Effects of virtual reality in the area of responsible decision-making training on adolescents

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Abstract. The number of emotional illnesses rises every year. The efforts of using HCI and VR technology to create prevention tools require to extend the design learning knowledge to provide appropriate emotional cognitive experiences. Research has shown that VR provides better engagement and improvement on basic emotional and social dimensions of learning, however, the literature shows that it is necessary for the continuous study to develop effective emotional learning experience addressed to the next generations on immersive virtual learning environment. This study aims to identify how VR experiences impact the learning of a specific emotional dimension on adolescents (responsible decision-making RDM) and identify which cognitive and experience elements have incidence in the design of the learning experience. Based on literature and theories of VR and learning sciences, we experimented using VR on learning sessions with a control group based in ethical and emotional situations using the SODAS method to learn responsible decision making. Results show that the VR group gets a higher score after the sessions, and qualitative and quantitative data reveals that learning timing, cognitive articulation, learning attribution, cognitive load, and specific emotional dimensions might be impacted by the emotional learning experience. The analyses provide helpful information for the further design of cognitive experiences on VR technology.

Keywords: Virtual Reality, Cognitive experience, Interaction design.

1 Introduction

Virtual reality technology (VR) has been the focus of many research disciplines that are trying to develop knowledge, analyze potential experiences, understand the effects of this technology in different fields and provide guidelines [1] for potential experiences or innovations.

While the number of emotional mental illnesses registered by year is rising, we see an educational opportunity to help the society, to address this, we look at the interaction design field and HCI technologies, to develop emotional and social prevention tools, using virtual immersive technology.

The efforts of immersive technology in mental health are numerous and in the latest years, a variety of experiments have been conducted with the purpose to understand the effects of VR technology on different emotional dimensions [2] and mental health subjects.

VR has been applied to the treatment of emotional illnesses such as anxiety, depression, stress, and cognitive rehabilitation [2]. In the social dimension, there are also experiments on behavior change and in social skills training, most of them [2] applying virtual reality exposure treatments (VRET) and some of them [3] mixing with cognitive-behavioral therapy.

This latest knowledge is settling the bases of VR technology's impact on social and emotional factors. However, a significant part of the efforts is focused on developing further palliative tools rather than proposing prevention and educational tools for mental health.

At the same time, educational VR products are in the market and emerging research is developing support, however, we observe a shortage of knowledge of VR on the design of complex cognitive experience, such as emotional education. We see that the development of IVLE's (Immersive virtual learning environment) requires to extend the knowledge production from a learning design experience side.

This study wants to extend the current knowledge from our literature review, getting the impact of the VR technology on adolescents on the responsible decision making emotional dimension of SEL, measuring learning and improvement in a mix of quantitative and qualitative data, identify cognitive and influencer factors on VR learning experience and providing knowledge-based considerations for design general and emotional learning experiences on an immersive virtual environment.

The results of this study will benefit in future design of products or services and on the research of cognitive processes on virtual learning experiences, considering factors for educational instances and helping also in the design of social and emotional training on VR platforms.

2 Literature Review

2.1 Emotional Learning

Emotional Intelligence literature [4, 5], establish a gradual development of emotional cognitive development from perception and recognition to understanding and regulation, while some literature [6] also establish that recognition and awareness of self and others is a basic emotional ability, some authors [7] complement the idea declaring that after the absorption of feelings, thoughts, and behavior will be an open space to complex emotional competences. At the same time, there are some publications [8] which declare that on emotional learning experiences it is easy to get raw knowledge about emotions but developing EI (emotional intelligence) requires deeper planned training.

A relevant perspective of emotional education is from CASEL (collaborative for academic social and emotional learning) Framework. which divides emotional learning into 5 dimensions most of them require a diversity of cognitive articulation [9] and the learning of other basic emotions.

2.2 VR, learning & social cognition

On the other hand, the immersive virtual learning environment (IVLE) creates high levels of engagement and motivation for educational experiences. Literature shows that VR can improve performance against traditional lecture dynamics. Research in the field [10] define socials and spatial discussions for virtual classrooms as an IVLE, several experiments [11, 12] declares a high knowledge absorption in virtual instruction learning experiences, and some of them connect the learning experiences with emotions on VLE, where students showed positive emotional dimensions during the performance. On the social dimension, research [3] got positive results on affective recognition but also in social attribution connecting emotional and social dimension with VR- SCT (social cognitive training) on students with high functioning autism ASD (Asperger spectrum disorder) and TOM (theory of mind).

