Østfold University College

COMMUNICATING EMOTIONS

DURING LECTURE

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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 reactions of fellow students or the lecturer, as well as other factors such as the physical conditions of the lecture room. Feedback between students and lecturers is typically given verbally, with no communication of underlying emotions. This may make it difficult for students or lecturers to assess the significance of underlying issues and comprehend the reasoning behind various student comments. As a solution to this problem, this report describes the design, development and evaluation of a system that allows students to communicate their emotions during the lecture while the lecturer monitors and responds to them in real-time.

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Chapter 1 Introduction

Emotion is an ever-present part of our lives, influencing almost every aspect of our actions. (Scherer, 2005) described emotion as an episode of interrelated, synchronized changes in the states of all or most of the individual's five subsystems in response to the evaluation of an external or internal stimulus event as relevant to the major concerns of the organism. It is possible to think of emotions as occurring on different timelines, with responses lasting a few moments or minutes, emotions lasting a few hours or days, and dispositions lasting a few decades or a lifetime. Typically, emotion has been measured in two ways: directly by self-report i.e., questionnaires presented after an experience that ask the user to assess their emotions about what happened, and indirectly by inference, analysis of filmed sessions with users that often combine the interpretation of think-aloud comments with decoding other emotional clues like a smile, gestures to form an impression of the user's emotional reactions. Several biometric methods have emerged in recent years, such as monitoring galvanic skin reactions, detecting minute movements of the facial muscles, and tracking mouse pressure. These signals give a complex record of the user's emotions and behaviour, which many in our society are still struggling to grasp entirely. Recently, interfaces and systems that evoke emotions like joy or irritation have sparked a lot of curiosity. However, there is no universally acknowledged method for measuring emotional reactions. Emotion measurement methods are thus required so that designers of emotion-relevant systems and products may listen to their consumers and change their designs depending on their emotional responses. Emotion measurement and investigation have recently been famous in education and learning-related research, where it has become clear that various links exist between emotions and learning.

When we discuss classrooms, they are emotionally and psychologically charged environments. Classroom emotions 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. During teaching and learning, the teacher, and the student experience various emotions, but they are typically kept to themselves and not voiced in front of the class. When it comes to learning, emotional experiences play a huge role since they affect almost every element of intellect in the brain. Improving the quality of students' educational experiences includes assessing their cognitive and emotional states throughout the lecture and changing instructions on the go to enhance understanding and develop a complementary approach toward education (Lujan et al., 2021). It is common for students to feel frustrated, anxious, or uninterested when they are confronted with quizzes, exams, or a topic that they do not fully understand properly. Distance learning and digital teaching media reduce physical contact and further degrade emotional communication. We need systems that support interpersonal communication in education (Poulou, 2014). Learners' concentration, desire to study, learning strategy selection, and self-regulation of learning are all affected by emotions. Several studies have shown that human cognitive abilities, such as attentiveness, memory and learning, rationality, and problem-solving, are impacted by emotional states (Um et al., 2012). 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 (Munaz and Tucker, 2014).

Emotion is equally crucial in classrooms. As technology increasingly permeates classrooms, opening the path for smart education. Smart tutoring systems and hugely

popular online classes, which will eventually replace conventional in-person learning settings, have grown in popularity in academia (Tyng et al., 2017). On the other hand, utilization of cutting-edge technology and software to enhance student learning and teaching, the concept of the "smart classroom" has gained popularity. By exposing students to real-time e-learning using audio-visual aids, multimedia, photographs, web conferencing, PowerPoint presentations, and two-dimensional visualizations, among other things, these classrooms aim to increase student engagement. Regardless of a student's understanding level, lessons will reach all students fairly. Using this form of training in the classroom enhances student-teacher contact, student-student interaction, and student involvement with the lecture topic. When the student-teacher relationship improves, pupils have a better feeling of self-worth (Nyadanu et al., 2015), which boosts their learning experience in the classroom. It will also enhance students' mental and physical well-being while improving their academic achievement. Farr-Wharton et al. (2018) performed research in which students at an Australian institution engaged in a study that explored the effect of lecturer-student contact. When demographic and socio-economic factors were taken into account, the data revealed that student participation and learning satisfaction completely influenced the student-lecturer relationship and intention to leave university. The student-to-student interactions will improve teamwork and cooperation, which are the main goals in education. Students will be more engaged in the class and their academic performance will increase because of the student-content interaction. Student-to-student interactions will increase collaboration and cooperation, which are crucial educational goals. Because of the student-content interaction, students will be more interested in class and their academic performance will improve.

To effectively communicate emotions between students and teachers during the lecture, to help the instructor teach more efficiently, and make the environment more conducive for teaching and learning, we must design a system based on principles of user-centred design in HCI and the baseline methodology provided by (Kurniawan S. 2004). (Issa and Isaias, 2015) discussed that system usability and user-centred design are becoming more crucial components of the software development process to improve and increase system capabilities, while also satisfying users' requirements and desires. Most emotion evaluation systems have weaknesses: they are lengthy questionnaire-based processes that are frequently employed exclusively at the beginning and end of the study. Several automated and direct methods based on sensors, artificial intelligence, cameras/videos, sliders, and measuring devices, among others, are also utilized for measuring emotions. However, it is well recognized that emotional state varies considerably over time and that emotion recollection is limited and usually distorted. The efficiency of many research investigations is jeopardized because of this disparity between reality and measurement. To address this difficulty, according to the research, a tool that (1) reliably analyses emotion, (2) is unobtrusive and pleasant enough to be delivered regularly, and (3) can be administered in any location is necessary to address this difficulty. This work focuses on self-reporting emotions and a better understanding of emotion measurement in real-time and without any obtrusion.

1.1 Research Questions

The purpose of this study is to design, build, and test a system that allows students to communicate their emotional reactions with the instructor. A central aspect of this study is

which interaction method is best to send emotions, and how students and teachers would feel when using such system during the lecture. Therefore, I present the following research questions below.

Research Question 1 What interaction methods can be used to communicate emotions during the lecture?

Research Question 2 Which type of interaction method is best to communicate emotions during the lecture?

Research Question 3 How useful the selected interaction method is to send emotions during the lecture?

Research Question 4 How useful this system would be for teachers, to monitor student emotions during the lecture?

1.2 Thesis Outline

Chapter 1 introduce the research topic, background, and motivation. Additionally, the research questions and the problem statement are discussed in this chapter.

Chapter 2 mentioned the related research under literature review.

Chapter 3 explains the methodology used to design and develop the system.

Chapter 4 describes the requirements gathering phase. It talks about the different informing sessions performed with the research participants to get the final design requirements for system implementation.

Chapter 5 discusses different design alternatives and how I reached to the final system design.

Chapter 6 discusses the final system's implementation and prototyping.

Chapter 7 discussed about the evaluation process. The results which came after the evaluation session.

Chapter 8 discusses the results and positive and negative aspects of the research.

Chapter 9 concludes the research.

Chapter 2 Literature Review

Emotion is a complex concept that has been handled in several different ways. Consider emotions as the coordination of multiple sub-systems 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. In psychology, an emotion is described as a state of thinking that creates psychological changes, which in turn cause bodily changes that mirror one's ideas and behaviour at the time. The key psychological elements that influence emotional states are persona, morality, temperament, and motivation. (D.G. Myers, 2004) mentioned that human emotions involve "... arousal of the body's systems, communicative actions, and cognitive experience." According to (Scherer, 2005), an emotion can be completely measured using convergent measurement, which involves assessing all component changes. The component changes are as follows: 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. Such extensive emotion measurement is expected to become a regular practice in the foreseeable future.

Emotions are unavoidable in all forms of communication. Emotions has been explored for decades by researchers, and various schools of psychology has developed numerous ideas for expressing various approaches to comprehend emotional states. The major emotional theories can be divided into three types: physiological theory (James-Lange Theory of Emotion (W. James, 1884), Cannon-Bard Theory of Emotion (W.B. Cannon, 1927)), neurological and cognitive (Cognitive Appraisal Theory (R.S. Lazarus, 1970)). Physiological theorists suggest that emotions are caused by answers within the human body. According to neurological theories, actions inside the brain cause emotional reactions. Finally, cognitive theories contend that thoughts and other brain activities are important in the formation of emotions.

The categorical model and the dimensional model are two separate ways of describing emotions. In Categorical model, emotions are identified using emotion-specific terms or class labels. The categorical paradigm employs either the six fundamental emotion classification of rage, contempt, terror, pleasure, sorrow, and surprise or domain-specific expressiveness categories such as tedium and bewilderment. This model contains both significant and irrelevant emotions. Each emotion has its own collection of characteristics that indicate inciting situations or behaviours. Most of the affective computing research has focused on the six fundamental emotions outlined above. The Dimensional model, on the other hand, denotes effects in three dimensions. In this approach, a common set of dimensions connects the many emotional states. They are characterized in a two-dimensional (valence and arousal) or three-dimensional (valence, arousal, and power) space. This category includes all emotions. 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 influence dimension represents the degree of power, such as emotional control.

Previous research has resulted in the development of a variety of tools for measuring emotions, ranging from surveys to facial movements, coding schemes to psychological and physiological procedures. Aside from such technologies, a variety of interfaces, including informative, interactive, and dimensional interfaces, are designed to assess emotions. The majority of these techniques are usually restricted to one aspect of emotion. Self-reports, for example, probe our subjective feelings, and whereas psychophysiological approaches detect bodily effects caused by emotion, and other strategies are centered on regular expressive behaviour. Several studies have recently attempted to integrate multiple methodologies to provide a more comprehensive evaluation of emotions when using mobile phones or gaming experiences. In this chapter, I looked at background research such as current studies and the relationship between emotions and learning, the concept of smart classrooms, self-reports, psychophysiological techniques, and other different methodologies and interfaces for measuring and evaluating emotions.

2.1 Emotion and Learning

Emotions have a tremendous influence on academia and accomplishment. These emotions may be both favourable and unfavourable, as well as powerful and constant. Students' attentiveness, enthusiasm, use of instructional methods, and self-regulation of learning are all influenced by positive and favourable emotions. Negative or unfavourable emotions also have an impact on learning through influencing students' focus, engagement, use of educational tools, and self-regulation of learning. It is critical for teachers to comprehend and respond to the emotions that students are experiencing. Teachers should be able to communicate with students on an emotional level due to some of the mentioned reasons:

- It will help instructors to reduce negative emotions in students and to create a classroom environment in which they may redirect the energy created by negative emotions towards studying (Goetz et al., 2013).
- It will help teachers boost students' enjoyment of learning and excitement for learning new things to deliver high-quality classes (Pekrun, 2014).
- It will help teachers and students to improve their behavior, as will their classroom interactions (Hagenauer et al., 2016).
- It will help students learn and improve their academic performance.
- It will help instructors to assist students to build ambition and skills by generating task-related positive sensations through effective emotional communication.

Based on the past research the following studies show a significant link between emotions and learning.

In 2020 (Subramainan and Mahmoud, 2020) carried an extensive examination of emotions in academic settings. Various forms of academic emotions have been identified, which may be divided into positive and negative categories. With positive emotions comprising pride, optimism, pleasure, relaxation, thankfulness, and appreciation and negative emotions include weariness, embarrassment, anxiousness, despair, sorrow, despair, and disdain. Teachers' emotions are impacted by two distinct environments: external, such as job stress and bad working conditions, and internal in the classroom, such as the behaviour of students. Whenever a lecturer's learning aim is attained, or when their

pupils follow guidelines, they may feel a sense of accomplishment. They get upset and disappointed, though, when kids demonstrate a shortage of commitment to comprehend and rage with their conduct. However, students' emotions are triggered solely by variables inside the classroom, such as instructors' emotions, off-task conduct, marks, indifference, and so on. Learners express more negative emotion when instructors lack spontaneity or are imprecise and display difficulty communicating and vice versa. Negative emotions had a greater influence on students' performance levels.

Homeostasis is described as any self-regulating process through which biological systems aim to maintain stability while adapting to events favourable to survival. In 2021, (Lujan et al., 2021) present homeostasis as a fundamental principle of physiology and education. The ability to read learners' comments, gestures, and body posture in actual environments is essential to creating fruitful educational experiences. Attending to students' queries and remarks, and analysing their intentional or inadvertent nonverbal cues, enables teachers to understand students' emotional and cognitive conditions. Teachers must therefore be conscious of their students' cognitive and emotional states throughout the class utilizing educational homeostasis to foster understanding and favourable attitudes towards education.

Encouraging teacher–student communication has a significant role in a pleasant classroom setting, reducing discipline issues, learners' attachment to education, and their anticipated social and academic accomplishments. In 2014, (Poulou, 2014) suggests a theoretical framework for understanding students' emotional and behavioural issues in classrooms by considering teacher-student encounters, social competence, and the setting of the learning environment in which they are taking place. The study showed that the teacher-student relationships are distant due to the discouraging or unpleasant teacher's comments and behaviour, lack of students' acceptable social capabilities, and the lack of freedom and motivating activities in the classroom setting, learners report increased emotional and behavioural challenges. For students with behavioural and social issues, the emotional intensity of teacher-student relationship may have a significant impact on their perspectives.

Students' emotional responses to low achievement remarks from an instructor are impacted by the cultural-educational context (Hansen and Mendzheritskaya, 2017). The study conducted in Russia, Germany, and the United States, according to research published showed a psychological transmission between teachers and students, with respondents believing that a student feels rage when his instructor is angry and vice versa. Clearly, students' responses to emotions displayed by university lecturers can be affected by educational and contextual settings, and such emotions might impact students' learning behavioural.

In 2012, (Sagayadevan and Jeyaraj, 2012) explore the connection involving instructor and student communication, emotional commitment particularly effective emotions displayed inside the lesson, and academic results like student performance and accomplishment. Though emotional involvement did not fully regulate the route among lecturer-student contact and academic performance, it did somewhat influence the lecturer-student relationship and student's learning. In 2014, (Mazer et al., 2014) have discovered links among instructors' communication patterns and pupils' emotional responses. A student's unfavourable emotional responses are likely to be exacerbated when the instructor is slow to respond or imprecise. Social benefits from the instructor and a projected need for emotional work in the classroom are key mediators in such results.

(Brooks and Young, 2015) centred on instructor style of communication as a determinant in students' academic experience. According to the findings, student emotion was influenced by a variety of factors, including teacher appreciation, positive behavioural -

altering methods, linguistic timeliness, and internet presence. When it comes to students' feelings in online classes, students' judgments of instructors' linguistic spontaneity and involvement in the curriculum strategies were proven to be the most relevant. The impact that an instructor's linguistic proximity may have on students' emotions of encouragement and favourable attitude toward the classroom and the instructor is enormous. Students will have favourable academic feelings if the teacher's communication conduct is pleasant. This research concludes that the significance of teacher interaction as an educational aspect has far-reaching consequences for students, particularly those involved in technology-based academic experience.

In 2014, (Goldman and Goodboy, 2014) investigated learners' emotional output in the classroom based on professor affirmation using broaden-and-build and emotional response theories. They found that when professors employed affirming behaviour in class, the learner displayed greater emotional engagement, support, and overall satisfaction with the lesson. Students said they put in less effort in class when teachers showed an interest in their progress. (Dowden et al., 2013) studies learners' interpretations of written comments, with a focus on their emotional states in Australian University. Students' emotions were shown to greatly impact their impressions of written comments in the study. For students to be able to adequately express their emotional experiences, effective written comments must be matched with teaching methodologies that encourage learners to engage in a meaningful discourse over the course of instruction. In 2015, (Hagenauer et al., 2015) investigated instructor emotions. A lack of classroom discipline was the strongest indicator of teachers' angry sensations. The level of student participation was also found to be a strong predictor of instructor emotions.

