Virtual Reality in Self-regulated Learning: Example in Art Domain

Jean-Christophe Sakdavong, Morgane Burgues and Nathalie Huet
CLLE-LTC CNRS UMR 5263, Université Toulouse 2 Jean Jaurès, 5 allée Antonio Machado, Toulouse, France

Keywords: Self-regulated Learning, Self-regulation, Motivation, Immersion, Control.

Abstract: In recent decades, learning devices using virtual reality (VR) environments have evolved rapidly. The potential positive impact of VR has been attributed to two characteristics: immersion, and control of interaction with objects in the environment. However, results from the literature have not always shown the presumed benefits and few of them have assessed the effects on self-regulation. This study aims to assess the impact of immersion and control on motivation, self-regulation, and performance. Participants had to acquire knowledge about sculptures by visiting a 3D virtual museum and then recall this knowledge. The participants were divided into four independent groups. They were: #1 In strong immersion (with VR headset) and active (control of interaction); #2 In strong (VR) and passive (non-interaction control) conditions; #3 In low immersion (tablet) and active conditions; #4 In low and passive immersion conditions. Intrinsic motivation and emotion were evaluated by a questionnaire, self-regulation was identified by behavioral indicators and performance was evaluated through a gap-fill exercise. Results showed that the "control" feature had a positive impact on performance, unlike immersion. Also, neither immersion nor control had an impact on motivation. However, immersion and control had a partial impact on self regulation. Educational implications will be discussed.

1 INTRODUCTION

Following the publication of the 2016 Charter for Cultural Education in Avignon (France), we decided to join this initiative, which aims to make artistic and cultural education accessible to all at school, college and university. In this context, this study focuses on the learning of artistic knowledge during virtual museum visits. In recent decades, learning devices have evolved rapidly through new technologies and are increasingly used in training sessions and in museums. However, learning is a complex process, supported by intrinsic motivation (Black Deci, 2000), influenced by emotions (Gendron, 2010) and requiring learners to use self-regulation strategies (Pintrich, 2000). Using new technologies such as Virtual Reality (VR) simulation environments may help students to learn, about art knowledge for example. The potential positive impact of VR in learning has been attributed to two characteristics: immersion and control of interaction with objects in the environment (Muhanna, 2015). It has been attested that a VR display is more immersive than a conventional display and computer (Mikropoulos Natsis, 2011). However, results from researches have revealed that performance was not systematically higher with the use of VR during a learning phase (Negut et al., 2016). Some authors have found higher performance in VR than via a lecture-based curriculum (Dubovi et al., 2017). The lack of consensus in the results could be due to the degree of control (active vs. passive) allowed by the immersion device. Control is characterized by the existence or lack of possible interaction on the virtual environment. Participants who can interact with the environment, such as by selecting or manipulating objects, are considered as having an active control. Conversely, participants who cannot interact with their environment are considered to have a passive control of their learning. It is recognized in the literature that being active in learning can improve performance (Hake, 1998). The interest of these new technologies is that they enable participants to be more active in their learning by offering them an interactive virtual environment.

Twenty years ago, results showed that in VR environments, an active control immersion was not always related to a higher performance than that with a passive immersion (Brooks, 1999). Now recent papers, with the improvement on VR technology,

Sakdavong, J., Burgues, M. and Huet, N.
Virtual Reality in Self-regulated Learning: Example in Art Domain.
DOI: 10.5220/0007718500790087
In *Proceedings of the 11th International Conference on Computer Supported Education (CSEDU 2019)*, pages 79-87
ISBN: 978-989-758-367-4

have revealed a positive effect of active immersion on learning performance (Jang et al., 2017).

By referring to the literature (Deci and Ryan, 2000), we expected that the impact of immersion and control on learning could be explained by an increase in intrinsic motivation, which is positively related to learning. Firstly, concerning the impact of the degree of immersion on motivation, VR is recognized as impacting motivation positively (Limniou et al., 2008., Visch et al., 2010). According to the literature (Dalgarno and Lee, 2010), 3D virtual learning environments, such as VR, increased motivation and user engagement in comparison with traditional 2D learning environments. However, no research has yet been done specifically on the impact of a high degree of immersion on the intrinsic motivation. According to the literature, we expected that immersion would have a positive impact on intrinsic motivation. Finally, the literature (Deci et al., 1981) showed that people with an active control of their learning have a greater intrinsic motivation than those who have a passive control of their environment. Referring to that, we expected that learners who have a high active control of the objects in a virtual environment would have a higher control of their learning. We expected that high control conditions would predict a higher intrinsic motivation than for those who have a low control of the objects in the environment.

