Virtual Learning Environment Design in the Context of Orientation Skills Acquisition for LUSI Class

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Abstract: Virtual Reality (VR) is an interesting technology in the context of learning especially for learners with learning disabilities. The design of virtual learning environments (VLEs) is a complex task due to the interdisciplinarity intrinsic to VR and its cognitive aspects. 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 (Learning Units for School Inclusion) classes 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.

1 INTRODUCTION

We present in this article a research work that took part of the ARVAD project (ARVAD, 2017). The aim of this project is to propose a solution based on virtual reality to enhance the traditional learning to acquire orientation skills in the LUSI (Local Units for School Inclusion) classes. These units accommodate pupils with cognitive or mental health difficulties, with the main objective of schooling, the development of adult autonomy and a sustainable socio-professional integration in society. The daily activity of orientation skills presents a real obstacle for these learners. Different pedagogical approaches are used: from learning how to read a map in class to real orientation skills in an urban environment. As part of this research project, we worked with the LUSI class of twelve learners aged 16-18 (only nine could participate to the experiment). Their major difficulty is managing their stress, which can be caused by several factors, including the crowd, the noise, the delay of the bus, their own delay or the forgetting of the transport card. Our objective is to provide solutions to this problem of autonomy of the orientation skills by using the techniques of virtual reality.

For the learners of LUSI class, we distinguish two types of disorders, cognitive (Lahav et al., 2002) and psychosocial (ASH02, 2011) (De Gasparo and Van Belleghel, 2012). From the point of view of behaviour, they succeed in adapting to places; to the people they meet by having the proper attitude. On the other hand, they have no introspection activity and they have major difficulty explaining why they are doing this or that action. The identified cognitive problems are located on 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, 2013) cited some examples that are based on clinical tests, and deal with different cognitive functions, such as working memory (Diamond and Goldman-Rakic, 1989), attention (Manly et al., 2001), auditory perception (Mody et al., 1997), oral and written language (Broomfield and Dodd, 2004).

The evolution of computer science has led to the development of several digital solutions for cognitive and linguistic remediation. (Botella et al., 2000) (Campos et al., 2004) (Conde et al., 2009) (Parfitt and Nguyen, 1998) (Sehaba et al., 2005) (Sehaba and Hussaan, 2013) noted that these

systems have the advantage of being more flexible and easily accessible. However, most of these systems do not adapt to the specificities and needs of each user. The emergence of virtual reality in computer sciences offers new experiences to users along with more powerful interaction and immersion possibilities. 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.) (Barot et al., 2013) (Barot et al., 2013) (Carpentier and Lourdeau, 2014) (Lourdeaux et al., 2002) (Mikropoulos and Natsis, 2011). All these learning systems using virtual reality techniques can be grouped under the acronym 3D-VLEs (Virtual Learning Environments) (Fowler, 2014).

The research trends towards this type of environment have an influence on the 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. We aim at giving teachers the opportunity to freely design computational scenarios by providing them with tools dedicated to the design, reuse and adaptation of each scenario to new pedagogical situation if needed. The initial proposal of this research effort has been discussed in (Chaabouni et al., 2015) (Oubahssi et al., 2013) (Tadjine et al., 2016).

This paper is structured as follows: the next section will present related research works on virtual reality and instructional design, we focus on educational scenario model design. We present in section 2 the context and objectives of our project and the main stages of the design of the orientation skills process. 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 (Nielsen, 1993). We draw a conclusion and present our research perspectives in the last section.

2 VIRTUAL REALITY AND LEARNING SCENARIOS

The 3D-VLEs (Virtual Learning Environments) are used in many domains including educational settings. The VLEs design 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.) (Bossard et al., 2008) (Marion et al., 2009) (Sehaba and Hussaan, 2013). Therefore, the design and integration of VLEs into learning are complex and costly process. The description of the pedagogical simulations must take into account the specificities of this environment (its structure and its dynamics) in order to describe precisely the operationalization and the control of the activities in the environment. We also note that the simple fact of using virtual reality is not enough to motivate the learners, just as aesthetic fidelity is not a guarantee of pedagogical effectiveness. Tools by themselves do not teach; appropriate theories and/or models to guide the design and development of this technology are needed (Chen, 2006). We might consider both didactic situations and scenario model.

