Communicating Emotions During Lectures

Arsalan Ali Sadiq and Georgios Marentakis[a]
Department of Computer Science and Communication, Østfold University College, Halden, Norway

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Abstract: Teaching and learning are processes that generate a wide range of emotions in both students and lecturers, which are often kept private and not expressed in the classroom. Emotions may arise in the classroom or auditorium because of the material being taught, the way it is taught, the interaction with fellow students or the lecturer, as well as other factors such as the physical conditions of the lecture room. In the classroom, emotion is primarily communicated in an covert way, as in the gestures or the speech of teachers and students which may not be sufficient for good communication, as for example, in large auditoria or during online teaching. In other cases, the emotional load itself may hinder the expression of students and teachers. We report here on the results of applying a user-centered design approach to the design and development of a system that allows students to communicate emotion during the lecture in an efficient way, while the lecturer monitors and responds to them in real-time. Our findings suggest that students are interested in a cross-platform application that can be run on both their laptop and mobile devices. Furthermore, they wanted a solution that would not distract them from the lecture and that they could use effortlessly. Based on the evaluation of a prototype, the overall feedback shows that the system we developed appears to be promising and the system's operation causes no disruption or concern while listening or delivering the lecture.

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1 INTRODUCTION

Emotion is an ever-present part of our lives, influencing almost every aspect of our actions. Emotion is critical in education and learning-related research, where it has become clear that various links exist between emotions and learning (Pekrun, 2014; Sagayadevan and Jeyaraj, 2012; Tyng et al., 2017). In this sense, classrooms are emotionally and psychologically charged environments. Emotions in the classroom can be triggered by the content being taught, how it is delivered, fellow students or the instructor's responses, and other factors such as the classroom environment. Emotions are essential from an academic standpoint due to their impact on learning and progress, but learners' emotional health can also be viewed as an educational goal. When students have a better learning environment, appreciative emotional experiences and academic achievement may be increased (Munoz and Tucker, 2014).

Communication of emotion in the classroom happens, however, mostly in covert ways and emotion is mostly encoded in speech or gestures of students and teachers. In some cases, as in large auditorium, the physical setup hinders the communication of emotion, due to low visibility or audibility. The same is the case in smart tutoring systems or online classes, which are becoming increasingly popular (Tyng et al., 2017). Even though exposing students to real-time e-learning, aims to increase student engagement, communication, in particular this of emotional cues, is arguably worsened in such settings. In other cases, the teaching style of a lecturer may result in that emotion is outside the focus. Importantly, emotional load itself may make it difficult for students or teachers to express themselves.

Systems that support the communication of emotion may thus prove to be helpful for both physical and online teaching. Most systems targeting emotions in the classroom work using machine learning techniques to automatically recognize students1 emotions. Even if effective, these often recognize a limited range of emotions and require physiological or optical signals from the users which may be cumbersome but also can cause privacy issues. In this paper, we contribute by presenting the results of applying a user-centered design approach (Preece et al., 2015) to understand users and design a system providing students the ability to communicate their emotions in the

[a] https://orcid.org/0000-0002-6563-9601

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classroom and teachers to monitor these emotions and react accordingly.

2 LITERATURE REVIEW

Emotion emerges as the coordination of multiple subsystems or elements, each of which relates to one or more of the typical expressions of emotional experiences, such as feelings, physical changes, or facial expressions. It is possible to differentiate between moods and emotions. Moods typically endure for longer periods, but they are frequently weaker and their origin is uncertain. On the other hand, emotions are frequently more intense, last shorter periods, and have a specific object or cause (Frijda, 1993). Emotions can be measured using convergent measurement, which involves assessing all component changes: ongoing adjustments to evaluation procedures at all levels of central nervous system processing, the neuroendocrine, autonomic, and somatic nerve systems' reaction patterns, and shifts in motivation caused by evaluation results, particularly in terms of action propensities, body motions and patterns of facial and vocal expressiveness, and the character of the subjectively experienced emotional state (Scherer, 2005).

