

Exploring Affective Technologies for the Classroom with the Subtle Stone

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ABSTRACT

Constructive emotional experiences are strongly related to effective learning. Yet, it is challenging for teachers, researchers and students alike to understand the emotions experienced in the classroom setting. Advances in wireless and sensor technologies open up possibilities for better supporting emotions. However, little work has explored how affective technologies in the classroom might operate. This paper describes a study where 15 high school students used the Subtle Stone: a tangible technology designed to support students' active emotional communication in the classroom. We report on how the students used and experienced this technology, and the values they demonstrated through this use: flexibility, privacy, agency, voice and reflection. We conclude by examining future possibilities for affective technologies in the classroom.

Author Keywords

Emotional communication, emotion, affect, classroom, learning, Subtle Stone, affective technologies

ACM Classification Keywords

K.3.1 Computer uses in education

General Terms

Design

INTRODUCTION

Affective computing is gaining increasing attention in the CHI community [5, 12, 20] as the potential of new technologies to detect or support the communication of affective states is being realised. There are many contexts where affective technologies might be usefully applied; here we focus on the classroom. Scaffolding constructive emotional experiences throughout learning interactions is considered essential to successful learning and teaching

transactions [18, 19]. Yet, recent research suggests that teachers find it challenging to interpret the emotional experiences of students [4, 8]. This highlights an interesting tension: if teachers are expected to adequately support and respond to their students' emotional needs, then they need some way to understand those emotional needs.

Recent work has demonstrated that wireless and sensor-based technologies can open up many potential pathways towards understanding emotional experiences [e.g., 16]. Similar technologies could be used in the classroom to capture emotional experiences. The classroom is however an environment with particular needs, an environment about which there is little prior work to draw requirements for the design of such technologies. Whilst, students may benefit from technologies that help them reflect on their own emotional experiences during learning, teachers may require quick, real time access to the emotional states of their students. The social context is complex, containing many different levels of relationships, power and authority.

We developed and deployed the Subtle Stone [2] to probe the design space of affective technologies for the classroom. The Subtle Stone allows a student to actively and privately convey her emotional state to the teacher throughout lessons. This paper reports on how 15 UK high school students (aged 12 – 13) used a Subtle Stone throughout 9 hours of German language lessons. Our qualitative analyses of the resulting rich dataset suggest that students find value in tools that support privacy and personalisation around their communication of emotional experiences. In addition, providing choice about when, and what a student communicates to her teacher empowers a student to understand and reflect on her own emotional experiences in the classroom. The final section of this paper reflects on the values students gained from using the Subtle Stone, providing a set of implications and future challenges for designing affective technologies for the classroom.

RELATED WORK

A number of theories relate emotion to learning [e.g. 15, 17, 19]. The cognitive-motivational model [19] describes how a student's learning is mediated by a student's motivation to learn, a student's learning strategies, and a student's cognitive resources. Emotion influences each of these

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CHI 2010, April 10–15, 2010, Atlanta, Georgia, USA.

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constructs in different ways. For example: emotion directs attention and cognitive resources towards an object or a task; emotion triggers, sustains or reduces academic motivation; and emotion influences the learning strategy adopted by a student. An emotional experience such as enjoyment of learning can therefore direct a student's full attention to the learning task, enhance a student's academic motivation, and enable the student to adopt flexible learning strategies such as elaboration or critical evaluation. This link between emotion and learning has captured the attention of diverse groups of researchers, from educational psychologists to computer scientists. At the heart of any of these research agendas lies the issue of how the researcher might capture data about a student's emotional experiences. Approaches range from asking the students themselves to report on their emotional experiences during a learning interaction [18, 19] to using physiological and biometric sources of data [3, 6, 7] to automatically interpret the emotional experiences of students.

What is evident within all this work however is that understanding the emotional experiences of students' throughout their learning interactions is not a straightforward task. The challenge entailed in understanding the emotional experiences of students does not solely lie with the researcher. Recent work has shown the difficulty teachers can have in understanding the emotional experiences of their students [4, 8]. This emotional communication gap identifies one area where technologies might support emotions in the classroom. Yet, very little work to date has explored how to support emotions in the classroom, let alone what role technology might play. It is to this space that our work contributes. We focus here in the main on technologies to support students' emotional communication in the classroom. From a study in a high school, we proposed a series of design requirements to support emotional communication between students and teachers [1]. These requirements were: provide privacy, support students in their reflection on emotion and provide real time communication between student and teacher. We then, using these requirements, developed a specific instance of an affective technology, called the Subtle Stone. We chose to take an active, self report approach, where the student chooses what and when to communicate to their teacher, rather than have emotions automatically communicated based on a student's physiology or biometrics. In part this choice was pragmatic since its development was considered to be less challenging than a biometric or physiological sensor based approach. Through its deployment and study of use in a classroom context, we aimed to gain a deeper understanding of the design space and the needs of students around affective technologies in the classroom.



