ESERA 2021
Fostering scientific citizenship in an uncertain world
30 Aug - 3 Sep 2021
Organised by University of Minho, Braga, Portugal

PRELIMINARY RESULTS OF A PARAMETRIC ANALYSIS OF EMOTIONS IN A LEARNING PROCESS IN SCIENCE

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In the last decades, several studies have highlighted the importance of emotions in the teaching and learning process. The classroom is considered as an emotional place, where the learning is influenced by cognitive and emotional-motivational mechanisms. Classically, emotions have been classified in seven basics categories. Furthermore, in educational settings, it is possible to evaluate other categories as engagement and attention. According with this vision, we designed an activity to analyse emotions and their flow when students are involved an inquiry-based activity. To avoid the biases in self-reports and the perceiver-dependent limitations of observational methods, we evaluated emotions with an automatic facial coding system. This system detects facial human expressions using facial reference points, and classifies their emotional value parametrically. The data shows different flows for each emotion. Thus, we observed a high level of attention's flow along the whole activity and a constant engagement of the participants. On the other hand, the joy and surprise flow are more variable, with highest values at the beginning and lower at the end. The negative emotions as anger, sadness, disgust, fear, and contempt are very low. This work opens to the possibility of objective parametrical evaluations of the emotional component of teaching-learning process.

Keywords: Emotion, Science Education, Conceptual change.

INTRODUCTION AND THEORETICAL FRAMEWORK

In the last decades, several studies have indicated the fundamental role and influence of emotions on learning, motivation, self-regulation, and academic performance (Pekrun & Linnenbrink-Garcia, 2014). Academic results are related to conceptual understanding processes, which depend on both emotional and cognitive elements (Mellado et al., 2014; Pekrun, 2006). These elements are mutually interconnected. Emotions are influenced by knowledge, likewise cognitive processes influence emotional experience (D'Mello & Graesser, 2012).

Emotional experience can be described with a small number of affective dimensions, including valence, engagement, attention and object focus (Harley et al., 2016; Pekrun, 2006). In education, the dimensional model can explain in detail the affective components that accompany learning, in all its complexity (Loderer et al. 2019). If the emotional components are ignored by teachers, they can limit the conceptual change of their students (Mellado et al., 2014).

Several studies on emotions in education have collected data through self-report measures (Pekrun, 2006), or the observation of experts, or both procedures simultaneously (Azari, 2020; Loreder, 2019). These methodologies (declarative or observational) present certain limitations. Self-report measures are difficult to construct and may be subject to response biases. Basically, we do not know if a person is able to perceive consciously and express correctly their own emotions (Izard, 2009; Pekrun, 2006). The observation of facial expressions is a method used to evaluate a person's emotion, due to movements of the facial muscles that usually accompany the emotional states. The Facial Action Coding System, also known as FACS (Ekman, Friesen, & Hager, 2002) is a perceiver-dependent observational method. It is a systematic approach to describe the presence and intensity of facial movements coded as Action Units (AUs). The difficulty of this method is that it requires intensive, long training and practice before Action Unites (AUs) codes can be reliably assigned

by experts (Barrett et al., 2019). However, algorithms have been developed to code human facial expressions automatically with a high degree of accuracy and they are commercially available (iMotions, 2008).

METHOD

Here, we describe preliminary results of the emotions that students expressed during an activity in which they attempted to estimate the contents of a sealed box. Emotions were analysed with a parametric method (no-declarative and no-observational).

An inquiry activity was proposed to 24 teaching students (15 women and 9 men) of the Faculty of Education-CFP of the Complutense University of Madrid. The activity regarded the process of cognitive generation of knowledge by inquiry. The participants had to predict the contents of a box, an activity proposed among others by Solís-Espallargas et al. (2015). The participants could not open the box or break it. That is, they had to make use only of their scientific-technical knowledge, such as observing, testing hypotheses, drawing conclusions, etc. They could utilise some magnets. The dimensions of the paperboard box were 9x6x20 cm. It contained the following Euro coins: two of 1 cent; one of 5 cents; one of 10 cents; one of 20 cents; one of 1 euro. All these coins moved freely inside it. A HD video camera was placed on a tripod in front of each student at a distance of 1 metre to obtain the best recording view of the face. The activity lasted twenty minutes. We divided the session into ten periods of two minutes each. After each period, students filled a form in which they reported their emotions. Here, we only describe the measurements obtained from the video recordings.

To evaluate the facial expression and their correlation to emotions' experiences from the video recordings, we utilized an automatic coding system (Affectiva®), based on the algorithm FACS, and developed by iMotions® (2018). It can detect head orientation (yaw, pitch, roll); interocular distance and 34 facial landmarks; 7 basic emotions; engagement; attention and 14 facial expression metrics. At each period, we analysed the percent of time the following parameters were measured by the system: the 7 basic emotions (anger, sadness, disgust, joy, surprise, fear, contempt), engagement and attention. A human observer compared these measurements with the videos, frame by frame, to evaluate the performances.

RESULTS

Our preliminary results suggest different dynamics for each parameter (Table 1). Throughout the 10 time periods, we observed a high (>60%) and constant level of attention. Engagement was the second largest parameter (~20%) and it remained relatively stable throughout. On the other hand, the parameters joy and surprise appeared less frequently and were more variable. Specific, joy shows highest values at the beginning and lower at the end. The negative emotions anger, sadness, disgust, fear, and contempt were very low. Manual observation confirmed that the parameters obtained by the software were coherent with human evaluation of the same parameters.