2.3 Emotional learning self-regulation and adaptation

While some studies are focused on basic emotion recognition, there are experiments on emotional adaptation and self-regulation. There is some particular experiment [13] that uses frustration game training through VR and biofeedback as a way to help participants on emotional regulation (ER) exercises. In a similar direction, spatial adaptation research [14] establishes a virtual affective architecture, using physical emotion recognition hardware to create emotional awareness and adaptation, using basic emotional concepts on adult participants. Research also discovered [15] the influence on the decision of VR on moral dilemmas and their reaction to different scenarios in adult participants.

The latest studies drive our concerns on learning virtual environments and the capabilities of VR technologies to teach beyond the basic emotional skills.

The literature of VR evidences a high number of emotional recognition and affection on experiments, however, we visualize a shortage of emotional interconnected skills revised by VR such as responsible decision making which requires the previous development of several basic emotional abilities such as empathy, ethical development, and the evaluation of consequences.

3 Hypothesis and Theoretical Background

This instance will be helpful to show how a particular educational method on VR, impacts the emotional cognitive process and provides information for further cognitive-emotional design on VR.

After literature, we understand that VR experiences have several capabilities to improve in emotional training however we want to see the effects in an interconnected emotional dimension.

Responsible decision making involves the development of different basic emotional skills. We believe that VR can simulate scenarios and create a trial environment and this could help in the learning experience of emotional cognitive processes. Particularly

we think that consequential components can help in the emotional dimension of responsible decision making.

3.1 Hypothesis

1. Students who experience emotional training on responsible decision making on VR will get higher scores than students who do not experience.

2. Creating a trial environment and showing the consequences of different decisions on VR will help in the emotional cognitive process of responsible decision making on adolescents.

The analysis of this will provide light on how is the cognitive experience and which factors of the design experience require attention.

3.2 Frameworks and Scales

To develop our study we decided to use the CASEL framework, as a multidimensional emotional tool, SEL is recognized in the educational environment with validated results on emotional education and provides clear learning for each emotional dimension.

From SEL the development of responsible decision making requires

- Considering the well-being of others
- Recognizing others, one's responsibility to behave ethically
- Base decisions on safety social and ethical considerations
- Evaluating the realistic consequences of various actions
- Making constructive, safe choices for self-relationships

Under this framework and in looking for a structure for our VR stories and the flow of our activities, we consider some educational findings [16] which says that most of the responsible decision making in class tools are based in similar rationales: set objectives, collecting information, generate options, evaluate and choose. In the same light, we find a consequential model called SODAS (situation, option disadvantages, advantages, solution) based on the identification of advantages and disadvantages which will help participants in the cognitive mapping process.

From Literature [9] we find different assessments and scales on the emotional dimension of responsible decision making on direct assessments SIP-AP (social information processing) [17] a computer-based assessment, TOPS (test of problem-solving) and SLDT (social language development test) [18]. On general assessment BAR ON Multi-factor[19], DESSA Deveraux Student Strengths Assessment [20], and SSIS-RS Social Skills Improvement System Rating scale [21].

A general assessment provides holistic reports of participants from different dimensions while direct assessment is more specific our criteria to choose was based like them in the case of SSIS was designed for third persons such as teachers or family express what they observe of the participant from an external perspective while BAR ON test Multifactor is a general emotional report which includes RDM but designed for the participant and not for external parts. In this case the decision to use this last to rely on the capability to create a general report which helps to see which emotional dimensions are changing in the assessment but also because they include RDM dimension with a combination of social and emotional design perspective.

4 Experiment

4.1 Participants

Around 30 volunteer students from 13 to 14 years old [22] were recruited in a public secondary school, which after a screening interview, 19 participants (4 female 15 male) matched the requirements and finished the sessions.

4.2 Procedures

Participants were separated into two groups; the control group (in the following CR) and the VR group (in the following VR). Both groups experienced ethical situations using the educational SODAS method (a situation, options, disadvantages, advantages, solution).

Our selection criteria for stories was matching the age and context of the students looking for common and realistic situations that they could be involved, and specific ethical dilemma which creates social and emotional consequences.