We analyzed the various research works that studying the question of scenario model design in VLEs. (Carpentier and Lourdeaux, 2014) and (Barot et al. 2013) 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 et al., 2010) proposed models allowing the explicitation of knowledge for agents that populate virtual environments. This knowledge relates to the structure and the dynamic of the environment as well as the procedures that teams can perform. (Sehaba and Hussaan, 2013) 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. (Marion et al. 2009) 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 and Teh, 2013) propose an analysis that focuses on the improvement of a pedagogical design model of virtual environments using formative research. This later model initially proposed by (Chen, Toh and Wan, 2004), allows to formatively develop and to evaluate simulations on a non-immersive virtual system. The analysis produced a five-level model to improve the pedagogical design of virtual environment.

These research works overcome some limits identified in (Carpentier and Lourdeaux, 2014) 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 (Carpentier and Lourdeaux, 2014) (Trinh et al. 2010) or the pedagogical design of virtual environment (Chen and The, 2013) or permit the personalization of the course (Sehaba and Hussaan, 2013). To overcome the lack of dynamic of the pedagogical scenario design, some works (Carpentier and Lourdeaux, 2014) (Trinh et al., 2010) 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 (Carpentier et al. 2014), 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 (Marion et al. 2009) 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. Trainers 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 and pedagogical constraints required by this type of environment.

3 THE ARVAD PROJECT

3.1 Proposition of a Learning Scenario Model

Financed by Agglomeration of Laval, the ARVAD project was conducted in collaboration with the INSH laboratory, the IEIAH (Technology Enhanced Learning (TEL) Engineering research team) of the LIUM laboratory and the Robert Buron High School in Laval (France).

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 classes. Our goal is to facilitate this learning through digital, and to provide trainers of the LUSI classes with an educational toolkit, allowing them to recreate virtual reality scenarios and to assess the learner's progress. We used 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 this research project relies on the interest of digital technologies in the learning for young people with cognitive disabilities. As stated by (Martin-Guttiérrez et al., 2017) younger students have always lived surrounded with technologies and are digital natives (Prensky, 2001) but relationships between technology and learning are not evident and virtual technologies are not an exception to this. But an investigation by (Mikropoulos et al., 1998) found that students had a favourable 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 (Kaufman et al., 2005) and students' psychomotor and cognitive skills (Feng, Duh and Billinghurst, 2008) permit 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: analysing and modelling existing learning situations, developing a functional demonstrator and testing the usability and relevance of the demonstrator in real situations.

Users took part of the design process and allowed the design of the prototype to evolve at each iteration. 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.

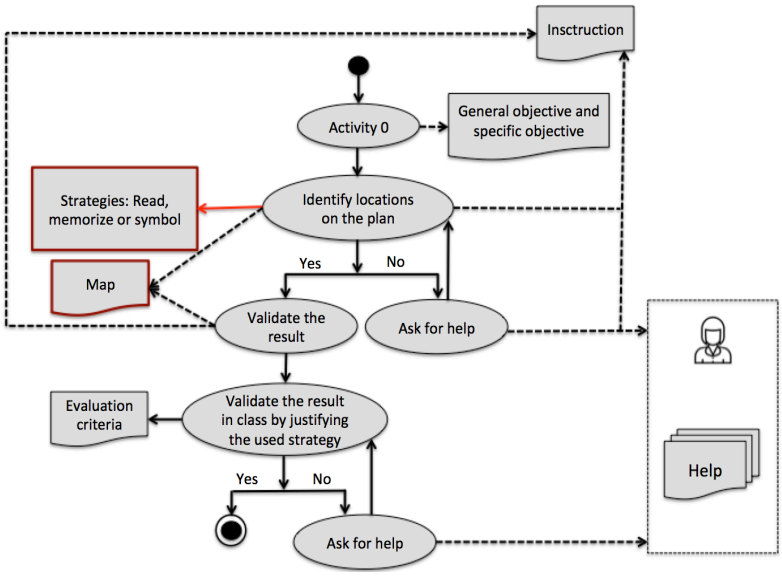


Figure 1: High School Category – Progress of activity 1 (Table 1)