Figure 1: A Subtle Stone and its box

THE SUBTLE STONE TECHNOLOGY

The Subtle Stone is a tool that allows students to self report their emotional experiences to their teacher in real time throughout learning interactions. The Subtle Stone (Figure 1) is a handheld orb covered in ribbed rubber containing 6 LED lights and a switch that is operated through a squeeze. At present the Subtle Stone displays seven separate colours: blue, green, red, purple, light blue, yellow and white. Each student creates their own colour:emotion language, by deciding for herself which colour communicates which emotion to her teacher, such that when a student decides to communicate an emotion to her teacher, she simply selects the colour associated with that emotion in her own colour:emotion language through squeezing her Subtle Stone until it displays the colour she requires. The colour continues to be emitted until the student decides to change the colour (and hence the emotion communicated) by squeezing the Subtle Stone or by switching it off.

A tablet PC supports the teacher in interpreting the students' communicated emotional experiences. Each Subtle Stone contains a radio which wirelessly transmits the colour currently being displayed by a Subtle Stone to a tablet PC which translates and presents the students' communications. Effectively the teacher interface (Figure 2) is a map of the classroom. Each person-shaped icon represents a student in the classroom in possession of a Subtle Stone. In an initial study with the Subtle Stone, the teacher reported finding the level of data presented to him through the students' Subtle Stone use overwhelming [2].

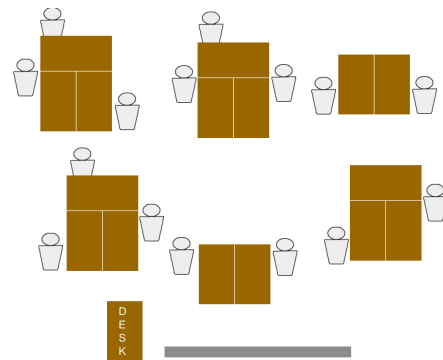


Figure 2: The Teacher Interface

As a result the current interface gives the teacher a general overview of the emotions experienced by the students in the classroom by indicating to the teacher through colour which students are reporting a “positive” emotion (a green student icon) and which students are reporting a “negative” emotion (a red student icon), and which students are not reporting any emotions (a grey student icon). The teacher defines for himself which emotions are positive and which are negative. Rollover text is provided should the teacher wish to know the specific emotion communicated by a student.

Although, the Subtle Stone was designed according to principles derived from our own study, there are some similarities between the Subtle Stone and affective communication devices [22] created according to the design principles laid out in the affect-as-interaction model [5]. For example, each device uses colour as a means of expressing emotional experience, and additionally each device puts the user in control of what they choose to express.

A STUDY EXPLORING EMOTIONAL COMMUNICATION IN THE CLASSROOM

In [4] we described the issues of understanding emotion throughout learning interactions and detailed a first study with the Subtle Stone specifically seeking to examine whether the Subtle Stone fulfilled its design requirements. Here we focus on the data arising from a second and larger study with the Subtle Stone. We explore the way in which the students utilised and experienced the Subtle Stones to understand the values that underpin the students’ use of an affective technology and the role that affective technologies might play in the classroom. The way in which the teacher utilised and experienced the information ascertained from the Subtle Stones is an interesting extension to this question, but one that is beyond the scope of this paper.

The participating class was a year eight German language class at a comprehensive high school in the South East of England. In total the study involved 15 students aged 12-13 (10 female and 5 male) who each had access to a Subtle Stone during their German lessons. The participating teacher had volunteered to be involved in the project from its outset. The teacher selected the class who would participate in this study based on his beliefs about which students would benefit most from the technology. The students received one chocolate each throughout the study in return for their participation.

The Subtle Stones were available for the students to use throughout four weeks of German language classes, equating to nine hours of use. Some students kept their Subtle Stones on their laps, other students kept the Subtle Stone on their desks, whilst other students kept their Subtle Stone inside a provided box.

