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Abstract— **Virtual reality (VR) technology has been applied in many sectors. Recent technological innovations have facilitated the access to virtual reality for anyone. VR offers new experiences to users that will make it possible to break the boundaries of formal education. But the design of educational environments named Virtual Reality Learning Environments (VRLEs) exploiting this technology is complex. We note that, because the pedagogical scenario have to be designed in the early time of VRLEs' design, it offers limited issues to teachers to adapt to new situations. We aim in this work at studying and proposing solutions to help trainers to design and spread their educational scenarios in the VRLEs.**

Keywords: Virtual Learning Environments, Learning Design, Pedagogical Scenario, Educational Simulation.

INTRODUCTION

The emergence of the virtual reality technology (VR), allows to offer new experiences to users due to new possibilities of interaction that are becoming nowadays more successful. These possibilities find a big interest in the field of learning. Educational environments based on VR allow the creation of original and dynamic situations for learning, independent of constraints, which can exist during real training, and they also bring specific advantages. We named Virtual Reality Learning Environments (VRLEs), semi immersive three dimensional (3-D) virtual learning systems. These environments combine characteristics like representational fidelity, learner interactions and identity construction [1]. Various works demonstrated advantages and utility of virtual reality for the learning, in particular in [2] [3]. However, VRLEs' design is a complex activity. Difficulties are at the same time technical and cognitive. Technical difficulties are inferred by the intrinsic interdisciplinary in the VR (computing schedules, devices (plans) haptics, distribution, etc.) and cognitive ones refer to the respect for the task's characteristics to be learnt, the transfer of learning (apprenticeship) towards the real world, etc. [4] [5]. According to the model of technology integration [6], 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 (its structure and its dynamics). To fully describe the learning experience, VLREs also need to specify the pedagogical requirements. Designers have to describe exactly the operationalization and the control of the activities in the environment. We aim in this work at studying and proposing solutions to help trainers to design and spread their educational scenarios in the VRLEs [5] [7]. In our approach, we start by studying the architecture, features and pedagogical objects embarked in existing VRLEs. Secondly, we shall propose a model helping teachers to structure their educational situations in the VRLE in an adaptive and reusable formalism according to the context. We consider that solutions based on patterns could be an interesting way of exploration. Patterns are good solutions for capturing, sharing and reusing design ideas [8] and managing design of knowledge and use of technology [9]. This paper is structured as follows. In the next sections, we present a state of the art of the main aspects of our research works, and then we propose a framework for describing the VLRE engineering process. Finally, we draw a conclusion and present our future works.

STATE OF THE ART

According to our study of existing VRLEs, we identified three main axis for our research work.

1) Axis 1: VRLEs design models

The usual approach is to start with technical considerations before addressing pedagogical issues. For example, Trinh and al. [10] 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). Chen and al. [11] propose a theoretical framework to guide the VRLEs design. This frame is divided into two subsets. The first is called "*macro-strategy*". It refers to the overall design of the VRLEs and involves 1) the identification of learning objectives (skills, knowledge, etc.) and the relationship between these objectives; 2) the identification of pedagogical scenarios allowing the learner to acquire the targeted learning; 3) identification of the help provided to the learner (resource information, tools, etc.) to facilitate the acquisition of targeted learning. The second subset is called "*micro-strategy*". It refers to the pedagogical scenarios adaptation according to the type of VRLE that one wishes to design. Chen and Teh [12] propose some improvements of the virtual environment pedagogical design model proposed in [11]. Ritz [13] provides guidelines for best practices in integrating immersive virtual reality, especially Cave Automatic Virtual Environment (CAVE), into teaching. These guidelines will address a practical need by informing and supporting educators in adapting instructional design to emerging technology. We note that the proposed models are not easy to achieve for trainers non-computer specialist. Also, they don't allow them to follow the design process of their own VRLEs.

