# Study on changes of physio-psychological reactions according to user's emotional response to virtual characters

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**Abstract: Considerable interest has been directed toward utilizing virtual environment-based simulations for teacher education which provide authentic experience of classroom environment and repetitive training. Beyond the realization of realistic simulation development, it is time to much emphasis should be placed on the consideration of how to develop a simulation that effectively improves learning performance. Emotional Interaction should be considered for more advanced simulation learning performance. Since emotion is important factors in creative thinking, inspiration, concentration, and learning motivation, identifying learners' emotional interactions and applying these results to teaching simulation is essential activities. In this context, this study aims to identify the objective data for the empathetic response through the movement of the learner's EEG and eye-tracking, and to provide clues for designing emotional teaching simulation. The results of this study indicated that intended empathetic response was provided and in terms of valence (positive and negative) states and situational interest played an important role in determining areas of interest. The results of this study are expected to provide guidelines for the design of emotional interactions in simulations for teacher education as follow; (a) the development of avatars capable of expressing sophisticated emotions and (b) the development of scenarios suitable for situations that cause emotional reactions**

**Keywords: Simulation for Teacher Education, Emotional Interaction, Virtual character, EEG, Eye-tracking**

## INTRODUCTION

Considerable interest has been directed toward utilizing virtual environment-based simulations that provide realistic experiences and enhance repetitive learning effects with level of difficulty controlled (Drews & Bakdash, 2013; Lu, Hallinger, & Showanasai, 2014). Especially, it has been reported that simulations for teacher education which provides authentic experience of classroom environment and repetitive training while controlling level of difficulty are effective for improving teacher efficacy and instructional skills, which is why simulation for teacher education is becoming more and more common. With the development of 3D graphics technology, the development aspect of the virtual environment such as realization of a virtual avatar that acts and speaks like a human in a virtual space and realistic space has already reached the same level as that of reality (Christensen, Knezek, Tyler-Wood, & Gibson, 2011; McCreery, Schrader, Krach, & Boone, 2013; Stavroulia, Makri-Botsari, Psycharis, & Kekkeris, 2014). Beyond the realization of realistic simulation development, it is time to much emphasis should be placed on the consideration of how to develop a simulation that effectively improves learning performance. In this respect, the color of the emotional interaction between the learner and the simulation should be added to the picture of teacher education simulation. In immersive media-based simulations, in-depth learning activities will be possible if not only information exchange for learning but also emotional interaction can be shared (Bradley & Kendall, 2014; Girod & Girod, 2008).

In learning through virtual simulation, interaction with content plays an important role as a lens to confirm the effectiveness of the learning provided by the simulation. Previous interactions in virtual simulation have been focused on controlling virtual avatars by applying various multi-modal interfaces or allowing virtual avatars to react according to the way in which pre-service teachers use the class demonstration simulator in virtual classrooms (Dieker, Rodriguez, Lignugaris/Kraft, Hynes, & Hughes, 2014; Hayes, Straub, Dieker, Hughes, & Hynes, 2013). However, for more advanced learning performance, interactions should be able to interact emotionally beyond the control of objects and avatars in virtual environments through simple interfaces. Since emotion is one of the most important factors in creative thinking, inspiration, concentration, and learning motivation, identifying learners' emotional interactions and applying these results to teaching

simulation is essential activities (Guilford & Hoepfner, 1971). Therefore, in order to apply the emotional interaction to the teaching simulation, it is a necessary process to identify the learner's emotional states and the area of interest in the simulation using the virtual student avatar with both objective and empirical way.

In this context, this study is an exploratory study to identify the objective data for the emotional reaction through the movement of the learner's EEG and eye-tracking, and to provide clues for designing learning environment for emotional teaching simulation by using the results.

## THEORETICAL FRAMEWORK FOR THIS STUDY

### Simulation for teacher education.

With the introduction of classroom simulations in teacher education, the lack of existing classroom exercise programs and school field practice can be complemented (Christensen, et al., 2011; Stavroulia, Makri-Botsari, Psycharis, & Kekkeris, 2014). In addition, experience in classroom practice in a safe environment with risk factors removed may provide practicing and learning of effective classroom management strategies for per-service teachers (Dieker, et al., 2008). Previous researches for teaching simulation have described the advantages of classroom simulation as follows:

First, classroom simulations can enable pre-service teachers to speak, reflect, and evaluate their own teaching and learning theories. Second, classroom simulations can provide an effective means of facilitating the practice of what was found in educational research. Third, in classroom simulation, pre-service teachers can try different teaching strategies for the same avatars. Fourth, the classroom simulation can be stopped at any time to plan a new class or reflect on the class, which means getting away from the pressure of time and becoming more flexible in practicing classes. In addition, it may enhance social interaction in the teaching-learning context (Jamaludin, Chee, & Ho, 2009).

