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Smart Ambience for Affective Learning (SAMAL): Instructional Design and Evaluation

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Abstract: While much has been written about how emotions affect cognition and memory [1], as well as how emotions attached to the success/failure of academic performance impact learning; little has been researched about the association between immersion in VR and emotions and learning. In this study we focus on the instructional design and evaluation of an innovative learning environment for affective learning which allows students to step into the virtual reality scenarios and through a series of interactive and immersive learning activities provides the learner with a unique learning experience, not found in conventional classroom learning. The design of instructional plans aims to work in conjunction with the virtual scenarios for learning and takes reference from Kolb's theory on experiential learning. The SAMAL (Smart Ambience for Affective Learning) instructional design offers a unique potential of stimulating the learner to engage in the educational virtual experience. Our preliminary findings show that a range of affect responses can be invoked through direct interaction with SAMAL learning scenarios which serves to extend the use of educational games as a supplementary learning tool and offers a new novel arena for learning.

Keywords: affective learning, smart ambience learning design, immersive learning scenario

Introduction

With the emerging application of Virtual Reality (VR) technologies in the higher and secondary education, little is known about the interplay between immersive virtual reality, emotion and learning of the learners. The CityU Smart Ambience for Affective Learning (SAMAL) project aims to develop innovative designs of learning VR scenarios (which we called SAMAL scenarios) that tap into the affect components of the learner. The design and the instructional flow of these learning SAMAL scenarios was created with the intent of looking into the effects of emotion upon learning.

Much has been written about how emotions affect cognition and memory [1], as well as how emotions attached to the success/failure of academic performance impact learning [6]; but little has been researched about the association between immersion in VR and emotions and learning. The SAMAL project aims to achieve this and more specifically to see if immersive / virtual reality environment can help to evoke emotions suitable for learning, and thus stimulate the learner to learn.

The correlation between emotions and learning are linked, as emotions influence learning. Literature links emotions to success/failure in school. Emotions within the educational setting most often relate to achievement (success/failure) and the associated feelings such as pride/happiness and sadness/shame [6]. Moreover, engaging in achievement activities result in emotions, based upon the perceived controllability of the activity and the value that the student places on it. For example, if a student has succeeded in controlling the activity and places positive value upon it, then positive feelings such as enjoyment will be the resulting feeling; and the opposite holds true if success is perceived as not being attainable. Features of the SAMAL design are linked to how the students can actively participate and control their movements within the virtual environment in order to reach their target, and experience the challenges of animal survival. Successes can lead to positive feelings resulting in greater learning about animal survival from this unique learning media. In the SAMAL design, the focus is placed upon creating a learning environment where the student can learn through a process of action based trial and error, whereby kinesthetic physical interaction with the virtual characters and environment are simulated. Through this process students can gain a deeper understanding/achieve successes of animal survival. This kind of experiential learning is linked to Kolb's theory of experiential learning cycle. Kolb postulates that learning occurs in four stages: concrete experience, reflection, abstract conceptualization, and then active experimentation, which then leads back to a new more formulated concrete learning [4]. Kolb's experiential learning cycle is shaped by earlier theories of Dewey, who stressed that effective learning is grounded in the experience and interaction, Lewin who gave emphasis to active based learning, and Piaget who linked intelligence to the interaction between the person and the environment [2]. SAMAL's trial and error learning approach incorporates aspects mentioned in the above.

Targeted to learners in tertiary and secondary education, the SAMAL project looks into the affective responses from the students as they engage in the virtual environment of SAMAL. Learner's interaction with immersive and affectively evocative virtual scenarios stimulates a release of energy in the body. This kind of kinesthetic body release taps into the feeling and cognitive state of the individual [3]. The SAMAL Learning Environment offers a new platform for learning- one that stimulates the learner to engage in the educational virtual experience through immersive interaction with the virtual characters, activities and environment, resulting in affect states that positively impacting learning.

In this paper, we focus on the instructional flow of the design and rationale of the SAMAL environment as well as to evaluate affective outcomes based upon the objective of determining the learning impact of emotion for learning topics in Life Science.

1. Instructional Design for SAMAL

SAMAL aims to stimulate the learners to learn more by invoking their affects through participating different virtual scenarios. We make use of 3D stereo projection to provide immersive feeling, cameras and motion sensors to detect learners' movements and gestures, and scent dispenser to provide olfactory stimulations. The layout of the SAMAL learning environment is shown in Fig. 1. It consists of two projectors, a silver screen, a wii-mote controller, a nunchuk and a wii-fit board. Polarized filter is placed in front of each projector for generating the stereo animation onto to the silver screen; while the wii-mote controller, nunchuk and wii-fit board are used as 3D interaction devices. Cameras and microphones are mounted on the walls to capture visual and audio input of the learners.