Following this (Tonguc and Ozkara, 2020) evaluated the alterations of emotions in 67 students throughout the lessons of Basic Information Technologies that registered in 3 distinct fields of a public university in the Mediterranean area. The students' facial emotions were analysed and digitally scanned in aspects of contempt, sorrow, pleasure, dread, disdain, rage, and astonishment using software designed using the Microsoft Emotion Recognition API and the C # programming language. They looked at how student moods changed throughout the lesson and if this variation was statistically meaningful based on their fields, sexuality, lecture durations, desktop position in the class, presentation style, and session information. The lecture had three parts: an intro, tasks, and a conclusion. Three steps were used to investigate the relevance of emotional differences and the link between emotion transformation and accomplishment. During the first phase of the lesson, emotions of disdain, anger, fear, and bewilderment surged, whereas emotions of joy, sorrow, and contempt declined. Throughout the last portion of the lesson, it was discovered that pleasure grew fast while all other feelings dropped. Only the sensation of sorrow differed significantly among fields, as per research findings. It is recommended that apparatus that offers immediate output to the instructor by automatically keeping track of the students' feelings across the class be made accessible across academic institutions, therefore assisting to an improvement in educational quality.

A sophisticated quantitative analytical approach called a twofold latent multilayer assessment was used by (Khajavy et al., 2018) to evaluate the relationships between feelings, classroom atmosphere, and communication readiness. The study involved 1528 Iranian secondary school students from 65 different classrooms. It is stated that anxiety, happiness, and WTC were all impacted by the classroom atmosphere. Instructors' support, learners' cohesion, and goal clarity shaped the classroom atmosphere. Teachers play a crucial part in this, since the classroom tasks teachers utilize and the environment, they establish can impact teacher support, student cohesion, and work orientation. Students' anxiety is reduced when they are in a pleasant educational atmosphere. WTC was found to

be influenced by both student and classroom satisfaction, whereas worry lowered WTC primarily at the student level, according to the study.

2.2 Smart Classrooms

A smart classroom is one that uses cutting-edge technologies to optimize the way students and teachers interact online. Clearly, emotion technology has a role in the smart classrooms. Electronic screens, windows, smart boards, assistive technologies, and other audio/visual aspects are used in the classroom to create learning more easy, entertaining, and participative. The technologies that are incorporated in smart classroom are as follows:

- Interactive flat screens, the foundation of any Smart Classroom, play a critical role in assisting faculty and learners in engaging in the lecture hall. Interactive flat screens have taken the role of conventional blackboards and interactive whiteboards as the major focus element in the classroom, attracting immediate interest and attention.
- Tablets, laptop computers, and other classroom learning equipment to help learners with researching, critical thinking, questioning, and assignments.
- Recharging systems are available in a range of sizes to accommodate all types of classes and are often made of high-quality components to ensure the safety of the classroom's pricey learning gadgets.
- Instructors can use content from outside their institution and incorporate it into their established school curricula using classroom apps.
- Conventional backlit projectors have been replaced in smart classrooms with visualizers, often known as document cameras. These simple presentation technologies offer the highest graphics, zoom, and connection choices, all of which are essential for a successful flipped classroom setting.
- Classroom conferencing technologies have grown in popularity as a means of bringing more knowledge into the lecture by allowing students to interact with people from across the globe.
- The capacity to record and broadcast lecture is a feature of smart classrooms that is sometimes underestimated. Students can participate in the smart classroom, either directly or through streaming or recorded classes.

The smart classroom can contribute to promoting student-teacher interaction, increasing students' grasp of concepts, providing educational technology to students and educators, developing children's capacity to imagine and be inventive, and promoting children's physical and mental growth while also enhancing their educational results. Ambient displays are another way that may be utilized to improve students' classroom experiences. The use of ambient intelligence technology in the classroom can identify student behaviour. Teachers can use ambient displays to gather information about student moods and involvement. According to researchers, ambient screens can provide real-time information and reactions in a classroom setting.

The ClassBeacons system, which employs distributed lights to represent instructors' continuous demonstration of how they split their attention between learners in the classroom by (An et al., 2019) in 2019. Evidence from 11 instructors in 22 class session's shows that this ambient information improved instructors' Reflective Awareness without

interfering with ongoing lession. In 2011, (Antona et al., 2011) describes a stack-based paradigm in the ClassMATE and PUPIL frameworks. A suite of adaptation-aware Classroom Window Managers was designed to host different educational applications and dynamically modify them based on the demands of the targeted classroom artifact. The students' information repository keeps a record of everyone's progress, and data are generated for the instructor to use in making modifications to the learning curve. It's also widely utilized to give individualized information tailored to each student's specific educational needs. The smart Classroom (Ramadan et al., 2010) iClass comprises of a diverse network with a huge number of sensor devices, actuators, and processor cores. The intelligent Class is a multiuser environment that may be used for a variety of educational purposes. The Echelon's iLON SmartServer, which is placed in the iClass, is indeed the foundation to the firm's energy efficiency and operational initiatives. Two Radio Frequency Identification systems are available: one for professors and another for learners. To assess the total Radio Frequency Identification system, a software agent was installed on the intelligent Class multi-media computer to use the automated students' attendance during the previous semester on one of the computers.

2.2.1 Communication of Emotion in Smart Classrooms

There are two sorts of emotional communication in smart classrooms. Automatic and Direct Communication of Emotion. In Automatic Communication of Emotion, the data from digital backchannel systems, sensors, agent-based systems, and cameras, as well as AI-based systems, are used to power automatic emotional communication. Whereas, handheld gadgets, and physiological sensors are used in direct emotional communication to assess emotional state.

Automatic Communication of Emotion

Smartphones are an excellent example of digital backchannel technologies to explore. Digital backchannel systems are particularly successful in increasing teacher-student engagement and improving the classroom atmosphere. (Jiranantanagorn et al., 2015) suggests a digital mobile backchannel system called ClasSense that helps students throughout a lesson to leave comments choosing from Kort's list of 12 learning-relevant emotional states (Kort et al., 2001): Frustration, Disappointment, Confusion, Satisfaction, Hopefulness, Confident, Dispirited, Boredom, Dissatisfied, Interest, Curiosity, and Enthusiastic. SentiStrength, a ClasSense system approach, is used to analyse student reactions in the form of emoticons every 5 minutes. This allows lecturers to keep an eye on the students' general attitude and make the lesson more engaging for them.

Likewise, this paper (Woolf et al., 2010) discusses how smart tutors recognize and respond to human emotion automatically through sensors. Due to the use of wireless sensors that give data on postures, motion, grip stress, face expression, and alertness, tutors can detect student mood. Less academically successful students that interacted with affective educational agents had better emotional results as well as lower levels of irritation and anxiety. Similarly in 2018, (Lascio et. al. 2018) illustrate how regular wearable sensors employ physiological data, ground truth data, and other materials may be used to assess students' emotional involvement throughout lessons in an effortless manner. Ultimately, the research may help designers create programs that enables students to self-inspect their involvement and respond to the input they receive. Instructors might also benefit from data

on disengaged students for consciousness, devising and evaluating strategies to re-engage learners.

In 2019, (Tiam-Lee and Sumi, 2019) analyses emotional responses. They combined typing logs, compile logs, as well as face-camera footage taken during code-solving activities and establish how they may be utilized to forecast effect. High accuracy in identifying students' emotions in the classroom can be useful in improving student's learning experience. This paper written by (Sharmila et al., 2018) presents a system to automatically detect the emotions of students in the classroom using facial expressions. It takes video as input, and the outcome is a system for detecting emotions. Finally, the classroom's attentive and inattentive students are counted in the result.

(Ahmed et al., 2013) explore agent-based systems that assess the performance of students and lecturers by analysing their emotions. In agent-based systems, an agent acts as a medium, i.e., an emotional translator, and communicator between the users and the system. The system utilizes a computational model to review and assess data depending on the lesson's perception by students. Agent-based systems may be very efficient in terms of performance if the input is adequate and precise.

Direct Communication of Emotion

The Subtle Stone (Alsmeyer et al., 2018) 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 system makes use of the idea of color to enable interactions between students and instructors. The Subtle Stone may now display seven different colors and seven different moods. The instructor's interface employs a Subtle Stone to portray all learners as separate person-shaped entities. With this new design, the concept of emotion is easier for young learners to understand in a rigorous atmosphere.

A paper written by (Wang et al., 2004) demonstrates a messaging system that displays the person's emotional condition via animated vibrant text. It utilizes a two-dimensional visual display to show conversational animations and data. This displays graphics for certain words or phrases. A physiological sensor connected to the human hand provides the system with information about their emotional state. 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.

2.3 Interfaces for Communicating Emotion

According to previous research, interfaces for communicating emotion are broadly classified into three categories. Interfaces for information, interaction, and dimension. Informational interfaces are primarily made up of some information or categories, each of which represents a different type of emotion. Interactional interfaces require a user to interact with the interface using a physical object in order to send emotion, whereas dimentional interfaces consist of one of two dimentional interfaces through which a user selects an emotion based on valence and arousal within those dimentions. Several research

studies are discussed below to provide more information on previous research on each of these interfaces for communicating emotions.

2.3.1 Informational Interfaces

(Pollak et al., 2011) introduces Photographic Affect Meter (PAM) and unique instrument for evaluating impact wherein users pick the picture that best reflects their current mood from a broad collection. Photographic Affect Meter, that takes seconds to complete and is intended to operate on contemporary mobile phones and other electronic computing devices, displays good reliability and validity throughout two investigations and is well adapted for rapid sample selection in context, according to our findings. This study offers a methodology for researchers who need to examine impact on a regular basis, as well as direction to those interested in building comparable measuring tools. In 2013, (Scherer, 2013) presented the Geneva Emotion Wheel as a self-reporting emotional experience measuring tool. It varies from other tools in that it arranges the words of emotion to be scored in a scientifically supported 2-D structure comprised of the valence and power aspects. Twenty words are structured in a wheel-like arrangement, with opposing points of the wheel's peaks expressing the perceived intensity. The Geneva Emotion Wheel has previously been broadly applied in research in many slightly verified forms. The Grid paradigm allows for the precise position of emotion words in the Valence × Power space to be determined. (Russel, 1980) presented the circumplex model of effect. In this model, emotions are dispersed on a two-dimensional surface in the framework. Valence is represented by the x-axis, while arousal is represented by the y-axis. Valence is the positive and negative degree of feeling, whereas arousal is the strength of emotion. The circumplex approach allows for the presentation of emotional experiences at any level of valence and arousal.

2.3.2 Interactional Interfaces

In 2001, (Chang et al., 2001) presented the LumiTouch technology comprising of two interactive image frames. Whenever one person caresses the picture frame, the other photo frame comes to life. This gesture is converted into light by using an Internet service. A semi-ambient display capable of effortlessly transitioning from the background to the front while also conveying emotions is presented. LumiTouch can help people personalize emotional language in addition to improve interaction with social connections. By building on previous work in telepresence and physical interfaces, LumiTouch investigates emotional interaction through touch.

In 2005, (Stahl et al., 2005) came up with the design for eMoto, a mobile messaging service, using a body motion assessment and a dimensional framework of emotion experiences. Sub-symbolic expressions, such as colours, patterns, and animations, are used by the service to communicate emotions in an open-ended manner. The findings demonstrate that the usage of these sub-symbolic expressions may serve as a basis for using as a creative tool while still enabling for communication to be located. The design input derived from body motions appeared to be valuable. It was also represented in our participants' descriptions of the terms. The same author in 2003 also explore developing an interactive service on top of MMS technology that improves communicative capability while permitting for uncertainty and free interpretation of emotional content. A new emotional interaction model called the affective gestural plane model is developed based on the variables shape, effort, and valence. This paradigm is used to create a mobile service for emotional communications that included gestural affective input. The

system responds by displaying emotional responses in colour, shape, and animations while the user is making affective gestures. The emotional expression functions as an animation in the background of the message, providing rapid feedback to the sender on the message's look. By gripping the pen, the user initiates this input. While writing, a pulse sensor incorporated inside the pen monitors the user's pulse.

2.3.3 Dimensional Interfaces

In emotional research, self-assessment procedures are commonly used to obtain subjective emotional evaluations. In 2016, (Betella and Verschure, 2016) created the Affective Slider by combining cutting-edge user interface designs and metacommunicative graphical representations. It is a computerized self-reporting system that consists of two slider knobs for assessing joy and alertness. The ability to gather assessments on continuous scales, which allows for more precise high-resolution assessments, is a benefit of slider controls.

In 2009, (Laurans et al., 2009) designed the emotion slider to gather self-reports of the polarity of users' interactions using interactive technologies. It's an extended wooden structure with a circular hold that can be pressed and dragged along the slider's primary axis. The hold provides some friction when pressed towards the instrument's ends, due to a set of springs buried within the box. The emotional slider may be mounted on a table and connected to a computer through a USB connection to collect the movements of the hold. All motions of the handle are recorded by the program and written to a log document. The latest edition of the emotional slider allows you to list your status on a scale of -11 to +11. The objective of the system was to create an obvious manner to describe one's emotions, allowing participants to concentrate on their experiences and minimizing intellectual participation in the reporting process.

In 2009, (Lottridge and Chignell, 2009) presented Emotrace which is an innovative approach for assessing emotional reactions on the valence and arousal aspects. Three emotrace prototypes were designed based on the results of a pilot research. Following that, 12 individuals were given brief movies to watch to generate emotions, with 4 self-assessment conditions and physiological recording. The tools were determined to be reliable since the evaluations accurately represented the emotional content of the videos. The sliders were determined to be more trustworthy in emotrace evaluation of emotional experiences. It suggested emotrace assessment of emotional user experience to supplement current user-interaction assessment methodologies.

2.4 Research Gap

Students' emotions may have a large impact on their learning and success. However, it is also one of the primary problems - the learner's uncaptured emotion, which plays a vital part in the teaching and learning process. Improving the quality of students' educational experiences requires evaluating their cognitive and emotional states throughout the class, delivering the emotional responses to the teachers, and changing instructions on the fly to improve comprehension and develop a positive attitude toward education.

We can say that not all methods for communicating emotions have been applied and tested in education. Previously, three main approaches utilized to input emotions in education are comments through a mobile application, capturing facial expressions, movements, and body postures using cameras and video footage as input, and measuring

physiological data via wearable sensors. Based on the knowledge of previous research, it can be said that these systems cannot be considered effective in evaluating and communicating emotions because they do not cover all dimensions of emotion. They are also incapable of determining what factor impacts students in the classroom, whether the lecture content, the pedagogical style, interaction with the teacher, or anything else. On the other hand, the ability to display students' emotional responses to professors in real-time and in a flawless manner during lectures is a critical responsibility. The technologies do not investigate the real-time presentation of student responses and replies to lecturers. On the teacher's side, displaying students' emotions is another essential factor in creating a better instructional setting. It enables the lecturer to change the lecture setting in response to student remarks and actively engage learners.

The main purpose of this research is to discover which interaction method is best to communicate emotion during the lecture, based on the previous literature and communicating with our research participants. Thus, by using a user-centered design approach and through informing and design sessions, I will try to analyse and design a system by which students can communicate their emotions conveniently during the lecture without any problem, also the teacher can see student’s emotions in real-time and respond to them, by making classroom learning better and more affected both ways.

Chapter 3 Methodology

This chapter describes the underlying methodological approach used in project work, as well as the various methods employed at each stage of the process. User Centred Design UCD is the primary methodology employed in this project (Abras et al., 2004). With close user involvement the final prototype is more likely to meet users' expectations and requirements. Another aspect which cannot be ignored is this system will be used in a social environment like classroom, so it is very important to select each, and every design requirement based on user convenience and comfort. Consequently, the central ideas and concepts found within this methodology directed each individual process and activity all through the project, from the early stages of prototype development and design, through evaluation and testing, to the final analysis of the collected data and subsequent presentation of the findings. Furthermore, this study will employ a qualitative research method that focuses on gathering information through open-ended and conversational communication. This method will not only answer "what" users think but also "why" they think that way. There are various qualitative research methods, but we will mostly use in-depth interviews, focus groups, and content analysis.