Table 1. Percent of time for each of the 9 selected parameters, they were measured by the system for each of the period. "Mean" indicates the mean value of each emotion for all periods.

	Anger	Sadness	Disgust	Joy	Surprise	Fear	Contempt	Engagement	Attention
Period 1	0,0%	0,1%	0,3%	9,4%	2,9%	0,3%	1,6%	25,1%	60,3%
Period 2	0,9%	0,0%	0,3%	7,5%	1,5%	0,5%	0,9%	22,3%	66,1%
Period 3	0,7%	0,0%	0,1%	3,9%	1,9%	0,1%	0,9%	17,2%	75,1%
Period 4	0,0%	0,0%	0,2%	4,6%	2,2%	0,4%	1,0%	20,6%	71,0%

Period 5	0,1%	0,0%	0,3%	3,6%	3,1%	1,1%	1,3%	19,4%	71,3%
Period 6	0,1%	0,0%	0,1%	5,0%	4,5%	0,6%	0,4%	21,0%	68,3%
Period 7	0,2%	0,1%	0,3%	2,2%	3,9%	0,5%	0,7%	19,4%	72,7%
Period 8	0,0%	0,0%	0,3%	3,9%	4,2%	0,5%	0,7%	21,9%	68,5%
Period 9	0,1%	0,0%	0,2%	3,3%	3,4%	0,8%	0,5%	19,6%	72,0%
Period 10	0,0%	0,1%	0,1%	4,5%	4,3%	0,5%	0,4%	21,7%	68,3%
Mean	0,2%	0,0%	0,2%	4,8%	3,2%	0,5%	0,8%	20,8%	69,4%

DISCUSSION AND CONCLUSIONS

This study shows the possibility to evaluate parametrically the emotions during an educational activity, while avoiding self-report biases. The data shows the parameters of attention and engagement predominated throughout the activity, which was confirmed with a human observer. The positive emotions, joy and surprise, were the most representative and interesting. They show changing flows throughout the process. These processes should be analysed with more attention in longer texts. The low percent of time that negative emotions were measured is consistent with the high level of engagement and attention. This work opens up the possibility for objective parametrical evaluations of emotional components during the teaching-learning process.

REFERENCES

Azari, B., Westlin, C., Satpute, A., Hutchinson, J., Kragel, P. A., Hoemann, K., … Barrett, L. F. (2020). Comparing supervised and unsupervised approaches to emotion categorization in the human brain, body, and subjective experience. https://doi.org/10.31234/osf.io/egh2t

Barrett, L. F., Adolphs, R., Marsella, S., Martinez, A. M., & Pollak, S. D. (2019). Emotional Expressions Reconsidered: Challenges to Inferring Emotion From Human Facial Movements. *Psychological Science in the Public Interest*, *20*(1), 1–68. https://doi.org/10.1177/1529100619832930

D'Mello, S., & Graesser, A. (2012). Dynamics of affective states during complex learning. *Learning and Instruction*, *22*(2), 145–157. https://doi.org/10.1016/j.learninstruc.2011.10.001

Ekman, P., & Friesen, W. V. (1986). A new pan-cultural facial expression of emotion. Motivation and Emotion, 10(2), 159–168. https://doi.org/10.1007/BF00992253

Ekman, P., Friesen, W. V., & Hager, J. C. (Eds.). (2002). Facial Action Coding System [E-book]. Salt Lake City, UT: Research Nexus.

Harley, J.M., Lajoie, S.P., Frasson, C., & Hall, N.C. (2016). Developing Emotion-Aware, Advanced Learning Technologies: A Taxonomy of Approaches and Features. *International Journal of Artificial Intelligence in Education, 27*, 268-297. https://doi.org/10.1007/s40593-016-0126-8

iMotions Biometric Research Platform. (2018). [computer software], (8.1 Version). iMotions A/S, Copenhagen, Denmark.

Izard C. E. (2009). Emotion theory and research: highlights, unanswered questions, and emerging issues. *Annual review of psychology*, *60*, 1–25. https://doi.org/10.1146/annurev.psych.60.110707.163539

Loderer, K., Pekrun, R., & Jan L. Plass J.L. (2019). Affective Foundations of Game-Based Learning. In Plass, J.L., Richard E. Mayer, R.E., & Homer, B.D. (Ed.), *The Handbook of Game-based Learning*. MIT Press.

Mellado, V., Borrachero, A. B., Brígido, M., Melo, L. V., Dávila, M. A., Cañada, F., & . E. (2014). Las emociones en la enseñanza de las ciencias. *Enseñanza de Las Ciencias*, *32*(3). https://doi.org/10.5565/rev/ensciencias.1478

Pekrun, R. (2006). The Control-Value Theory of Achievement Emotions: Assumptions, Corollaries, and Implications for Educational Research and Practice. *Educational Psychology Review*, *18*(4), 315–341. https://doi.org/10.1007/s10648-006-9029-9

Pekrun, R., & Linnenbrink-Garcia, L. (2014). *International Handbook of Emotions in Education*. Abingdon, United Kingdom: Taylor & Francis.

Solís-Espallargas, C., Escriva, I., Rivero A. (2015). Una experiencia de aprendizaje por investigación con cajas negras en formación inicial de maestros. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias 12*(1), 167-177