Learning is also impacted by self-regulation (Pintrich, 2000), which is an active and conscious process, allowing the construction of knowledge. As we have not found any study on the effect of active immersion on self-regulation, we think it is an important field to investigate. Finally, we hypothesize, by referring to learning literature (Bransford et al., 2000) that a high immersive and high control condition promotes learning performance and self-regulation. This study aims to assess the impact of our independent variables, immersion and control on our dependant variables: motivation, self-regulation, and performance.

2 METHOD

2.1 Participants

Sixty-one students, without any art courses (thirty-six females and twenty-five males, average age = 22.66, SD = 3.80), were recruited on the campus of the University of Toulouse II Jean Jaures, and the University of Toulouse III Paul Sabatier. Participants performed the assignment alone, without a classmate and accompanied only by the experimenter. The lack of knowledge of art especially of the three target sculptures used later was checked. All of the students were completely unfamiliar with art.

2.2 Materials and Groups

Participants had to acquire new art knowledge in a 3D virtual museum visit. The digital environment was specifically designed for the experimentation (c.f. Figure 1, 2 and 3). The museum contains four sculptures by Michelangelo to study: “David”, “Moses”, “Pietà” and “Dying Slave”. The learning was evaluated for the three last sculpture, while “David” was used for a familiarization task.

The learning task was a free pace of knowledge related to the three sculptures. Participants had thirty minutes to acquire knowledge of the three sculptures and they use their time freely without constraint. This was followed by a memory task in the form of a gap-fill exercise. The task consisted in memorizing knowledge on each virtual sculpture after hearing spoken information.

Participants were randomly assigned to one of four independent groups. The difference between the groups were the level of immersion and control.

Group #1 was a high immersion and active group (N=15), its participants had a VR headset and a pointer remote. They could move around the sculpture and could obtain information by selecting a part of the sculpture using the remote. Group #2 was a high immersion and passive group (N=15), they had the same VR headset and remote. The perspective moved automatically around the sculpture, they did not have to move around the sculpture and they did not have to select any part of it to get information, they only click on a panel to get information.

Group #3 and #4 were in low immersion, using an Android tablet instead of a VR headset and their finger touch instead of the pointer remote.

They had the same 3D virtual environment. Group #3, was a low immersion and passive group (N=16) and group #4, a low immersion and active group (N=15).

The VR headsets were Google Daydream mobile headsets having 3 degrees of freedom (3 DoF) with a 3 degrees of freedom pointer remote. The Tablets were Android HP Pro Slate 12' displaying the 3D scenes over the 2D screen and using gyrometer and magnetometer to see around (3 DoF as with the VR headset).

Figure 1: Virtual environment "Moses".

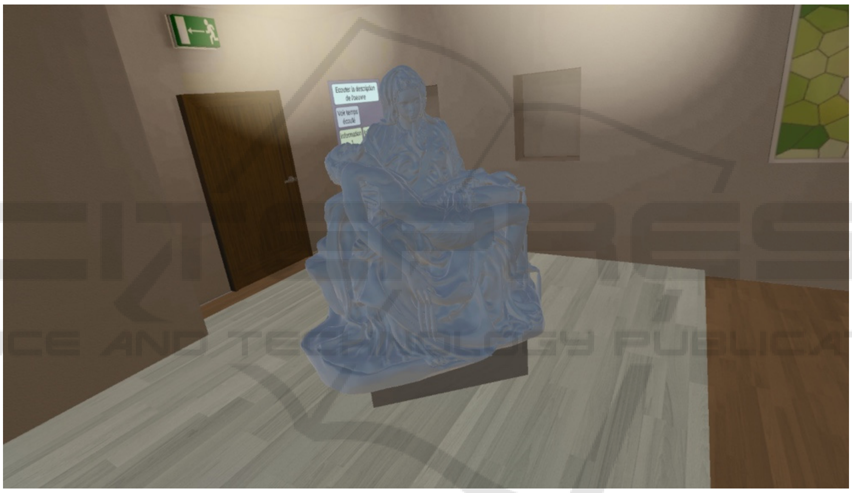

Figure 2: Virtual environment "Pieta".