Emotions are commonly described either by using categories or by using dimensions. With categories, emotions can be specified using emotion-specific terms or class labels such as: rage, contempt, terror, pleasure, sorrow, and surprise or domain-specific expressiveness categories such as tedium and bewilderment. Each emotion has its own collection of characteristics that indicate inciting situations or behaviours. Emotions can also be described using dimensions, typically two (valence and arousal) or three (valence, arousal, and power). The valence component of emotion determines whether it is positive or negative and extends from painful sensations to pleasant feelings. The arousal dimension describes the amount of excitement depicted by the feeling, which might vary from lethargy or tedium to intense exhilaration. The power dimension represents the degree of power, such as emotional control (Mauss and Robinson, 2009).

A variety of tools for measuring, reporting, recognizing emotions exist, ranging from surveys, and various self-reporting schemes to automatic recognition based on facial movements or physiological data (Mauss and Robinson, 2009). In human computer interaction, common procedures involve the self-assessment manikin (SAM) (Bradley and Lang, 1994), the Geneva emotion Wheel (Scherer, 2005), the Circumplex Model of Affect (Russell, 1980), but also sliders for valence or arousal (Laurans et al., 2009; Betella and Verschure, 2016), or referring to photographs (Pollak et al., 2011). Recently, there was criticism against using emotional categories or underlying dimensions to measure emotion as these approaches do not take into account the embodied, dynamic, and social nature of the emotional experience (Boehner et al., 2007; Sengers et al., 2008). Tools were proposed that allow users to express their emotion in an interactive way by drawing, pressing, touching, or using other modalities (Höök, 2008; Isbister et al., 2006; Ståhl et al., 2009; Chang et al., 2001). Automatic recognition of emotion is also quite common in affective computing (Kort et al., 2001; Picard, 2000) and has been applied in several setting involving physiological models, facial expression, movement, voice cues, and other modalities.

Emotions in the Classroom are quite common as a result of learning and interacting. Various forms of positive and negative academic emotion categories have been identified such as pride, optimism, pleasure, relaxation, thankfulness, and appreciation as well as weariness, embarrassment, anxiousness, despair, sorrow, despair, and disdain (Subramainan and Mahmoud, 2020). Understanding students' emotional and behavioural issues in classrooms requires the consideratio of teacher-student encounters, social competence, and learning environment setting (Poulou, 2014). (Sagayadevan and Jeyaraj, 2012) explore the connection involving the instructor and student communication, emotional commitment particularly effective emotions displayed inside the lesson, and academic results like student performance and accomplishment. (Brooks and Young, 2015) centered on instructor style of communication as a determinant of student academic experience. (Mazer et al., 2014) have discovered links among instructors' communication patterns and students' emotional responses.

Smart classrooms often use tools to enhance the communication between students and teachers. One variety are clickers, which are essentially classroom response systems that may employ simple button interfaces or advanced wireless handheld transmitters to collect student votes and transmit data via infrared signals (Siau et al., 2006; Lantz, 2010). Clickers instantly gather and compile student responses, and then display the aggregated results in the classroom. Graphical but also tangible systems have also been proposed such as the ClassBeacons system uses scattered lighting to indicate how instructor divide their attention among students in the classroom (An et al., 2019). Some systems target communication of emotion in some capacity. These can be classified as these

using automatic or direct communication of emotion. In automatic communication of emotion, data from digital backchannel systems (Jiranantanagorn et al., 2015), wireless sensors (Di Lascio et al., 2018), agent-based systems (Ahmed et al., 2013), or cameras (Sharmila et al., 2018) are used for emotion recognition and automatic emotional communication. The Subtle Stone (Alsmeyer et al., 2008) is a portable gadget that allows students to express their emotions to their teachers by utilizing seven different colors that stand for seven different emotions. The instructor's interface employs a Subtle Stone to portray all learners as separate person-shaped entities. A messaging system that displays the person's emotional condition via animated vibrant text was demonstrated in (Wang et al., 2004). It utilizes a two-dimensional visual display to show conversational animations and data. This displays graphics for certain words or phrases. Findings from an experiment performed in an online educational context indicate that a UI that provides feelings and emotions allows online users to engage with one another more effectively.