3.1 Design Methodology and User Centered Design (UCD)

UCD is an iterative design approach that requires designers to keep users' needs in mind at every stage of the process (Abras et al., 2004). To integrate clients throughout the design process, UCD professionals use a hybrid of research and design approaches, which produces highly usable and approachable solutions for them. To get understanding of user needs, designers utilise a variety of analytical methods like questionnaire, surveys, and productive brainstorming approaches. Understanding, analysis, design, implementation, and evaluation are all part of UCD process, which strives to develop useable interactive systems as shown in Figure 1.

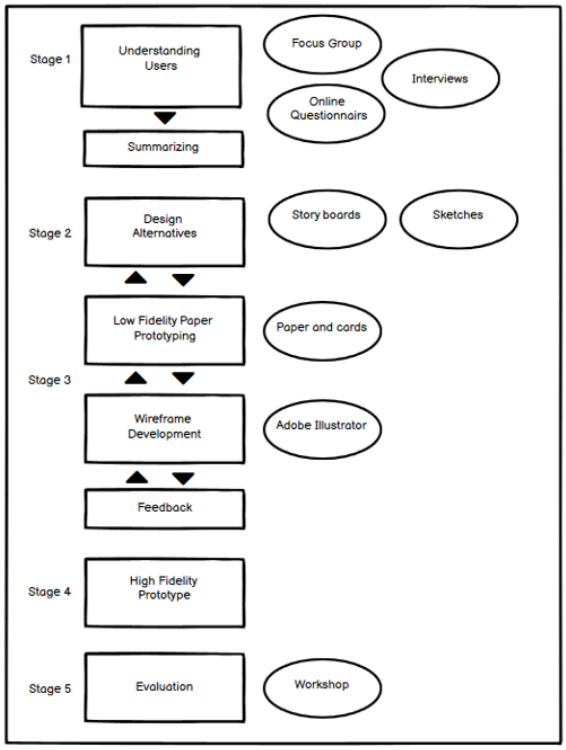


Figure 1 Design Methodology for Emotional Communication

The goal is to develop a system that allows students to communicate about how they are feeling during a lecture. Therefore, the Design Process is divided into four primary phases which is purely based on the design methodology taken by the book (Kurniawan S. 2004).

1. Gathering Requirements
2. Design Alternatives
3. Implementation
4. Evaluation

3.2 Gathering Requirements

Several methods could be used in the design process to gather requirements, which are explained step by step in the sections below. As UCD is a complex and evolving process based on the development of requirements over time, the sequence of these methods is not fixed, and more processes could be added to refine the final requirements. I decided to divide the requirement gathering phase into two parts. The first step is to identify the most appropriate interaction method (interaction used between the user and the system for example, tangible or GUI based interaction method) for communicating student emotions in the classroom. The second step is to identify the interface type (type of interface for example, categorical, dimensional, or an interactional interface) that is being used for that

interaction method. The requirement gathering phase is divided into two major stages with a goal to determine:

1. Interaction Method
2. Interface Type

To find the best suitable interaction method, at the start of requirements gathering phase, those participants who are unfamiliar with the term's interaction design, interaction methods, and communicating emotions in the classroom will benefit from the presentation. Both questionnaire and interview methods are used to obtain not only participants' opinions on various interaction methods, but also to speak with them in greater depth about their choice, which the questionnaire does not allow. This requirement gathering phase is divided into the stages listed below.

1. Presentation
2. Paper Prototypes
3. Questionnaire
4. Interview
5. Requirement Analysis
6. User Stories and Story Boarding Technique

To learn about the most appropriate interface type. I made the decision to create a simple questionnaire and hold a focus group session with the participants. The questionnaire will allow me to obtain their opinions on various interaction types, and the focus group session will provide us with information about what participants think about the selected interaction method and interaction type in a social setting. This requirement gathering phase is divided into the stages listed below.

1. Questionnaire
2. Focus Group
3. Requirement Analysis

3.2.1 Presentation

It is critical to explain the problem to the user during the interaction design process. A user could be anyone who is not a computer science or interaction design student, which is why it is critical for me to explain the research topic and problem to the user. A presentation was created for the user to explain emotion in general as well as the importance of communicating emotions in the classroom. This presentation also informs users about the various types of interaction methods that can be used to interact with the system in a classroom situation. As a result, the participants will learn the fundamentals of emotions and communicating emotions, as well as various interaction methods that can be used as an input system to build such a system.

3.2.2 Paper Prototypes

Paper prototypes are very important because they provide a more realistic way to understand the concept which could not be possible with just theory. Prototyping is an essential component of the design phase since it enables the designer to evaluate and modify their concepts. A prototype is a representation of the suggested system that may be

used to evaluate or verify various components of the concept. Prototyping is a technique for testing a concept before committing a lot of resources to it. It involves using a variety of tools and methodologies to test a concept. Prototypes can be as basic as a piece of paper used to explain a concept or as complex as a prototype used in pilot trials. It is not necessary for a prototype to be a complete product. Prototyping is the process of testing theoretical concepts in the actual world (Frayling, 1994).

As previously stated, that not all the participants in the design sessions were familiar with the term interaction design and different interaction methods. It is critical to inform them about the various interaction types/methods that were available based on previous research, as well as to ask them about their own opinions and preferences. Several prototypes were made based on the previous literature and ideas, to provide the user a better understanding of communicating emotions in classroom and how it could be converted into a useful interaction method, that a student can use to transmit his/her emotions in the lecture.

3.2.3 Questionnaire

Questionnaires are a method of gathering statistical information and user feedback. They are identical to interviews in that they might include closed or open questions, and they can be given to a broader group of people, allowing for more information to be collected than would be feasible in interview research. The data acquired by these questionnaires, will determine the type of analysis that may be conducted on a collection of data. It is possible to utilize a qualitative or quantitative analytical method or a mix of both qualitative and quantitative approaches.

The main goal here is to determine whether the users are interested in such a system and what type of interaction method they would prefer to use. In this research, a questionnaire will be design that will be provided to the user with different type of questions that could be open or close ended questions. The main aim is to record user opinion about the need of the system, and if they need a system like this then what kind of interaction, they are seeking for this system. Considering the answers a further analysis will be done to finalize the design requirements. A sample question is provided below that could be asked to get user opinion about, what kind of emotion they experience usually while sitting in the lecture, and what is the source of their emotion.

- *While sitting in a lecture, which kind of emotions you experience the most. 1) state emotions or 2) trait emotions.*
- *What is the source of your emotions? Are they mostly connected to the lecture?*

To discover the reason for the participants' selection and to expand the requirements in an open-ended manner. I decided to conduct one-on-one interviews with the participants in the next section. This will allow the participants to discuss their choice in a relaxed and causal manner and why they chose a specific interaction method.

3.2.4 Interview

An interview is a wonderful approach to conduct a purposeful discussion with a respondent. By getting into considerable detail and comprehending whatever the customers desire, interviews provide more personal suggestions than a poll. Interviews may be valuable for gathering information on a user's happiness with an item and their ideas after using it. When testing the prototype, there are four main types of interviews that may be used to obtain data. The first method is to conduct structured interviews. In a structured interview, the researchers have a series of structured questionnaires that the respondents must reply, and

they do not stray from the queries that have been established. The unstructured interview is the second type of interview. In an unstructured interview, the investigator does not arrange any questions ahead of time; instead, the researcher seeks to have a casual dialogue with the respondents, tailoring the inquiries to their individual experiences.

The primary purpose of these personal interviews is to collect user feedback on system development and to determine which interaction method is best suited for our system. In this research, we are planning for an unstructured interview session with the users, the main aim would be to get their opinion about communicating the emotion and whether they need this system or not, if they need it then what kind of system they are looking for, what interaction type should we select for the system, and how useful this idea would be for them while listening to the lecture.

3.2.5 Focus Group

The aim is to design a system that allows students and teachers to communicate their emotions during classroom lectures in real time. A focus group would consist of our research participants to collect their opinions about the system in general, as well as to get users' opinions about system usage in front of other class members. This is significant because this system has a social component that cannot be overlooked, and I must ensure that the students do not feel uncomfortable while using the system.

3.2.6 Requirement Analysis

After conducting interviews or observations, we will have a lot of qualitative and quantitative data. Interpreting the significance underlying the facts and determining the ramifications for the design takes rigorous and time-consuming examination at this phase. The information may be categorized and structured in a variety of ways, including relevance, appropriateness, and attractiveness. This phase's major purpose is to uncover common standards and characteristics in the data obtained. The findings of this process can be employed in other phases, such as the design or assessment phases. "The focus of the design should be on determining what are the intended values to be supplied to end users and other stakeholders, and then building and assessing those values into the service," says the author (Kaasinen, 2005). Furthermore, the analysis may raise new concerns that must be addressed. "Previously constructed assumptions may also be contrasted with the findings. The new understanding gained via interpretation aids not just in design phase but also in targeting the proper user group and usage scenario" (Olsson, 2009). Based on the analysis, final requirements of the system will be derived. The main take away from this session would be what interaction type to use and how will our design look like in terms of the implementation.

3.2.7 User Stories and Story Boarding Techniques

Sequential art that visualizes a story is known as storyboarding. Motion picture productions inspired this technique. An excellent technique to illustrate an idea or notion is to use storyboarding. The designers may see whether idea will succeed by creating a narrative board of it. Storyboarding may also aid designers in identifying problems early in design stage, as well as allowing them to put themselves in the footsteps of the consumers (Zimmerman and Forlizzi, 2014).

Different user stories will be created on the user requirements to better understand the interaction of user with the system and to cover different interaction aspects. The outcome of this session would be a better understanding of the user interaction with the system, that will help in design the system more solid and providing the best user experience.

3.3 Design Alternatives

Once the requirements are clear, we will move towards the next phase which is converting these requirements into paper and now designing them in a more realistic way. This would involve different methods, like story boarding, sketching, paper prototypes and high-fidelity prototyping techniques. The input to this phase would be requirements and the outcome will be a prototype that could be used for the evaluation purpose and to validate the hypothesis.

3.3.2 Design Sketches

A user interface sketch, often known as a mock-up, is a graphical UI mock-up created by a designer when developing an application. Sketching is a unique type of drawing that designer use to suggest, investigate, revise, and share their ideas. In this phase, researcher will make drawings to present, revise, share, and criticize ideas in a physical style. Several design alternatives will be used that will lead us to the basis of low fidelity paper prototypes.

3.3.3 Design Requirements and System Design

Based on the phases of requirement gathering, paper prototypes, interview, focus group, and discussions about various interaction types and interfaces. I'll conduct an analysis and determine the system design requirements. Based on these requirements, a final system design will be created with the objective of addressing demands and requirements of the users.

3.4 Implementation

Both Low-Fidelity and High-Fidelity Prototypes will be made to evaluate the research questions. A low-fidelity paper prototype of the emotional communication system will be constructed after defining the representative user groups and their requirements, based on different design alternatives. Starting with paper prototypes since they are less expensive and require less time to develop, and they are easier to update than a high-fidelity prototype. To construct the low-fidelity prototype, the designer used paper and markers. To evaluate different versions of our proposed system, with the low-fidelity prototype yielding most data for the least cost. Whereas, High-fidelity prototypes provide a genuine interaction with the product, complete with real-world functionality. They are generally computer-based and enable for genuine user engagement. The user interface is shown as accurately as is conceivable in high-fidelity prototypes. To develop high-fidelity prototypes, the designer will individually examine its information gathered from the previous design stages. To guarantee that the final prototype design is UCD, instead of the consequence of the designer's own preferences, the designer will coordinate with the user on each stage of the development. Once each user had reported their results, the designer took the information gathered and developed an iteration of the prototype to build a final system prototype. The

outcome of this stage would be an interactive prototype that the user could use to evaluate the system in read world environment.

3.5 Evaluation

Early prototypes are used to assess the viability of the general design, whereas subsequent prototypes are used to assess the complexity of the system design and user interface. The major aims of evaluation are to analyse the system function, check the user's experience with its system, and discover any unique issues with the system. The key aim of this phase is to evaluate the prototype, and to answer the initial research question.

Many researchers have always struggled with deciding between quantitative and qualitative research methods. In general, quantitative research is defined as the methodical and empirical analysis of processes employing figures, arithmetic, and the analysis of numerical information. The method of estimation acts as the essential connection in quantitative research between empirical knowledge and the numerical articulation of quantitative relationships. Data in quantitative research is typically selected and analysed numerically (Goertz & Mahoney, 2012) (Singh, 2006). Contrarily, qualitative research is a wide phrase that refers to research approaches that analyse experiences, actions, and interactions in order to understand events without relying on figures, mathematics, or statistical data analysis (Merriam & Tisdell, 2015). Based on our analysis of the literature and our understanding of the problem. This study will employ a qualitative research method that will collect data through open-ended and conversational communication.

Moreover, to answer the research questions different methods will be used in this phase of evaluation, which included designing an evaluation questionnaire, conducting a session with the users and teacher, and analysing the user response. We will ask participants to use the system in real-world environment while the teacher delivering the lecture. The teacher will also see student emotional response in real-time and to respond to different students' emotions. A questionnaire will be designed to record students and teacher response and to do the further analysis and results.

3.6 Summary

This chapter has provided insight into the User Centred Design (UCD) methodology, as well as various other methods used in each phase of the project. In practice, the book has influenced my methodology approach (Kurniawan S. 2004). This book was critical in providing both a structural blueprint and an academic foundation for the work. The design phases ultimately result in the creation of a high-fidelity prototype designed to answer the research questions through field deployment and evaluation.

Chapter 4 Requirements Gathering

The requirements gathering phase also known as informing is an important aspect of our research, will be discussed in this chapter. It will allow for the investigation of many options for the emotional communication system and helps in selecting the best interaction method of engagement for emotional communication throughout the lecture. In this chapter, the methods involved in determining accurate user requirements are discussed and condensing them into a format that could be used in system implementation. This phase focuses on the analysis received from a diverse group of university students on interaction methods that should be used in the classroom setting, and the optimum interaction type for an emotional communication system. Two informing sessions are performed with research participants, documenting their remarks. Final design requirements are derived based on the analysis of the informing sessions.

4.1 User Selection and Formal Procedures

The first stage in the informing and designing phase was to select participants so that we could use the User Centred Design approach and continue our research based on these participants' opinions and perspectives. In recruiting participants, I explicitly set out to reach users who had at least a minimal interest in computer systems in general. Like the users who have no interest in photography may be unsuitable for testing a creative camera software, just as users who have no interest in computer systems may be unsuitable for testing an application aimed at emotional communication. Most of the participants were recruited by talking with students in the IT department of Østfold University College, while the others were found through the university's friend's circle.

4.1.1 Consent Form

Participants were needed to sign a consent form before taking part in the project. This form detailed the nature of the research and the specific collection of data, as well as informing participants of their choice to quit consent at any moment throughout the duration of the project. The form was presented and signed on paper during the informing. The form's design was based on a format specified by the Norwegian Centre for Research Data (NSD), with the contents perfectly tailored to this project.

4.2 Determine Interaction Method

It was discovered during the initial discussion with participants that not all our participants were familiar with the different interaction methods and communication of emotion in the classroom. A session was planned to introduce the research project and the concept of emotional communication, as well as how it might help them in the classroom. This requirement gathering session is categorised into five sub phases as shown in Figure 2.

