USING SENSORS TO DETECT STUDENT'S EMOTION IN ADAPTIVE LEARNING ENVIRONMENT

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Abstract: The purpose of this paper is a case study of the development of a device that could collect and evaluate bio-signals by people engaged in learning activities. The physiological reactions of the body, affects the conductivity of the skin producing bio-signals that provides the opportunity to estimate some basic human emotional states. In particular stressful situations have resulted in increased moisture in human skin, reducing the resistance and increasing the conductivity of the skin to electrical current. In this case study there is a reference to adaptive collaborative learning support. This work suggests that emotional state regulation may be an important factor in implementing the adaptivity of learning activities.

1 ADAPTIVE COLLABORATIVE LEARNING SUPPORT

Adaptive support, providing assistance to student when and where it is needed, might improve or make more suitable many fixed forms of support (Rummel and Weinberger, 2008), and has been shown a more positive effect on student learning (Kumar, et al. 2007). Nevertheless it is difficult to design an ACLS (adaptive collaborative learning support) system due to the fact that it is very complicated and it contains several adaptive rules and parameters that must be taken into account. The aim of this work is to support a collaborative learning activity.

To achieve comprehensive information about the people who are collaborating there is a need to collect information about a wide range of features that affect the quality of collaboration. An important aspect might be the mood of team members during their collaboration. Taking into consideration all the necessary features of a collaborative scenario, the objective is to regulate, to differentiate and resolve various issues and problems that arise during collaborative activity in order to convert students to active learners, increasing interaction and mainly increase confidence levels of students to develop cognitive skills. Therefore an adaptation pattern can function as a scaffolding mechanism to regulate the educational procedure.

2 STUDENT EMOTIONS

Emotions are very important functions that affect students' academic motivation, behaviour, performance, health, and development of their personality.

Many researches started in 1950 (Zeidner, 1998) have considered with the anxiety of students during tests and produced sufficient knowledge that can inform the educational practice. However, apart from the stress, there is little research on the other emotions of students, since it is difficult to draw firm conclusions about the feelings experienced by most students (Schutz and Pekrun, 2007).

Students are getting confused when faced with contradictions and misunderstandings (Festinger, 1957; Graesser, et al. 2003; Graesser and Olde, 2005; Piaget, 1952). They are also getting disappointed by the difficulties that may appear during the learning activity (Dweek, 2002; Stein and Hernandez, 2007.

The influence of emotions during problem solving, and participation in educational activities is very important because it can affect positively or negatively the learning process (Allen and Carifio, 1995). Emotions are very relevant to cognitive function and thus play a key role in all phases of problem solving, influencing the representation and the reception of information. According to modern emotion theories, the strong or weak emotion arousal depends on how great a difficulty is and the

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valence, positive or negative, depends on how the person evaluates the inconvenience that has been appeared to him (Mandler, 1984b; Lazarus, 1991). For example, if someone is stuck and she/he is unable to bypass a difficulty, then the valence may be interpreted as highly negative (Dweek, 2002). There is no comprehensive theory that deals extensively with the emotions (e.g., confusion, frustration, etc.) that may occur during educational activities, and considering how they affect performance. There is some evidence that positive and negative emotional experiences play a role during problem-solving. For example, flexibility, creative thinking and effective way of making decisions are connected with experiences that have a positive effect (Fielder, 2001; Isen, et al. 1987; Isen, 2001).

The student class is an emotional space. The fact that learning and achievement is critical to students' educational development means that the academic activities often provoke strong emotions.

