “noise” as parameter (Table 1).

Table 1. Example of variables for an orientation skill activity

Activity name	Stress Parameters							
	Noise		Timer			Obstacle		
	With	Without	Display		Duration		Present	Absent
			Yes	No	Limited	Unlimited		

Thanks to the observation process, we are able to propose a version of a model of scenarios (as illustrated in Fig.1), which leads us to propose a conceptual model of different pedagogical scenarios based on the needs of the referring teacher. Fig. 1 illustrates the course of the learning situation related to *Activity 1*, beginning with Activity 0 (Table 2). The objective of this activity is to locate different places on a map. The pedagogical strategy being used in this example is to work individually, and afterwards collectively for the correction.

Thus far, we note that the given scenarios are adaptable to the learners' progress (suggesting an itinerary to be followed first with visual and / or audible indications or without indication, adding noises from environments, etc.). In the suggested scenarios, the general objective of having learners move independently while managing stress with a map and benchmarks in the environment is fulfilled. In the meantime, we have identified several intermediate objectives that allow for a gradual learning towards this general objective (Fig. 2). Each intermediate objective is composed of a pedagogical sequence, which is divided into activities. The sequences are independent of one another because they do not respond to the same intermediate objectives.

Table 2. Example of orientation skills activities achieved in LUSI class

Activities	Objectives	Variables
High School Category		
Activity 0	Preparation for activity 1 & activity 2	No variable

Activity 1	Locate places in high school (with numbers)	Type of maps (1a: map with many words and images indices, 1b: map with many word indices, 1c: map with few words and image indices)
Activity 2	Identify places in high school (with colours)	No variable, only the map with many indices is used
City Category		
Activity 0	Preparation for activity 1 & activity 2	No variable
Activity 1	Locate on a city map	No variable
Activity 2	Locate important places with a grid	Search strategy with imposed grid

The set of these sequences constitutes a group of activities. The teacher assigns a specific sequence to one or more learners depending on their competency levels on orientation skills. In our study, we distinguish two groupings of learners according to two competence levels:

- Group 1: is the grouping of learners with a low level of competence on orientation skills. For example, group 1 always starts activities with a simplified map because they have difficulty moving on a complex map (with a lot of path choices).
- Group 2: is the grouping of learners with an average level of competence on orientation skills. For example, group 2 always begins activities with a complex map because we consider that they are able to move with a simple map.

We found that for the same objective, the teacher does not evaluate the same competency:

- For the same objective, the same activity may be used, but with lower or higher level of requirements according to the handicap and education level.
- For the same objective, activities of different (gradual) levels may be used.

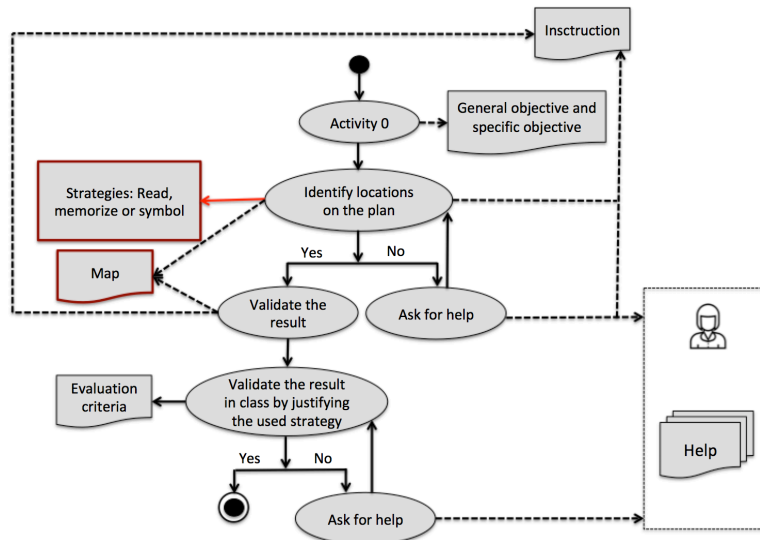


Fig. 1. High School Category – Progress of activity 1 (Table 1)

To evaluate the learner progress, a scale is used by the teacher according to the academic evaluation system (acquired, being acquired, almost acquired, not acquired). This makes it possible to locate them in relation to their competence booklet. Fig. 3 illustrates an example of a learner's pedagogical path with the different adaptations (change of activities, adaptation of objectives, etc.).