1. Presentation
2. Designing Paper Prototypes
3. Designing the Questionnaire
4. Interview
5. Result and Analysis

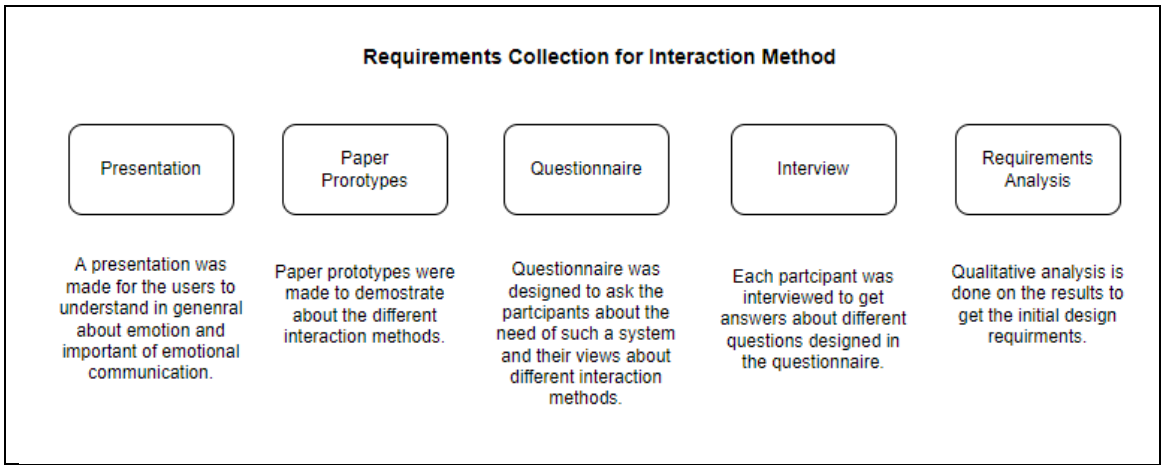


Figure 2 Requirements Collection for Interaction Method

4.2.1 Presentation

A presentation was prepared for the participants. The general research study and idea of emotional communication were introduced at the beginning, and I explained emotions and their importance to the participants in the lecture hall using various emotions. I also explained to them about interaction design and how many different interaction methods exist based on previous literature research. As shown in Figure 3, a tangible interaction method is shown and explained to users as to how it works and how it can be used as an input method for our system. Aside from this method, several others are presented with different slides, such as GUI-based interaction and interaction through intelligent systems such as a camera that can automatically capture a user's emotion.

As a result, the participants learned the fundamentals of emotions and emotional communication, as well as various interaction methods that can be used as an input system to build such a system.

Figure 3 Screenshots of Presentation (Emotions and Tangible Interaction)

4.2.2 Paper Prototypes

As previously stated, not all the participants in the design sessions were familiar with interaction design. It was critical to inform them about the various interaction types/methods that were available based on previous research, as well as to ask them about their own opinions and preferences. I created some paper prototypes for this purpose, as shown in Figure 4. For example, in the middle, a camera prototype is designed to capture a user's emotions based on image analysis and then send them to the professor. On the right, a smart band is displayed, from which the user can select his emotion and send it using a smart band or watch. An ambient light cube is shown on the left, which can be used to reflect student emotion by changing its light based on different emotions.

Figure 4 Screenshots Paper Prototypes. Left: Ambient light to display emotional response. Middle: Camera to capture emotion. Right: Smart band to send emotion, and a scale to send emotion by sliding left or right.

4.2.3 Questionnaire

A questionnaire is designed to gather the initial thoughts of the participants about their emotion and the need of such a system by which they can send their emotional response the classroom. The main goal here is to determine whether the users are interested in such a system and what type of interaction method they would prefer to use. These are open-

ended questions that are posed to the participants to elicit their responses and record them using the Dictaphone application. The following are the questions for the personal interview.

1. *What is the source of your emotions when you are sitting in a lecture?*
2. *Would you like to express your emotions during the lecture?*
3. *Could you describe a situation, where you are sitting in a lecture and you felt some strong emotions and you wanted to communicate them, but you could not. These emotions could be anything related to lecture settings, or the way lecturer is delivering the lecture.*
4. *Do you think there is a need of a system by which you could express your emotions?*
5. *How would you like to express your emotions in the classroom, or what kind of system you are looking for, any ideas?*

4.2.4 Interview

The researcher met with each participant individually after designing paper prototypes for the interview. The primary purpose of these personal interviews is to collect user feedback on system development and to determine which interaction method is best suited for our system. Each interview lasted about 15 to 20 minutes and began with some paper prototypes of various interaction methods that could be used as input methods for our system. The participants were asked questions and their responses were recorded using the Dictaphone application, which was attached to a Nettskjema form. The interviews followed the pattern outlined below in general. Figure 5 depicts some screenshots from the personal interviews. On the right, a female participant is wearing a paper prototype of an emotional band. A participant on the left examines various paper prototypes.

1. *Each participant was provided with a written consent form to sign.*
2. *Explain emotions in general, as well as the research concept. Explained different interaction methods.*
3. *Describe various paper prototypes to the participants to offer them some ideas on different forms of interactions.*
4. *Ask the participants questions and record their replies, but because this is a follow-up and more of a development-based interview, I strived to build my concept and the questions were altered depending on the situation.*
5. *Conducted an interview with the participant based on the questions and prototypes, attempt to build some ideas, and record the audio of the conversation using the Dictaphone app for preliminary requirement analysis.*

Figure 5 Participants are examining different Paper Prototypes

4.2.5 Requirements Analysis

Based on the participants' responses to the questionnaire and interviews. The initial requirement analysis is performed depending on each question.

1. *What is the source of your emotions when you are sitting in a lecture?*

All the participants stated that their main source of emotions is sitting in a lecture and the way the professor is teaching, the topic of the lecture, the environment in the classroom, and how the teacher responds when they ask the teacher to explain something. It means that their emotions are mostly state emotions, triggered by how the teacher teaches the topic or delivers the lecture. This affects their emotions.

2. *Would you like to express your emotions during the lecture?*

All the participants replied yes, they intend to express their feelings throughout the lecture. Because it will assist students to enhance their learning experience in the classroom. It will have a direct influence on their education.

3. *Could you describe a situation, where you are sitting in a lecture and you felt some strong emotions and you wanted to communicate them, but you could not? These emotions could be anything related to lecture settings, or the way lecturer is delivering the lecture.*

According to the responses of the participants, there were numerous occasions when they wished to send their emotions in some way but were unable to do so due to the lack of such a system. According to the responses, most participants described such scenarios as real-life examples. For example, one participant stated that he was sitting in a classroom listening to a lecture and was unable to understand the concept or the way the teacher was delivering it, but he was too shy to express himself in front of his classmates, so his emotional state changed, and he lost interest in that topic. Participants mentioned that they were unable to ask the teacher about their emotions because they were embarrassed, discouraged, and did not want to disrupt the flow of the lecture in front of other students.

4. *Do you think there is a need for a system by which you could express your emotions?*

All the participants said that there is a need for such a system in the classroom. The concept of emotional communication during lectures seeks to narrow the gap between students and instructors, assist instructors to teach more effectively and create an atmosphere more favourable for teaching and learning.

5. *How would you like to express your emotions or what kind of interaction method would you prefer?*

According to participant responses, most participants prefer a GUI-based solution. The following are the reasons they provide:

- GUI is simple to comment on and submit immediately. Quick and may be delivered with a one-button click.
- People can interact in silence using GUI, but lighting and other hardware components can be highly distracting.
- Emotions are sent silently using GUI, which is not possible with other hardware-based interactions.
- The use of a GUI allows for concealed communication. Hardware is more transparent, and everyone would be aware of it.

Based on the findings and analysis of user feedback. Users are excited to have a system that will allow them to express their emotions in the classroom. We can conclude that they would prefer a simple and quick interaction with the system to express their emotion. Almost every participant stated that their primary goal in the classroom is to listen to the lecture even if it is not interesting or fully understandable, and that if they become involved in an interaction that takes a longer time to communicate emotion, they will become distracted and may miss important information from the lecturer. Most participants chose a GUI-based cross-platform solution that could run on both a laptop and a mobile phone while taking notes. Based on the results of this analysis, we will proceed to the next requirement, which is to determine what type of interface the user would prefer for the GUI.

4.3 Determine Interface Type

As per the previous informing session, users selected a Graphical User Interface (GUI) based interaction. The next critical question is what type of interface we should implement for the GUI, and what is the user preference. So, I decided to hold another informing session with the participants, with the main goal of determining the best suitable GUI interface type. This requirement gathering session is divided into three sub phases as shown in Figure 6.

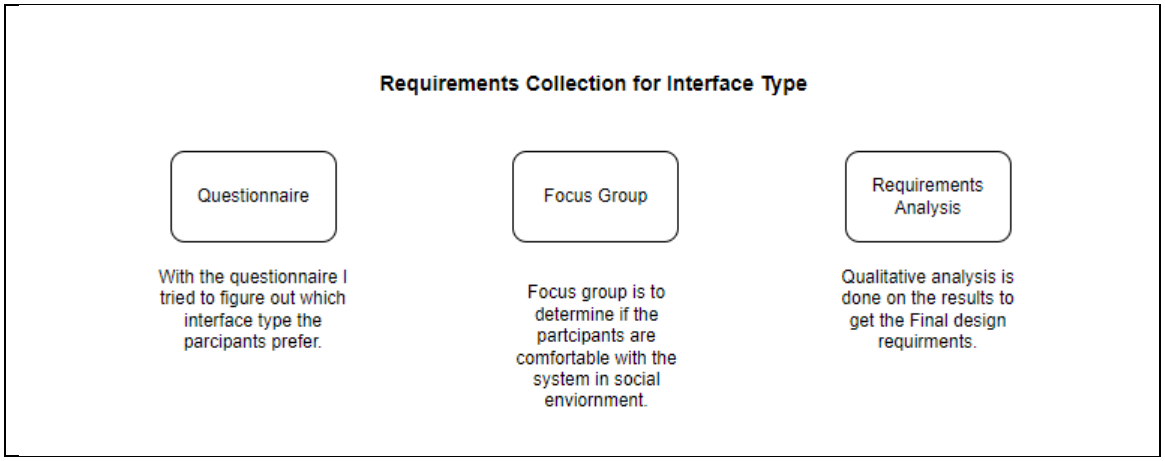


Figure 6 Requirements Collection for Interface Type

As seen in previous research, there are various types of GUI that exist and have been experimented with. Categorical, Dimensional, and Interactional based GUI are the three main types of GUI. In a categorical GUI a user will select their emotions from several categories and then send them using the button. With only a few buttons and emotion categories, this is the most basic sort of interface. In a dimensional GUI user might be shown a one- or two-dimensional space in which to select a suitable emotion. A two-dimensional space is used to select emotion based on arousal and valence. This is how a user may regulate the strength of their emotions. On the other side, with an interactional GUI a user can express his emotions by drawing/interacting his emotion on the screen with some object and that object represents a specific emotion. Another consideration is the intensity of emotion that can be handled by applying pressure to the object on the screen.

For the convenience and better understanding of the user. I have made some paper prototypes of each kind of GUI interface which is shown in Figure 7. The main goal is to show these to the users and ask which one they prefer.

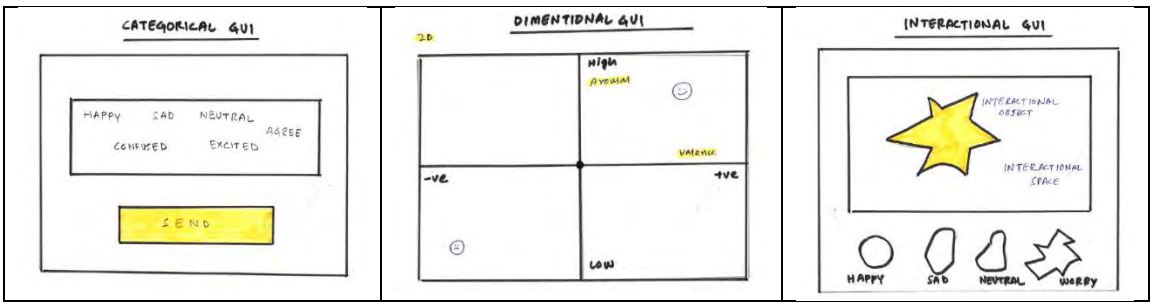


Figure 7 Paper Prototypes of Interface Types

4.3.1 Questionnaire

When these paper prototypes were completed, I convened the second round of informing session with the participants, asking them about alternative interface types and which one

they would want to see implemented in the system. Participants are given a questionnaire to fill out so that their comments may be recorded for the next step in the requirement analysis process. The applicants were asked two questions, the answers to which are shown below. In the informing session these two questions are asked to the user and their response is recorded through a Nettskjema form. The result of each question based on user response is discussed below in the result section. Some of the questions which are asked in the questionnaire are given below.

1. *Which interfaces type you would prefer for the GUI among the three types, please provide a valid reason for your selection.*

2. *Would you like to add/remove any feature from the presented sketches, please provide your comments?*

4.3.2 Focus Group

In addition, the researcher decided to hold a focus group session with the users and present them with our basic design concept. The main purpose of this session was to ask them if they are comfortable using this system in a social setting, such as a classroom, and in front of other students. The key points from the focus group are listed below.

- Describe the interaction method and interface type we chose for this system.
- Request feedback or changes to the current design.
- Inquire whether they are comfortable using this type of system in the classroom.

4.3.3 Requirements Analysis

3. *Which interfaces type you would prefer for the GUI among the three types, please provide a valid reason for your selection.*

Based on the responses of the participants, it appears that the participants prefer a hybrid of categorical and dimensional interfaces through which they can select and send their emotions. The participants chose this type of interface because they want to send their feelings quickly and without bothering others. Aside from that, they preferred the dimensional interface due to the ease of selecting appropriate arousal and valence.

4. *Would you like to add/remove any feature from the presented sketches, please provide your comments?*

Participants provided their comments on additional features which they want in the GUI when it comes to the application. They are as follows:

- Multiple emojis to choose from to express more emotions.
- A more comprehensive version of the application including a profile and emotional feedback history.
- Comment box to send a comment along with the emotion.
- Message template so that they could select from the template instead of typing the message
- One participant provided an idea about the GUI design which is quite different and interesting from the one shown by me the participant.
- Anonyms response sending option.

- Cross-platform application.

5. *Do you think this chosen interaction method is comfortable to use in a social setting like a classroom?*

It appears that all the participants stated that they are at ease using this system in public. Figure 8 depicts a focus group session held at the university.

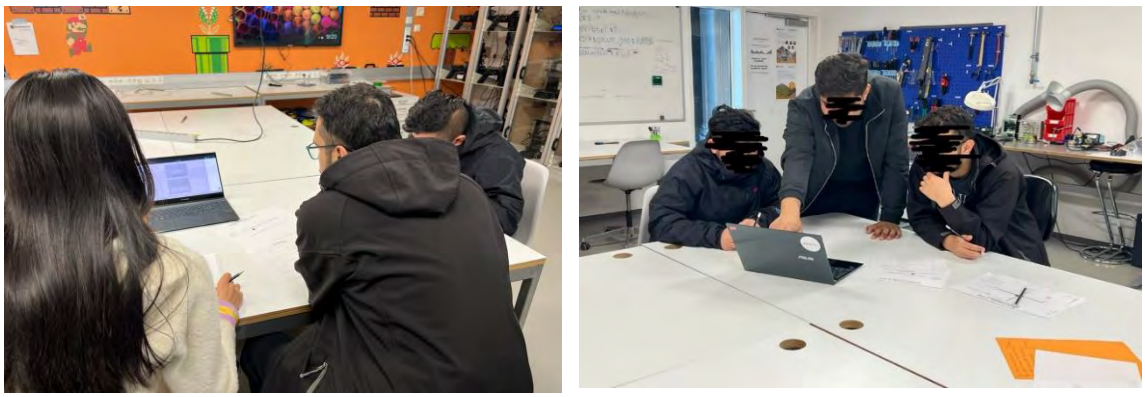


Figure 8 Focus Group

4.4 User Scenarios

User scenarios are user stories that were created to demonstrate how users might act in a system to reach a goal. User scenarios were created to help ideate, iterate, and usability testing the optimal solutions by understanding users' motivating factors, necessitates, obstacles, and more in the sense of how they would use a design.

User Scenario 1

While attending a lecture, John notices that the lecturer is not delivering the topic as expected. He became aware of a shift in his emotions and realized that he was no longer interested in the lecture and that he needed to express these feelings. Through the "Emotional Communication" application on his laptop, John communicated his emotions to the Professor. Because of some ambiguous concepts, Professor noticed that John's interest in the topic had waned. The professor addresses this issue by delving deeper into the subject.