Summary. Emotion is an intensively studied phenomenon which is known to have a large impact on student's learning and success. Arguably providing ways to enhance the communication of emotion in the classroom would improve the quality of students' learning experience. And vice-versa bi-directional communication could help teachers also communicate emotions in the classroom in more flexible ways.

The review above indicates that mostly automatic methods for recognizing emotion have been used in the classroom. Even though these are important, they often face significant problems as they have a restricted number of emotional states and use sensors or cameras which may prove cumbersome or pose important privacy concerns. Direct reporting of emotions, on the other hand, is more promising in this respect, however, it has not been studied extensively. In particular, the wealth of methods for direct communication of emotion in the literature have not taken into account neither the potential of different interaction techniques. Emotion can be expressed through categorical, dimensional, or interactional input interfaces. In a categorical interface emotions are selected using categories, in a dimensional interface emotions are reported using dimensional spaces, and in an interactional interface emotions are expressed by drawing/interacting with a representation on a screen or an object. Furthermore, systems for the direct communication of emotions may be graphical or tangible. The potential of these emotion input spaces and interaction techniques has not been investigated in the context of communicating emotion in the classroom.

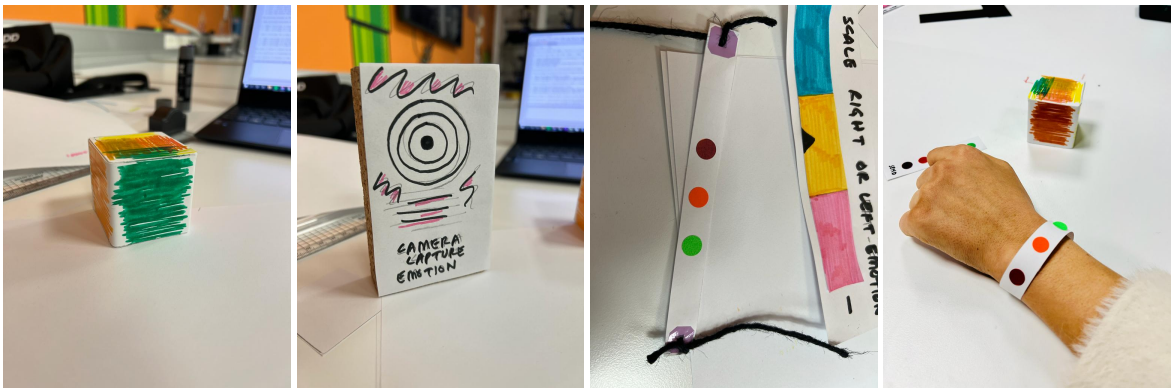
This is what drives this work. By applying a user-centered design approach (Preece et al., 2015), feedback is obtained about different methods for communicating emotion and different approaches to system design. In particular, we look into how different interaction and emotion input methods in the literature are perceived by users for the purpose of communicating emotion in the classroom. Subsequently, we integrate the feedback we received and design a prototype which we evaluated. The evaluation aims to help us understand whether the selected interaction method and interaction type can be successfully used to communicate emotions during the lecture and whether it allows lecturers to monitor student emotions during the lecture. The design process involved: 1) gathering requirements, 2) designing alternatives and prototyping, and 3) evaluation. All the participants are provided informed consent in accordance with regulations of Norwegian Centre of Research Data (NSD).

3 INFORMING

During this phase, we obtained early feedback on appropriate interaction methods (graphical or tangible) and emotion input techniques (categorical, dimensional, or interactional) for designing systems for communicating emotion in the classroom. The process consisted presenting participants with a presentation and relevant paper prototypes followed by an interview with two phases and a focus group. The first phase of the interview was about getting general feedback and focusing on the interaction method and the second about getting feedback on the emotion input technique. A total of five participants (all university students, 3 male, 2 female) participated. The focus group was run in order to contrast participant opinions but also in order to understand better the implications of the social aspect of communicating emotions in the classroom.

The *presentation* presented the concept of emotion as well as the possibilities offered by systems communicating emotion in the classroom. Furthermore, several examples of how different graphical and tangible interaction methods can be used to communicate emotion were provided drawing on the existing literature. These were also illustrated by *paper prototypes* which demonstrated how different interaction methods could be used to communicate emotion (see also Figure 1).