Before we illustrate the design of virtual scenarios, we first highlight the instructional plan for SAMAL learning as follows:

1. At the beginning of tutorial, the SAMAL instructor provides an introduction to what is SAMAL and states the learning objectives of the SAMAL Project: The instructor will explain that the students will experience two different SAMAL activities that relate to Life Science topics. The instructor will highlight the educational purposes of this activity and the interactive components of the virtual reality experience. The instructor will indicate to students that some of them will be players and some will be watchers.
2. Students will be provided with 3D glasses in order to view the 3D projections.
3. A demonstration of the two SAMAL activities, namely, the Animal Jumping Scenario

and the Hummingbird Flying Scenario will be carried out by the SAMAL instructor, introducing how to operate the wii-mote controller, the nunchuk and the wii-fit board in order to control the flight of the hummingbird virtual character and the jumping movements of the virtual animal characters.

4. In the first exercise, the Animals Jumping Scenario, students who volunteer to be participants will try out the learning scenarios themselves based on the learning objectives of this activity. Players will move and control the wii equipment in order to accumulate and release energy for jumping. The other students will observe the players, observing, giving advice and support.
5. In the second exercise, the Hummingbird Flying Scenario, students who volunteer to be participants will try out the learning scenarios themselves based on the learning objectives of this activity. Players will move and control the wii-equipment in order to navigate and reach the flower for gaining sustenance. The other students will observe the players, observing, giving advice and support.
6. After participating in these scenarios, the students (both the players and the watchers) will complete our questionnaire devised to determine the effectiveness of the SAMAL activity and affective outcomes.

In the following, we will describe the design and the design rationales of these virtual learning scenarios.

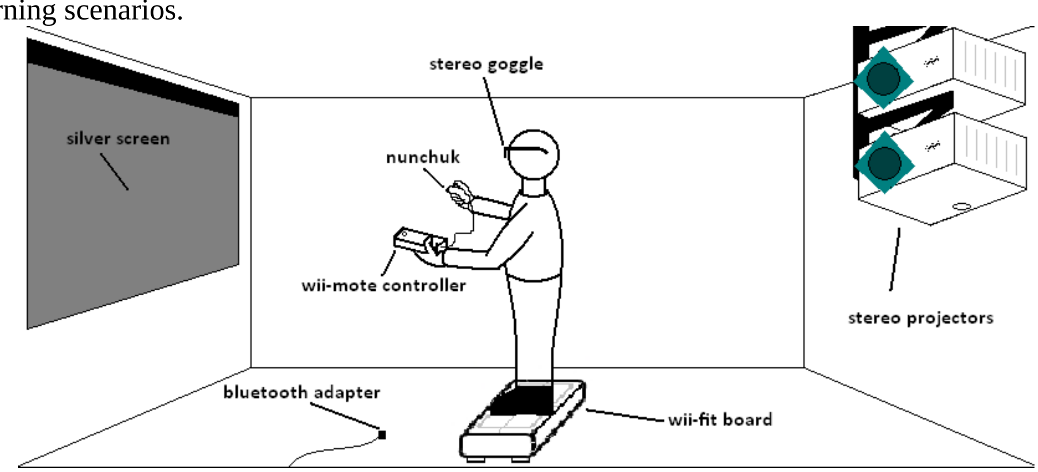

Figure 1. Layout of SAMAL learning environment

2. AMAL Experience of an Animal Jumping Game

The objective of Animal Jumping scenario is to allow students to experience the jumping ability of different animals when they have the same scale as human beings. Furthermore, to let learners compare the difference between animals and humans, there are five different kinds of animals for learners to choose for the comparison. In SAMAL, the animal jumping scenario involves visual and interactive stimulations to facilitate the learners to put themselves into different kind of animals which then competes and compares with the jumping power with human beings. We separate the design into two aspects that focus respectively on the ‘visual” and the “interactivity” experience for the learners.

“Visual” Design:

- The selected animal is scale up to 1:1 and shown side-by-side with human beings such that the students can easily compare the jumping power, and hence the jumping height, of the designated animal with human beings.

- To simulate that the exertion of energy is needed for jumping, an energy bar is shown on the screen to indicate the energy accumulated for the jumping process.

"Interactivity" Design:

- A pressure sensor (the wii-fit board) is provided for the player to measure his/her own body weight. The body weight affects the jumping power based on the equation, according to Newtonian mechanic.
- Motion sensing device such as the wii-mote and nunchuk controllers are provided, so that the player can kinesthetically shake the wii controllers to store energy for the jumping process. The faster the player shakes the wii controllers, the longer the bar (indicating the higher the energy level). The player can then initiate the jumping process by pressing a button on the wii-mote.