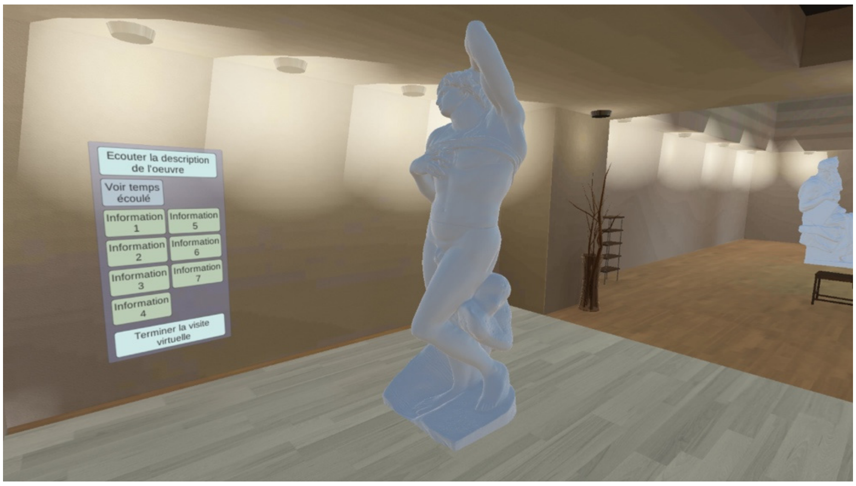

Figure 3: Virtual environment "Dying slave".

2.2.1 Familiarization

The familiarization period (identical to the test) consists in the discovery of one sculpture, the “David” by Michelangelo.

This familiarization was intended to train the participant, during ten minutes, to use the material and its resources. This familiarization period is specific to each group (tablets or virtual, passive or active), but they had the same time and the same knowledge to acquire, according to the conditions. During the familiarization phase and for all conditions, the participants discovered that the museum visit consisted of two activities: visually observing the sculpture, and hearing information on the artwork. They could listen two types of information, a global presentation of the sculptures and specific information on specific areas of the artwork. After the familiarization visit, participants had to do a familiarization test, to have a clear idea and to know what they would be asked to do for the actual test. This familiarization test consisted of completing a gap-fill exercise for sculpture learning before the actual test. It was specified to the participants that the exercise on the familiarization sculpture would not be evaluated, but that the test with the other three sculptures would be.

2.2.2 The Test

The test consisted of the same steps as the familiarization period, the visit of three sculptures, then the completion of a gap-fill exercise.

During the visit, the participants had to listen to general information about each sculpture, and also to specific information about details of it (e.g. information 1 = The legs of the “Moses”, c.f Figure 1). However, the final performance of participants was evaluated, using the same fill-gap exercises for each participant.

The sentences for the gap-fill exercises were picked from the general information and from the detailed information that they could listen during the visit. For each of the three sculptures, four gap-fill exercises were proposed, each with three holes to be completed by finding the missing words. (e.g : The weight of the statue rests on a single [leg] and therefore on a foot in majority. With time the [microcracks] appear on this foot and go up in the leg, which puts [statue] in danger; [fill-gap to complete])

This made to a total of 12 words to be found per sculpture, 36 for the 3 sculptures. When the answers were correct they scored 1 point score, when there was no answer or a mistaken one, they got a 0 point score, the highest score was 12 points per work and 36 points in total.

2.2.3 Measure of Self-regulation

To measure self-regulation, two behavioral indicators were selected in reference to the Pintrich model, 2000. These indicators are operationalised through the use of control panel by participants (figure 2).

- Time planning, also called “time management” in the litterature, is operationalised by the number of clicks on the clock that displays the time elapsed during their visit (Bouffard-Bouchard and Pinard, 1988)).