Several different data collection methods were employed to permit analysis that would enable us to understand students’ emotional experiences in the classroom, as well as students’ experiences of the Subtle Stone:

- A log file stored each student’s use of the Subtle Stone, detailing the emotion reported by the student, when the student began reporting the emotion, and when the student finished reporting the emotion.
- Each student completed a Beliefs and Attitudes questionnaire, where each student reported her beliefs about her ability in German, and her attitude towards learning German.
- The students completed a questionnaire at the beginning and the end of each class. The questionnaire required the student to report on her general mood and her current experience of the seven emotions communicated through the Subtle Stone.
- Each student was given a diary and asked to make entries throughout the course of the study about her emotional experiences in her German classes. How and when the students completed the diary was left to the discretion of each individual student.
- The students were interviewed in small (2 – 5 students) groups of their own selection towards the end of the study. The semi-structured interview covered topics such as what the students thought about the Subtle Stones, as well as how they believed their teacher used the information provided by the technology.

A theme-based analysis was applied to the transcribed interview data and diary data. A Spearman’s Rank Correlation test was applied to the Subtle Stone log data and Beliefs and Attitudes questionnaire data.

THE SUBTLE STONE IN THE CLASSROOM

Overall the Subtle Stone was well received in the classroom by both the teacher and the students. In total 908 reports of emotional experience were communicated over the nine hours that the Subtle Stones were available to use (each class lasted for one hour). The mean number of reports given over the study period by a student is 61, and the mean duration of use by a student is seven hours and two minutes. Even the longest use of the Subtle Stone is not equal to the nine hours for which it was available. In part this could be because the Subtle Stones can be off, and students did leave them off presumably when they did not feel they were experiencing one of the seven emotions communicated by the Subtle Stone, or when they did not want to communicate something to their teacher.

In Figure 3 we see the mean number of reported emotional experiences decreases over the course of the study, with the students reporting on average 19 emotional experiences in the first session with the Subtle Stone, to reporting 9 emotional experiences to their teacher in the final session with the Subtle Stone. The lowest average use of the Subtle Stone occurs in classes on the 4th and 11th of February, where the students report on average seven emotional experiences to their teacher.

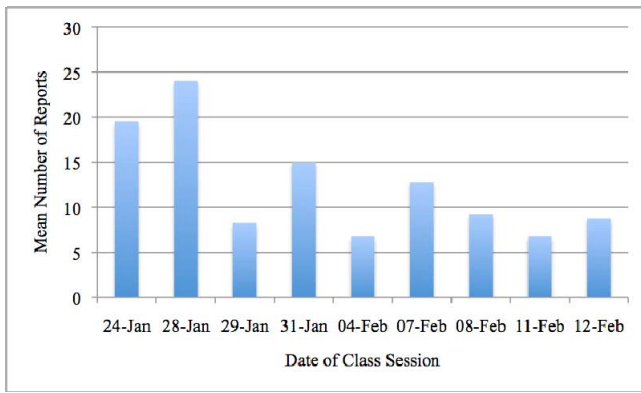


Figure 3: Mean Number of Emotions Reported in Each Class

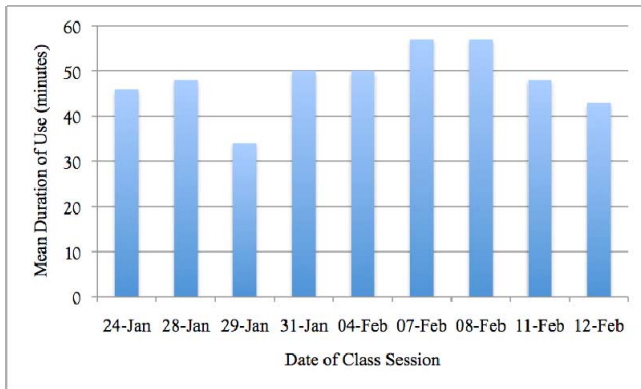


Figure 4: Mean Duration (min) of Subtle Stones Reporting Emotions in Each Class

Figure 4 shows the mean time that each Subtle Stone was on and reporting an emotional experience to the teacher throughout the course of the study. Whilst the number of emotions reported to the teacher decreases over the study period, the Subtle Stones remained on and reporting an emotion to the teacher for between 40 to 55 minutes for eight out of the nine classes observed in this study.

A Spearman’s Rank Correlation test measured correlations between the students’ use of the Subtle Stone and the students’ beliefs and attitudes towards German. A significant negative relationship exists between the variability in the students’ reports (whether the student tends to report one emotion over the course of a lesson, or a variety of emotions) and the students’ attitude to learning German ($r_s = -.551, N = 15, p = .033$, two tailed). This suggests that the more important a student thinks learning German is, the less likely the student is to report a variety of discrete emotions over the course of a lesson. There were no significant relationships between the quantity of reports given by the students and their Belief and Attitude profiles.

In summary, the continued use of the Subtle Stones with little external incentive indicates that the students experienced value in simply using the tool during their lessons. We now go on to explore how the Subtle Stone was

used and experienced to understand what these values might be.