3.2 Example of a Learning Scenario

The learners of the LUSI class are asked to carry out various educational activities related to orientation skills so that they could develop more autonomy in their personal and professional lives. While doing so, an observation is being made on a number of activities, as illustrated in Table 1. The activities being carried out can be characterized with different variables and parameters characterising 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 2). 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 1). 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 main characteristic of the given scenarios is that they 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 1: Extract of the various orientation skills activities achieved in LUSI class

Activities	Objectives	Variables
High School Category		
Act.1	Locate places in high school	Type of maps
Act.2	Identify places in high school (with colours)	No variable, only the map with many indices is used
City Category		
Act.1	Locate on a city map	No variable
Act.2	Locate important places with a grid	Search strategy with imposed grid

Table 2: Example of variables in orientation skills activities

Noise	Timer	Obstacle
With/ Without	Display (Yes/No) Duration (Limited/Unlimited)	Present/Absent

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.

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.).

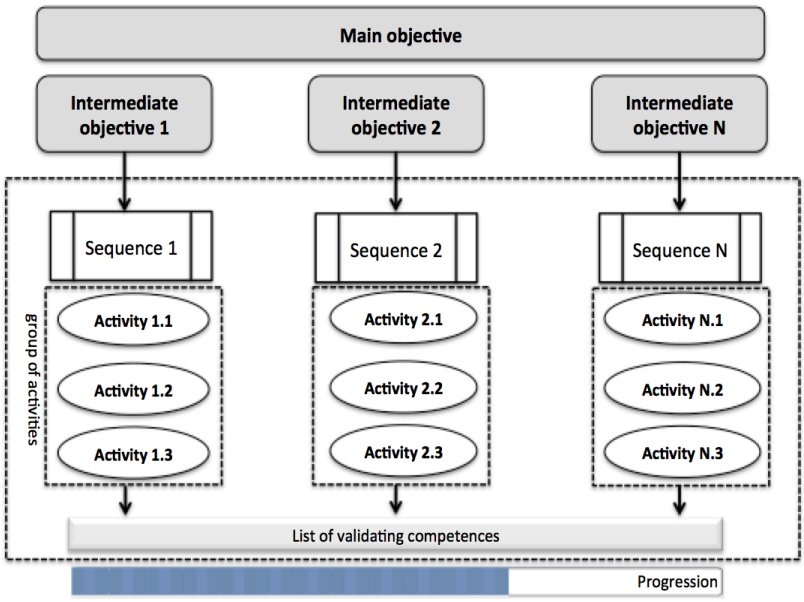


Figure 2: Progress of Activity 1 (Table 1)