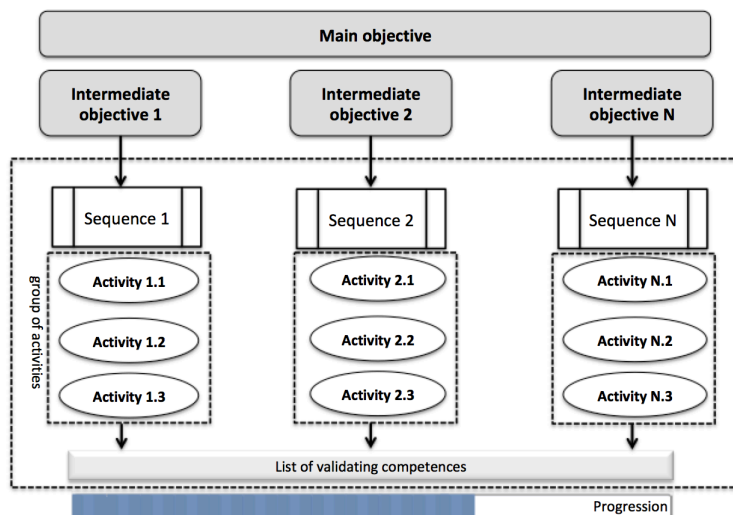


Fig. 2. Progress of Activity 1 (Table 1)

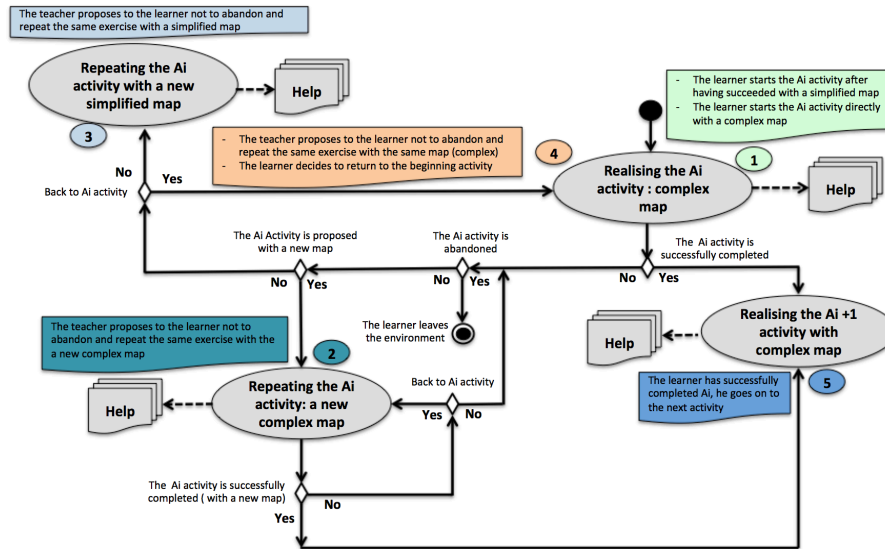


Fig. 3. The progression of a learning path with a complex map

4.2 The ARVAD Environment

We proposed a set of specifications characterizing a virtual reality environment and adapted to specific needs and scenarios according to the analysis and modeling of existing pedagogical situations. This allowed the development of a virtual environment enabling the pedagogical team to define orientation skills scenarios and learners to carry out the activities related to the objectives set. For carrying out these activities, the learner has a joystick, a synchronized tablet displaying a 2D map, and visual indices (images or texts) (Fig. 4). We developed a non-immersive virtual reality environment in the form of a window into a virtual world displayed on a computer monitor and the interaction made via a mouse or a joystick.