- Story 1 “Drop out school with friends”
- Story 2 “Best friend Stealing from store”
- Story 3 “Rumor of Cheating in a relationship ”

Fig. 1. VR ethical dilemmas developed for the sessions

In both groups, the situation and the options were given on the activity in the case of VR experienced on the immersive story through virtual doors which they have to

explore after watch the general situation. In the case of CR, we used a traditional method based on mental simulation and imagination exercises, during which the teacher read the stories to the students while they listened and tried to imagine the situation.

In both cases a worksheet was given to fill the SODAS activity and where the situation and the options where written so they can consult after anytime they need.

4.3 Structure of the sessions

The session was applied in a school and the two rooms are used for the sessions are belonging to the art and design department. We developed 5 sessions of around 45 minutes each in the following arrangement.

The first session was focused on a pre-test of responsible decision making (in the following pre-test) for this we used a general emotional assessment BAR ON Multi-factor, which gives multidimensional data of emotions of the participant. The test was computer-based and made by students individually.

Sessions 2, 3 & 4, were structured firstly giving general instructions for both groups, students did not receive the worksheet until the end of the experience of the story and the options of the situation, in the case of CR students, they have to hear the story from the mediator (teacher) and the options on it and in the case of VR they have to explore all the story and all the options and then both groups received the paper sheet of SODAS situations to identify advantages and disadvantages. After identifying advantages and disadvantages, on the worksheet, we asked participants to choose an option and then we asked why you choose this option? to see if they are willing to provide arguments and reasons for their choices

On every page, there are some questions to help students to do the metacognition process and to raise qualitative data that will be processed, the questions are "What did you learn today?", "Why that is Important for your life?". Every worksheet contains the story and the options of the session so they can back to read and consult whenever the students need it.

Session 5 was structured as a post-test a similar an arrangement using the BAR ON test but adding a survey after that about VR and the topic for the students who wanted to fill it, and is a personal appreciation about the VR elements which helps to learn responsible decision making.

4.4 Setting & Technical Considerations

The Platform used to develop the VR stories was Cospaces.edu, using a premium account, and a combination of video, audio, and interaction buttons was developed for the tasks. Each story contains neutral voice audio developed using Text to speech tools with the purpose to contextualize the situation and provide instructions to participants. Then participants have to explore the options and consequences using VR buttons provided in the scene and using the physical button of the VR headset.

The activity was developed simultaneously so the arrangement of the rooms was 9 students with 9 desks and chairs and a distance of 2 meters for embodied interaction. In the CR room, we have a similar arrangement with 10 participants.

For development, we used a VR Bobo z6 headset and for participants, 10 android mobile phones and 10 with Xiaomi VR play were used with corresponding earphones so there is no sound interference with each other.

The VR stories took for students around 5 to 10 minutes of exploration and the language of all the activities was English except for parents' documentation and surveys, a traditional Chinese version was developed.

5 Results

5.1 Improvement Responsible Decision Making

On the pre-test, we identify a difference between CR and VR, where CR group got higher values on the BAR ON test on the RDM dimension (Std dev CR 15.34, against VR 8.71).

In the post-test, we got positive results on the VR group almost all the students show a better score than the pre-test, (Std dev. from 8,71 to 11,44), (Average score. from 58.8 to 72.4). While CR group stay or decrease their score on the post-test (Std dev. from 15,3 to 17,2) (Average score from 63.5 to 58.2). The comparison of improvement shows a significant difference between the two groups (Std. dev CR 1,922 against VR 2,731) Fig. 2.