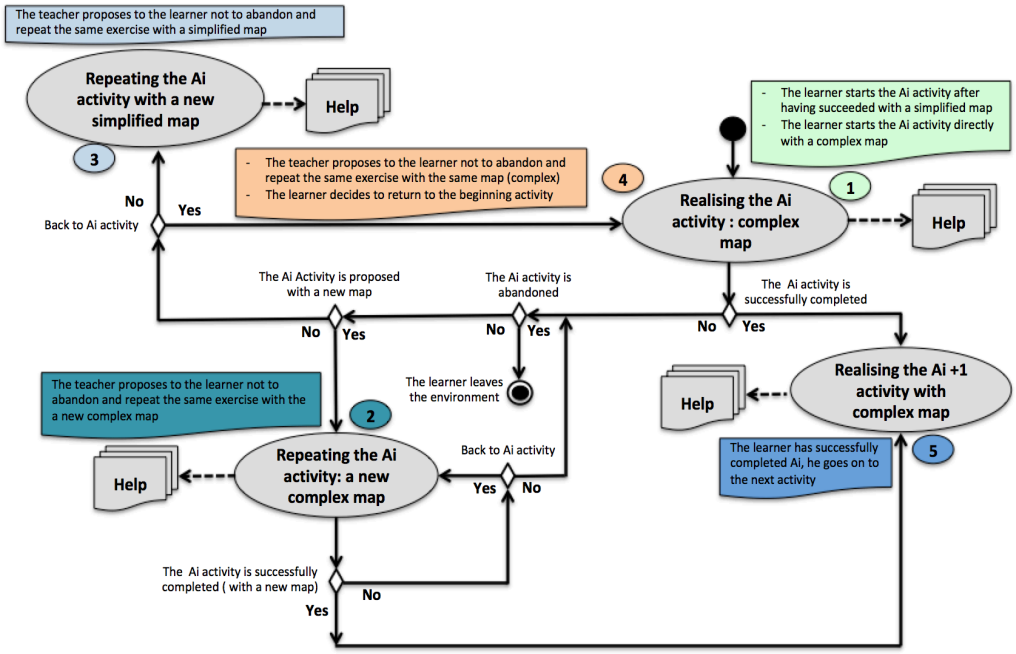


Figure 3: The progression of a learning path with a complex map

3.3 The 3D Environment

Following this analysis and modelling of existing pedagogical situations, we proposed a set of specifications summarizing the main one of a virtual reality environment to adapt specified needs and scenarios. 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 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.

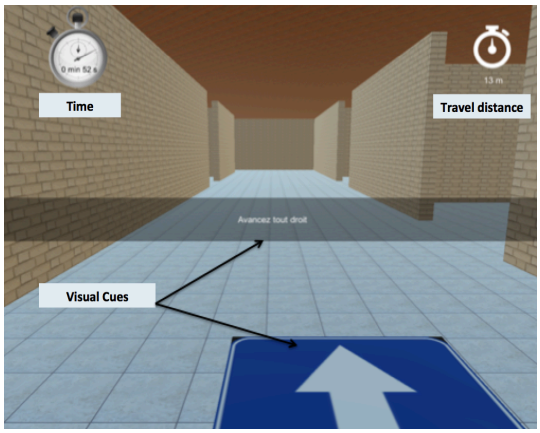


Figure 4: 3D Environment Screenshot

As shown in Fig. 5, the ARVAD execution environment uses 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 generated 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.

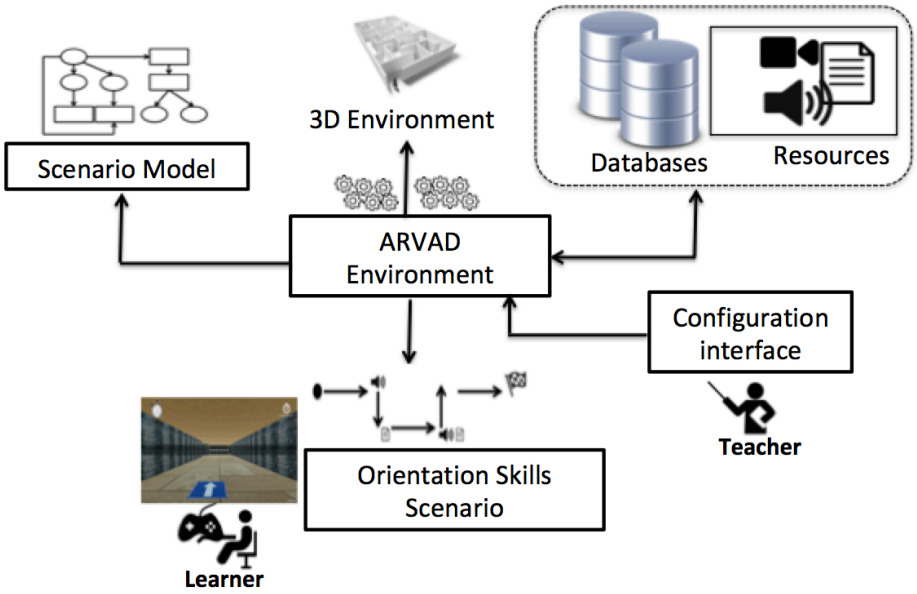


Figure 5: ARVAD Software Architecture

Fig. 6 depicts the software architecture of the ARVAD environment. It is composed of two functionalities modules, a teacher's module and a learner's module.

The teacher module is composed of the following functionalities:

- *Mapping map*: Permits to set up or to associate a map to an orientation skills activity.
- *Managing orientation skills activities*: Permits to create to set or to delete an orientation skills activity. Teacher can generate new orientation skills scenario.
- *Managing tracks/indicators*: Permits 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), success or not of an activity. The teacher can export the results.
- *Managing learner sessions*: Permits to create, to modify or to remove a learner profile, and to define activities for learners or group of learners.