Fig. 2 shows a side-by-side comparison of a fish and a human. Fig. 3 shows the jumping process of both a human and a fish with the same amount of energy. Since a fish has different appearance and structure from human beings, there is a difference of the jumping height. The final heights reached by the fish and the human being will be shown on the screen (Fig. 4). After several trials, the player will gradually learn that the jumping power of the human being and the selected animal maintains a certain ratio.

Figure 2. Side-by-side comparison

Figure 3. Jumping Process

Figure 4. Comparison of jumping heights between a fish and a human

3. SAMAL Experience of an Animal Survival Game

A game that enables the learner to experience the survival for an animal is developed based on the navigation of Hummingbirds in search for food. The choice of a Hummingbird as an example is chosen because the bird has to flap its wings rapidly in order to hover in the mid-air. It also needs to fly forward and backward [7] for food or escape from danger. In the Hummingbird Flying Scenario, students will act as a hummingbird, trying to overcome the difficulties in flight controlling and food hunting, like how to reach the flower for nectar (food) and avoid flying into the obstacles (trees, fences and etc. in the scene). The kinesthetic rapid shaking of the student arms echo the flapping of wings of the hummingbird. The use of the body heightens the immersive experience. The students control the flying direction and speed by carefully controlling the pressure of the legs and flapping the arm to control respectively. It is important to note that in SAMAL we DO NOT seek to accurately simulate the physics or the biology of the flying bird. The activities are designed mainly to give the students a personal experience of the challenges of seeking for food to survive and the affect that evoked in the process of overcoming these challenges. In SAMAL, the hummingbird flying scenario involves visual and interactive stimulations to facilitate the students to put themselves into the hummingbird and try to survive by food navigation and feeding.

"Visual" Design:

- A scene of countryside with trees, flowers, fences, pools, grass, mountains and sunshine is designed to provide a pleasant and enjoyable simulated environment so as to draw the students into the scene.
- A hummingbird perching in its birdhouse at the beginning (Fig. 5).
- An energy bar is shown on the screen indicating the existing energy level of the hummingbird; this bar aims to give a sense of urgency as the energy is depleting that energy (hence food) is needed for survival. The energy level decreases continuously once the activity started, once it drops to zero, the hummingbird will be depleted. In other words, the students have to replenish the dropping energy.

"Interactivity" Design:

- The player controls the direction of the hummingbird flying by stepping and moving on a pressure sensing device (the wii-fit board). The wii-fit board is divided into four regions: namely 'Top-Left', 'Top-Right', 'Bottom-Left' and 'Bottom-Right'. If the player exerts pressure on the 'Top-Left' and 'Bottom-Left', the hummingbird will go left and vice versa depending on the pressure exerted on wii-fit board.
- The hovering in the air of the hummingbird (Fig. 6) is controlled by a motion sensing device (the wii-mote and nunchuk controllers). The player is asked to shake the wii controllers vigorously with the hands, like the flapping of wings, and, if done properly, the hummingbird will take off, fly and hover in the air.
- When the hummingbird succeeds in reaching the flower and sucking the nectar (Fig. 7) from the flower, the energy bar will lengthen showing the increased level of energy. This design aims to demonstrate a paradox of the survival of a hummingbird that in fact happens in real life for all kinds of birds: the more the hummingbird flies around to seek for food (and consuming more energy), the more frequent it has to eat to refill the used energy.
- If the player succeeds in controlling the hummingbird to reach all five flowers before energy depleted, the player had successfully survived in this environment as a hummingbird (Fig. 8). Otherwise, if the hummingbird runs of energy, an 'energy depleted' screen will be shown to indicate that the player had failed.

Figure 5. Perching in birdhouse

Figure 6. Flying towards flower

Figure 7. Sucking nectar (food) from a flower

Figure 8. Energy replenished – bird survival achieved

4. Affective Outcomes of the SAMAL Designs

In our evaluation of the effectiveness of SAMAL learning scenarios, we devised a questionnaire to see if SAMAL promotes or stimulates appropriate affective states as the result of immersing and interacting with SAMAL. It also looked at the correlation between affect and learning between players and watchers to see if the interactive immersive experience offered to players promotes greater affect and thus promotes greater learning for players versus watchers.