User Scenario 2

John is sitting in on a lecture and notes that the Professor is delivering the lecture in great depth and precision. He was feeling happy and content at the time, and he wanted to tell the Professor about it. John pulled out his phone and opened the "Emotional Communication" app, communicating his emotions to the Professor.

User Scenario 3

John is attending a lecture; he enjoys the lesson, but he has a few questions about a specific topic and would like some answers. He opened his laptop's "Emotional Communication" application and typed a question in the comment box. He sends this question to the professor, who notices John's comment in the detailed version of the application and answers all his questions.

User Scenario 4

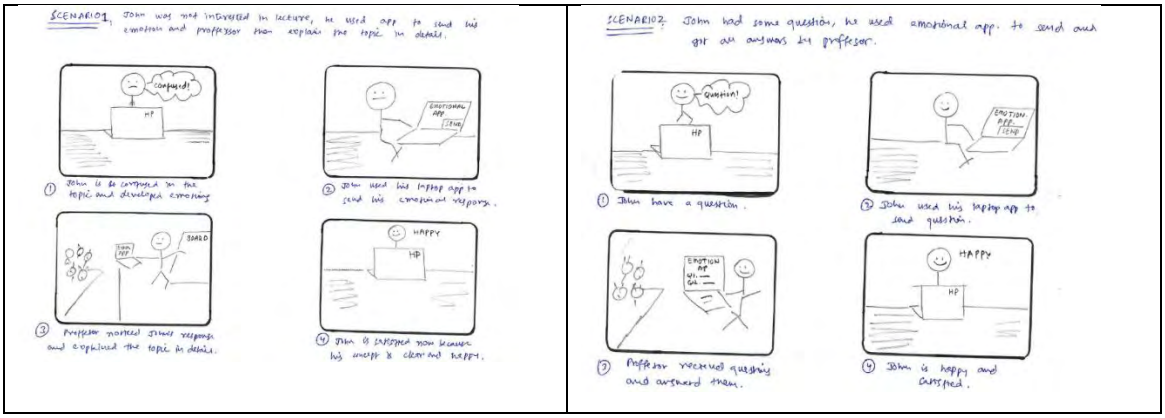
The professor is delivering a lecture in the classroom. The real-time screen of emotional communication is already open on a display. The screen's colour changed every 5 minutes during his lesson, and the professor suddenly noticed that the colour was shifting toward red, indicating that students were not happy or satisfied. The professor investigates the specifics of emotional responses and discovers that the previous topic is difficult for students to grasp due to a lack of real-world examples. The professor tried to explain the topic again with more examples, and the screen's colour has now changed to greener, indicating that the students are happier.

User Scenario 5

The professor delivered the lecture. He opened the application's detailed version and noticed that many students were confused about a specific topic and required additional explanation. Then he tried to take more questions on the subject, which eventually clarified the concept and satisfied the students.

4.5 User Stories

User stories are an important, deep human component of the design process. They are told from the user's point of view and are used to lead and motivate design decisions. Several user stories are created as shown in Figure 9.



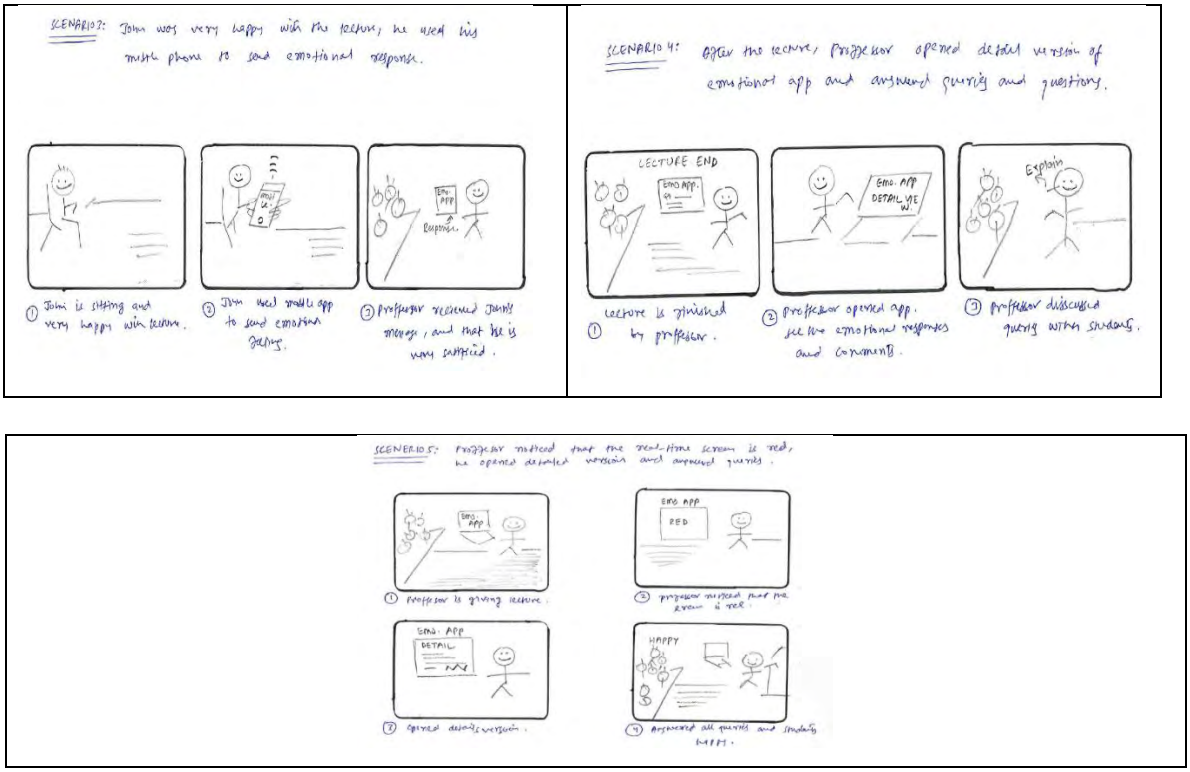


Figure 9 Different story boards

4.6 Summary

Informing was done with the research participants to design a system by which students can communicate their emotions during the lecture. In this phase, the two main goals were to determine the best suitable interaction method and interface type for our system. Several methods taken from the book were used (Kurniawan S. 2004). Presentation, paper prototypes, questionnaires, interviews, focus group sessions, and qualitative analysis of user response and requirements were all part of these methods. According to the results, the user preferred a GUI-based interaction with a mix of categorical and dimensional interface types. Using it as a foundation, I will proceed to my next phase, which will involve designing various design alternatives for the system using the UCD process.

Chapter 5 Design Alternatives

5.1 Initial Design Sketches

For the understanding of users, different design sketches were made that represent different ideas based on different interface types shown in Figure 10. It helped the user get the initial idea about system user interface. Based on the initial finding during the design session an initial version for teacher side of application is also made which is shown in Figure 11.

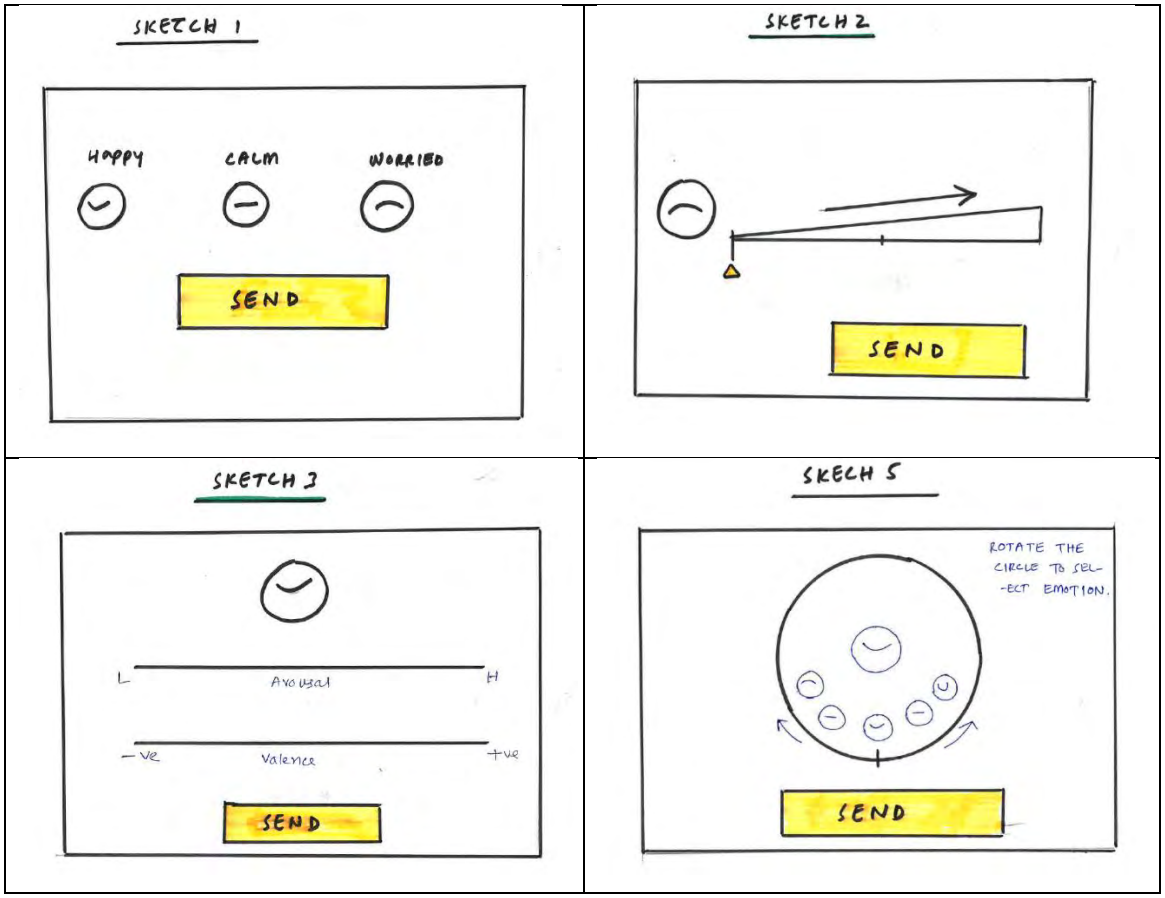


Figure 10 Design sketches based on different interface types.

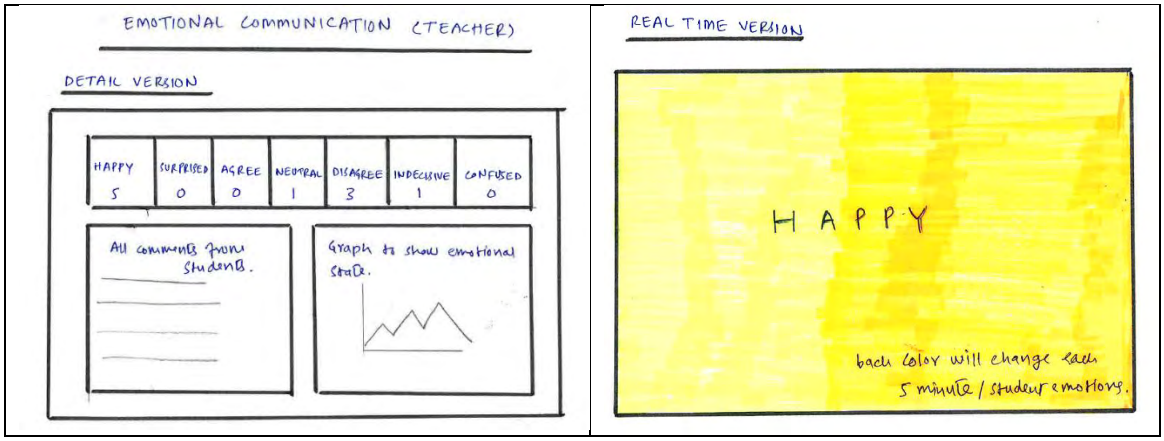


Figure 11 Initial design sketch for teacher side of application

5.2 Design Requirements

Based on user design sessions, paper prototypes, interviews, focus groups, and discussions about various interaction types and interfaces. We arrived at the following system design requirements.

- *For the evaluation, a cross-platform, high-fidelity prototype will be created.*
- *The application will have both a student and a teacher side.*
- *A student side will have a mix of categorical and dimensional interface types, and a user will be able to select an emotion based on a two-dimensional emotional wheel.*
- *The emotions used in the interface were derived from the previous research paper.*
- *In the textbox, a user can send emotion anonymously or with his/her name.*
- *The teacher will have two screens: one real-time and one that will represent an ambient colour display based on students' emotional responses. This display's colour will change based on the average emotional value from the student side.*
- *When a student sends an emotion, the emotion appears on the teacher's screen for a few seconds before disappearing.*
- *A detailed version of the screen will also be available for the teacher, allowing the teacher to analyse emotional responses in the form of a real-time graph. This screen will also display all the emotions sent by the user, either with their names or anonymously.*

5.3 System Design

Based on the literature review and various informing sessions with our participants, I arrived at the final system design depicted in figures 12 and 13. We presented our users with all of the interaction methods that could be used as an input method for emotional communication in order to determine which one is best suited for them. Among several options, users preferred graphical user interaction. Our participants' main argument and

reason was that during a lecture, their focus and goal is to listen to and understand the lecture, and they do not want to lose their focus due to some complex interaction. Because most students have their laptops open during lectures, they wanted a system that could easily send their emotions inside the laptop screen, like a simple taskbar application. Some participants requested that this application be available on mobile devices as well, so I will make this prototype cross-platform so that participants can use it on both PC and mobile. When it comes to choosing between categorical, dimensional, and interactional interfaces. Participants preferred a mix of categorical and dimensional interfaces because they stated that they would like to not only select the emotion but also have arousal and valence-based emotions. Taking these points into consideration, as well as the idea from (Scherer et al. 2013), I created a 2D emotional wheel that was intended to be a cross-platform application. It met the needs of participants who wanted to categorize their emotions as well as those who wanted to select emotional arousal and valence. On the teacher side, the interaction is also GUI-based, with a real-time and detailed version of the application. This idea was inspired by the informing phase with our participant students, and I wanted to ensure consistency on both sides through the same type of interaction.

Student side of application contains of an emotional wheel with 12 different kinds of emotions taken by the research done by (Kort et al., 2001) i.e. Frustration, Disappointment, Confusion, Satisfaction, Hopefulness, Confident, Dispirited, Boredom, Dissatisfied, Interest, Curiosity, and Enthusiastic. Each emotion is represented by four different size of circles each represent arousal or in other words strength of each emotion. A user can select an appropriate emotion and send it through the button given below both anonymous and with name. On the other hand, the teacher side of the application has two screens i.e., Real-time and Detail version. A real-time screen will change its colors based on the average emotional response by the student which could tell a teacher about average emotion of the classroom. If a teacher wants to see the detail view, then he can see the detail screen to check how many emotions have been sent and a graphical representation of emotion over time of his lecture. Figures 12 and 13 shows design in detail.

5.3.1 Student Screen

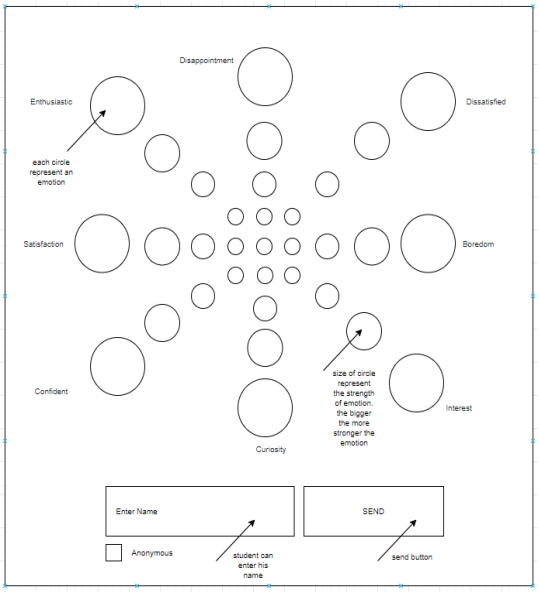


Figure 12 Student screen. Every circle on the student screen represents a different emotion. A user can select an emotion by clicking on a circle. The size of each circle represents the level of arousal or emotional intensity. A user can choose an appropriate size based on his emotions. By pressing the send button, you can send a response with or without a name.