The learner module is composed of the following functionalities:

- *Asking for help*: Permits to the learner to access to the help at any moment in the game by clicking. Different types of aid are given according to the teachers' settings.
- *Reading of the instructions*: To achieve the activity, the learner can hear or read the indication (according to the teachers' settings).
- *Moving into the environment*: Permits to achieve the activity. The learner uses the joystick to move around in the environment.
- *Visualizing the map*: Permits to the learner to visualize his/her orientation plan and gets his position in the environment.
- *Restarting the activity*: Permits to the learner to restart his activity from the beginning. The last attempt is recorded.

- *Pause/Exit*: Permits to the learner to take a break at any moment. This pause is not taken into account when the activity is timed.

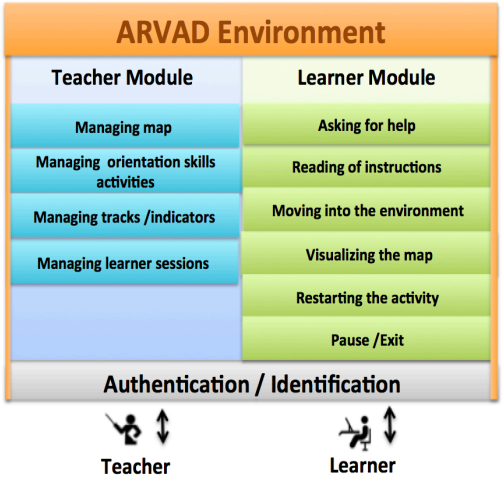


Figure 6: The two main parts of the ARVAD Environment

4 PILOT STUDY

4.1 User Story

This pilot study was realized with nine learners (aged between 15 and 18) from the LUSI class at the Laval Robert Buron high school, France. With the pedagogical team, we organized the learners into two groups according to the abilities and skills of each one. Table 3 shows an overview of the profiles of each group.

Table 3: Learner's group profile of the pilot study

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

We conducted the pilot study in order to assess the feasibility and the usability of the proposed system. We defined a set of objectives to evaluate if the functionalities and modalities of interactions (Table 4):

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

The scope of the experiment does not still permit to evaluate the effectiveness of the pedagogical approach.

Table 4: List of 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 manages to make the global link between the tablet and the virtual environment
05	The learner is able to move with visual 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 (know how to implement)

4.2 Method and Protocol

The aim of the pilot study is 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 (Nielsen, 1993). According to the model of (Dillon and Morris, 1996) we evaluate the concept of attitude, mainly the concept of perception of the user. To do so, we observed 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 defined 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 3), 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 experiment objectives to evaluate the virtual environment during the learner's activities (Table 4). 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 4) 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 realised 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.

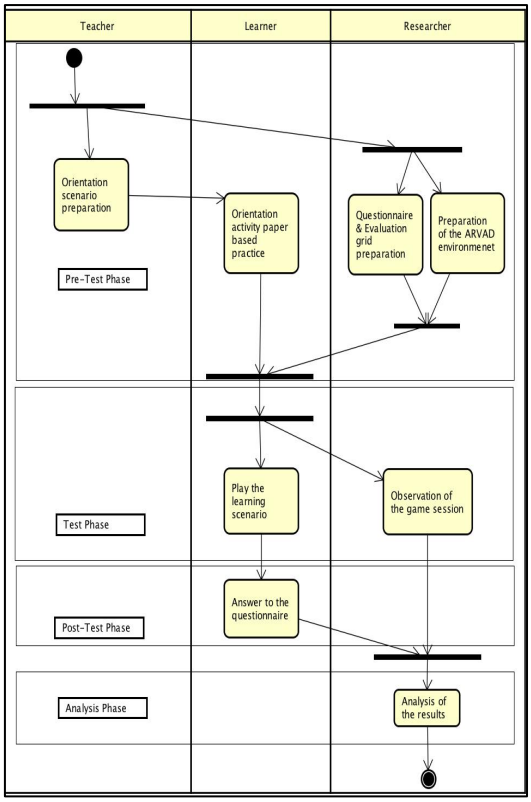


Figure 7: Activity Diagram of the Pilot Study Process

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.