- The metacognition indicator (Pintrich, 2000) is operationalised by the number of times information heard and replayed (for both general and specific information).

Each participant's behaviours are recorded and compiled in the form of traces on a trace server by the application. Thus, by analysing these traces, each behaviour is count, as the time consulting or the number of information and coded "1". Through this behavior, good self-regulator is learner who consult regularly the time they have left according to Bouffard-Bouchard and Pinard (1988). It allows them to manage their learning by choosing, for example, to allocate their time to one information rather than another according to their estimated degree of memorization.

2.2.4 Measure of Intrinsic Motivation

To measure the motivation, especially the intrinsic motivation, wich is positively related to performance (Black and Deci, 2000), we used the questionnaire from (Deci et al., 1994). It is an adapted French version of the questionnaire built following the Vallerand procedure (Vallerand, 1989). This questionnaire is completed by the participants after completing the task of learning information about the three sculptures

It contains 17 items divided into four subcategories: interest, perception of competence, pressure, perception of choice (for example, an item for the dimension of interest: While I was visiting the museum, I realized how much fun I was having.). Participants had to indicate their degree of agreement with the items on a 7-point Likert scale, ranging from "1: Absolutely wrong for me" to "7: quite true for me". The higher score a participant got in one of the dimensions, the more it showed that they were in agreement with it. For example, if a participant had a high score on the perceived competence it indicated that they felt competent.

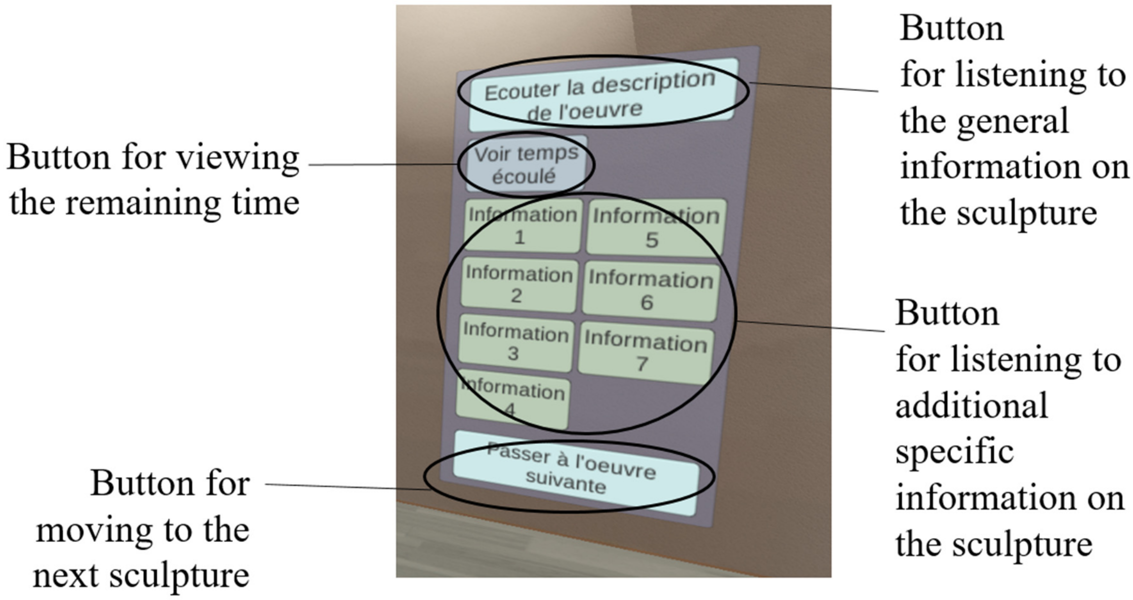

Figure 4: Control panel.

Similarly, if an individual had a high score in the "pressure" dimension it meant that they felt under pressure.

2.2.5 Emotional Perception

Because emotional perception may vary according to the work of art and may influence learning (Tan, 2000), we checked the potential difference between the sculptures by assessing the participant's emotional perception of each work of art. There was only one item per sculpture. Participants were invited to indicate their degree of emotion perceived when reacting to each sculpture on a 5-point Likert scale, ranging from 1: no emotion perceived to 5 strong emotion perceived.