2) *Axis 2: VRLEs learning scenario models*

Many studies in the field of VRLEs have addressed the issue of modeling pedagogical situations in virtual environments. For example, Sehaba and Hussaan [14] propose a system that allows personalizing for each patient the running of virtual games for the evaluation and rehabilitation of cognitive disorders. Marion and al [3] propose a learning scenario model POSEIDON able to integrate VRLE in the learning process. The approach is based on metamodeling ensuring the genericity of the modeling, regardless of the nature or domain of VRLEs. The authors use a meta-model that provides an abstract representation of virtual environments, allowing its model to be both generic and machine-readable. Fahim and al [15] 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. Chen and al [11] 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. According to Le Corre and al [16] an educational scenario in the VRLEs allows to organize the training for a pedagogical purpose, however the scenario is designed for any learner without taking into account the individualities, which can slow learning. These authors [16] identified the weaknesses of the Intelligent Tutorial System (ITS) PEGASE for virtual reality learning environments [17] and identified its lack of connection with the pedagogical scenario, its lack of modularity and its lack of individualization. To fill these weaknesses, they proposed an ITS called CHRYSAOR based on POSEIDON. This new proposal allows to define an educational scenario as an example of an environment based on the knowledge of the environment representing the domain model, totally expressed in Mascaret, contrary to POSEIDON. Based on the study of these research works, we noticed that the pedagogical models are planned at the early stages of the environment's design and all the possible pedagogical situations must have been considered.

3) *Axis 3: Architecture of VRLEs*

The work of this axis is about VRLEs software architectures. Lanquepin and al [18] propose a platform called HUMANS (Human Models based Artificial eNvironments Software), a generic framework designed to build custom virtual environments, this approach involves the dynamic computation of situations that varies depending on pedagogical rules, moreover, it is not easy to handle by non-computer specialists. It is also interesting to note that main goal of this platform is to propose a set of software covering the VRLE life cycle from the design to its exploitation by the learners and trainees. Gerbaud and al [19] offer a technical infrastructure not for trainers but for engineers seeking to develop VRLEs again, by reusing existing components. A first study of this work led us to note that they do not address the problem of the definition and the adaptation of the scenario models directly by the trainers according to the pedagogical situations that they could meet.

A VRLE-ORIENTED PROCESS ENGINEERING FRAMEWORK

We noticed that in various existing VRLEs, the modeling of learning situations must be planned early, during the environment design phase. But in this case, it may be difficult for trainers to adapt educational scenarios to new learner's situation or context. Our goal is to propose a solution, which allows helping and guiding trainers in producing VRLEs adapted to their needs. The approach we choose to adopt is teacher-centered and iterative [20]. We define a framework for describing a VLRE process engineering of several steps from the definition of the learning situation to its deployment/operationalization in the VR environment. At the beginning of the process, trainers expressed their needs according to their learning situation, with the help of a virtual reality scenario model. Therefore, this step consists in the formalization of learning situations. A good way to formalize teacher's needs is to use a pattern based approach. A pattern-based formalization, considering its semi-structured data, allows teachers-designers to express their pedagogical needs without extensive loss of semantic information while representing their pedagogical intention with a pattern-based editing tool [7] [9]. Then, we suggest the creation of pedagogical scenarios that define an orchestrated sequence of learning activities within this formalism. The second step consists in identifying the virtual reality needs (the 3D environment and the virtual reality tools to use). In this step, teacher-designer or community of teachers choose and adapt a virtual reality environment in which they instantiate a pedagogical scenario. The questions we have to deal with are: (1) which architecture we shall use to create this services (2) How we insure the interoperability of the various 3Ds environments? (3) How we shall face limits of compatibility of the technical components? At this stage, a constraint is to provide virtual-reality tools and teachers-friendly-environments which means tools that teacher may use by themselves for specifying their learning needs. A third step in the process of operationalization is to create a pedagogical scenario and to select a virtual reality environment. The main activity consists in operating the scenario on the chosen environment. At this step, the generation of a new VRLE or evolution of existing one based on teacher needs comes true. So, we aim at providing the operability of pedagogical scenario on any 3D environment. The fourth step of our process consists in the simulation and testing activities to adapt the selected VRLE. Finally, we proposed to analyze tracks recovered from the test phase in order to anticipate as much as possible the VRLE future adaptations and modifications. We illustrate the process we proposed in a case study. A professor of history wishes to time-travel with his students in an historic city to better explain actions to study. First of all, the teacher comes with an idea of a learning scenario and expresses and formalizes it via an editor. The system generates a structured and reusable scenario as a pattern. Then the professor of history selects an already existing 3D environment of such a historic city. The adaptation service is going to apply the necessary features to return the compatible environment and then it sends it to the service of integration. The latter is going to instantiate the scenario on the chosen environment and generates the new VRLEs.

CONCLUSION

In this article we presented the general context of our research work, as well as a state of the art of some works dealing with the educational design in the VRLE. We proposed a framework for describing a VLRE engineering process. Further to our reports, we aim at proposing to the teachers- designers a set of methodological and technical tools allowing them to design and operationalize their learning situations, without being constrained by the technical difficulties, which are related to the use of technology in a virtual reality environment. Our challenge is to facilitate the design of pedagogical scenarios and their deployment in virtual reality various environments by the teachers themselves. In such way, teachers may offer pedagogical situation well suited to learners.