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 learner'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
1	Same departure and arrival point of the paper map
2	A new departure and arrival point with indications
3	A new departure and arrival point without indications

4.3 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 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). They were all able to easily locate themselves on the map in the tablet (tracing the requested itinerary). Objectives O1 to O3 in Table 4 were satisfied. Some of them had more difficulties to understand and use the link between the tablet and the virtual environment (O4, O6 in Table 4, 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 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 O5 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	Activity	Distance	Time	Help
1	1 2 3	31.2 25.9 51.5	51 47 133	0 0 2
2	1 2 3	30.8 25.8 21.3	66 58 34	5 5 6
3	1 2 3	36.1 21.7 53.9	82 51 122	0 0 1
4	1 2 3	32.1 24.9 28.4	143 103 127	0 0 0

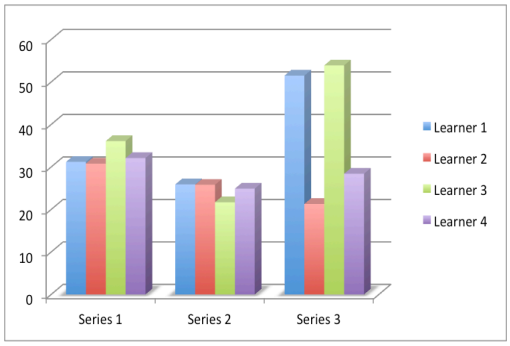


Figure 8: Results of Group 1: Distance travelled (in meters)

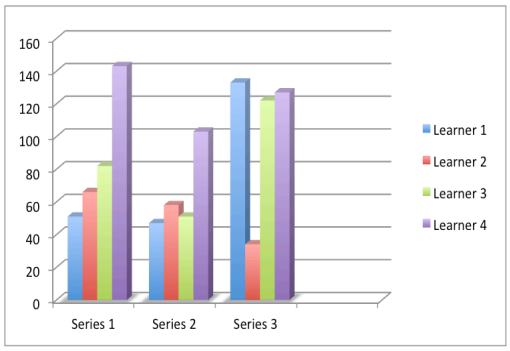


Figure 9: Results of Group1: Time of travel (in seconds)

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 series, despite change with the points of departure and arrival, the indices permit the learners to locate themselves in the environment. 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	O4/O6	O7
1	1 2 3	Ok Ok Ok	Ok Ok Ok	Ok Ok A few	Ok No Ok	Ok Ok -
2	1 2 3	Ok Ok Ok	Ok Ok Ok	Ok Ok Ok	Ok Ok Ok	Ok Ok -
3	1 2 3	Ok Ok Ok	Ok Ok Ok	Ok Ok No	No No A few	Ok Ok -
4	1 2 3	Ok Ok Ok	Ok Ok Ok	Ok Ok Ok	No A few A few	Ok Ok -

5 CONCLUSION AND PERSPECTIVES

VLEs based on virtual reality techniques proved to be efficient in learning but some limits have been identified, as they do not always permit teachers to adapt the learning situation to the learner's paths. The aim of this work was 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. We have developed our own environment rather than reusing existing environments that would have provided better visual feedback but would not have allowed us to develop our adaptable scenario models. 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 effort to provide operationalization (machine-readable model) still remains semi-automatic to deploy a new scenario, the teacher having to parameterize variables in text files. The experimentation 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. It remains to develop an editor that will facilitate the design or simple parameterization of scenarios in different environments (simple labyrinths or city in 3D) and the follow-up of the different paths by the teachers and in a reflexive way by the learners (applicable to several environments, regardless of the domain or type of simulation to be played). 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.

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REFERENCES

ARVAD,. 2017. Project Web site. http://www-lium.univ-lemans.fr/~oubahssi/ARVAD/

ASH02., 2011. Troubles des fonctions cognitives – pistes pédagogiques. *Enseigner - Aux élèves en situation de handicap - En unité d'enseignement - http://ash.ia02.ac-amiens.fr/IMG/article_PDF/Troubles-des-fonctions-cognitives-pistes-pdagogiques_a220.pdf.*

Barot, C., Lourdeaux, D., Lenne, D., 2013. Using planning to predict and influence autonomous agents behaviour in a virtual environment for training. *In Cognitive Informatics & Cognitive Computing (ICCI*CC), 2013, 12th IEEE International Conference . pp. 274-281.*

Barot, C., Lourdeaux, D., Burkhardt, J-M., Amokrane, K., Lenne, D., 2013. V3S : A Virtual Environment for Risk-Management Training Based on Human-Activity Models. *In Presence, Teleoperators and Virtual Environments, 22(1) :1–19.*