To set up the orientation skills activities, the teacher uses a configuration interface communicating with the ARVAD execution environment. This interface permits:

- Management and configuration of the travel plans;
- Management of learners or group of learners, set up of activities according to learning profile and pedagogical progression;

- Analysis of the results of the activities achieved;
- Management of the learner's accounts.

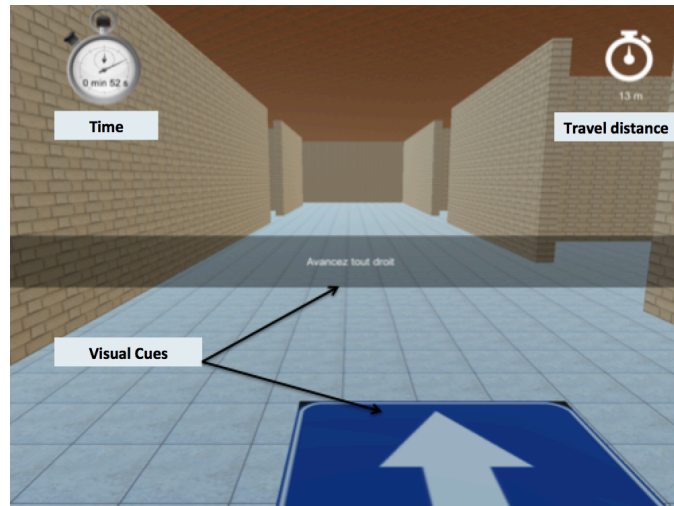


Fig. 4. ARVAD Environment Screenshot

As shown in Fig. 5, the ARVAD execution environment integrates a model of orientation skills scenario and the 3D environment (a labyrinth). A server is dedicated to the management of data and resources. An instance of the 3D orientation skills scenario model is defined through the setting up of the activities generating a scenario for a learner or a group of learners.

The environment includes two main parts. The first one is dedicated to the learner, playing the scenario defined by the trainers. The second part (not developed at this time) will allow the teacher to set pedagogical scenarios according to the learner's profiles and their pedagogical progression and save the results to track the progress of these learners.

The virtual environment has been developed with the cross-platform game engine Unity as a desktop version, where the user navigates using a joystick, related to a tablet. The design of the scenes did not try to provide authentic situations but only one close to the reality. Data of the various games play by each learner are recorded in databases.