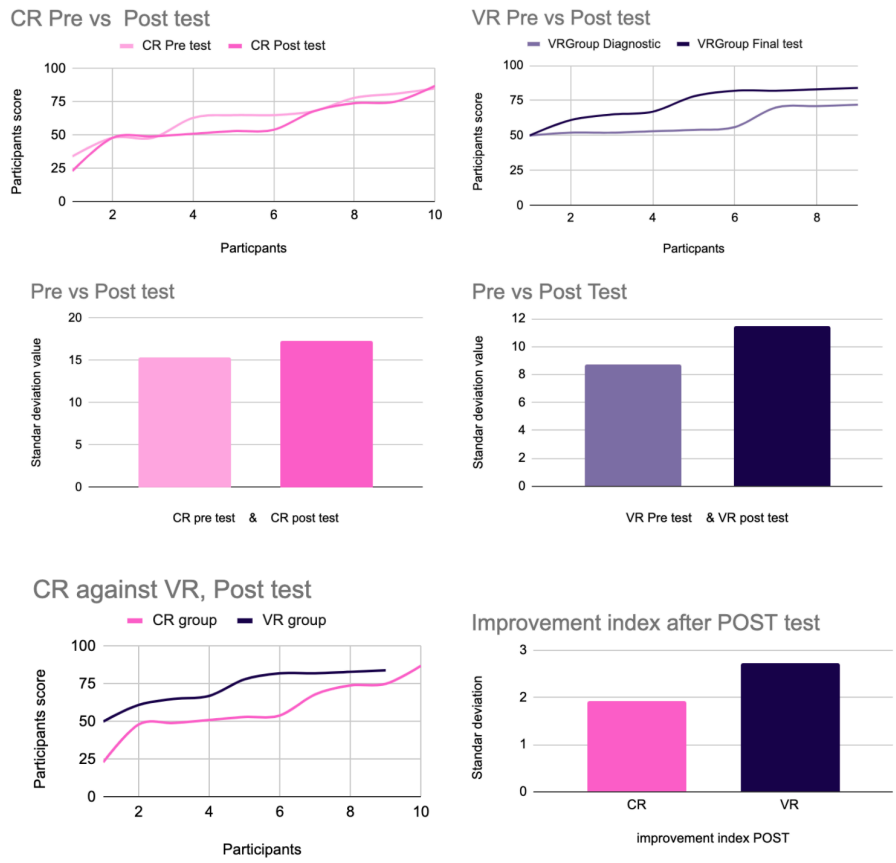

Fig. 2. CR against VR group pre and post-test and Improvement index and group comparison

To see if there is a correlation between attendance of the sessions and the result of the post-test we crossed the data of the post of each participant with the number of sessions that each of them did. CR (correlation -0,16) and VR (correlation -0,48)Fig 3, due to the lower values, there is not a clear correlation between the attendance to the sessions and the improvement showed by the participants on RDM in the post-test. The quantitative data shows for example that some participants attend 2 of 3 sessions and have a higher score and improvement than some participants which attend all the 3 sessions, so we didn't find a proportional relation from more sessions higher score of RDM on the post-test.

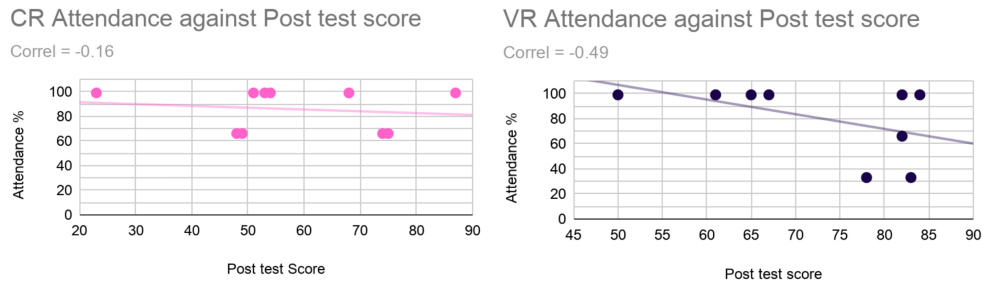

Fig. 3. Correlation between attendance and score in post test

Combination of qualitative and quantitative data show that each participant requires a different number of sessions to evidence a cognitive reflection about the emotional learning topic of RDM, while some students identify by themselves the goal of the activity and the expected learnings after one session, some students only rely on the story of the session without further analysis.

5.2 SODAS analysis

Students on CR (Mental Simulation) did a high cognitive articulation exercise identifying more advantages and disadvantages than the VR group (515 to 328).