Exploring the Students’ Use and Experience of the Subtle Stone

The self report approach embedded choice into the affective technology. In total the Subtle Stone provides three choices to its student users. First, the students as a class chose the emotional terms communicated by the Subtle Stone. Second, each student chose which colour displayed by the Subtle Stone was linked to each emotional term communicated by the Subtle Stone. Third, the students had control over what and when they communicated their emotional experiences to their teacher via the technology. Exploring how the students’ were able to use these choices as well as their experiences of making these choices provides a means of understanding the students’ values around affective technologies in the classroom. In the following sections we give a brief description of how each of these choices were designed and how the students utilised and experienced these choices.

Choosing Appropriate Emotional Terms

The students and the class teacher worked together to choose the emotions that would be communicated via the Subtle Stone. The students spent some time discussing in small groups the various emotional reactions they might have to a number of school scenarios. Following this the students relayed the emotions they felt were most experienced in their day-to-day classes to the rest of the group. Using these emotions the students voted on the top seven emotions experienced in the classroom. The students choose the emotions angry, frustrated, nervous, bored, tired, happy and proud.

Table 1 details the average amount of time the students spent reporting each emotional term to their teacher via the Subtle Stone. The students reported feeling happy throughout their German language lessons most, and angry the least.

Emotional Term	Average time spent reporting emotion (%)	Total number of reports of emotional term
Happy	43.3	271
Tired	17.7	132
Bored	12.3	154
Frustrated	9.3	118
Nervous	7.5	109
Pride	5.6	57
Angry	4.4	67

Table 1: The Students’ Use of each Emotional Term

Throughout the interviews seven students make comments with regard to the emotions that they originally chose to communicate to their teacher throughout their learning.

Here Ciara (pseudo-names are being used throughout this paper) and a group of four other girls are discussing what they thought of the Subtle Stones. Along with the other students in the group Ciara indicates that she did not think the choice of emotional terms was completely representative of the emotions she experiences during her German lessons.

“I think the Subtle Stones are quite good but I think we should have been able to pick different emotions because not all of them show how I’m feeling. There are only a few colours and I think there should be a few more. A lot of the time you’re like really confused and we don’t have a colour for that really so you just have to turn it off.”

Within another group Josie hints at the difficulties she had with the emotional terms chosen by the class, and additionally the challenge of labelling an emotional experience using solely one word.

“I think some of the emotions seem the same. Like angry and frustrated are like the same. And when you’re like sad [the Subtle Stones] don’t have an option for that. And they should have one for mixed emotions, like sometimes I’m feeling happy about one thing and sad about something else. And there are some things you just want to add to it, because you don’t really feel any of them, you feel another one and then you don’t know what to put down.”

And in Luci’s interview with her friends she extends this difficulty with naming emotions to the desire to have a less fixed approach to emotional communication in the classroom.

“Like you could have a neutral emotion, which could mean like, you don’t want to say you’re bored or something. Or if it’s something that you can’t really describe then it could be like a neutral one. So you could have a happy neutral or a sad neutral.”

Creating a Personal colour:emotion Language

The Subtle Stone technology enables students to map the emotions being communicated to the teacher to the set of colours that are displayed by the Subtle Stone. Each student created their own colour:emotion language at the start of the study before using the Subtle Stone. Throughout the study the students had access to a crib sheet which detailed their own colour:emotion language, should they require it.

Whilst none of the colour:emotion languages are exactly the same as each other, definite trends can be seen in what colours students choose to convey particular emotional terms. For example, 12 students chose to represent the emotional term “angry” with the colour red, 7 students chose to represent the term “boredom” using the colour white, and 6 students chose to represent nervousness with dark blue, and tiredness with light blue.

When discussing what the students felt was useful about the Subtle Stones a number of students raised the issue of privacy. In this transcribed excerpt Holly is discussing with her group the importance of not having to share how you are feeling in class with your friends and fellow students:

“It’s good that people shouldn’t know how you’re feeling because if you’re feeling sad and you’ve got something that might be making you feel sad, then people will be asking you all the time why you’re feeling sad, and you don’t want to tell them. Sometimes you don’t want your mates to know and that’s why it’s good that it’s secret.”

Two other students expressed this sentiment. But not everyone agreed it is always good to keep these emotional experiences secret from your friends. As Susie explains:

“Yeah, but it’s kind of good if you do know because then they can be careful with what they say.”

In addition, the intrigue created around having a secret language caused some problems for one student.

“People don’t know what your colour means. But, it’s quite annoying because if somebody is on my table and I change the colour then they take the [crib] sheet without asking to find out what I’ve just told Mr Simpson.”