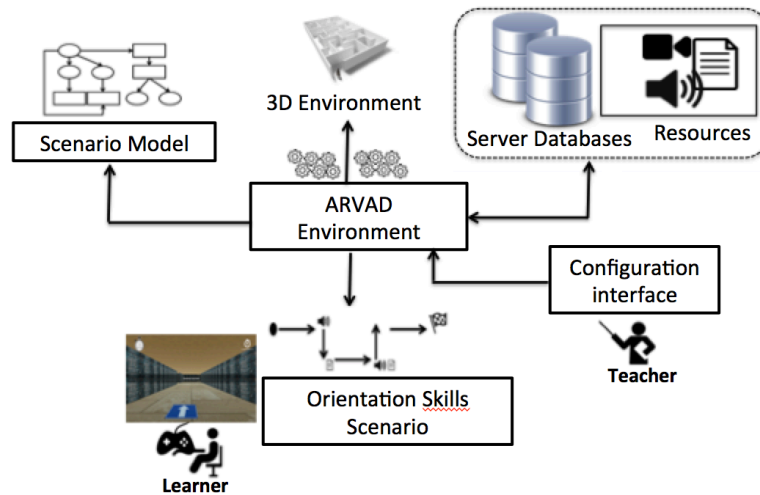


Fig. 5. The ARVAD execution environment

The software architecture of the ARVAD environment is illustrated in Fig. 6. It is composed of two functionalities modules, a teacher's module and a learner's module. The teacher may *manage a learner sessions* to create, modify or remove a learner profile, and define activities for learners or group of learners. During a session, he can *manage tracks/indicators* to visualize the different activities achieved by learners or group of learners for a period of time selected. Some indicators may be: date, learner code, number of activities achieved by a learner, distance travelled (by activity), and success or not of an activity. The teacher can export the results. When defining a scenario, the teacher can *manage orientation skills activities* and set up or associate a map (*mapping map*). When learners play a session they can *read the instructions* at any moment to achieve their activities (hear or read the indication) according to the teachers' settings before *moving into the environment* with the joystick. They can *visualize their orientation plan* and gets their position in the environment and *ask for help* at any moment in the game by clicking. Different types of aid are given according to the teachers' settings. At any moment it is possible to *restart the activity* from the beginning. The last attempt is recorded. *Pause/Exit* permits to the learners to take a break at any moment. This pause is not taken into account when the activity is timed.

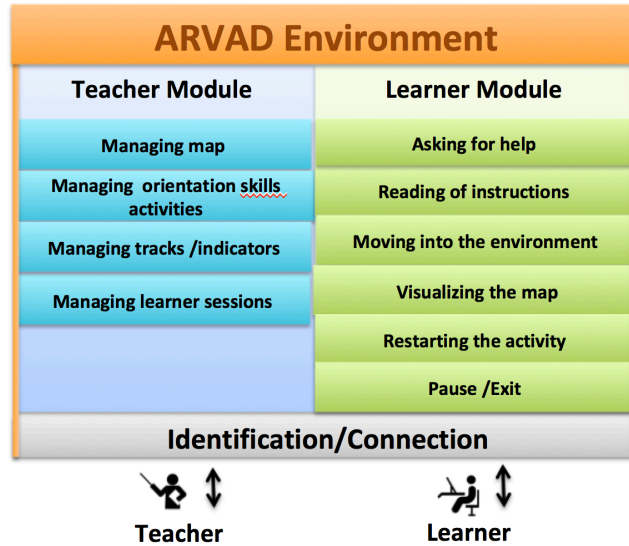


Fig. 6. ARVAD Software Architecture

5 Pilot study and Results

This section provides first a description of the pilot study and then describes the methodology for the evaluation of the VR based environment and gives and discusses results.

5.1 User Story

In order to assess the feasibility and the usability of the ARVAD environment, we conducted a pilot study. We defined with the teacher referent a set of objectives to evaluate if the functionalities and modalities of interactions (Table 3):

- Are well adapted to the LUSI class learners;
- Allow one or more skills to be easily worked;
- Allow one or more skills to be easily evaluated.

The experiment scope does not still permit to evaluate the pedagogical approach effectiveness. This pilot study was realized with nine learners (aged between 15 and 18) from the LUSI class at the Laval Robert Buron high school, in France. With the pedagogical team, we organized the learners into two groups according to the abilities and

skills of each one. Table 4 shows an overview of the profiles of each group.

Table 3. The pilot study objectives

O1	The learner gets to locate easily on the map (tablet)
O2	The learner is able to move easily in the virtual environment
O3	The learner can easily visualize the indices (image, pictogram)
O4	The learner understands the link between the tablet and the virtual environment
O5	The learner is able to move with visual or textual aid in the virtual environment
O6	The learner is able to make the link between the positioning in the 3D environment and the positioning on the tablet (use the aid)

Table 4. Learner's group profile

Group	Size	Capacities and Skills
1	4	Difficult access to reading or very difficult understanding of instructions. Use of pictograms.
2	5	Easy access to write and understand a simple instruction

5.2 Research methodology

The pilot study was used for this research along with quantitative and qualitative data. The aim was to evaluate qualitatively the feasibility of the pedagogical approach and some aspects of the usability of the virtual environment. We empirically verify usability criteria of the environment such as learnability, efficiency, memorability, errors or satisfaction [38]. According to the model of [18], we evaluate the concept of attitude, mainly the concept of perception of the user. To do so, we define a list of objectives (table 3) to observe how the perception of content on the screen (visibility, display, texture) was perceptible, the perception of the contents on the shelf and the link between the tablet and the main screen. We define a protocol based on two learning groups (Group 1 and 2) and four steps: pre-test, test, post-test and results analysis. Fig. 7 proposes an activity diagram of the pilot study process.