2.1 Students' Emotional Effects in Learning Activities

The experimental research showed that the mood and the emotions facilitate the processes of working memory, such as positive information relating to the person is stored in long term memory and it is retrieved more easily when he or she is in positive mood. On the contrary this process is getting very hard when this person is in a negative mood, and even worse if the information is negative (Olafson and Ferraro, 2001). This suggests that positive mood can enhance students' motivation to attend actively learning processes, while a negative mood can trigger avoidance tendencies. It is important to consider that creative, flexible, and holistic ways of thinking are facilitated by a positive mood, while a negative feeling enhance complexity and poor creativity and flexibility (Lewis and Haviland-Jones, 2000). Most of these studies have focused on students' anxiety during the test (Zeidner, 1998, 2007). Research on stress during tests showed that this feeling reduces the performance in complex or difficult learning tasks that require cognitive resources (e.g., a difficult math problem). In contrast the performance is not affected when the test is easier and less complex. Various models have been proposed to explain the negative effects of stress. These models assume that stress includes activation of considerations unrelated to the specific learning task limiting students' engagement to the learning activity and thus causing greater effort. Students who are worried about a failure can not focus on learning process. Stress decreases students' interest and internal motivation. But in some cases stress can motivate students to invest extra effort to avoid failure.

It would not be correct to assume that positive emotions always cause positive results and negative emotions cause negative results. Instead, the results depend on the mediation procedures and specific requirements of the project under consideration. More specifically, positive emotions, such as activating the pleasure of learning are probably beneficial for the students' performance in most circumstances. Negative emotions such as the deactivation, the despair and boredom can be assumed as inconvenience to any kind of academic performance. Also, the effects of positive emotions of deactivation like relief and relaxation, often is harmful. Similarly, negative emotions such as stress, shame, and anger may exert ambiguous effects, reducing the attention and interest, or enhancing the student's external incentives for greater effort and better performance. Therefore, trigger of negative emotions can improve performance in specific cases, although in most cases affects negatively.

2.2 Adaptivity in Students' Emotions

The emotional regulation includes the augmentation of the enjoyment of learning and the reduction of the anxiety. Emotional intelligence has developed cognitive skills for this purpose (Matthews, et al. 2002). In the academic context, the treatment focused on the problem seems to be the most appropriate adjustment (e.g. with intensive effort to better prepare to perform to a test). The emotion-oriented treatment may also be an adaptive solution. Dealing with this treatment includes relaxation techniques, avoiding stressful thoughts and biofeedback techniques. The following factors which are under teachers' control seems to be important to students' sensation.

- Teaching quality. Factors, such as lack of structure, lack of clarity and excessive demands are known to enhance the students' anxiety during the test (Zeidner, 1998). Instead, well-structured teaching and clear explanations may increase the students' capacity to control their feelings.
- Quality of teaching motivation. There are two important ways to motivate students based on academic values and cause various emotions. First, if the learning environment meets the students' needs, then it is likely to create positive emotions. Second, the teachers' enthusiasm can facilitate the

adoption of positive students' feelings through observation and emotional transmission (Hatfield, et al. 1994).

- Support of autonomy and self-regulated learning in order to achieve emotional control.
- Creating appropriate structures that learning goals are achieved. There are learning practices involving individualism, competition and collaboration structures in the classroom (Johnson & Johnson, 1974). The learning structures promote students' successful efforts to maintain control over their emotions.

3 AFFECTIVE COMPUTING

The work on synthesis and analysis of emotions is an interdisciplinary scientific field consisting from the combination of computer science, psychology and cognitive science (Allen and Carifio, 1995).

3.1 Galvanic Skin Response (GSR)

This technique is associated with the change of electrical properties of the skin when external voltage is applied. This is a test of the sweat function, which measures the change in conductivity of the skin during the flow of low voltage current after a stimulus. The recording of the conductivity (or the inverse of conductivity i.e. resistance) is based on the application of external constant voltage to the skin (Lykken & Venables, 1971). Then the voltage across a fixed resistor in parallel with the resistance of the skin is measured. This work will attempt to proceed deeper in the design and the operation of a GSR sensor. The edges of the human body (hands and feet) have a very high proportion of sensory nerves endings and so they become ideals for the application of skin resistance measurements.