REFERENCES

[1] C. Fowler, "Virtual Reality and Learning: Where Is the Pedagogy?", *British Journal of Educational Technology,* vol. 46, no. 2, pp. 412-422, 2015.

[2] J. Martín-Gutiérrez, C. Efrén Mora, B. Añorbe-Díaz and A. González-Marrero, "Virtual Technologies Trends in Education", *Eurasia Journal of Mathematics, Science and Technology Education,* vol. 13, no. 2, pp. 469-486, 2017.

[3] N. Marion, R. Querrec and P. Chevaillier, "Integrating Knowledge from Virtual Reality Environments to Learning Scenario Models-A Meta-modeling Approach", Int. Conf. on Computer Supported Education, 2009.

[4] K. Carpentier and D. Lourdeaux, "Generation of Learning Situations According to the Learner's Profile Within a Virtual Environment", Int. Conf on Agents and Artificial Intelligence, pp. 245-260, 2014.

[5] L. Oubahssi and C. Piau-Toffolon, "Virtual learning environment design in the context of orientation skills acquisition for ulis class", *Int. Conf. on Computer Supported Education*, Funchal, Madeira, Portugal, pp. 47-58, 2018.

[6] P. Mishra and M. Koehler, "Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge*",* vol. 108, Teachers College REcord, pp. 1017-1054, 2006.

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

[8] P. Goodyear, "Teaching as design", *HERDSA Review of Higher Education,* pp. 27-50, 2015.

[9] Y. Mor, "Embedding design patterns in a methodology for a design science of e-Learning", *Christian Kohls & Joachim Wedekind, ed., "Problems Investigations of E-Learning Patterns: Context Factors Solutions",* 2010.

[10] T.-H. Trinh, R. Querrec, P. De Loor and P. Chevaillier, "Ensuring semantic spatial constraints in virtual environments using UML/OCL", pp. 219-226, 2010.

[11] C. J. Chen, S. C. Toh and W. M. Fauzy, "The Theoretical Framework for Designing Desktop Virtual Reality-Based Learning Environments", *JILR,* vol. 15, pp. 147-167, 2004.

[12] C. J. Chen and C. S. Teh, "Enhancing an Instructional Design Model for Virtual Reality-Based Learning", *Australasian Journal of Educational Technology, Vol. 29, n°5,* 2013.

[13] L. T. Ritz, "Teaching with CAVE virtual reality systems: Instructional design strategies that promote adequate cognitive load for learners", SMTC Plan B Papers. 5, 2015.

[14] K. Sehaba and A. M. Hussaan, "Adaptive serious game for the re-education of cognitive disorders", *AMSE Journals, Advances in modeling, series Modelling C,* vol. 3, no. 73, pp. 148-159, 2013.

[15] M. Fahim, A. Jakimi and L. El Bermi, "Pedagogical Scenarization for Virtual Environments for Training: Towards Genericity, Coherence and Adaptivity", *IJAERS,* vol. 3, no. 12, pp. 96-103, 2016.

[16] F. Le Corre, C. Hoareau, F. Ganier, C. Buche and R. Querrec, "A Pedagogical Scenario Language for Virtual Environment for Learning based on UML Meta-model. Application to Blood Analysis Instrument", in *Proc. of the 6th Int. Conf. on Computer Supported Education*, pp 301-308, 2014.

[17] C. Buche, C. Bossard, R. Querrec and P. Chevaillier, "PEGASE: A generic and adaptable intelligent system for virtual reality learning environments", *Int. Jal of Virtual Reality,* vol. 9, no. 2, pp. 73-85, 2010.

[18] V. Lanquepin, K. Carpentier, D. Lourdeaux, M. Lhommet, C. Barot and K. Amokrane, "HUMANS: a HUman Models based Artificial eNvironments software platform", in *VRIC*, Laval, France, 2013.

[19] S. Gerbaud, N. Mollet, F. Ganier, B. Arnaldi and J. Tisseau, "GVT: a platform to create virtual environments for procedural training" in *Virtual Reality Conference*, Reno, NE, USA, pp. 225-232, 2008.

[20] E. Tan and K. D. Könings, "Teachers as participatory designers: two case studies with Technology-Enhanced Environments", *Instructional Science,* vol. 43, no. 2, pp. 203-228, March 2015.