During the first step, the pedagogical team organized learners in two groups (Table 4), prepared an orientation map (on paper), the activities to be realized (duration, objective) and defined evaluation criteria (according to the skills to be tested for each group). The teacher then worked the orientation activity with the learners of the two groups (paper based map). For the post-test phase, an evaluation grid has been developed by researchers and a questionnaire for learners according to the objectives of the pilot experiment to evaluate the virtual environ-

ment during the learner's activities (Table 3). The map and the learning game scenario model were operationalized on the tablet and in the prototype of the virtual environment. In the second step (test), each group of learners plays their learning game scenario in the virtual environment. During each game session, the research team observes the learners' activities and notes their observations on the evaluation grid. For each objective (Table 3) we evaluate if the learner was able to achieve it. In the third step, the researchers submit a questionnaire to the two groups of learners. The objective of this questionnaire is to have a learner's feedback on the realized activities. The questionnaire was submitted by oral and the research team recorded answers. Finally, in a last step, the researchers conducted an analysis of the results and defined the improvements elements to the virtual environment.

During the test step, each group realized 3 sets of scenarios of the same activity (*moving from point A to point B*) but with a different variant depending on the group (with visual aid for Group 1 and with textual indications in Group 2). The skills to be evaluated were not the same for the two groups.

For example, among the skills to be assessed for Group 1, we can cite:

- I know how to go from a point A to a point B on the tablet map without indices.
- I know how to go from a point A to a point B using the visual aid in the virtual environment.

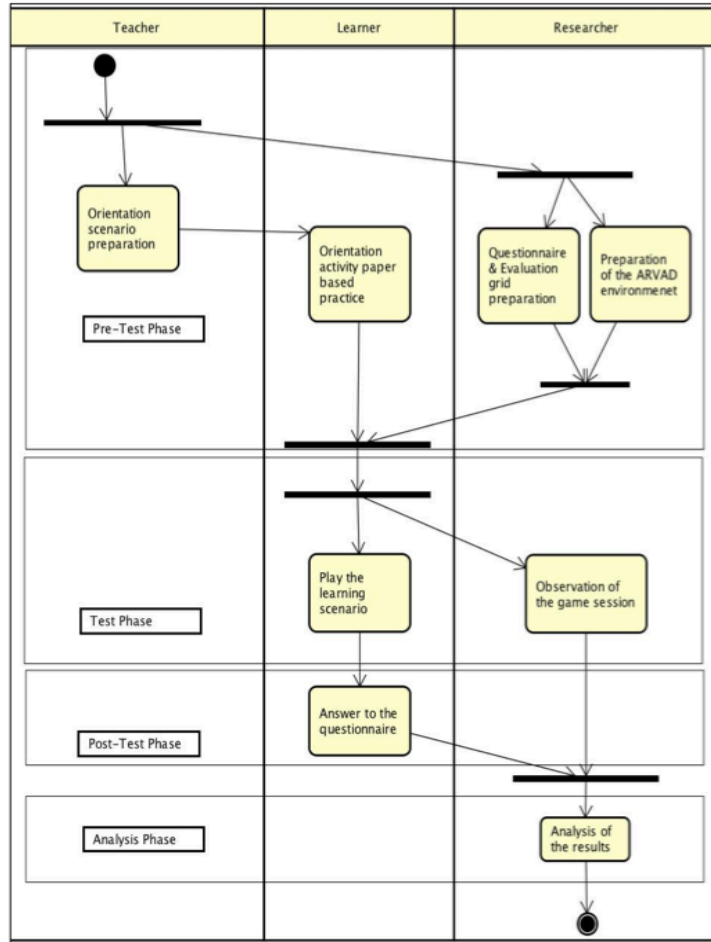


Fig. 7. Activity Diagram of the Pilot Study Process

Each learner was asked individually to study the map on a tablet, which is the reproduction of the one that was played in class. Then he/she explains what he/she should do, before realizing his/her activities in the virtual environment. At any moment they could get help (by asking directly to the project team members conducting the experiment) or by clicking with the joystick to spot on the map of the tablet where they were located in the environment. The time (in seconds) and distance covered (in meters) were recorded in order to evaluate the efficiency according to the mode of use.