3.2 GSR Sensor Design

The electrical circuit is connected to an Arduino duemillanove (http://www.arduino.cc/) which is used as an analog to digital converter. Two leads are attached to two fingertips. One lead sends current up to 5V and it is connected to the power pin of arduino. The other is split into two wires the one is connected to the analog pin 0 of arduino and the other wire is connected to a 110 KOhm resistor and then to the ground.

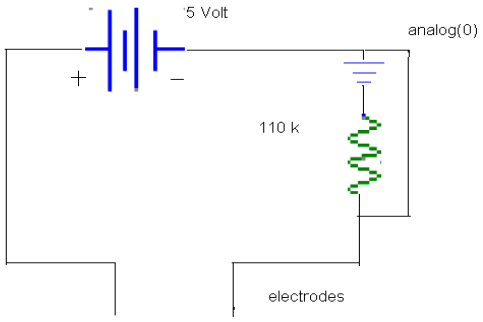

Figure 1: The GSR sensor electrical circuit.

The open-source electronics prototyping platform Arduino duemillanove is programmed in such a away to send the bio-signal value through the USB port to a computer application. This setup measures, GSR bio-signals every 30 milliseconds. The values are read from arduino analog(0) and they imply the change in resistance of the voltage going through the body. Every student has an identical user code. Every value read is graphed, and a progressive average is calculated to smooth out the values. A baseline reading is taken for 10 seconds if the readings go flat (fingers removed from leads). The progressive average value of measurements for each student is inserted in a database table with the student's code and the timestamp. The measurement range is from 0 to 255. The low level values have white colour in the graph, the medium level values have green colour, the higher values have orange colour and the highest values have red colour. During the learning activity a small window is displayed to the student and he/she can easily recognize his /her emotional state. Also the teacher role has monitoring options and he can open display windows for each measured student and follow up student's emotional state during the activity. There are also options to reconstruct the emotional graph of one or more students for a particular date.

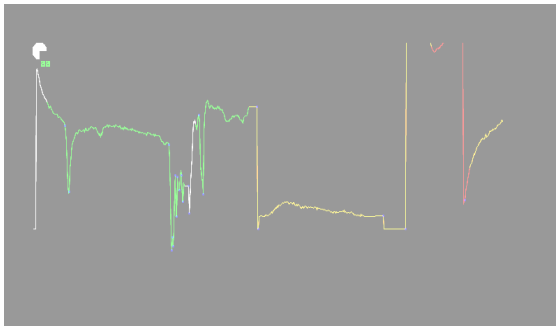

Figure 2: The GSR graph for user "aa".

3.3 Measurement Ranges

Initially for every user predefined quartiles are used as a measure of emotions variability. The interquartile ranges are defined as in descriptive statistics. So every captured GSR value is classified into four categories according to the following:

- For values between 0 and 0.25 of measurement range, low value category with white colour. The measured values near 0 cause low white graph lines and may indicate boredom.
- For values between 0.25 and 0.50 of measurement range, normal value category with green colour indicating calm.
- For values between 0.50 and 0.75 of measurement range, high value category with orange colour, indicating a short of anxiety.
- For values greater than 0.75 of measurement range, high value category with red colour, indicating stress.

Assuming that every measured subject may have its own sentimental quartiles, it was decided a test measurement to precede the main activity. During this trial activity every user is measured while observing critical words rolling across his application window one at a time. According to psychologists there ore some words which nearly all people will react to. The test measurement average values are stored in the database in a specific table. After the trial activity a k-means clustering algorithm is applied on each user's measurement, defining the new inter-quartile range values which are specific for that user. These new range values are stored in the database for each user code and they are used in the next measurements.

4 RESEARCH ISSUES

This research is considering two basic issues:

- Whether the GSR measures will operate as scaffold to students, through biofeedback, to regulate their emotions mainly their stress during the learning activity and under pressure.
- Whether the GSR measures will support the teacher to adapt the learning activity according to students' emotions (i.e. make the activity more interesting if the student seems to feel boredom or support the student to overcome a stressful condition).