The higher the score in one of the sculptures was, the more it showed that the individual experienced a strong emotion.

2.3 Procedure

The first two phases of the study were identical for all participants. The first phase included the general instructions, the consent request. It also measured the level of knowledge of the participants before any learning and in addition, the individual's emotional perception of each sculpture was assessed.

The second phase was to familiarize participants with the materials according to the condition to which they were randomly assigned, VR or tablets, active or passive control. The familiarization also enable them to become familiar with the gap-fill test, which was the same for everyone, no matter the condition.

In the third phase, called learning, they visited the museum with three sculptures and heard spoken information for each sculpture. Then, demographic variables were assessed by a questionnaire followed by the intrinsic motivation questionnaire. Completing those questionnaires could also be considered as an interferent task before the recall gap-fill task.

At the end of the experiment, all participants responded to the three gap-fill exercises successively by filling the blanks, to measure learning performance.

3 RESULTS

3.1 Emotional Perception

Results from the one way analysis of variance (ANOVA) with the sculptures as repeated measures showed that the three sculptures were not equally emotionally perceived, $F(2,120) = 27.23$; $p < .001$.

The "Pieta" sculpture, was significantly perceived as arousing the most emotion ($M= 3.11$; $SD = .90$). The other two ones did not arouse a strong emotion, both were equal ($M=2.34$; $SD = .90$ for the "Moses" sculpture; and M= 2,34; SD = . 96 for the "Dying slave").

For the rest of the study, we will use the sculptures as a repeated measure because of this difference in emotional perception.

3.2 Performance

A three-way ANOVA with Immersion and Control as independent factors and the sculpture as the repeated measure was computed. Results showed a significant effect of the control condition, F (1, 57) = 8.32; p = 0.006, η2p = 0.13.

Participants in active conditions significantly outperformed (M = 5.69, SD = 0.37) those in the passive conditions (M = 4.18, SD = 0.37).

No relationship was found between immersion and performance, F(1, 57) = 0.22 ; p = 0.64.

A significant effect of the sculpture, F (1,57) = 6.46; p = 0.014, η2p = 0.10 was found. The “Pieta” was significantly more successful in terms of performance (M = 6.08, SD = 2.81) than the “Moses” (M = 4.79, SD = 2.60) and the “Dying slave” (M = 3.90, SD = 2.89).

Finally, no interaction between sculpture and control was found, F (1,57) = 0.93; p = 0.76, η2p = 0.02 and no interaction between immersion and sculpture, F(1,57) = 1.97, p = 0.17, η2p == 0.03.

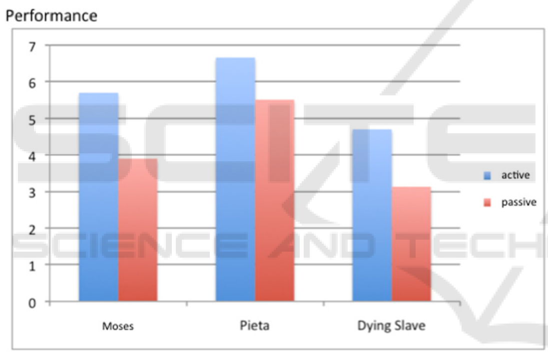

Figure 5: Performance per sculpture according to the control condition.

3.3 Self-regulation

Two indicators were used to measure self-regulation, (1): the frequency with which individuals consulted the time remaining; (2): the number of times information was listened or re-listened.

Results for the number of time consultations revealed a significant effect of immersion, F(1,57) = 23,766, p <.001, η2p = .294, and a significant effect of control, F(1.57) = 4.678, p = .048, η2p = .067. No interaction effects were revealed, F (1,57) = 304, p = .584, η2p = .005. Thus, participants in a high-immersion condition consulted on average more time (M = 7.96, SD = .80) than participants with low immersion (M = 2.40, SD = .81). Similarly, active individuals consulted on average over their remaining time (M = 6.33, SD = .81) more than passive individuals (M = 4.03, SD = .80). We did not record the number of time consultation per sculpture, preventing us from performing analyzes for each one of them.