Telling the Teacher

The Subtle Stone gives the student full control over what they communicate to their teacher, and when they choose to communicate this emotional information. At the start of the study the researcher told the students: “You can use your Subtle Stone whenever you want to tell your teacher how you are feeling during lessons.” To exemplify how the students exercised this choice, and how this choice impacted on their experiences of the Subtle Stone and emotions in the classroom, we present the case of John.

John believes that learning German is important, and he reports feeling very happy in the class since he is with his friends. Table 2 outlines the emotional experiences that John reports to his teacher via the Subtle Stone.

Emotional Term	Time spent reporting emotion (%)	Number of reports of emotion
Happy	62.4	23
Tired	15.2	11
Pride	6.8	3
Bored	5.8	8
Nervous	5.1	9
Angry	3.0	8
Frustrated	1.7	6

Table 2: John’s Use of Each Emotional Term

John reports mostly positive and activating emotions to his teacher when using his Subtle Stone. John makes nine entries in his diary, each of which briefly reflects upon a German lesson and his emotional experiences within that lesson. John's diary entries also indicate that John's recollections of the emotions experienced in his German lessons are markedly positive, yet the percentage of emotions, such as angry, frustrated and nervous, recorded in his diary is double to that reported using the Subtle Stone. Further, John's reporting of boredom in his diary entries is three times that reported using his Subtle Stone. For example:

"German: For the first part of the lesson I was really bored. For the rest of the lesson I was mainly happy except for when the teacher kept asking questions to random people. That made me nervous." Excerpt from John's diary on the 24th January.

To illustrate the way in which John chooses to use his Subtle Stone we present a vignette giving an account of John's Subtle Stone usage on the 28th January. At the start of the lesson John reports (using the pre-class emotion questionnaire) that he feels moderately happy and tired, as well as a little bit proud and bored. He also reports that the class teacher, a student in the class, and the resources he suspects will be used throughout the day's lesson are having a moderately strong positive influence over his emotional experiences. The class focuses on the construction of sentences in the perfect tense, and is divided up into six main tasks, some of which are completed in small groups, others of which are completed independently. Throughout the lesson John predominantly reports that he is feeling happy to his teacher, reporting happiness throughout just under 80% of his Subtle Stone use, and frustrated for 10% of his Subtle Stone use. However, at the end of the class John uses the post-class questionnaire to report that by the end of the class he is feeling most strongly bored, and a bit happy. John also reports that the class teacher has had a strong positive influence over his emotional experiences, and another student in the class, and the resources that were used in the session continue to have a moderately strong positive influence over his emotional experiences.

John makes a diary entry for the class session that reads:

"Came into the lesson very happy. The first activity made me bored. I remained fairly happy for the remainder of the lesson."

In just under half of the lessons observed as part of this study John reports boredom as the emotion most strongly felt at the end of his German lessons. Yet, only 6% of John's overall use of the Subtle Stone is reporting boredom to his teacher. In tandem with this, John reports throughout the study in both the pre and post class emotion questionnaires that the class teacher has a strong positive influence on his emotional experiences. This data hints at John making conscious decisions as to what to

communicate to his teacher with regard to his emotional experience. We see John rarely reporting to his teacher that he feels bored, even though questionnaires completed at the end of each lesson suggests that boredom is the strongest aspect of his emotional experience in the classroom.

The opportunity and value of being in control of what a student tells her teacher is reflected in seven interviews. For example, Josie's group are discussing whether they always told their class teacher everything about their emotional experiences. Whilst the majority of her group believed they did, Josie says:

"When I'm like not really interested in what we're learning I don't like putting it onto bored, because even if I was bored I wouldn't say that I was bored."

Two students also report making decisions about what is important to tell their teacher, and what they consider not important or necessary. In the following interview the group of girls are discussing whether the Subtle Stones were distracting for their learning. During this discussion Ciara says:

"No, I think [the Subtle Stones] are fun. I don't really take notice of mine. I normally put it on an emotion at the beginning of the lesson and put it in the box. If my emotion changes completely then I'll change it, but if it changes for like one minute while I like, I need a wee or something, then I don't change it. I don't change it like that if something little happens."

Alongside utilising the control that the Subtle Stones provide in terms of when and what a student chooses to communicate to their teacher, two students also report having to think more about their emotional experiences because of the responsibility felt in providing their teacher with useful information. In the following excerpt the students (again a group of girls) are discussing what they felt was useful about having the Subtle Stones in the classroom. During this discussion Phillipa agrees with the girls that the Subtle Stones are helpful in the classroom, and expresses why she believes this to be the case:

"They help you [...] They help you think about how you're feeling because you have to put them on the right emotion. Kind of, you know like. You know like when you're doing something and you don't really know how you're feeling because when you're busy you don't think about it. But with the Subtle Stones you have to think about how you're feeling because you've got to get them on the right emotion."