5.3.1 Teacher Screen

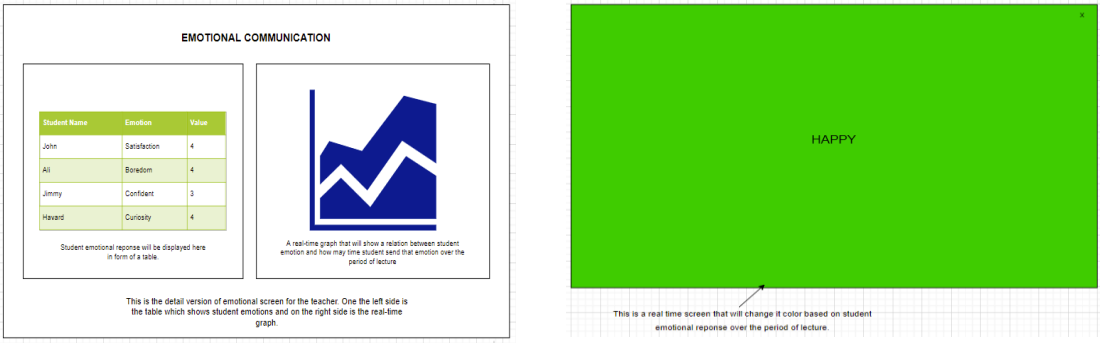


Figure 13 . Teacher screens. A teacher has two screens. On the left side, there is a real-time screen. This screen's colors change based on the average student response. Positive to negative emotional responses are represented by the colors green to red. While delivering a lecture, a teacher can monitor student emotions by looking at this screen. The detail version of the teacher screen can be found on the right side. It includes a table that shows the total number of emotional responses from students during the lecture. Also included is a graph, both a line and a pie graph, to monitor student emotions in a more interactive manner.

5.4 Summary

This chapter provided a thorough overview of various design options. Several sketches were created to help users understand the various interface types. The final system requirements were determined based on the user's response. Because users were interested in both types, a mix of categorical and dimensional interface types was chosen. A student screen with a two-dimensional interface and different circles representing different emotions is designed. The size of each circle represents the level of arousal or intensity of emotion chosen. A real-time screen that represents average student response in the form of a colors range from green to red was designed for teachers. This screen will assist teachers in real-time monitoring of students' emotions, and a detailed version of the screen is also provided in case a teacher wants to see details about student emotions throughout the lecture.

Chapter 6 Implementation

An interactive prototype was necessary to evaluate the research questions RQ3 and RQ4, for that we used React Javascript to develop a cross platform application that could run both on PC and Mobile. This application used a firebase database on the backend, and the reason for choosing React Javascript is due to its modularity and ease of use. React allows integration of third-party libraries which makes designing and coding easier as well as competent. As for the backend, firebase is selected due to it being simple and lightweight. It is an efficient prototyping tool for backend web development and is quick and easy to integrate and setup.

6.1 Use Case Diagram

This use case in Figure 14 represents a student's interaction with the system to send an emotion, as well as the teacher's interaction to see this emotion in real-time. Essentially, the color of the real-time ambient display will change based on the average response of student emotions.

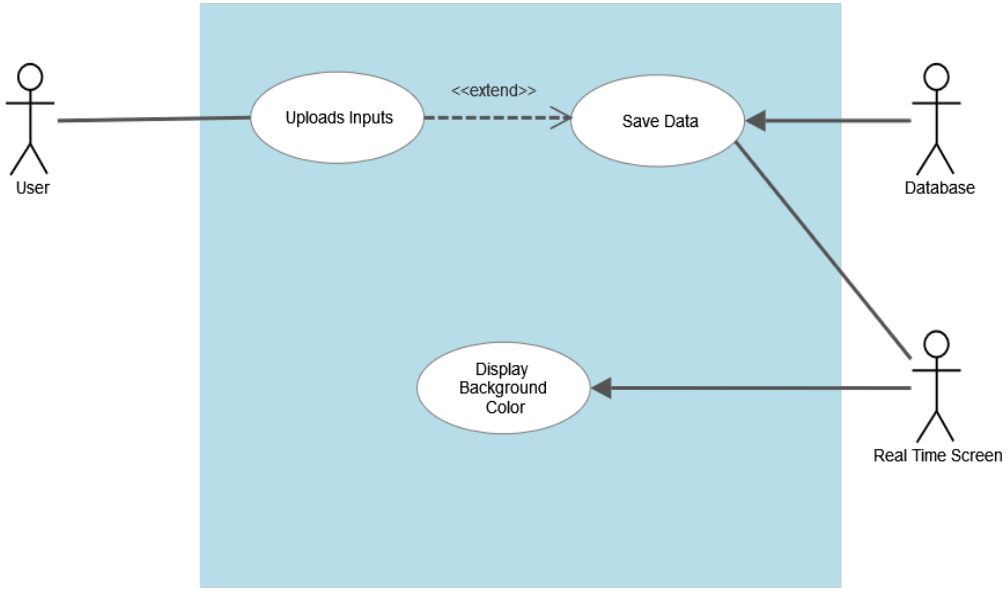


Figure 14 Use Case Diagram for Real Time Screen

This use case in Figure 15 represents the interaction between the student and the emotional communication system and the teacher interacting with the detail screen. A detail screen is basically by which a teacher can see the history of emotional responses send by the student and view the emotional response in a graphical version like a graph. This helps

the teacher to analyse how many responses he got in the lecture and what is the average emotion of the class.

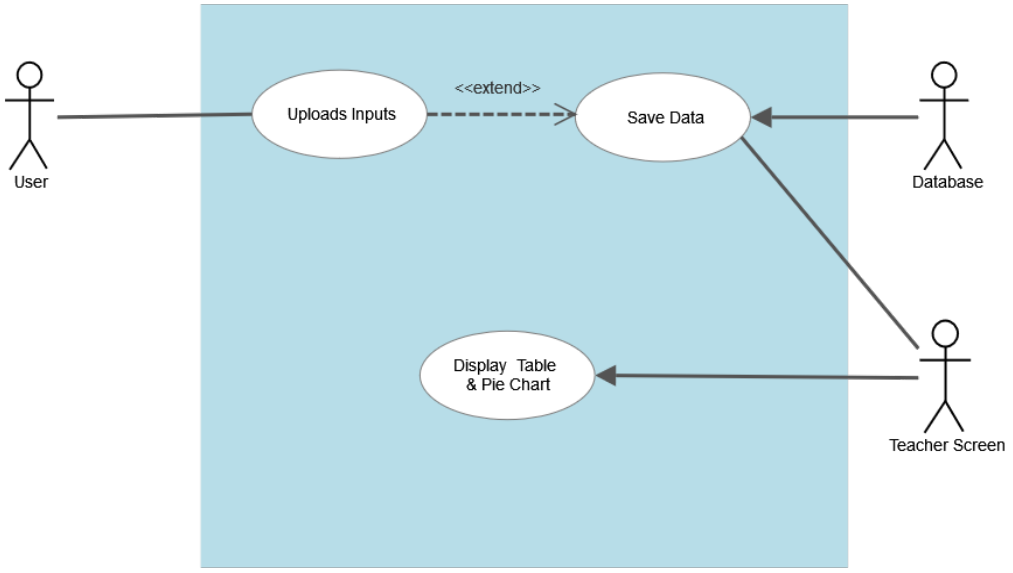


Figure 15 Use Case Diagram for Detail Screen

6.2 Sequence Diagram

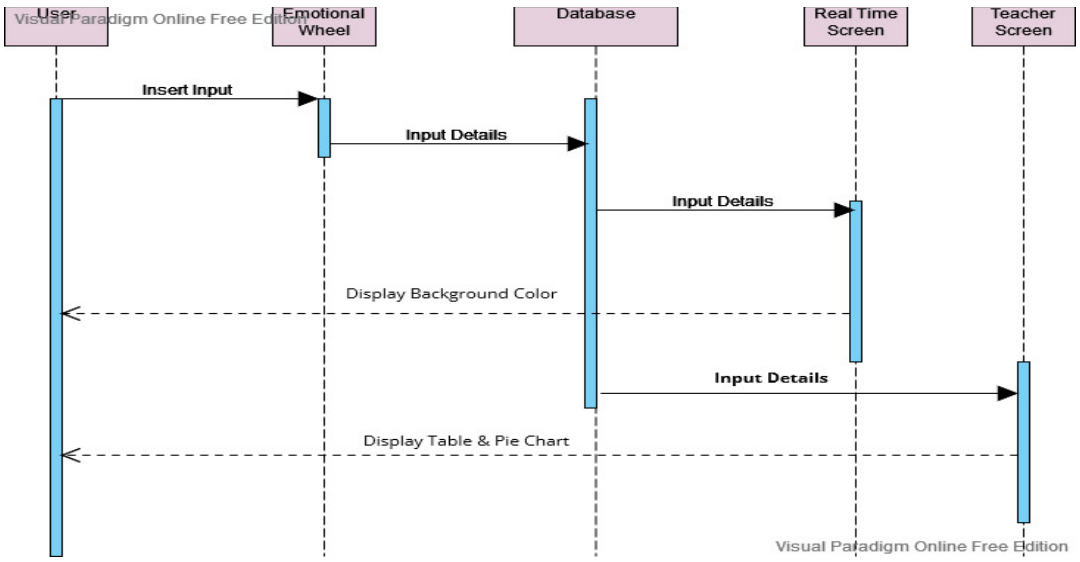


Figure 16 Sequence diagram of the system

6.3 Application Front End

The front-end design of this project consists of 3 screens:

1. The Student Screen
2. The Detail Screen for Teacher
3. The Real-Time Screen for Teacher

6.3.1 The Student Screen

The student screen allows students to communicate their emotions during a lecture. It consists of 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, according to what they are feeling during the lecture. Each emotion has been assigned a colour between green and red based on the positivity or negativity of the emotion respectively also known as valence. The student can choose to either send their response anonymously or with their name entered in the Name field provided. Their response will be stored in the database. Figure 17 shows the student screen to send an emotional response.

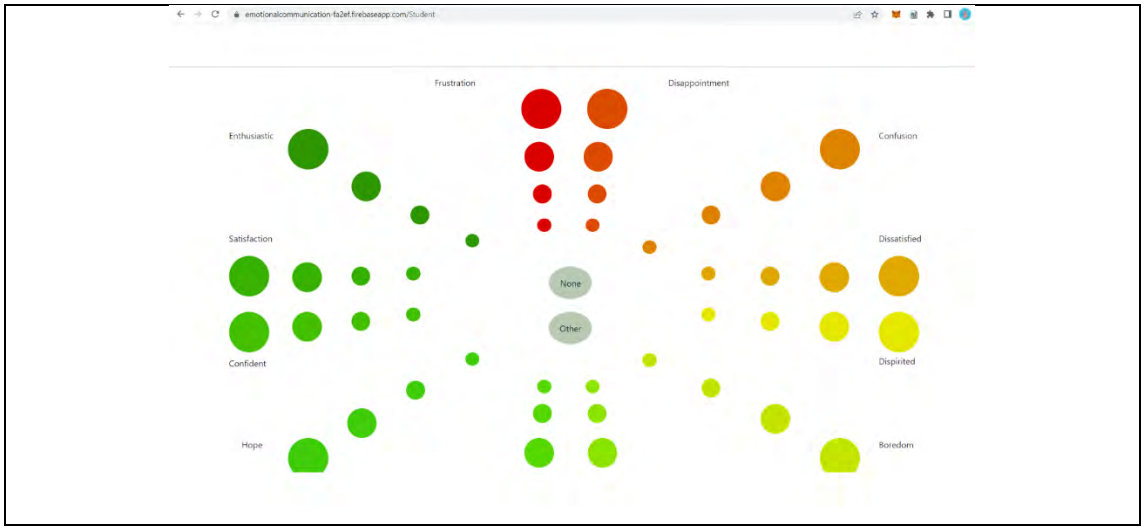


Figure 17 Student screen to select an emotion and send

The design of the emotional wheel is done using the grid system of bootstrap. Bootstrap is a framework that is supported in React and it provides design templates for different interface components such as forms, buttons, navigation etc. Its grid system allows layouts of different shapes and sizes due to a 12-column system. It divides the screen into 12 columns and however many rows required. For the emotional wheel, the screen is divided into 12 columns and 12 rows, with each button in its specified location to give it a wheel shape. The Name field is also provided as an input form field where the student can enter their name and it will be disabled if the student selects the Anonymous checkbox. As soon

the student submits their response by clicking on the Send button, it will be stored in the database.

6.3.2 The Real-time Screen for Teacher

This screen will be shown to the teacher during the duration of the lecture, and it will display the emotional response from the students to the teacher by the change of its background colour in real time. By default, the colour of the screen will be green, and the colour will change within a red to green colour gradient based on the emotional responses. It will show to the teacher what the students are feeling on average during the lecture from the range of emotions, enthusiastic to frustrated, through its background colour. Figure 18 shows a real-time ambient screen of teacher screen to monitor emotion.

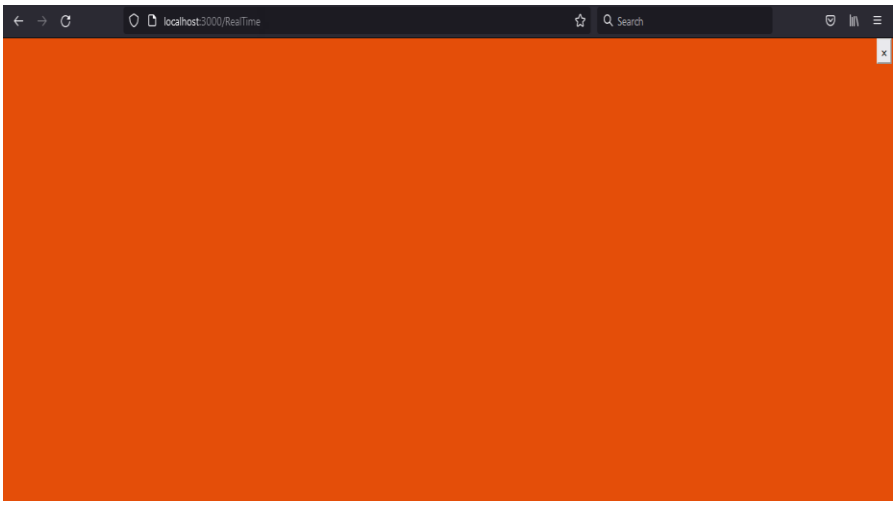
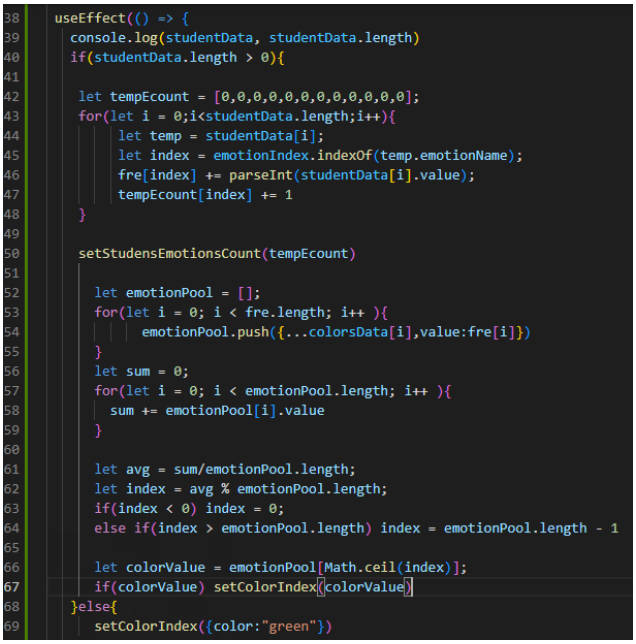


Figure 18 Real-time screen for teacher

States and Hooks have been used for the real time logic. The useEffect hook is used here and is particularly effective as it will be triggered anytime an update happens to the React component. So anytime a new student response is entered in the database, the useEffect hook will trigger and hence, run the piece of code mentioned within the hook. The student data is fetched from the database within the hook and stored in the studentData state. All the emotions from the studentData state are then stored in an emotions' array along with their values and color. The values are then added, and their mean calculated and based on the rounded off value of the mean, the emotion that corresponds to that value is selected from the array and its color is passed to the real time screen component and used to set the background color of the screen. The logic is shown in the code below.



```
useEffect(() => {
  console.log(studentData, studentData.length)
  if(studentData.length > 0){

   let tempEcount = [0,0,0,0,0,0,0,0,0,0,0,0];
   for(let i = 0;i<studentData.length;i++){
        let temp = studentData[i];
        let index = emotionIndex.indexOf(temp.emotionName);
        fre[index] += parseInt(studentData[i].value);
        tempEcount[index] += 1
   }

   setStudensEmotionsCount(tempEcount)

    let emotionPool = [];
    for(let i = 0; i < fre.length; i++ ){
         emotionPool.push({...colorsData[i],value:fre[i]})
    }
    let sum = 0;
    for(let i = 0; i < emotionPool.length; i++ ){
      sum += emotionPool[i].value
    }

    let avg = sum/emotionPool.length;
    let index = avg % emotionPool.length;
    if(index < 0) index = 0;
    else if(index > emotionPool.length) index = emotionPool.length - 1

    let colorValue = emotionPool[Math.ceil(index)];
    if(colorValue) setColorIndex(colorValue)
  }else{
    setColorIndex({color:"green"})
```

Figure 19 Real-time screen colour logic code snippet

As soon as the teacher closes the real time screen using the cross button on the top right corner shown in Figure 19 another screen will be shown to the teacher which will contain the entire session's student data in tabular and graph form.