The questionnaire asks the students to respond to a list of feelings that they felt while engaging in the two activities Animal Jumping and Hummingbird Flying. Note that students could select more than one feeling, making the responses higher than the total number of students. It also asks students to indicate how much they think they have learned as a result of engaging in through these two SAMAL experiences. In this initial study, we extended an invitation to various local upper secondary students from the Science and Art streams to visit and to “learn” with SAMAL in the format of a tutorial. After engaging in the SAMAL tutorial students were asked to fill in our questionnaire. 104 students participated in this initial study: 31 players having the role of active immersion and 73 watchers who participated on an observational level. The feeling states for players and watchers correlated with the degree of learning is shown in Tables 1 and 2 below.

Table 1 denotes the feeling states for players and then provides a cross correlation between feelings and learning. Overall, most players reported feelings on the positive end of the spectrum. 61.29% players responded that they were curious and also happy, as well as excited and interested (both at 54.84%). 19 out of the 21 players (90.48%) indicated that they had 'learned a lot'. In summary, there was a strong correlation between having positive feelings and learning for players.

There were also more players responding that they had both positive and negative feelings whilst engaging in the activity (29.03%) whereas only 1.37% of the watchers reported that they had both positive and negative feelings while viewing. This correlates to the above data showing 9 players, or (29.03%) report that they felt frustrated while engaging and according to student feedback some players replied that they could associate with the challenges that the bird had in flying and controlling flight as it is difficult to fly, thus felt frustrated while in playing the player role.

For the watchers as seen in Table 2, the three top responses were interested (69.86%), curious (56.16%), and awed/amazed (43.84%). This data indicates that there is positive feeling states of higher intensity (ie) happy and excited associated with the players who have had an immersive VR experience with SAMAL than for those who were in the watching position, who noted positive feelings of a lower intensity (ie) interested, curious and awed/amazed. The same holds true for learning, as 52 out of the 73 watchers (74.29%) indicated that they had learned a lot which is still positive but not as high as for those players.

Table 1. The Range of Affect States for Players Correlated with Learning

31 people in total		**Player**		
Feeling	**Responses**		**Q4: Learnt a lot**	
Happy	19	61.29%	18	94.74%
Curious	19	61.29%	16	84.21%
Interested	17	54.84%	15	88.24%
Excited	17	54.84%	17	100.00%
Awed/Amazed	11	35.48%	10	90.91%
Frustrated	9	29.03%	7	77.78%
Insightful	6	19.35%	5	83.33%
Irritated	2	6.45%	1	50.00%
Bored	0	0.00%	0	0.00%

Table 2. The Range of Affect States for Watchers Correlated with Learning

73 people in total		**Watcher**		
Feeling	**Responses**		**Q4: Learnt a lot**	
Interested	51	69.86%	41	80.39%
Curious	41	56.16%	30	73.17%

Awed/Amazed	32	43.84%	29	90.63%
Happy	29	39.73%	23	79.31%
Excited	20	27.40%	16	80.00%
Insightful	13	17.81%	12	92.31%
Bored	3	4.11%	0	0.00%
Frustrated	0	0.00%	0	0.00%
Irritated	0	0.00%	0	0.00%

5. Conclusion

Higher affective states promote greater learning, little is still known about the interplay between immersive virtual reality, emotion and learning. This pilot project is among the first of its kind to look into if immersive virtual learning scenarios making use of VR technologies may be a viable tool in education to evoke positive affects in for learning. Based upon the design which promotes interacting with the VR characters and environment, SAMAL allowed the students to experience from an affect sense what it is like for animals to survive, thus increasing students learning interest in the topic. In our case, this project focuses on the concepts of animal survival. Students may cognitively understand survival needs through various learning; however an immersive VR educational programme/activity that offers to students an opportunity to fully immerse in survival tactics gives them a deeper understanding of the concept of survival, as the students can 'feel' the experience in their body, and feel the emotions of survival in this real time activity. Students can connect to the bird, as they perceive themselves as that bird (full immersion) in the VR scenario.

Our data showed that there was a difference in both emotions and learning between players who had an immersive experience and watchers who were more in the passive position. Overall, most players reported feelings on the positive end of the spectrum, providing feedback that SAMAL was a positive affective experience for most. However, there was a marked difference between those who played (active immersion experience) and those who watched (observing more passive experience), indicating that an active immersive experience results in a stronger affect state and also provides greater learning for those who participated in this study.

SAMAL allows the user to 'get into' the scene and interact with the VR characters/ environment actively. Active participation, along with being immersed through the senses and psychologically are features of virtual immersive environments that can promote learning [5]. This SAMAL project extends the use of educational games as a supplementary learning tool which can offer a new novel arena for learning. SAMAL enables students to learn though an immersive interactive experience, tapping into the affective state of the learner, thus stimulating learning in a unique way.

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