Bossard, C., Kermarrec, G., Buche, C., Tisseau, J., 2018. Transfer of learning in virtual environments : a new challenge ?. *In Virtual Reality September 2008, Volume 12, Issue 3, pp 151–161 Virtual Reality...*

Botella, C., Banos, R., Villa, H., Perpina, C., Garciapalacios, A., 2000. Virtual reality in the treatment of claustrophobic fear: A controlled, multiple-baseline design. *Behavior Therapy, vol.31, 2000, pp. 583-595.*

Broomfield, J., Dodd, B., 2004. Children with speech and language disability: caseload characteristics. *In International Journal of Language & Communication Disorders, 39 3: 303-324. 2004.*

Campos, E., Granados, A., Jiménez, S., Garrido, J., 2004. Tutor Informatico: Increasing the Selfteaching *in Down Syndrome People, Computers Helping People with Special Needs, 2004, pp. 629–629.*

Carpentier, K., Lourdeaux, D., 2014. Generation of learning situations according to the learner's profile within a virtual environment. *In Agents and Artificial Intelligence, number 449 in Communications in Computer and Information Science, 2014, pp. 245–260.*

Chaabouni, M., Piau-Toffolon, C., Laroussi, M., Choquet, C., 2015. Indexing learning scenarios by the most adapted contexts : An approach based on the observation of scenario progress in session. *In the 15th IEEE International Conference on Advanced Learning Technologies – ICALT 2015, Hualien (Taiwan), pp.39-43, 6-9 July 2015.*

Chen, C. J., Toh, S. C., Wan, M. F., 2004. The theoretical framework for designing desktop virtual reality-based learning environments. *Journal of Interactive Learning Research* , 15 (2), 2004, pp.147-167.

Chen C. J., 2006. The design, development and evaluation of a virtual reality based learning environment. *Australasian Journal of Educational Technology, 2006, 22(1), pp. 39-63.*

Chen, C.J ., Teh, C.S ., 2013. Enhancing an instructional design model for virtual reality based learning. *Australasian Journal of Educational Technology.*

Conde, A., De Ipiña, K., Larrañaga, M., Garay-Vitoria, N., Irigoyen, E., Ezeiza, A., Rubio J., 2009. LAGUNTXO: a rule-based intelligent tutoring system oriented to people with intellectual disabilities. *In: Lytras M.D. et al. (eds) Visioning and Engineering the Knowledge Society. A Web Science Perspective. WSKS 2009. Lecture Notes in Computer Science, vol 5736. Springer, Berlin, Heidelberg*

De Gasparo, S., Van Belleghel, L., 2012. L'ergonomie face aux nouveaux troubles du travail: le retour du sujet dans l'intervention, in Hubault (coord.). *Actes du séminaire de Paris 1 du 11, 12 et 13 juin 2012. Persistances et évolutions : les nouveaux contours de l'ergonomie. Toulouse, Octarès.*

Diamond, A., Goldman-Rakic, P.S., 1989. Comparison of human infants and rhesus monkeys on Piagets AB task: Evidence for dependence on dorsolateral prefrontal cortex. *Experimental Brain Research, vol. 74, 1989, pp. 24–40*.

Dillon, A., Morris, M.; 1996. User acceptance of information technology : theories and models. *Annual Review of Information Science and Technology, 1996, pp. 3-32*.

Feng, Z., Duh, H. B.L., Billinghurst, M., 2008. Trends in augmented reality tracking, interaction and display: A review of ten years of ISMAR. *In the7th IEEE/ACM international symposium on mixed and augmented reality (ISMAR), 2008, Cambridge, UK. doi: 10.1109/ISMAR.2008.4637362.*

Fowler, C., 2014. Virtual Reality and Learning: Where is the Pedagogy?. *British Journal of Educational Technology, 46, 2, 2014*.