6.3.3 The Detail Screen for Teacher

This screen will be shown to the teacher as soon as the real time screen is closed. Here the teacher will be able to see all the students' data fetched from the database in a tabular form. The table will show the Student Name, Emotion Name and Value and will contain all the entries of the students who participated in the emotional communication during the session. The student's name will be empty if the student is anonymous.

Student Name	Emotion Name	Value
	Dispirited	4
	Frustration	-4
	Disappointment	-4
	Enthusiastic	3
	Disappointment	-2
	Disappointment	-2
	Enthusiastic	3
	Confusion	-4
	Frustration	-4
	Enthusiastic	4
	Frustration	-4
	Satisfaction	2
	Frustration	-4
	Boredom	4

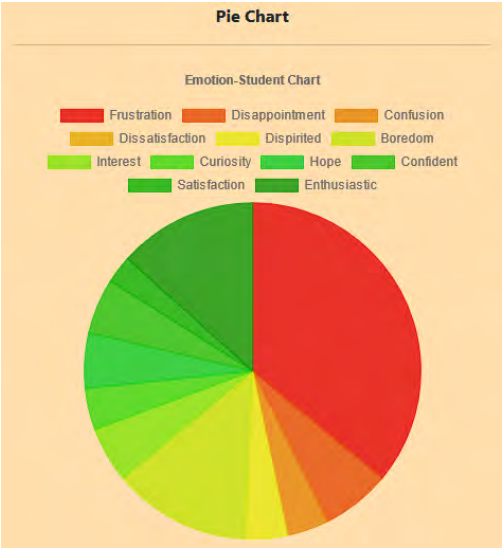


Figure 20 The detail screen table for student emotions

A detail version of teacher screen is shown in the Figure 20. Where on the left side it is the student emotional responses, and on the right side is the chart which shows different student emotions for visualization. The table is designed using a bootstrap table class and layout. The student data fetched from the database is mapped onto it. The teacher screen also contains a pie chart that illustrates the student-Emotion relationship. Each sector of the pie chart demonstrates an emotion, and the angle of the sector is adjusted according to the number of students who sent that emotion i.e., the count of that emotion. The bigger the emotion count, the bigger the sector. After fetching the student data from the database, the number of each emotion is counted and stored in an Emotions count array which is then passed to this screen component to be used for the pie chart. The emotion name and its count are shown when the pie chart sector is highlighted.

The pie chart is made using the React ChartJS library. This is a widely used charting library and provides samples for different kinds of charts and graphs including bar graph, line chart, pie chart etc. Integration of this library in the system allows the use of these various charts and the datasets and labels of the chart can be changed according to the user's requirements.

6.4 Application Back End

The back end in this project relates to Firebase Firestore. Firestore is an easy-to-use cloud database which provides users with fast queries to fetch, read, update data etc. hence, it is one of the best backend end tools for our system. It is also easy to integrate and setup. In this project, the student data which includes the Student's Name, the Emotion Name and the Emotion Value sent through the emotional wheel is being stored in the database under the collection "students. Each time a student will submit a response, a new document will be created under this collection signifying a new student entry as shown in Figure 21.

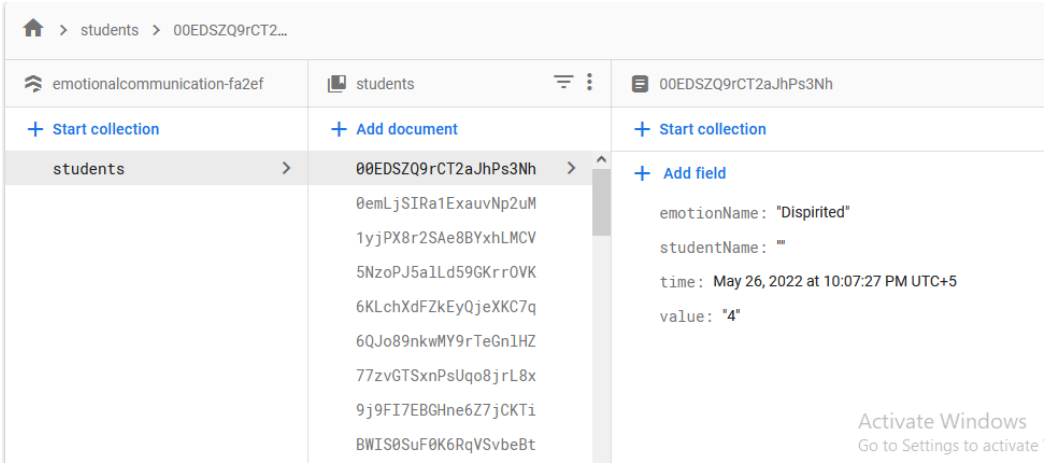


Figure 21 Firestore database for the application

Two functions have been created in the code which deal with the writing and reading of data in the database. The function responsible for writing data in the database relates to the Send button on the Student Screen. As soon as the button is clicked, the function for adding the details in the database will be called. The second backend function in the code is responsible for fetching the student details from the database. This data is then used both for the Real Time screen colors as well as displayed in the tabular form and pie chart form on the Teacher Screen. The code for the function to fetch data is shown in the Figure 22.

```
import {addDoc,collection,getFirestore,serverTimestamp} from "firebase/firestore";
import RealTime from "../components/RealTime";

export const handleAddEmotions = async (data)=>{
    try{
        const db = getFirestore();

        await addDoc(collection(db,"students"),
            {...data,
            time:serverTimestamp()
        })
    }catch(ex){
        throw new Error(ex)
    }

}
```

Figure 22 Function for writing data in database

6.5 Summary

To address research questions RQ3 and RQ4, an interaction prototype was developed using React Javascript to create a cross-platform application that could run on both PC and mobile. The backend of this application was a Firebase database and React Javascript was chosen for its modularity and ease of use. This app has two screens: one for the student to communicate his emotions and one for the teacher to monitor the student's emotions. The teacher can monitor student emotion during the lecture by looking at the real time screen,

which is a plain screen with changing colors. It is a type of ambient display whose colors change based on average student response. A teacher has another screen that displays a more detailed version of a student's response. This prototype will be tested in a real-world setting with students and teachers evaluating the system.

Chapter 7 Evaluation

A final system design for students and teachers is prototyped based on the design requirements obtained from design sessions with our participants. Figure 23 shows the pictures from the evaluation session, where a professor is delivering a lecture and a student is using the system to send his emotion. The following research questions will be addressed to determine whether the developed system meets the design's needs.

1. *How useful the selected interaction method is to send emotions during the lecture?*
2. *How useful this system would be for teachers, monitor student emotions during the lecture?*

Figure 23 Evaluation session with teacher and students at the university

7.1 Method

The system was evaluated by five university students and a teacher from the university's IT department. All participants were required to sign a Consent form created by the NSD. The Emotional Communication application was installed on the students' and teacher's laptops and mobile phones before the commencement of the lecture. The students were shown how to use the interface to select and communicate their emotions. The teacher was also shown the application's Real-time screen and the detail version, as well as instructions on how to monitor emotional responses on both screens. The teacher chose a Deep Learning topic (Long Short-term Memory Networks LSTM) because the students were interested in current research in Machine Learning and AI and the lecture lasted for 30 minutes.

During the lecture, users evaluated the system using the mobile and PC applications provided. Some were using laptop computers to take notes and use the application to express their emotions, while others were using mobile phones. The basic instructions were

to use the system whenever they felt the need to express themselves to the lecturer. I sat on one side of the room as the researcher, watching and observing the participants. The students were completely focused on the lecture most of the time, but I have noticed that students occasionally send emotional responses through the application when some terminology in that topic is unclear or when something appears very interesting. When the teacher went into greater depth about the topic and discussed the more technical aspects of LSTM, for example, I noticed that the students' facial expressions changed from concerned and focused on their laptops to less concerned and focused on their laptops. I noticed the time, and after the lecture, I examined the detail version of the teacher screen, and it appears that most of the emotional responses were negative at 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 learn about the total number of emotional responses and to analyse the overall class emotion during the lecture.

A questionnaire was created for both students and teachers to record their response after using the system in the classroom. Following the lecture, students, and teacher evaluated the system. The purpose of the assessment is to assess the system's effectiveness for students to transmit feelings and for teachers to observe students' emotions in real-time.

7.2 Results

How useful the selected interaction method is to send emotions during the lecture?

1. Rate how easy was it for you to interact with the system during the lecture?

All the participants said that it was super easy to interact with the system. According to the participants' response, the developed system is effortlessly simple. All the student's responses are positive. It depicts that the following emotional communication system can be deployed and used practically in classroom settings.

2. If there is any difficulty while interacting with the system, please elaborate.

All the participants answered that there was no difficulty when interacting with the system because the system was deployed as a cross-platform application and has a very simple interface of both student and teacher side. The student side of the application consists of an emotional wheel containing 12 emotions. The teacher side of the system consists of two screens i.e. The Real-time Screen depicting the emotions through hues and the other screen that shows the data related to student emotions in tabular form.

3. Do you think the system fulfilled your need of sending the emotion during the lecture?

All the participants answered that the system fulfilled their need of sending emotional response. According to the student responses, as the system is helpful in taking inputs of students in an unobtrusive manner, there is no disturbance or uneasiness is created with the

use of system. The system does not distract the attention of students and teachers during lecture.

4. While sending the emotional response, did you easily find out the matching emotion you wanted to send?

Most of the participant had no difficulty finding the right emotion. Only one said he spend more time to find the matching emotion, and he could not find the best suitable emotion, so he selected the closest one. Most of the participants' responded that there was no difficulty in finding out the emotions they felt. The 12 emotions displayed on the emotional wheel represented on the student screen are selected after thorough research on student behaviour and emotions in the classroom. One participant said that he found difficulty to find the relevant emotion, which means this area needs to be improved with more research and providing an option to select more emotions.

5. Was the system comfortable to use in front of other students?

All the users said that they were comfortable while using the system in front of others. All the student's responses are Yes, which indicates that the use of the system in front of other students is comfortable. Each student has an account from which they can send emotions anonymously or with an identity. Students can privately view their emotional history.

6. Is there any additional functionality you would like to add into the GUI interface?

The additional functionality recommended by students is as follows:

- A 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.
- Missing emotions could be added by an additional button etc.

The addition of such functionalities will improve the working of the student side system. It will help in a more precise expression of emotions by the students improving the quality of emotional communication.

How useful this system would be for teachers, monitor student emotions during the lecture?

1. Rate how easy was it for you to monitor student emotions by looking at the color of real-time screen?

Teacher said it was very easy to monitor student emotion by looking at real-time screen every 3-5 minutes. According to the teacher's response, the system helps in easy and quick monitoring of the students' emotions. The teacher can guess the atmosphere of the classroom just by looking at the screen. The teacher can easily change the classroom environment from negative to positive by changing his attitude, pedagogical style, and the lesson's content.

2. Do you think the pie graph shown on the screen, helped you understand and analyse different student emotions, during the lecture?

Lecturer responded that the detail version of the screen helped a lot to analyse the students' emotions in more detail. According to the teacher's response, the graph helped analyse the lecture impact and the classroom atmosphere. The graph shows the summary of student emotions during the whole lecture. It can help the teacher understand the overall lecture response from the student. The teacher can review the lesson and improve his/her lessons, teaching style, and attitude according to the response received from students.

3. How often you looked at the screen to monitor student emotions during your lecture?

Every 3-5 minutes, the teacher looked at the screen to know about student emotions. The average time for the teacher to view the student's response on the screen is 3 to 5 minutes. The teacher can view student responses without getting distracted from the lesson because of the system. The system can operate smoothly with classroom activities. It can improve the effectiveness of lessons and the classroom environment concerning emotions.

4. Please comment, is there any time, when you looked at the real-time screen and you thought that the student emotions are more towards negative, and then you explained the topic a bit more in detail or changed the topic, and it helped changing the student emotions towards more positive or vice versa?

Mostly the student emotions were positive during discussion so the teacher cannot really test this part. This notion, according to the teacher, cannot be tested. Because mostly the student average response was positive during the whole lecture. This notion can be tested more thoroughly on a wider number of people, and a more length lecture with students from multiple disciplines.

5. Is there any additional functionality you would like to add to the interface which could help you better understand and analyse the student emotions?

The following additional functionalities are suggested by the teacher for improvement of the teacher side system:

- Add a textbox to the student screen so that the student may describe in detail what section of the lecture is bothering him, and the instructor can quickly understand his concerns.
- The instructor should be able to recognize emotions related to time. If the instructor wishes to see the average of feelings during the first 15 minutes of class, she can look at an emotion report for the first 15 minutes of class.

7.3 Summary

The evaluation session was held in a university lecture hall with five students and an IT department teacher. Before the commencement of the lecture, both students and teachers were given basic instructions on how to use the system on both sides. The lecture lasted 30 minutes and covered a topic related to machine learning and artificial intelligence. Based on student feedback, it appears that the GUI based interaction method was simple for all students to use and that no one had difficulty interacting with the system. When it comes to selecting the matching emotion from the system interface, one student stated that he spends more time selecting the matching emotion, so this area could be improved by providing a feature by which a user can select more emotions or draw some emotion based on their feelings. With the exception of the additional features mentioned in the preceding section, the overall student response was positive. The real-time screen, on the other hand, was very useful to the teacher in monitoring the student emotions in real-time by looking at the screen every 3-5 minutes. The teacher wished to expand the interface in order to determine which section or topic of the lecture was bothering the student. Furthermore, the teacher desired a report on average emotion feelings over a specific time period.

Chapter 8 Discussion

One of the primary goals of this research is to design, build, and test a system that allows students to communicate their emotions to the instructor during the lecture. By focusing on this goal, several research questions arose, ranging from locating any related research to the best suitable interaction method and designing a prototype that can be evaluated in a classroom environment with students and teachers.