But, one student also realises that there are some difficulties in thinking about and reflecting on your own emotional experiences. For example, Sam notes:

"When you think about your emotions, then they often change."

Finally 11 students see value in using the Subtle Stones during class since it gives them an opportunity to influence the running of the lesson. For example in James' interview the students discussed whether they thought the class teacher found the information provided by the Subtle Stones useful in his teaching. James states:

“We take “learning to” lessons where we learn to learn and it's basically telling us how the teachers' teach, not learning that teachers can adapt to their class. So if you find one way of learning really difficult, the class tells you that the teacher will teach you in that way and it won't help you. But being able to tell Mr. Simpson how you're feeling is quite useful because he can change his lesson and then you don't have to sit and get irritated about what he's doing.”

James goes on to consider whether he believes the Subtle Stones so far have had an influence over Mr Simpson's teaching:

“I think he kind of maybe uses a bit more of a variety of things in a lesson. Because when we did the listening task earlier, he only did a few of those and normally he would probably have done all of them. Maybe some people thought it was boring or frustrating.”

In summary then, the Subtle Stone technology provides a series of choices to students in terms of what, how and when they communicate aspects of their emotional experiences to their teacher and the data suggests that students were able to make considered and active use of these choices. We go on now to explore the values and needs for affective technology in the classroom, based on their expression in the students' use and experience of the Subtle Stone.

Reflections on the Values Exemplified in Use

Overall, the students expressed five distinct values through their use and reported experiences with the Subtle Stone. These are: flexibility, privacy, agency, voice and reflection.

Flexibility: An initial choice faced by the students and the teacher when using the Subtle Stone is to decide upon *what* emotional terms will be communicated by the Subtle Stone technology. The students' choices alone might indicate that the students in this particular class had fairly negative emotional experiences during their German lessons. However, the students' used the Subtle Stones instead to communicate that they were happy to their teacher throughout just under 45% of the classes when the Subtle Stone was available. In addition to the Subtle Stone log data, the students actively reflected on their initial choices for emotional terms in interviews, with a number of the students remarking that the choices made simply weren't representative of their actual emotional experiences in the classroom. Together this indicates that the students found choosing a set of emotional terms to collectively describe their emotional experiences in the classroom difficult. This data emphasises the individuality that surrounds what a

student might experience in classes, and additionally what students may wish to communicate to their teacher throughout their learning experiences. Whilst the Subtle Stone provided a certain amount of flexibility to the students given that it allowed the community of users to choose for themselves which emotions might be appropriate for communication in the classroom, it is possible that making this choice as a group led to significant difficulties because the students did not all have sufficiently similar emotional experiences in their German lessons. Boehner et al [5] advise designers of affective technologies not to attempt to formalise the unformalisable, arguing that one cannot create a fixed set of emotional terms that work for everybody in every situation. Our finding provides further empirical support for this design guideline.

Privacy: The second choice given to the students centred around *how* the students communicated their emotional experiences to their teacher, with each student creating their own individual colour:emotion language. In this study some students valued this choice since it engendered privacy around their emotional communication. And for some students it wasn't simply that an individual may not want fellow students within the class with whom they were not close to know how they were feeling during their lessons; some students also reported not wanting their friends to know how they were feeling. This need to understand and to some extent control the audience of emotional communication is reflective of Goffman's notion of self presentation [10]. Students want to be able to create different emotional faces depending upon who they know is listening. Some students therefore need the security rendered through private communication to be able to communicate their emotions to their teacher given that these emotions may not be those that they would want to communicate to their friends and acquaintances. There are intricacies within this data however which indicate that privacy is not a straight forward need for all students. Whilst some students wanted absolute privacy, others felt that there may be benefits in sharing emotional information with trusted people, such as friends, since those friends may be helpful in providing appropriate support to the student in question.

Agency: The third choice for the students was about *when* they communicated particular emotions to their class teacher. For some students the relationship with the teacher clearly influenced the emotions that they were willing to express to their teacher. Communication (or lack of) around boredom is an interesting example of such choice. The vignette provided in the previous section shows John actively making decisions about what he feels is appropriate to express to his class teacher at a given point, an action that is also reported by a number of students in their interviews. Again, this value reflects the need to tell different stories to different audiences at a given point in time [10]. What we see also playing out within this setting is Boehner et al's notion of affect as the product of social

and cultural interactions [5]. Our students shaped the emotions they expressed to their teacher based upon their conceptions about how a given emotional expression would be received by their teacher. Other work around sharing personal information through technologies reflects this need to control what information is shared with others in accordance with social and cultural relationships [13]. In [13], users with a location-awareness device (Sun Valley) at times deceived others with regard to his or her current location depending upon their beliefs about what was appropriate for a given audience to know. Similarly to our students, Sun Valley users wanted at times (for whatever reason) to be able to conceal details about themselves from others.