Gutiérrez, J. M., Domínguez, M. G., González, C. R., 2015. Using 3D Virtual Technologies to Train Spatial Skills. *in Engineering. International Journal of Engineering Education 31(1), 323-334.*

Kaufmann, H., Steinbugl, K., Dunser, A. Gluck, J., 2005. General training of spatial abilities by geometry education in augmented reality. *Cyberpsychology & Behavior, 2005, 8(4), 330.*

Lahav, O., Mioduser, D., 2002. Multisensory virtual environment for supporting blind persons' acquisition of spatial cognitive mapping, orientation, and mobility skills.. *In Proceedings of the 4th Conf Disability, Virtual Reality & Assoc. Tech., Veszprém, Hungary, pp 213-220*

Lourdeaux, D., Fuchs, P., Burkhardt, J-M, Bernard, F., 2002. Relevance of an intelligent tutorial agent for virtual reality training systems. *Int. Journal of Continuous Engineering and Life-Long Learning, 2002, 2 (1-4), pp. 214 - 230.*

Manly, T., Anderson, V., Nimmo-Smith, I., 2001. The differential assessment of children attention: The Test of Everyday Attention for Children (TEA-Ch), normative sample and ADHD performance. *Journal of Child Psychology and Psychiatry, vol. 42, Nov. 2001, pp. 1065-1081.*

Margaryan, A., Littlejohn, A., Vojt, G., 2010. Are digital natives a myth or reality? University students' use of digital technologies. *Computers & Education, 2011, 56, pp. 429-440.*.

Marion, N., Querrec, R., Chevaillier, P., 2009. Integrating knowledge from virtual reality environments to learning scenario models-A meta-modeling approach. *INSTICC International conference of Computer Supported Education, 2009, pp. 254–259.*

Martín-Gutiérrez, J., Mora, CE., Añorbe-Díaz, B., González-Marrero A., 2017. Virtual Technologies Trends in Education. *Eurasia Journal of Mathematics, Science and Technology Education*. 2017;13(2):469-86. doi: 10.12973/eurasia.2017.00626a.

Mikropoulos, T., Chalkidis, A., Katskikis, A., Emvalotis, A., 1998. Students'attitudes towards educational virtual environments. *Education and Information Technologies, 1998, 3(2), pp. 137-148.*

Mikropoulos, T.A., Natsis, A., 2011. Educational virtual environments: A ten-year review of empirical research (1999-2009). *Computers & Education, 56 (2011), pp. 769-780.*

Mody, M., Studdert-Kennedy, M., Brady, S., 1997. Speech perception deficits in poor readers: auditory processing or phonological coding?. *Journal of experimental child psychology, vol. 64, Feb. 1997, pp. 199-231.*

Nielsen, J., 1993. Usability Engineering. *The book, Boston, Academic Press.*

Oubahssi, L., Piau-Toffolon, C., Clayer, J.P., Kammoun, F., 2013. Design and operationalization of patterns: Case of a training situation of personal assistance for public in professional integration. *Int. Conf. on Software Technologies (ICSOFT 2013), Reykjavik(iceland), 29-31 July 2013, p.488-495.*

Parfitt, L., Jo, J., Nguyen, A., 1998. Multimedia in Distance Learning for Tertiary Students With Special Needs. *ASCILITE, Australasian Society for Computers in Learning in Tary Education, 1998, pp. 561–569.*

Prensky, M., 2001. Digital Natives, Digital Immigrants. On the Horizon, 2001, 9(5), pp. 1–6. doi:10.1108/10748120110424816.

Sehaba, K., Estraillier, P., Lambert, D., 2005. Interactive Educational Games for Autistic Children with Agent-Based System. *4th International Conference on Entertainment Computing (ICEC'05), number 3711 in Lecture Notes in Computer Science (LNCS), pp. 422–432, Springer. September 2005, Sanda, Japan.*

Sehaba, K., Hussaan, A.M., 2013. Adaptive serious game for the re-education of cognitive disorders. *AMSE Journals, Advances in modeling, series Modelling C (Special issue on Handicap) 73(3): 148-159.*

Tadjine, Z., Oubahssi, L., Piau-Toffolon, C., Iksal, S., 2016. A process using ontology to automate the operationalization of pattern-based learning scenarios. *Scientific Book Chapter In Communications in Computer and Information Science (CCIS), edited by Springer-Verlag, 2016, pp. 444-461.*

Trinh, T.-H., Querrec, R., Loor, P. D., Chevaillier, P., 2010. Ensuring semantic spatial constraints in virtual environments using UML/OCL. *In VRST'2010 Proc. of the ACM symposium on Virtual reality software and technology, 2010, pp. 219-226.*