Three series of displacement (scenarios) per learner were proposed (Table 5). The project team monitored the process, observed the learn-

er's activities and questioned the learner at the end of the session on the basis of the planned questionnaire and noted observations on the evaluation grid.

Table 5. Displacement series for the two groups of learners

Series	Description
<i>1</i>	Same departure and arrival point of the paper map
<i>2</i>	A new departure and arrival point with indications
<i>3</i>	A new departure and arrival point without indications

5.3 Results and Discussions

The analysis of the results from the post-test questionnaire submitted to the learners and the evaluation grid completed during the test (results presented for Group 1 in Table 6, Table 7 and Fig. 8, Fig. 9), made it possible to verify some of the usability criteria. The feasibility of the approach was validated as learners of the two groups were able to move in the virtual environment, locate themselves on the map in the tablet (tracing the requested itinerary) and achieved a series of activities (no abandonment). Only one learner (learner 4) unfamiliar with the joystick had some difficulties during the series (can be observed through the travel time recorded). Objectives O1 to O3 in Table 3 were satisfied. Some learners had more difficulties to understand and use the link between the tablet and the virtual environment (O4, O6 in Table 3, Table 7). Those who did not use the link with the tablet and the help proposed (by clicking with the joystick), randomly explored the environment for the first attempt in search of the arrival point. Then they used their memory to locate objects to achieve the series of displacement, thus the time taken to complete the activity or the covered distance in the two first series was greater, in a ratio of 1 to 3 for the time in the case of learner 4 compared to the best results of learners of the Group 1.

The time taken to complete the activity and the covered distance was variable according to the learners without being directly linked to the different types of help proposed. Objective O6 seems more difficult to achieve. We still noted in series 3 (changed start and arrival points - no indices provided in the virtual environment) that time and covered distance was greater for the two groups (see results Table 6, Fig. 8, Fig.9 for Group 1- except for learner 2 and 4). We observed that Learner 2 used systematically the aid provided in the environment but the results

(in terms of distance and time) were not better than the others (except for the last series).

Table 6. Results of Group 1

Learner	Series	Distance	Time	Help
1	1	31.2	51	0
	2	25.9	47	0
	3	51.5	133	2
2	1	30.8	66	5
	2	25.8	58	5
	3	21.3	34	6
3	1	36.1	82	0
	2	21.7	51	0
	3	53.9	122	1
4	1	32.1	143	0
	2	24.9	103	0
	3	28.4	127	0

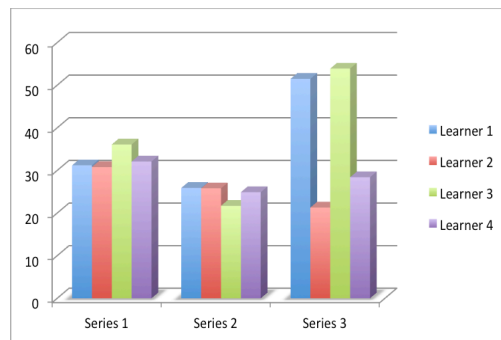


Fig. 8. Results of Group 1: Distance travelled (in meters)