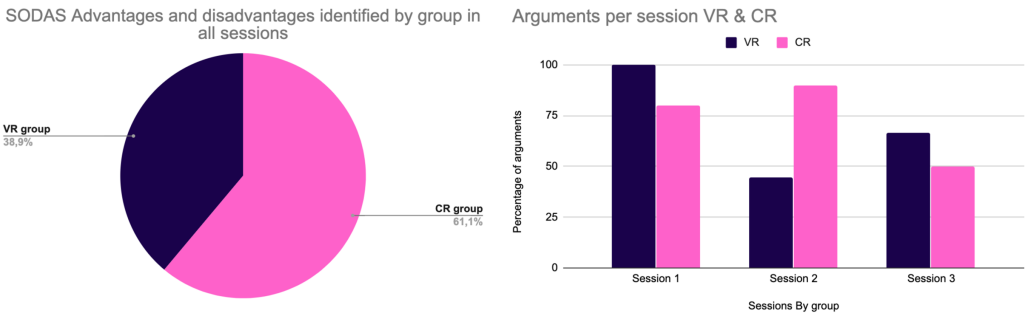

Fig. 4. Cognitive articulation of two groups and Argument per group on SODAS activity.

Immersive learning experiences could restrict the cognitive articulation process while participants identify new elements in a particular situation. However, students in the VR group were more willing to provide arguments and reasons for their SODAS choices (Session 1 and 3). Fig. 4.

5.3 Qualitative Analysis

The qualitative data contemplates analysis of the questions, “What did you learn today?" and "Why that is Important for your life?" those questions have the purpose to complement the quantitative data and understand how the participants learn after every session, see the changes during the process and get the attribution of knowledge on the different emotional dimensions of responsible decision making.

We analyzed the questions using a qualitative theming technique, where we found 5 themes for the first question.

What did you learn today?	**Why that is Important for your life?**
VR and related	Responsible decision making
about themselves	About future situations
About consequences, choices, decisions, options.	About success
About the topic of the session.	About the topic of the session
About future situations	

Table 1. Theming, learning attribution, qualitative analysis.

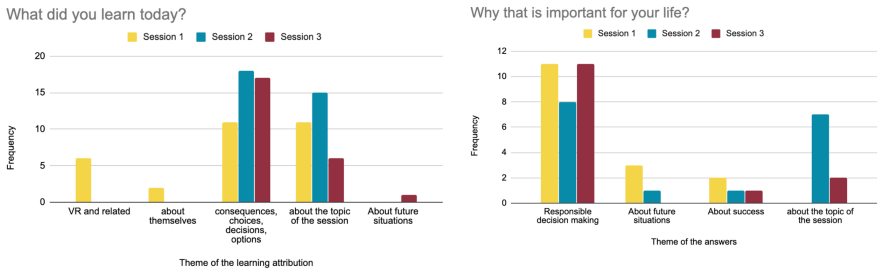

Fig. **5.** Learning Attribution by session qualitative theming analysis.

The first session participants reflect about VR, Responsible decision making, the topic of the session, and about themselves. The second session participants focus their

reflection on learning in RDM and the topic of the session and the third session participant concentrates their reflections on RDM, The topic, and future situations.

There is a change in what the adolescents declare to learn by sessions from a technical impact of the medium and personal appreciations to a deeper understanding of the emotional decision-making area and future situations.

We identify a change of learning attribution through the question (what did you learn today?) of every session from a technical to an emotional domain, the impact of VR medium creates the first sense of attribution, participants feel they are learning about the technology after every session the impact of the VR medium was becoming lower and the impact of the content raised.

5.4 Qualitative SEL Analysis

To analyze the learning attribution of the participants and understand which emotional dimensions of responsible decision making the participants learned in the VR experience we use the SEL framework which define 5 main dimensions of responsible decision making learning from the emotional perspective:

- Considering the well-being of others
- Recognizing others, one's responsibility to behave ethically.
- Base decisions on safety social and ethical considerations.
- Evaluating the realistic consequences of various actions.
- Making constructive, safe choices for self-relationships.

We analyzed the qualitative data and the learning attribution questions using these five domains to understand which areas of learning were more impacted by the VR and CR experience.

First session participants show reflections of learning from the VR group pointing to “Recognizing others and one’s responsibility” and "Evaluating realistic consequences of various actions". While CR group focus on “Base decisions on safety social and ethical consideration, and also "Evaluation of consequences of various actions.