The first phase of the interview was more general and questions investigated the source of participant's emotions in the classroom and whether participants wanted to express these. Participants were also asked



(a) (b) (c) (d)

Figure 1: Paper prototypes used in the study. a. ambient light to display emotional response, b. camera prototype to detect emotion through facial expression, c. smart band and a scale to send emotion, and d. participants of the study examining different paper prototypes.

to describe relevant situations and whether they believed a system for communicating emotions would be helpful. Subsequently the focus shifted on obtaining feedback on the appropriateness of graphical or tangible user interfaces for communicating emotions. The second phase focused on emotion input techniques. To this end, participants were presented with paper prototypes of categorical, dimensional, and interactional interactions for graphical or tangible interfaces focusing on their interaction method preference (see Figure 2). In the focus group, we asked participants to discuss and argue about their chosen method but also reflect on how well it can adapt to the social aspects of the teaching and learning.

Results. All participants reported aspects of the learning material, process, and environment as the main source of their emotions (i.e. state rather than trait emotions). All participants agreed on the importance of being able to express their feelings during lectures. They reported on numerous occasions in which they wished to communicate their emotions in some way but were unable to do so due to feeling shy, embarrassed, or discouraged. All agreed that a system for communicating emotion would contribute much to solve this problem.

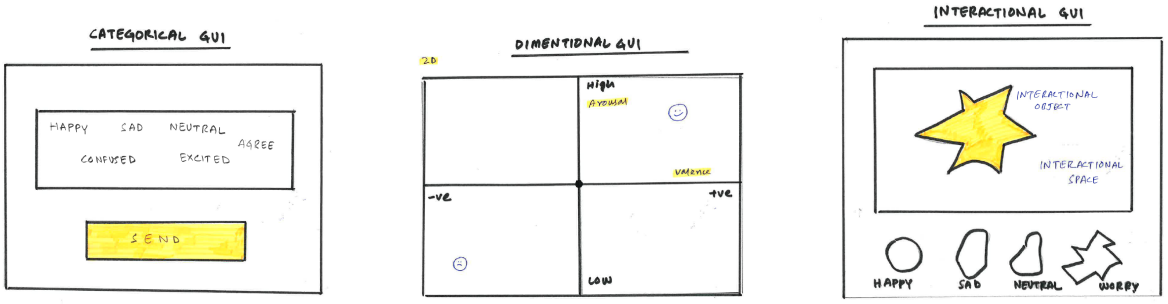
Most participants preferred a GUI-based solution because they found this is simple and quick to interact with, not distracting, less noticeable, and providing good privacy and possibilities for concealed communication. They felt that interacting with a tangible system can be distracting, perhaps also noisy, and likely easily noticeable by others. It seems that speed, simplicity, and privacy is favored by participants. The GUI-based approach was also favored because it could be used both when taking notes on a laptop but also when interacting with a mobile phone. Concerning interaction type, it appears that participants preferred categorical and dimensional interfaces. They found selecting appropriate arousal and valence to be an easy task. Participants favoured multiple emojis to choose from, personalized profiles and emotional feedback history, and comment boxes with templates, as well as the possibility to provide input in an anonymous way. The results seem reasonable considering that the primary goal of students in a classroom is to listen to the lecture and not get involved in lenghty interactions. The often private nature of emotions seems to also influence participants responses.

4 DESIGNING AND PROTOTYPING

Based on user feedback, a number of user scenarios and stories were developed based on the requirements to help us understand better user feedback and possibilities for design. Different design sketches were also made to elaborate on the requirements. Subsequently we decided to concentrate on prototyping a graphical cross-platform prototype including a student and a teacher view.

The student view (Figure 3 (a)) supported anonymous or named input and provided an emotion input space containing two dimensions with relevant emotions placed on its circumference. The interface resembled this of the Geneva Emotion Wheel (Scherer et al., 2013) and contained a 12-scale emotional wheel with 4 intensity values, ranging from 1 to 4, for each emotion. The student can select an emotion from the wheel as well as its intensity, 1 being the lowest and 4 being the highest. We adopted the emotions used in (Kort et al., 2001).