To communicate emotion, researchers have previously used systems such as automated systems comprised of sensors, artificial intelligence, and direct emotional communication techniques such as handheld devices and animated and colourful text conversations. Based on preliminary findings from previous research, these mentioned systems cannot be considered very effective in evaluating and communicating emotions because they are incapable of determining what factor influences students in the classroom, whether it is the lecture content, the pedagogical style, interaction with the teacher, or anything else. Displaying students' emotions to a teacher, on the other hand, is an important factor in creating a better learning environment. The technologies do not investigate the real-time display of student responses to lecturers. A critical responsibility is the ability to display students' emotional responses to professors in real-time and flawlessly during lectures. It enables the lecturer to adjust the lecture setting in response to student comments and actively engage students.

Based on previous research, I decided to work on this area further to find the best suitable method that will allow students to communicate their emotion during the lecture and the teacher to monitor students' emotion in real time while delivering the lecture. I chose a user-centered design approach because I want to involve the students as much as possible in this research so that the final system is solely based on their preferences and dislikes. Thus, using a user-centered approach and informing and design sessions, I attempted to analyse and design a system in which students could easily and conveniently communicate their emotions during the lecture, as well as the teacher could see students' emotions in real-time and respond to them, thereby making classroom learning better and more affected both ways. The main goal of the requirement gathering phase was to identify the best suitable interaction method and interface type for our system. To determine the interaction method and interface type, several methods were used, including paper prototypes, questionnaires, interviews, focus group sessions, and qualitative analysis. To discuss the various interface types with users, various design alternatives were created, including categorical, dimensional, and interactional interfaces. According to the findings of these design sessions, participants are more interested in a cross-platform GUI based application that can be installed on their laptops and mobile phones to communicate their emotions. For the system, they chose a GUI-based interaction method and a mix of categorical and dimensional interfaces. By holding several design sessions with our research participants following the final design requirements analysis and focus group session with the user, I created a prototype that can be tested in a real-world environment. For implementation, I used React Javascript and Firebase to create and deploy an application for both mobile and PC that students and teachers can easily access while evaluating the system.

Based on the results from evaluation session, the system appears to be promising. After testing the system with participants in real-time and collecting feedback via a questionnaire, all users appear to be very comfortable with the chosen interaction method. When interacting with the system in the classroom, the users appear to be very positive. The user

also stated that interacting with the system in front of others and in a social setting was not difficult. The system met the requirement of sending emotions during the lecture. Because the system is useful in collecting student input in an unobtrusive manner. The use of the system causes no disruption or uneasiness. When asked to send an emotional response, the participants were asked about the emotional wheel and finding the matching emotions. According to the responses, it appears that most users found their emotions easily and responded positively, but a few participants stated that they spent some time selecting the best matching emotion. That is, there is a need to improve the emotional wheel and add more emotions to it, or to conduct more extensive research with a large user group to find more suitable emotions. Another approach would be to include a button somewhere near the emotional wheel so that if a user cannot find the best matching emotion, he can press that button and draw some emotion or choose from a larger range of emotions. We also asked users how we could improve our current user interface, and based on their responses, it appears that users want to type some comment along with their emotion, so that if an emotion does not fully express their feelings, they can type and explain their feelings in a more textual way. A participant also stated that rather than selecting an emotion and then pressing the send button, it would be faster to simply select the emotion from the wheel and it would send it immediately; however, if we do this, people may send incorrect emotions instantly, or they will be unable to type feelings alongside the emotions they send, as desired by other users.

The teacher who delivered a lecture during the evaluation session was also asked to provide feedback via a questionnaire. According to the teacher, the system facilitates easy and quick monitoring of the students' emotions. Based on the real-time screen and instant feedback, the teacher stated that he could easily change the classroom environment from negative to positive by changing his attitude, pedagogical style, and lesson content. The detailed version of the application was also appreciated by the teacher, who stated that it allows him to see student emotional responses in greater detail. Some of the suggestions made by the teacher included providing tags with emotions so that he could learn more about student emotions and why they occurred. Our student participant who used the system also recommended this feature. In addition, the teacher requested interval feedback on student emotion, such as what the student's average emotional response was during the first 15 minutes of the lecture.

According to the overall feedback results and after testing the final system prototype in a classroom, all users felt that the emotional input and transmission to teachers were unobtrusive. The system's operation causes no disruption or concern. Throughout the class, neither students nor teachers are distracted by technology. The emotional communication system satisfied the users of the student side system's need to send feelings. Monitoring students' emotions, according to a teacher who uses the emotional communication system, is simple and quick. A few users suggested some additional features for the student screen to express feelings, as well as a textbox to the Teacher panel to better understand the emotions.

Chapter 9 Conclusion

In this master thesis, I used a User Centred Design approach to design and develop a system by which a student can send his emotion during the lecture, and, on the other side, the teacher could monitor students' emotions and deliver his lecture in a better way. Through previous literature review, I tried to answer my first research question, which was about the interaction methods that could be used to send emotions. I found out that the researcher has used different interaction method to measure student emotions, which includes, sensor-based, through hardware tools, and measuring the body posture and facial expressions through a camera. Based on this knowledge, I have done the informing phase and tried to find the best method through various design sessions with the research participants. It can be concluded that the users were looking for something quick and easy, and their main argument for this easiness is that in the lecture settings their main goal is to listen to the lecture, and they would not like to interact with something very complex that could take most of their time. It was found that a cross-platform GUI-based application is preferred by our participants. To evaluate the research question about the usefulness of this application for both students and professors I conducted an evaluation session based on the prototype developed. It was a 30-minute lecture delivered by a university professor to various students, I asked the student and teacher to evaluate the system based on a questionnaire and a discussion after the system use. As a result, the overall feedback shows that the emotional communication system appears to be promising and the system's operation causes no disruption or concern while listening or delivering the lecture.

Bibliography

Abras, C., Maloney-Krichmar, D., & Preece, J. (2004). User-centered design. *Bainbridge, W. Encyclopedia of Human-Computer Interaction. Thousand Oaks: Sage Publications*, *37*(4), 445-456.

Ahmed, F. D., Tang, A. Y., Ahmad, A., & Ahmad, M. S. (2013). Recognizing student emotions using an agent-based emotion engine. *International Journal of Asian Social Science*, *3*(9), 1897-1905.

Alsmeyer, M., Luckin, R., & Good, J. (2008). Developing a novel interface for capturing self reports of affect. In *CHI'08 Extended Abstracts on Human Factors in Computing Systems* (pp. 2883-2888).

An, P., Bakker, S., Ordanovski, S., Taconis, R., Paffen, C. L., & Eggen, B. (2019). Unobtrusively enhancing reflection-in-action of teachers through spatially distributed ambient information. Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems,

Antona, M., Leonidis, A., Margetis, G., Korozi, M., Ntoa, S., & Stephanidis, C. (2011). A student-centric intelligent classroom. International Joint Conference on Ambient Intelligence,

Betella, A., & Verschure, P. F. (2016). The affective slider: A digital self-assessment scale for the measurement of human emotions. *PloS one*, *11*(2), e0148037.

Brooks, C. F., & Young, S. L. (2015). Emotion in online college classrooms: Examining the influence of perceived teacher communication behaviour on students' emotional experiences. *Technology, Pedagogy and Education*, *24*(4), 515-527.

Chang, A., Resner, B., Koerner, B., Wang, X., & Ishii, H. (2001). LumiTouch: an emotional communication device. CHI'01 extended abstracts on Human factors in computing systems,

Di Lascio, E., Gashi, S., & Santini, S. (2018). Unobtrusive assessment of students' emotional engagement during lectures using electrodermal activity sensors. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, *2*(3), 1-21.

Dowden, T., Pittaway, S., Yost, H., & McCarthy, R. (2013). Students' perceptions of written feedback in teacher education: Ideally feedback is a continuing two-way communication that encourages progress. *Assessment & Evaluation in Higher Education*, *38*(3), 349-362.

Farr-Wharton, B., Charles, M. B., Keast, R., Woolcott, G., & Chamberlain, D. (2018). Why lecturers still matter: the impact of lecturer-student exchange on student engagement and intention to leave university prematurely. *Higher Education*, *75*(1), 167-185.

Frayling, C. (1994). Research in art and design (Royal College of Art Research Papers, vol 1, no 1, 1993/4).

Goertz, G., & Mahoney, J. (2012). A tale of two cultures. In *A Tale of Two Cultures*. Princeton University Press.

Goetz, T., Lüdtke, O., Nett, U. E., Keller, M. M., & Lipnevich, A. A. (2013). Characteristics of teaching and students' emotions in the classroom: Investigating differences across domains. *Contemporary educational psychology*, *38*(4), 383-394.

Goldman, Z. W., & Goodboy, A. K. (2014). Making students feel better: Examining the relationships between teacher confirmation and college students' emotional outcomes. *Communication Education*, *63*(3), 259-277.

Hagenauer, G., Gläser-Zikuda, M., & Volet, S. E. (2016). University Teachers' Perceptions of Appropriate Emotion Display and High-Quality Teacher-Student Relationship: Similarities and Differences across Cultural-Educational Contexts. *Frontline Learning Research*, *4*(3), 44-74.

Hagenauer, G., Hascher, T., & Volet, S. E. (2015). Teacher emotions in the classroom: associations with students' engagement, classroom discipline and the interpersonal teacher-student relationship. *European journal of psychology of education*, *30*(4), 385-403.

Hansen, M., & Mendzheritskaya, J. (2017). How university lecturers' display of emotion affects students' emotions, failure attributions, and behavioral tendencies in Germany, Russia, and the United States. *Journal of cross-cultural psychology*, *48*(5), 734-753.

Jiranantanagorn, P., Bhardwaj, P., Li, R., Shen, H., Goodwin, R., & Teoh, K.-K. (2015). Designing a mobile digital backchannel system for monitoring sentiments and emotions in large lectures. Proceedings of the ASWEC 2015 24th Australasian Software Engineering Conference,

Kaasinen, E. (2005). User acceptance of mobile services: Value, ease of use, trust and ease of adoption. In: Citeseer.

Khajavy, G. H., MacIntyre, P. D., & Barabadi, E. (2018). Role of the emotions and classroom environment in willingness to communicate: Applying doubly latent multilevel analysis in second language acquisition research. *Studies in Second Language Acquisition*, *40*(3), 605-624.

Kort, B., Reilly, R., & Picard, R. W. (2001). An affective model of interplay between emotions and learning: Reengineering educational pedagogy-building a learning companion. Proceedings IEEE international conference on advanced learning technologies,

Laurans, G., Desmet, P. M., & Hekkert, P. (2009). The emotion slider: A self-report device for the continuous measurement of emotion. 2009 3rd International Conference on Affective Computing and Intelligent Interaction and Workshops,

Lottridge, D., & Chignell, M. (2009). Emotrace: Tracing emotions through human-system interaction. Proceedings of the Human Factors and Ergonomics Society Annual Meeting,

Lujan, H. L., Raizada, A., & DiCarlo, S. E. (2021). Critical skill of teaching: learning the cognitive and emotional states of our students during class. *Advances in Physiology Education*, *45*(1), 59-60.

Mazer, J. P., McKenna-Buchanan, T. P., Quinlan, M. M., & Titsworth, S. (2014). The dark side of emotion in the classroom: Emotional processes as mediators of teacher communication behaviors and student negative emotions. *Communication Education*, *63*(3), 149-168.

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.

Munoz, D. A., & Tucker, C. S. (2014). Assessing students' emotional states: An approach to identify lectures that provide an enhanced learning experience. International Design Engineering Technical Conferences and Computers and Information in Engineering Conference,

Nyadanu, S. D., Garglo, M. Y., Adampah, T., & Garglo, R. L. (2015). The impact of lecturer-student relationship on self-esteem and academic performance at higher education. *Journal of Social Science Studies*, *2*(1), 264-281.

Olsson, T. (2009). Creating, managing and sharing memories with mobile phones: A user-centred design approach. In.

Pekrun, R. (2014). Emotions and Learning. Educational Practices Series-24. *UNESCO International Bureau of Education*.

Pollak, J. P., Adams, P., & Gay, G. (2011). PAM: a photographic affect meter for frequent, in situ measurement of affect. Proceedings of the SIGCHI conference on Human factors in computing systems,

Poulou, M. (2014). The effects on students' emotional and behavioural difficulties of teacher–student interactions, students' social skills and classroom context. *British Educational Research Journal*, *40*(6), 986-1004.

Ramadan, R. A., Hagras, H., Nawito, M., El Faham, A., & Eldesouky, B. (2010). The intelligent classroom: towards an educational ambient intelligence testbed. 2010 Sixth international conference on intelligent environments,

Sagayadevan, V., & Jeyaraj, S. (2012). The role of Emotional Engagement in Lecturer-Student interaction and the Impact on Academic Outcomes of Student Achievement and Learning. *Journal of the Scholarship of Teaching and Learning*, *12*(3), 1-30.

Scherer, K. R., Shuman, V., Fontaine, J., & Soriano, C. (2013). The GRID meets the Wheel: Assessing emotional feeling via self-report. *Components of emotional meaning: A sourcebook*.

Sharmila, S., Kalaivani, A., & Gr, S. (2018). Automatic facial emotion analysis system for students in classroom environment. *International Journal of Pure and Applied Mathematics*, *119*(16), 2887-2894.

Singh, Y. K. (2006). *Fundamental of research methodology and statistics*. New Age International.

Ståhl A., S., P. and Höök, K. (2005). A foundation for emotional expressivity.

Subramainan, L., & Mahmoud, M. A. (2020). Academic Emotions Review: Types, Triggers, Reactions, and Computational Models. 2020 8th International Conference on Information Technology and Multimedia (ICIMU),

Tiam-Lee, T. J., & Sumi, K. (2019). Analysis and prediction of student emotions while doing programming exercises. International conference on intelligent tutoring systems,

Tonguç, G., & Ozkara, B. O. (2020). Automatic recognition of student emotions from facial expressions during a lecture. *Computers & Education*, *148*, 103797.

Tyng, C. M., Amin, H. U., Saad, M. N., & Malik, A. S. (2017). The influences of emotion on learning and memory. *Frontiers in psychology*, *8*, 1454.

Um, E., Plass, J. L., Hayward, E. O., & Homer, B. D. (2012). Emotional design in multimedia learning. *Journal of educational psychology*, *104*(2), 485.

Wang, H., Prendinger, H., & Igarashi, T. (2004). Communicating emotions in online chat using physiological sensors and animated text. CHI'04 extended abstracts on Human factors in computing systems,

Woolf, B. P., Arroyo, I., Cooper, D., Burleson, W., & Muldner, K. (2010). Affective tutors: Automatic detection of and response to student emotion. In *Advances in intelligent tutoring systems* (pp. 207-227). Springer.

Zimmerman, J., & Forlizzi, J. (2014). Research through design in HCI. In *Ways of Knowing in HCI* (pp. 167-189). Springer.

Kurniawan, S. (2004). Interaction design: Beyond human–computer interaction by Preece, Sharp and Rogers (2001), ISBN 0471492787.
Scherer, K.R., (2005). What are emotions? And how can they be measured?. Social science information, 44(4), pp.695-729.
Russell, J.A., (1980). A circumplex model of affect. Journal of personality and social psychology, 39(6), p.1161.
D.G. Myers, (2004) "Theories of emotion," Psychology: Seventh Edition, New York, NY: Worth Publishers, 500.
W. James, (1884) "What is an emotion," Mind, vol. 9, no.34 pp. 188-205.
W.B. Cannon, (1927) "The James-Lange theory of emotions: A critical examination and an alternative theory," The American journal of psychology, vol.39, no.1/4, pp.106-124.
R.S. Lazarus, J.R. Averill, and E.M. Opton, (1970) "Towards a cognitive theory of emotion," Feelings and emotions, pp. 207- 232.