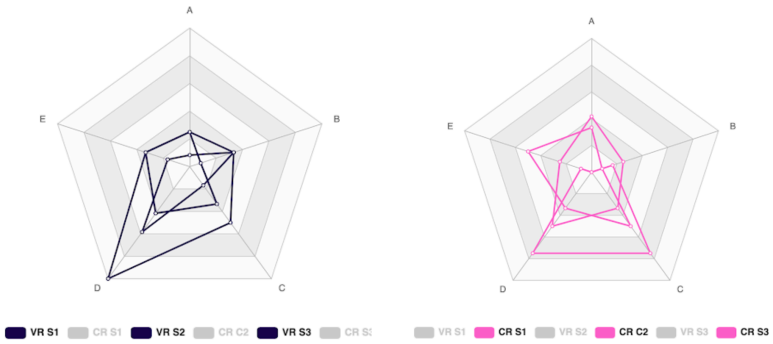

Fig. 5. Dimension of Responsible decision-making learning by session in two groups VR left CR on the right.

Second session participants show reflections of learning from the VR group pointing clearly to the "Evaluation of consequences" but also involving at least all the dimensions of learning. While CR group declares learnings in the "Well-being of others and coincidently with the other group in the evaluation of consequences.

In the third session CR group declare learnings in several areas pointing higher to "Making constructive choices for self-relationships" and " Base decisions on safety social and ethical considerations"

While the VR group present a difference in evaluating the consequences of various actions. Students on the CR group show learnings in the diversity of RDM dimensions, while students on the VR group show a clear learning trend to the "Evaluating the realistic consequences of various actions" dimension.

6 Discussion

6.1 Improvement of Responsible decision making

Results analysis shows that VR technology can improve the level of learning responsible decision making in post-assessment, compared with traditional methods of improvement in performance such as mental simulations and imagination exercises. A structured set of 3 sessions shows a significant difference in learning considering qualitative and quantitative data, proving our hypothesis. In terms of timing of learning our study shows that there is not a proportional relation between the number of sessions and deeper emotional learning, awareness timing or future behavioral change on RDM,

even with the help of VR medium the metacognition process of RDM seems independent of every participant and might require a different number of sessions, different gaps of time to digest or supplement activities. We identify that there is an incidence in the general overall improvement of the participant, however, the timing of awareness seems independent of each adolescent and might rely on personal background dimensions rather than the VR medium and could be a matter of further research and discussion for IVLE design.

Cognitive articulation

On the other hand, our study expresses that the identification of elements that are not on the storytelling of VR, once the participants are outside the VR environment might be affected by a lack of mental effort and that could reverberate on a shortage of cognitive articulation. Participants could rely on and what they watched on VR and decrease effort on imagining new scenarios of advantages and disadvantages.

Cognitive load theory (CLT) and prior research [23] show that on problem-solving activities there is a "completion problem effect", students with partially completed work usually learn more and perform better than fully completed work samples on future test experiences. This can explain that VR participants got better scores and lower identification of advantages and disadvantages. However, we believe that answers can be part of a deeper issue about the design of cognitive processes on immersive technology.

While our structure of tasks for VR was designed with a complementary activity after the immersive experience, intrinsic cognitive load [24, 25] factors might be playing a relevant role in the completion of tasks and the design of VR learning experiences. The complexity of emotional dimensions on VR experience (intrinsic cognitive load) might be considered also some "faded completion principles" [26] of learning and a progressive timeline of activities.

The results also show that there is a possible consequential cognition component [27] on VR which impacts the willingness or disposition to provide arguments when participants have to choose an option. We believe that VR can engage participants to elect carefully and develop consequential thinking considering future repercussions.

6.2 learning attribution progression

Qualitative data frequency Fig. 5, show the learning progression with a technical attribution of learning to the technology in the first session, participants believe that they learning about technology and attribute their learning to the VR medium, however, the general and clear progression evidence that is first impact effect when participants associate their learning to responsible decision making, so we identify that there is an immediate relation of learning attribution to the VR technology.

This shows that VR technology might impact the learning attribution of emotional (or general) learnings on the experiences of the first, based in our qualitative data this impact might be different by the participant relation with the immersive technology, and a learning experience might require to monitor the learning attribution after sessions.

6.3 SEL dimensions of learning

Our experiment shows that CR got a diversity of emotional dimension learnings of RDM we can attribute that to the process of mental simulation. Imagination processes are less structured and involve a free flow thinking where the cognitive mapping process is less explicit and individual more than collective, each participant can visualize different situations that can get different consequences and actions, and consequently, there is a diversity of emotional dimensions.