### The Cognitive-affective Theory of Learning with Multimedia.

Cognitive-affective Theory of Learning with Multimedia (CATLM), based on Cognitive Theory of Multimedia Learning (Mayer, 2005), emphasizes cognitive and emotional processing in multimedia learning. That is, this theory adds motivation and emotional consideration to the recent theory of multimedia learning. Most importantly, CATLM provides learners with learning materials other than words and pictures, extending them to simulation learning based on virtual environment and avatar. In this theory, it is concluded that emotions and motivational elements reinforce learning by mediating learners to focus on learning materials.

When it comes to reviewing studies that apply emotional instructional design which is accordant with the purpose of this study, there are three key representative researches. First, D'Mello, Lehman, Pekrun, & Graesser (2013) conducted research examining the state of emotions of confusion is beneficial to learning. Magner, Schwonke, Aleven, Popescu, & Renkl (2014) examined whether descriptive illustrations in multimedia learning design function as a synchronous provision of motivation or as a role of variance. Finally, Plass, Heidig, Hayward, Homer, & Um (2013) looked at how the design of multimedia learning materials would cause positive emotions to learners and how these positive emotions would promote cognitive processing, ultimately resulting in cognitive and emotional outcomes). A review of these prior studies meet the needs of providing direction and clues to the research for emotional design of immersive media.

### Simulation Based Learning.

In recent years, the important goal of learning is not only to derive a theoretical framework for students, but also to expose them to situations in which they can gain experience by applying acquired knowledge and skills. The way to help meet this objective is the use of simulations that replicate real-world situations. These simulations contribute to the learning process by transferring conceptual theories to the ultimate application (Brozik & Zapalska, 2003). A simulation-based learning refers to a learning environment in which the procedures or systems of the real environment to be learned are provided in a simple, controlled and replicated environment. Simulations have been used extensively to provide training and assessments that have not been tried due to cost and risk factors in real-world situations, such as medical, aviation, military training, and construction sites (Drews & Backdash, 2013; Lu, Hallinger, & Showanasai, 2014). Simulation allows the learners to experience the consequences of their actions and decisions through repeated training and adjustment in the face of problem situations. However, simulations have the advantage that they do not pose any real risk due to learners' erroneous decisions and actions.

As a means of learning and training, simulation has been reported to have many advantages. First, it is possible to provide repeated training, a longer practice than the real world allows, and precisely measured results through an effective evaluation system. Second, the simulation is able to master various risk training with the problems in the real world excluded. Third, simulation provides active learners with decision-making and problem-solving skills that can be applied to social sciences. Fourth, simulation provides effective ways to strengthen self-esteem and improve

conversation skills compared to case study, which is evaluated as a relatively similar type of learning environment (Thompson & Dass, 2000). One of the most important activities in learning through simulation is the confirmation of results derived through the process of decision making and feedback on them.

## METHOD

### Participants

Participants for this study included 13 preservice teachers attending at Cheonnam University in Kwangju, Korea in fall semester, 2017. A convenience sampling was conducted for this study. The subjects were recruited through open advertisement on the web and paid.

### Material and Tasks

The material for this study was video clips using the scenarios of both sad and angry situations applied by virtual student characters. Specifically, iClone was used to produce the overall video clips. Based on the study of Etzel. et al. (2006), background music coincident with the sadness and angry videos were applied respectively (i.e., Spartacus for sad situation and crimson tide for angry situation). And another thing, to reflect the emotional elements of the virtual student characters, the gesture and expression were applied based on Ekman (1993)'s research. The experimental task for this study was to present a solution for the situation of virtual characters after watching the video clips of virtual student characters.

### Variables and research design

The independent variable of this study was the states of emotional atmosphere in the video clips provided. The emotional states provided by virtual student characters and background music were presented in two states (sad and angry). There were two dependent variables in this study; (a) empathetic response and (b) area of interest (AOI). Specifically, arousal and valence states, which were the objective emotional variable of the participant watching the video, was examined for empathetic response. As for the AOI, confirmation of the learner's interest in the virtual characters and objects in the presented learning material was identified. The overall experiment design was a repeated design based on two conditions.