Results for the number of listened and re-listened information (general and specific) revealed no immersion effect, F (1,57) = 0.09; p = 0.77, η2p = .002, no control effect, F (1,57) = 0.44; p = 0.51, η2p = .008, and no interaction effect, F (1.57) = 3.17; p = 0.08, η2p= 0.05. The number of listened and re-listened information did not show any significant difference according to the sculpture, F (1,57) = 1.28., p = 0.26, η2p= 0.02.

Only the indicator of Self-regulation “listening and re-listening” was positively related to performance, r=.434, p<.001. Moreover, performance related to the “Pieta” sculpture was positively correlated with the number of times participants listened and re-listened, r = 0.26; p = 0.04. Performance related to the “Dying slave” sculpture was also positively correlated to the number of times participants listened and re-listened, r = 0.66; p = 0.004. In contrast, no significant correlation was found between these variables for the “Moses” sculpture.

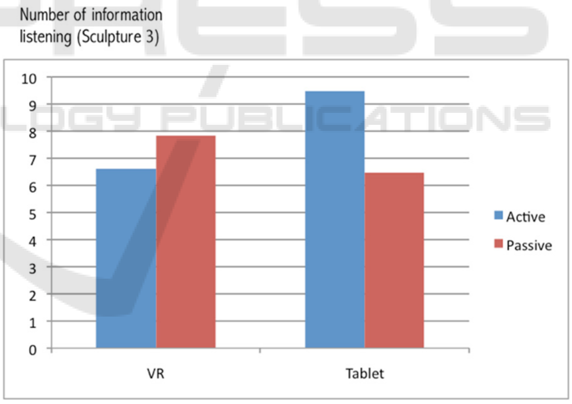

Figure 6: Interaction effect of control and immersion on the number of times information was listened and re-listened (general and specific) on the third sculpture.

3.4 Intrinsic Motivation

Anova revealed no effect of immersion, F (1, 57) = .305; p = .583, η2p = .005, no control effect, F (1,57) = .168; p = .683, η2p = .003 and no interaction effect between immersion and control on intrinsic motivation, F (1,57) = .118; p = .732, η2p = .002.

No effect of immersion, control and interaction was found on every sub-dimension of intrinsic motivation. More precisely, no immersion effect was revealed for dimension 1 of interest, F (1,57) = .062, p = .805, η2p = .001, no control effect, F (1,57) =. 306, p = .583, η2p = .005, and no interaction effect, F (1,57) = 255, p = .616,, η2p = .004. For dimension 2, perceived competence, no effect of immersion was found, F (1,57) = .002, p = .967, η2p = .000, of control, F (1,57) = .175, p = .677, η2p = .003, or interaction, F (1,57) = 53, p = .819,, η2p = .001. For dimension 3, perceived choice, the results did not show any effect of immersion, F (1,57) = 1,042, p = 312, η2p = .018, of control effect, F (1,57) =. 450, p = .505, η2p = .008, or of interaction effect, F (1,57) = 361, p = 550, η2p = .006. Finally, the Anova on the dimension 4, pressure, revealed no effect of immersion, F (1,57) = .188, p = .667, η2p = .003, and no effect of control, F (1.57) = 1.420, p = .238, η2p = .024. No significant effect was revealed for interaction, F (1,57) = 3,463, p = .68, η2p = .057.

Furthermore, only the sub-dimension 2, perceived skills, was positively related to performance, r=.35, p<.05. The global score on the intrinsic motivation scale was not related to performance, and the three other sub dimensions were not related to performance.

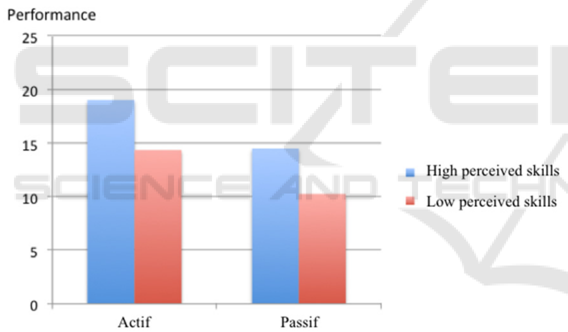

Figure 7: Performance rates by control condition and perceived skills, sub-dimension 2 on motivation scale.

