Visualization of Learning Process and Learner's Emotions: Current State, Limitations and Future Work

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VISUALIZATION OF LEARNING PROCESS AND LEARNER'S EMOTIONS: CURRENT STATE, LIMITATIONS AND FUTURE WORK

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ABSTRACT

In a context of learning, visualization of learners' processes and states can provide an intuitive understanding of learning processes and learning states. As a result, learners and teachers are able to take appropriate steps to improve learning.
Physiological data such as electrodermal activity and cardiac response are adopted as a non-invasive method to detect stress and emotion, providing awareness and feedback to learners. However, there is little research on sensor data visualization considering human-computer interfaces and user experience.
This paper summarizes the state of emotion visualization in a learning context and discusses limitations of previous studies on learners' experience. Design considerations based on emotion visualization are compared to design principles for user interfaces and user experience, which shows the shortcomings of current approaches to emotion visualization. We show the importance of combining design and learning considerations for emotion visualization and intervention. The paper concludes with remarks on future work.

KEYWORDS

Information visualization; Physiological sensors; Emotion; User experience; HCI

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1 INTRODUCTION

With an effective visualization of learning process and learners' emotions, learners and teacher could apprehend the learning progress directly, in addition to getting a deeper insight into the occurrence (Rushmeier et al., 1997). In a learning context, various visualizations are explored in Massive Open Online Courses (MOOCs). Most visualizations are designed mainly for teachers (Figure 1, left) and the visualizations developed for learners focus on directing learners to what to learn next (Jivet, 2016). Jivet (2016) presented the Learning Tracker which displays learners with the current learning status (Figure 1, right) by using a traditional visualization method (radial chart).

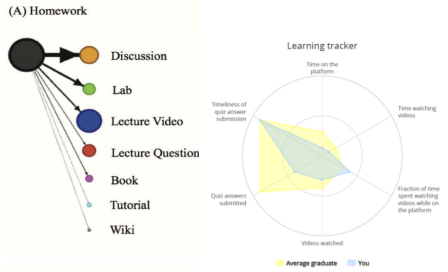

Figure 1. Visualizations in MOOCs (left: resource use (Breslow, 2013), right: learn tracker (Jivet, 2016)

Similarly, visualization methods using a learning context stem from traditional information visualizations.

However, as a visualization and a visual intervention for learners should be meaningful, easy to recognize and supportive, the traditional visualization methods widely used by researchers and analysts may not be appropriate or even effective. For example, MoodWings (MacLean et al., 2013) utilizes wearable sensors to detect stress and mirror the stress level back to users. Colorful butterflies with flappable wings were used and tested in a simulated task. The interviews with users revealed that the intervention itself was the stressor for the task. This indicates that the emotional visual and physical intervention should be ruminated to reflect user's voice and experience. As emotion visualization for learning support has not yet been investigated, this paper surveys recent studies in emotional support focusing on visualization. The aim of this survey paper is to highlight the importance of emotion visualization in a learning context and proposes future work in this topic.

2 CURRENT STATE OF EMOTION VISUALIZATION AND LIMITATIONS

Emotional states of users are generally reported by users through self-report. Using wearable sensors, emotional states of users can be derived using sensor data. When users are prompted to report their emotional state, facial images such as SAM (Self Assessment Manikin) (Bradley and Lang, 1999) are used. Similar to SAM, in Huisman and colleagues (2013), the cartoonist images with body posture are used to indicate their emotion.

Figure 2. Images used in LEMtool (Huisman et al., 2013)

However, when emotion is visualized back to users, facial images are rarely used. For example, AffectAura is designed to show users' emotional state throughout the day by using the timeline visualization with series of "hot/cold" metaphor-based bubbles (McDuff et al, 2012). Carnea and colleagues (2015) presented the metaphor-based visualization of emotion using a colored halo and outlines which is designed to interact with users.