Voice: The continued and relatively consistent use of the Subtle Stone suggests that the students found enough value in the technology that they were willing to spend time using the tool during class. A value emerging from the interview data suggests that the students believed that their emotional communication was ‘heard’ by the class teacher. In making choices about what the students reported to their teacher regarding their emotional experiences the students began to feel that using the Subtle Stone gave them some level of control over the lesson. Indeed, some students believed that the teacher used the information garnered from the Subtle Stone to tailor his lessons better to the group. We consider that this value may become a crucial part of affective technologies in situations where one person has more control over the situation than another. For example, in contexts such as the classroom there is only so much the individual student can do to regulate their own emotional experiences. Individuals such as the class teacher have a much greater role in responding to students’ emotional experiences since they have greater power to influence the running of the lesson.

Reflection: Some students also saw value in having greater awareness of their own emotional experiences. The students reported working hard throughout their lessons to use their Subtle Stones to tell their teacher the “correct” emotion. In the interview data two students considered that having to think about what to tell their teacher in terms of their emotional experience helped them to become more aware of how they were feeling throughout their lessons. The Subtle Stones acted as a tool that reminded them of their emotions whilst they were learning. This is important if one considers that being more aware of one’s own emotional experiences can lead to a greater ability to mediate those experiences in ways that can be beneficial [12]. Especially given the positive impact emotional awareness and regulation can have on a student’s learning [11]. However, there is a trade-off attached to actively reflecting on emotional experiences in the classroom, namely, thinking about one’s emotional experiences within a classroom environment requires a conscious effort and diverts attention from the content being taught and learnt.

DISCUSSION: THE FUTURE OF AFFECTIVE TECHNOLOGIES FOR THE CLASSROOM

In this paper we have explored how an active affective communication technology, the Subtle Stone, was experienced in the classroom. We have discussed the way its design features were used by students in communicating emotions and how these uses illustrated various values that they appreciated.

We recognise however that this study is limited in various ways. It is based on the application of one particular affective technology within the classroom. The design ethos of the technology may have communicated specific values to students through its use. For example, an initial requirement for the Subtle Stone was to provide privacy to students around their emotional communications. Therefore, it is possible that the students’ use of the Subtle Stone emphasised the need for privacy, which in turn impacted on the students’ experiences and value of privacy with respect to their use of affective technologies in the classroom. The analysis additionally focuses only on affective technologies in the classroom from the students’ perspective. To comprehend the full story we also need a parallel understanding of the teacher’s experience and needs, an analysis of which is currently in progress.

Having said this, one of our aims in conducting this study was not to suggest that the Subtle Stone is the answer but rather to use the experiences with the Subtle Stone to help us better understand issues of supporting emotion in the classroom. We now turn our attention to possible future directions for affective classroom technologies based on the understandings from this study.

In terms of potential broad aims of affective technologies in the classroom the students particularly valued both being more aware of their own emotional experiences during learning, and being able to impact the progression of a lesson through providing feedback to their class teacher.

Students reported that the Subtle Stone supported reflection on emotional experience by giving them a way of thinking about their emotions through the process of communicating emotional experiences to the teacher. Other work, for example [16], has used biometric and physiological data to encourage reflection on emotional experiences. Such methods may work equally well within the classroom context. However, as noted earlier, there is a careful balance that must be made between encouraging the student to reflect on their own emotional experiences, and distracting the student away from the learning objectives of a lesson. Addressing this balance might lead to affective classroom technologies providing retrospective opportunities for reflection on emotional experiences. For example a technology similar to Microsoft’s SenseCam, already explored as a tool appropriate for teacher reflection [9], may help students to reflect on their own emotional experiences in the classroom. Alternatively a technology

similar to the Affective Diary [16] may provide useful reflection and learning to students.

Our data showed that students' valued their emotional communication being listened to and when appropriate responded to by the class teacher. This finding has clear implications on the design of affective technologies for the classroom. In the first instance representations of students' emotions should be developed that enable the teacher to understand students' emotional experiences. Here, there is a balance to strike between providing a truly flexible and interpretative approach to emotional expression in the classroom and supporting easy interpretation for a teacher with many different responsibilities. Additionally, our previous work has suggested that teachers sometimes have difficulties not only understanding students' emotional experiences, but also responding to them [4]. This implies that any representation of emotional experience in the classroom also needs to help a teacher understand how to respond to the emotional experiences of his students. This may take the shape of an automated system that recommends courses of action by way of principles to the teacher based on its knowledge of students' emotional experiences and the lesson plan. Alternatively an affective technology for the classroom could support the teacher in his learning and reflection on the relationships between factors such as teaching practice and students' emotional experiences.