4 CONCLUSION

The aim of this study was to determine the impact of immersion and control on performance, motivation, and self-regulation.

In accordance to our hypothesis and the literature, it appears that learners improved their learning performance when they were active. Giving the possibility of controlling the actions during task allows individuals to be more involved and to use behavioural self-regulation strategies (Bruner, 1957) that are conducive to learning. Indeed, the behavioural strategies of self-regulation "listening and re-listening" are related to learning, in accordance to our hypothesis.

It also appears that the different sculptures did not bring the same perception of emotions. These results brought us to test our hypothesis on all the sculptures and on each sculpture independently. Consequently we believe that further research should be undertaken to investigate more thoroughly the impact of emotions on learning and the impact of immersion and control, using new technological tools for studying emotions (Pan et al, 2006).

However, contrary to our expectations, immersion did not have an impact on performance and had no effect on listening to information. We also found no relation between immersion, control and intrinsic motivation and no relation between intrinsic motivation and performance.

For a better understanding of these results it might be relevant to consider the theory of cognitive load (Sweller, 1988). This theory assumes that the load is limited and must be distributed. However, it is possible that the resources mobilized to learn how to use the tool and how to deal with the gap-fill exercise memory task were excessive. Thus, there was not enough essential load available to be effective whatever the conditions. Participants without any knowledge of art had to manage their learning about art and their learning of new tools. In this perspective, a scale of perception of the mental effort was filled by our participants. The results revealed a significant perceived effort in using the functionality of the tool, whether in high immersion with VR (M = 5.61, SD = 1.63, Min: 1, Max: 9) or low immersion with tablet, (M = 6.37, SD = 1.73, Min: 1, Max: 9). There were no significant differences in perception of the effort between the two conditions of immersion, t (59) = -1.75, p = .085. The extrinsic load of the task was too important, no matter the condition, thus impeding learning because it reduced the resources available for the essential load. For future studies, the reminder task could be simpler, in the form of a multiple-choice questionnaire for example, to limit the intrinsic load. The familiarization phase could be longer to reduce the extrinsic load. It could also be to reduce the number of information to be recalled, making the visit only for a single work of art.

This cognitive overload could also have caused a competition between the metacognitive activity and the learning cognitive activity, thus preventing an appropriate self-regulation behaviour, such as time management, planning. Furthermore, according to (Kirschner et al., 2006), a self-exploration task, in active condition, can lead to too much workload and thus hinder the very activity of learning.

Furthermore, our study was limited to a recall task; that is the knowledge that needed to be acquired was on the lowest level of Bloom's taxonomy (Anderson et al, 2001); it does not test understanding.

Furthermore, the lack of results for intrinsic motivation may be due to the fact that our protocol induces extrinsic and not intrinsic motivation in participants because of the attractiveness of testing new technologies rather than of the task of learning about art. Only one dimension of intrinsic motivation provides a good prediction of performance: the perceived competence. This may be linked to the Self Efficiency Belief of (Bandura, 1986), which is also a predictor of performance in this theory. To conclude, we can recommend that learners not be overload, which can be done by limiting the amount of information to be learned and adjusting the recall phase.

In conclusion, it appears that learners improve their learning performance when they are active. Having control over the task allows participants to be more involved and to implement behavioral self-regulation strategies that are conducive to learning. However, contrary to our expectations, immersion affect neither performance nor listening to information. It should be noted that studies of the impact of immersion on learning and motivation are still in their beginning, which explains the number of contradictory results on this subject. Similarly, no researches has previously been done on the impact of immersion in VR on self-regulation, hence the interest of pursuing research on this topic.

Thus, the virtual learning environment design will have to take into account a set of factors that have an impact on performance. New technologies, when used without taking these factors into account can lose their educational value.

ACKNOWLEDGMENT

This study was supported by the research project LETACOP founded by the ANR (National Research Agency) – ANR-14-CE24-0032.

The virtual reality development was conducted by the AD2RV association.

REFERENCES

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Wittrock, M. C. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives, abridged edition. White Plains*, NY: Longman.

Bandura, A. (1986). Social foundations of thought and action. *Englewood Cliffs, NJ, 1986*.