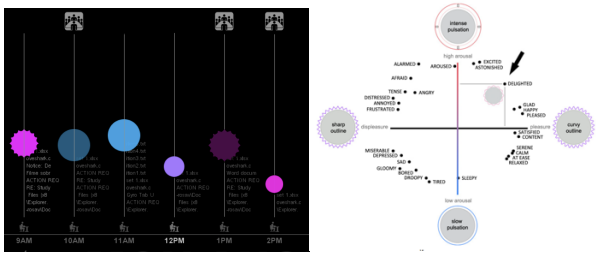

Figure 3. Visualization using metaphor (left: AffectAura (adapted from McDuff et al, 2012), right: Emotion-Prints (Carnea et al,. 2015))

In the mobile agent EMMA (Figure 2) learners are asked to input their current emotional state using the pictorial scale and the agent responds learners with appropriate facial images (emojis) and empathetic messages (Ghandeharioun et al., 2018).

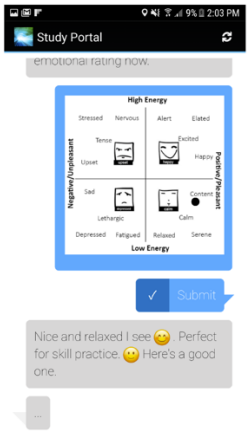

Figure 4. EMMA-Emotionally Intelligent Personal Assistant) (Ghandeharioun et al., 2018).

Most approaches to visualize emotions stem from the traditional methods of visualization including user interface and user experience design. However, the design considerations for emotional support are distinctive from the traditional user interface and from user experience design. For example, Nielsen's 10 usability heuristics (Nielsen, 1995) include mainly the pragmatic qualities which emphasize on design without errors and consistent interaction. The user experience questionnaire (Schreppe, 2018) extends the pragmatic quality by hedonic quality and proposes the attractiveness as the core area of user experience.

The design considerations of emotional visualization proposed by Carne and colleagues (2015) include pragmatic qualities such as generality, simplicity, distinguishability and intuitive visuals. However, context appropriateness, correspondence to users and emotional support areas are not easy to fit under the umbrella of neither design principles nor scales.

Furthermore, Yun and colleagues (2017) proposed the design consideration of a learning companion as 1) human fellow learner, 2) positive learning experience, 3) instructional benefits, 4) task and non-task-oriented messages, 5) simple and stylish visuals, 6) correspondence to learners, 7) dialogue initiation and 8) force reflection, which may fit under the hedonic quality of a user experience scale, yet with immense reduction.

3 DISCUSSIONS

Visualization provides useful information intuitively along with an opportunity to look deeper into the phenomena. As emotions play an important role in learning, visualization of emotional state not only provides learners with awareness of their states but also supports them to regulate their emotion.

Our study focused on a few studies that attempted to visualize emotional states using a metaphor-based visualization and traditional methods. We have found that the studies which investigate emotion visualization are not prominent in a learning context. Furthermore, when comparing the design considerations rooted from a learning perspective with the ones from a design perspective, it was observable to see the difference in principles and also in details.

Affordable wearable sensors have been investigated rigorously for emotion detection, but there is a lack of guidelines for visualization and interventions which communicate and interact with learners.

Based on our study, we remark a few important aspects to account when designing a visual intervention as a learning support.

First, design considerations for emotion support for learners should not start from the traditional design principles or scales yet, it should stem from learners' perspectives and experiences. To do this, understanding learners in various contexts should be considered and reflected in the design process.

Second, design and pedagogical support should be combined in design considerations for emotion visualization. As both approaches have strengths in different areas and both have their stronghold, not only the design aspects but learning aspects should be considered and an iterative user-centric approach should be taken.

4 CONCLUSION

As previous studies on emotion visualization for learning support have not been explored extensively, to authors' knowledge, we have only considered few studies in emotion visualization for this short paper. However, we analyzed previous visualization methods in emotion and derived the implications for future directions of visualization of emotion which can reflect learners' needs and experience emphasizing on both design and pedagogical approaches.

Our future study will entail extensive reviews of user-centered emotion visualization as a learning support from 1) design approach, 2) pedagogical approach and 3) data visualization approach.

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