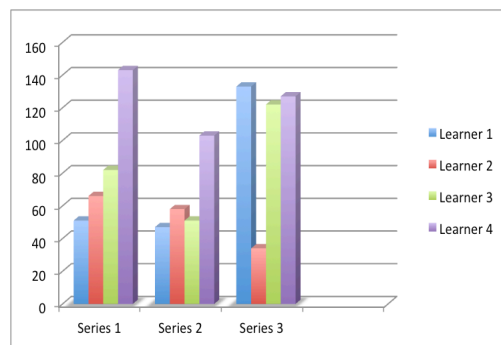


Fig. 9. Results of Group1: Time of travel (in seconds)

The first two series permit to verify the usability of the prototype and the skill (I know how to go from a point A to a point B using the visual aid in the virtual environment). In the last serie, learners enable to locate themselves in the environment with the use of indices despite change with the points of departure and arrival. Learners used more internal skills instead of exploiting the link between the map on the tablet and the environment. Group 2 presented results rather similar as Group 1.

Table 7. Results of Group 1 by objectives for each series of activities

Learner	Series	O1	O2	O3/O5	O4	O6
<i>1</i>	1	Ok	Ok	Ok	Ok	No
	2	Ok	Ok	Ok	Ok	No
	3	Ok	Ok	-	Ok	Ok
<i>2</i>	1	Ok	Ok	Ok	Ok	Ok
	2	Ok	Ok	Ok	Ok	Ok
	3	Ok	Ok	-	Ok	Ok
<i>3</i>	1	Ok	Ok	Ok	Not clear	No
	2	Ok	Ok	Ok	Ok	No
	3	Ok	Ok	-	Ok	Ok
<i>4</i>	1	Ok	Ok	Ok	Ok	No
	2	Ok	Ok	Ok	Ok	No
	3	Ok	Ok	-	Ok	Ok

6 Conclusion and perspectives

The use of virtual reality techniques has shown their effectiveness in the field of learning, but some limitations have been identified notably for the design of learning environment by teachers themselves. We based our research study on the framework proposed in [37] and results of previous works [11][39][45]. Design of VRLE should combine three sources of knowledge: technology, pedagogy and content beginning with pedagogical affordances to maximize learning outcomes [21]. Existing research works exploiting pedagogical scenario model do not always allow teachers to adapt the learning situation to the learner's course. Our findings from these works show that the learning scenario design is tackled with virtual agents embedded in the environment. Most models proposed are specific to a particular domain and technical environment. The scenario model must be planned from the early times of design of the environment where all the possible situations must have been considered.

The aim of the research presented in this paper has been to propose a learning environment exploiting virtual reality and scenario-based models that could be adapted by teachers to learning situations in the context of learners with cognitive disabilities. This research work identifies some limitations with existing solutions and studies the design and operationalization of learning situations in the form of scenario models. It takes place in the context of LUSI class and involves a specific learning situation of acquisition of orientation skills. We propose a solution based on virtual reality technology to enhance traditional learning and provide trainers with an educational toolkit, thus allowing them to recreate virtual reality scenarios and assess the learners' progress for learning orientation skills.

We have developed our own environment rather than reusing existing solutions because they do not allow us to deploy our learning scenario oriented LUSI class. The solution produced is authentic but in a simplified reality that can be complicated according to the learner's learning profile and promotes repetition which is an important learning spring for this learner audience. The pilot study based on qualitative evaluation validated the feasibility and usability of the pedagogical approach implemented in the virtual environment. The main improvements relate to the teacher part, to permit the adaptation of learning scenario to the learners and enable their monitoring. We aim to develop an editor that will facilitate the simple conception or parameterization of scenarios in different environments (simple labyrinths or 3D cities) and the monitoring of different paths by teachers and in a reflexive way by the learners (applicable to several environments, regardless of the field or type of simulation to play).

Future experiments should evaluate interfaces and usability on the part of the teacher and the effectiveness of pedagogical approach. We will also need to address the follow-up of learners and the adaptation of scenarios by teachers according to profiles and learning situations.

Acknowledgements : This work was funded by Agglomeration-Laval (France). We want to thank all partners of this project. We would also like to thank especially the learners and teachers for their full support and key contributions: the Laval Robert Buron high school, France.

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