On the VR group, the flow, the structure of the task, and the storytelling designed for the experiment were structured with a consequential component and that narrowed the absorption process [28] of participants to one of the dimensions of RDM, which is related to the realistic evaluation of consequences. This could explain the clear orientation of that SEL dimension (Fig 6).

As our control group shows, the identification of emotional learning dimensions is affected by the freedom of thinking in the learning process, when the story is presented by VR experience to participants is already interpreted by explicit characters, environment, animations and tasks, this may reduce the intrinsic cognitive load of the responsible decision making knowledge (or any emotional knowledge) but may also reduce the diversity of knowledge attribution if the content is highly explicit or narrow.

7 Considerations for design

A) Learning timing

Design for emotional learning experiences on VR technologies should consider that every participant will have a different evolution of their cognitive process and the number of sessions will not be directly related to the level of emotional learning. More sessions will not always lead to deep understanding and learning.

B) Monitor Learning progression

Because we identified an impact from VR medium in the learning attribution we believe that learning experience on VR should consider use tools to monitor the learning attribution, understand what the people is learning and what are the incident factors on the learning experience can provide useful insight about when the participants are influenced by a first impact of the technology or not.

This is also helpful to understand the scopes of the engagement of VR technology in this context and at the same time provides feedback on the cognitive process of participants. Is relevant keep in mind the power attributed to the VR technology as a learning tool and understand that VR on emotional learning experiences might be a reason to create unexpected emotional outcomes, monitor the learning attribution in this type of training can help to elucidate the curve learning of the participants and can help to get reasons of that process.

C) Freedom of imagination in the process

From our results of the experiment, we understand that some elements such as storytelling, the way as the content are shown and structure of the task of the participants have influence in the dimensions of learning, the elements mentioned can narrow the cognitive process of participants to some specific dimensions if they are highly explicit or specific. We identify an inverse relationship between the specificity and explicitness of this element on VR learning and the diversity of the learning dimensions, from our control group which got a diversity of dimensions of learning and VR which got a narrow and specific dimension.

We believe that consider mind rooms or spaces for interpret the VR story but also consider how specific are the task of the VR experience in relation to the knowledge to achieve is relevant to give an appropriate sense of freedom for the participants.

Give for example a certain degree of interactivity in the choices of the participants and the capability to change or impact the narrative could give a different sense of freedom and create an experience with a diversity of learning dimensions. At the same time, the creation of the content should consider explicit or implicit action in the behavior of the VR characters according to every learning outcome.

D) Cognitive load

Design for IVLE should consider the intrinsic cognitive load factors of the content, divide when it's appropriate and separate by sessions and apply learning completion principles that could help to a better understanding of the content from the student perspective.

8 Conclusion

In conclusion, VR technology improved the learning of responsible decision making and could probably improve other emotional skills, combined by complementary activities, however, we identify that designing immersive virtual learning experiences should require considering several aspects which are playing a relevant role in the cognitive experience. Our contribution benefits everyone who will be in the position to design or create a cognitive experience on VR but also anyone who is looking to

develop a structure for a VR experience, providing considerations to look before a development process.

8.1 Limitations

Because the similar characteristics of the sample applied to the same school in a particular place of Asia, the identified factors might reflect only the human behavior of the specific region, however, further study should involve multicultural backgrounds to see the differences and transversalities on the topic.

The school context where the participants come from have a higher relation with technology on the academic curriculum (in relation to other schools of the area), some participants have a close relationship with VR technology while others not at all, this could compromise some results shown during the experience.

The platform used to build VR experience provides non-Asian cultural avatars, this might impact the visual empathy process of some participants and some cultural attachments during the learning process.

The size of the sample should also matter to consider the results of this experiment, the behavior of the variables and the quantitative outcome could experiment changes in a different sample.

8.2 Future work

Further work will continue elucidating the cognitive process of VR technology on training experiences, acquire and develop knowledge of how to design an appropriate VR educational experiences, (considering simple and complex skills) could evidence the factors which are playing relevant roles in the absorption process and will be one of our concerns.

We believe that further research should also consider evaluating content and cognitive load factor design during the learning process and how they may affect users in an immersive virtual learning environment.

Future work will also involve the idea to incorporate digital tools inside of IVLE to monitor the cognitive factors and also the learning attribution this could provide helpful data that can be gathered from inside of the VR experience.

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