Tools for supporting emotions in the classroom need to be flexible in terms of what emotions are embodied by the tool. Researchers such as Höök et al [12] and Boehner et al [5] have chosen to unformalise emotional expression by using mixtures of colour, texture and movement to represent the felt experience of the emotion, rather than using a set of concrete and static emotional terms. Interestingly this is an approach that one student user began to describe when she talked about creating colours for a "positive neutral" and a "negative neutral", rather than for a particular emotional term. It also reflects the students' difficulties in representing mixed emotions with the Subtle Stone. In terms of tools that facilitate emotional communication in the classroom this approach may prove troublesome given the interpretive work that must be done by the teacher (or peer) in order to respond to that emotional experience. The interpretative approach as used by eMoto [22], the Sensual Evaluation Instrument [14], the Affective Diary [16] and Affector [21] requires the receiver of the communication to understand enough about the sender, or be able to discuss the chosen expression with the sender, to enable interpretation of the artistic expression of emotional experience. Teachers on the other hand often work with many students implying that teachers may lack the necessary knowledge, shared understanding and time required to discuss and decode all students' unformalised expressions of emotion. In addition, it may well be challenging for a teacher to interpret such data in real time throughout a lesson. A future challenge for emotional

communication technologies within the classroom is therefore to create technologies that both give students the freedom to express their emotions, whilst providing teachers with representations of those expressions that are readily interpretable by the teacher.

The social context of the classroom is complex, containing relationships between circles of friends, fellow students, and teachers. What a student may want to communicate about an emotional experience to their teacher, may very well not be the same as what a student would want to communicate with her friends, or even more broadly her classmates at that very same point in time. As such affective classroom technologies need to provide students with ways of controlling who knows what about their emotional experiences. One means of doing this is through a secret language that only a particular audience is able to decode. However, as some of our students noted there may be value at times with sharing emotional experiences with different audiences in the classroom. It is here that the use of a secret language becomes less fruitful. A secret language does not easily allow for a student to select a particular audience for emotional communication at a given point in time, since once a student has shared her secret language it becomes difficult to stop sharing that language. Additionally, the use of a secret language does not offer many alternatives to the student user in terms of plausibly denying emotional information from particular audiences. Students and friends may feel slighted if a user chooses not to share her language with them. Ongoing research around social networking may provide some frameworks for how technologies could provide users with opportunities to select audiences on an ad-hoc basis. However, the real challenge may very well be designing these frameworks into technologies in such a way that the value of affective technologies in the classroom (feedback to the teacher and reflection on emotional experience) is not lost.

It is crucial that designers and technologists seeking to develop affective technologies for the classroom consider that students are sensitive in what they want communicated to their teacher (or anybody else) about their emotional experiences. Using self report in the Subtle Stone allowed the technology to be sensitive to this need, encouraging the student to reflect on their own experiences and chose whether this is something they want to communicate to their teacher. Appropriately designed biometric or physiological sensor-based technologies may also fulfil this need. A biometric or physiological approach may even have advantages since such a technology may give students access to small changes in their bodily experience of emotion that they would otherwise have overlooked. Given the value students see in reflecting on their emotions, classroom-based biometric technologies could prompt students to reflect on their emotions through the presentation of biometric data, but continue to leave the student to decide for herself how she wants to express this experience, if at all.

CONCLUSION

The classroom is a context within which appropriately designed affective technologies may play a crucial role to improve learning and teaching experiences. A key contribution of this work is the deployment of an affective technology in order to understand the design space and the needs of users within this context. The exploration of 15 students' use and experience with this technology throughout nine hours of German language lessons provides a set of student values which have implications for the design of future affective classroom technologies. Students need flexibility in terms of how they express their emotional experiences. Students require means of understanding and controlling who has access to data about their own emotional experiences so that they are able to respond to the social and cultural relationships existing within the audience of their communication. Students also require agency. Emotions are produced through social and cultural interactions and as such students need to be in control of what emotions they communicate to their teacher. Students value being able to reflect on their emotional experiences, leading to a greater understanding of what emotions they feel whilst they are learning. Finally, students want a voice in the classroom. Students need to have a sense that the information they provide to their teacher may influence how the teacher continues with a lesson and their learning.

ACKNOWLEDGMENTS

Many thanks go to the students and teacher of Sackville School for participating in the study.

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