Black, A. E., Deci, E. L., 2000. The effects of student self-regulation and instructor autonomy support on learning in a college-level natural science course: A self-determination theory perspective. *Science Education*, 84.

Bouffard-Bouchard, T., Pinard, A. (1988). Sentiment d'auto-efficacité et exercice des processus d'auto-régulation chez les étudiants de niveau collégial. *International Journal of Psychology*, *23*(1-6), 409-431.

Bransford, J., Brown, A., Cocking, R., 2000. How people learn: Brain, mind, experience and school. Washington, DC: *Commission on Behavioral and Social Sciences and Education*, National Research Council.

Brooks, B. M., 1999. The specificity of memory enhancement during interaction with a virtual environment. *Memory*, 7.

Bruner, J. S., 1957. *Going beyond the information given. Contemporary approaches to cognition*, 1(1).

Dalgarno, B., Lee, M. J., 2010. What are the learning affordances of 3-D virtual environments?. *British Journal of Educational Technology*, 41(1).

Deci, E. L., Eghrari, H., Patrick, B. C., Leone, D., 1994. Facilitating internalization: The self-determination theory perspective. *Journal of Personality*, 62.

Deci, E. L., Nezlek, J., Sheinman, L., 1981. Characteristics of the rewarder and intrinsic motivation of the rewardee. *Journal of personality and social psychology*, 40(1).

Deci, E. L., Ryan, R. M. (2000). The 'what' and 'why' of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11,* 227–268.

Dubovi, I., Levy, S.T., Dagan, E., 2017. Now I know how! The learning process of medication administration among nursing students with non-immersive desktop virtual reality simulation. *Computers Education*, 113.

Gendron, B., 2010. Capital émotionnel, cognition, performance et santé: quels liens ? In Du percept à la décision: Intégration de la cognition, l'émotion et la motivation. Louvain-la-Neuve, Belgique : De *Boeck Supérieur*. Doi : 10.3917/dbu.masmo.2010.01.0329.

Hake, R. R., 1998. Interactive-engagement versus traditional methods: A six-thousand student survey of mechanics test data for introductory physics courses. *American journal of Physics*, 66(1).

Jang, S., Vitale, J. M., Jyung, R. W., Black, J. B., 2017. Direct manipulation is better than passive viewing for learning anatomy in a three-dimensional virtual reality environment. *Computers Education*, 106.

Kirschner, P. A., Sweller, J., Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*, 75-86.

Limniou, M., Roberts, D., Papadopoulos, N., 2008. Full immersive virtual environment CAVE in chemistry education. *Computers Education*, 51(2).

Mikropoulos, T. A., Natsis, A., 2011. Educational virtual environments: A ten-year review of empirical research (1999–2009). *Computers Education*, 56(3).

Muhanna A., 2015. Virtual reality and the CAVE: Taxonomy, interaction challenges and research directions. Journal of King Saud University, *Computer and Information Sciences*, 27.

Negut, A., S-A., Matu., F.Alin Sava., David, D., 2016. Task difficulty of virtual reality-based assessment tools compared to classical paper-and-pencil or computerized measures : A meta-analytic approach. *Computers in Human Behavior*, 54.

Pan, Z., Cheok, A. D., Yang, H., Zhu, J. Jiaoying Shi, J., 2006. Virtual reality and mixed reality for virtual learning environments. *Computers Graphics*, 30. Doi:10.1016/j.cag.2005.10.004

Pintrich, P., 2000. The role of goal orientation in self-regulated learning. *Handbook of self regulation*. San Diego, CA, US: Academic Press.

Tan, E. S., 2000. Emotion, art, and the humanities. In M. Lewis J. M. Haviland-Jones (Eds.), *Handbook of emotions. 2nd edition*. New York: Guilford Press.

Vallerand, R. J. (1989). Vers une méthodologie de validation trans-culturelle de questionnaires psychologiques: Implications pour la recherche en langue française. *Canadian Psychology/Psychologie Canadienne*, *30*(4), 662.

Visch, V. T., Tan, E.S. Molenaar, D., 2010. The emotional and cognitive effect of immersion in film viewing, *Cognition and Emotion*, 24(8)., Doi:10.1080/026999 30903498186

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive science*, *12*(2), 257-285.