The teacher view had a real-time screen and a



(a) Categorical (b) Dimensional (c) Interactional

Figure 2: Design sketches based on different interface types.

summary screen. The real-time screen showed arriving emotions on an ambient color display background whose color changed based on the average emotional response (using a green to red colour gradient based on the emotional responses). When a student sent an emotion, the emotion appeared on the teacher's screen for a few seconds before disappearing. A detailed view was also available for the lecturer, supporting analysis and reflection on student input. This view displayed all the emotions received, user names, etc in tabular form in the order they were received and a graph showing emotions based on their time of arrival during the lecture (see Figure 3).

React JavaScript was used to develop a cross-platform application that could run both on PC and Mobile. React was chosen due to its modularity and ease of use. A firebase database was used on the back-end to store emotional responses and other related data used in the application.

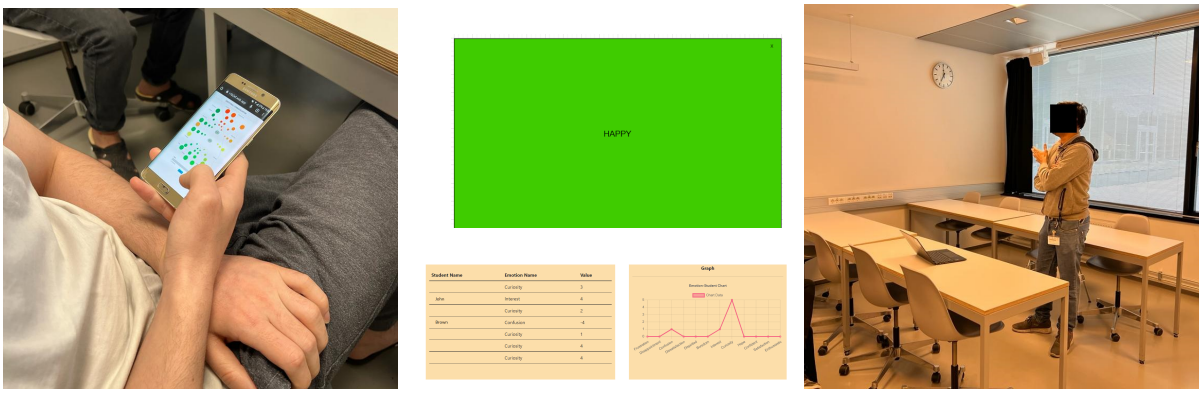
5 EVALUATION

A realistic situation was set up in order to evaluate the system and investigate the effectiveness of the design choices for students to transmit and for teachers to observe students' emotions in real-time (see Figure 3. In particular, we wanted to observe hwether the selected emotion input technique and interaction method was usable for students but also for monitoring and reviewing student emotions by the lecturer. The intention is not to provide or analyze data about student emotions during lectures.

Five students and a professor from the school's IT department participated in the evaluation. Evaluation was done in a lecture room in which the professor lectured on a topic related to machine learning while the students followed. Before the lecture began, the prototype was installed on the computers and smartphones of the participants. During the lecture, users used the prototype on their smartphone or their PC. Some communicated emotions using their laptop computers while taking notes and some using their mobile phones. The first author sat in the room and observed the users. The students were completely focused on the lecture most of the time, but occasionally sent emotional responses through the application when some terminology in that topic was unclear or when something appeared very interesting. When the teacher went into greater depth about the topic and discussed the more technical aspects of Long Short Term Memory networks, for example, students' facial expressions changed and students appeared to be concerned and students focused on their laptops. The emotional response log showed this change with negative emotions communicated during this time. Most of the students used their laptops to take notes and send emotional responses, and one student occasionally used his mobile phone during the lecture period to send emotional responses. The teacher was mostly delivering the lecture, but he would occasionally glance at the real-time screen to see the average emotion of his students. The teacher also went to the detail version of the screen after the lecture to reflect on the total number of emotional responses and to analyse the overall class emotion during the lecture.

Both students and the lecturer provided feedback after using the system in the classroom using a questionnaire. In the questionnaire, they rated how easy it was to use the system during the lecture and whether they had any difficulties interacting with the system, whether the system fulfilled their need of sending emotion, whether it was easy to send appropriate emotional responses, whether it was comfortable to use the system in front of other students, and whether there was any additional functionality they would like to add to the user interface.