### Measure

In this study, the equipment of Epoc+ (Emotiv) was used to measure the learner's emotional variables through EEG. To determine the state of arousal (i.e., how comfortable or excited), the ratio of beta and alpha waves extracted from measured EEG signals was calculated. To determine the state of valence (i.e., positive or negative state of mind), the activation levels of the two cortical hemispheres in the brain were compared. Brain waves measured at the four positions (AF3, AF4, F3 and F4) of the frontal cortex were used. As for the eye-tracking, SMI (Sensor Motoric Instrument) iViewX was applied. The learner's AOI was confirmed during the video viewing. The overall experiment and the formula for examining the states of arousal and valence states through EEG measurements are shown in the figure 1 below.

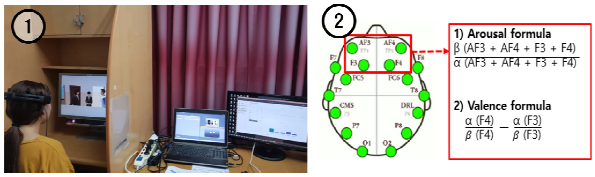


Figure 1. Experimental conditions(①) and formula for EEG measurement (②)

### Analysis

EEG was measured under two conditions according to the emotional situations presented by video clips. Since the measured EEG was the raw data presented in time units, the FFT process was performed using Telescan (LAXTHA) software. The sizes of alpha (8-12Hz) & beta (12-30Hz) bands were extracted by frequency units. The power values extracted from four channels (AF3, AF4, F3, F4) corresponding to the frontal lobe were derived from the temporal valence and arousal state according to the formula for calculating the Valence and Arousal presented in the previous session. As for AOI, the number of eye-gaze views on AOI using a grid was visualized using heat map according to the result of analysis of eye-tracking data.

## RESULTS

The Figure 2 and Figure 3 represent the result of time series analysis of valence (positive and negative) and arousal (high and low) states of learners, the degree of hyperactivity of the left and right hemispheres of the brain of alpha waves (8-13 Hz) and beta waves (13-30 Hz), which are related to the emotional response, according to the emotional conditions of video clips.

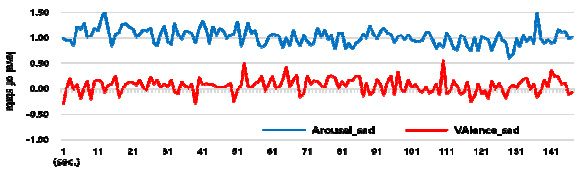


Figure 2.Time series analysis of empathetic response to sad video clip

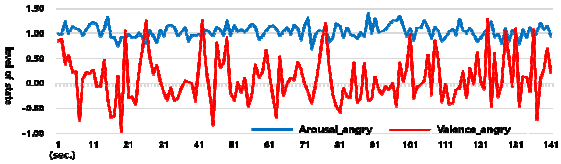


Figure 3.Time series analysis of empathetic response to angry video clip

The levels of valence which showed the positive and the negative states of learners' empathetic response induced through the virtual student characters and scenario showed relatively low, which means negative empathetic response for sad and angry situations. On the other hand, the states of arousal indicating high and low emotional states were relatively high, which means there is no significant difference in terms of arousal (high and low) states.

When it comes to the results of the data on the learner's area of interest through eye-tracking, it was confirmed that learners selected the area of interest by the atmosphere provided by the situation rather than by the emotional judgment factors. It can be tentatively concluded that situational interest plays a predominant role in determining learner's area of interest. The figures below is a graphical representation of the average number of eye-fixation count through grid analysis (4x7 for sad video and 4x10 for angry video). As shown in the figure 4 and 5, it can be confirmed that more eye-fixation is taking place in the object to which the emotion is to be input rather than to the causal factors of the emotion.

Figure 4.Average eye-fixation count by grid analysis (sad situation)

Figure 5. Average eye-fixation count by grid analysis (angry situation)

## DISCUSSION

Through this study, it is possible to accumulate objective and empirical data for designing emotionally interactive simulation for teacher education. Now that the sad and angry feeling represent negative valence states (Nicolaou, Gunes, & Pantic, 2011), the presented video materials could induce the intended empathetic response in terms of valence states. These results have it that, the proviso for the designing learning environment which can induce the intended emotional states in the terms of positive and negative situation can be prepared. These results will enable the construction of simulation for classroom environment, which can provide various emotional conditions that pre-service teachers will experience in the future.

The results of eye-tracking showed that situational interest plays an important role in determining areas of interest for learners. These results indicate the importance of elaborated scenarios in the design of simulations for teacher education (Lai et al., 2013). The occurrence of area of interest means that motivation for learning is formed, which is why it is important to facilitate contextual scenarios for designing simulations for teacher education.

In addition, the results of this study are expected to provide further guidelines for the design of emotional interactions in simulations for teacher education as follow; (a) the development of avatars capable of expressing sophisticated emotions and (b) the development of scenarios suitable for situations that cause emotional reactions

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