All participants found the system to be easy to use and effortless and had no particular difficulties. They also mentioned that the system fulfilled their emotional communication needs to a great extent. Fur-



(a) (b) (c)

Figure 3: Prototyping and evaluation: a. student using his mobile device to evaluate the system, b. teacher screens both real-time and detailed version, c. lecturer during evaluation.

thermore, they did not feel the system invited unwanted attention or disturbed in any way. The selection of emotions to chose from was adequate for most participants, however, some mentioned needing more time than expected to find emotions in some cases. Users mentioned they were comfortable with using the system in front of others. As additional functionality they recommended: a larger text box to send messages to teachers to explain the emotion better, inclusion of more options for emotions for more in-depth precision of emotional communication, one-click option for sending emotion, and that missing emotions could be added by an additional button etc.

The lecturer also responded to a number of questions related to how easy it was to monitor the real-time screen, the extent to which the graphs helped understand and analyze student emotions, how often they looked at the screen, and their impression about the emotional state of students during the lecture. The lecturer monitored the student emotion every 3-5 minutes and found that the real-time view supported easy and quick monitoring of the students' emotions and also a feeling about the overall atmosphere of the classroom. Lecturer responded that the detail version of the screen helped a lot to analyse the students' emotions in more detail and in understanding how it can be possible to adapt teaching. However, the teacher mentioned that they would like to participate in a larger scale evaluation to become able to commend more specifically on how such a system may affect teaching and learning. They also suggested to provide support for specifying thematically the lecture moments and provide better possibilities to browse emotions over time.

6 DISCUSSION

Motivated by a desire to improve the communication of emotion during lectures, we investigated the literature in order to understand how emotion may be communicated in the lecture hall. Our investigation showed that categorical, dimensional, or interactional input methods have been suggested for communicating emotion. Furthermore, it also showed that mostly graphical and tangible interaction techniques are being used in smart classrooms. To understand better, how users react to different combinations of the aforementioned interaction types and methods we created paper prototypes and performed interviews and a focus group with students.

The results showed that users tend to prefer a graphical system as it is fast to use and does not expose their reactions to fellow classmates. Furthermore, users seem to like categorical or dimensional interfaces for communicating emotion as they are less willing to engage in more lengthy interactions or contemplate on their emotional state during lectures. Based on this feedback, we created a graphical system using which students can communicate their emotions using an emotion wheel type interface. We also provided a cross-platform graphical interface so that a lecturer can monitor each arriving emotion, the tendency as this emerges by averaging received emotions, and a detailed view for the emotions received. The evaluation showed that this combination of interaction method and emotion input technique provides an easy way to communicate emotions in the classroom. The lecturers also found the received information relevant and likely useful in planning their future lectures. We also received several suggestions for additional features which we plan to integrate in an ex-

tended version of the system that will be evaluated on a larger scale.

Despite the small scale, this study is encouraging with respect to the potential of systems for directly communicating emotions in the classroom. Such systems seem to be favoured by students and teachers and to be able to enhance communication during lectures. We are motivated to expand on this research, and design a larger scale study by involving more students and lecturers in order to understand better the potential of this system in affecting teaching and learning. Furthermore, we are interested in investigating other interaction techniques, such as ambient displays, which were not in the focus of this study. The resulting system can also be used to help understand better the development of emotions in the classroom or the lecture hall and the interaction between teacher behaviour and student emotion (Zembylas, 2007; Titsworth et al., 2013). In addition, it can help study the cultural aspects of emotion development across the world.

7 CONCLUSION

In this article, a user-centered design approach was applied to design and develop a system using which students can communicate their emotional states to lecturers during lectures. The feedback we received showed that students are looking for something quick and easy which does not interfere much with attending to the lecture or makes their emotions visible to unwanted receivers. A GUI providing the ability to select emotions arranged in a two-dimensional space seemed to be quite appropriate for this application, as was also confirmed by the evaluation we performed. The overall feedback shows that the design we propose is promising and can potentially help deliver a better teaching and learning experience.

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