5 RELEVANT WORKS

GSR emotional detection is one of the first methods applied from scientists mainly psychologists to detect stress (Epstein & Fenz, 1967) and as lie detector (Prokasy & Raskin, 1973). Now days there are many GSR sensor designs using NXT lego, arduino and customized circuits (i.e. Cornell University). These all techniques were applied to individuals while they were watching a film, hearing some critical words, during examination or watching a lecture. They did not so far consider their subjects as members of a learning group and they did not deal with subject's emotions in relation to the learning context. This work attempts to apply GSR emotion detection as support to students and to the teacher during a collaborative learning activity.

6 THE COLLABORATIVE ACTIVITY SUPPORTED BY THE GSR MEASUREMENT

The student collaboration was supported by a videoconference tool called Big Blue Button (http://bigbluebutton.org/). The activity was separated into two phases. Two collaborative techniques were used jigsaw (Gallardo, et. al. 2003) and fishbowl (Leonard, et al. 1999). Jigsaw was adopted because it is an effective learning technique with increasing positive educational outcomes. The jigsaw process encourages listening, engagement, and empathy by giving each member of the group an essential part to play in the academic activity. The fishbowl technique was used because it allows an entire group to participate in a conversation. During the first face there were two expert groups composed of six and seven students each. Then at the second face there were four groups with two to four students each. The GSR measure was applied to a group of four students. The support from the sensory emotion estimate was impressive. The student that initialises the presentation of the group assignment was very anxious and her GSR values were continuing to be very high (red range). The teacher reacting to this condition asked from another member of this group to continue the presentation. At first the new representative was very anxious too, but later on he regulated his stress and finally his graph was green. The teacher noticed that in the mean time the measures of the other two students of the group that were silent were very low (white range). So, he asked them questions about their participation into

the group project and he assigned to them a more active role. There was a significant reaction by the one student displayed on her monitoring window, showing some anxiety but not stress. The other student continued to be calm. After this activity the students that used the GSR sensor filled a questionnaire.

6.1 Evaluation of the GSR Support

The research process followed the interpretative approach. The structure of the questionnaire followed the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003).The applied UTAUT model was based into four core determinants performance expectancy, effort expectancy, social influence, facilitating conditions; and three control variables: gender, experience, and voluntariness of use.

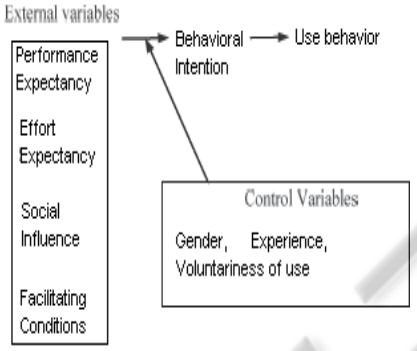

Figure 3: The applied framework.

The survey subjects were one male and three females postgraduate Master's degree students. Since the sample was too small, there are not expectations for safe conclusions. Nevertheless it is a starting research and there is the opportunity to have an initial feeling about it. After completing the questionnaire the students were interviewed separately. All of the students found the GSR application very helpful and easy in order to realise their feelings. The three students, one male and two females considered that the GSR graph supported them in dominating their anxiety through biofeedback and they think that this self-regulation resulted in better performance. The male student regulated his stress in longer time than the two females. The fourth student (female) failed to interact with the GSR application through biofeedback due to technical problems. All students suggested that this is a useful support to learning activities and they would be willing to reuse this GSR sensor in other academic activities.

7 CONCLUSIONS

This work is a case study of an initial effort to detect student's emotions mainly stress and boredom during learning activities. Furthermore it tries to apply adaptive methods in order to succeed emotion regulation. Considering this scope, the whole activity was successful and the initial feeling was that student emotion sensation is a very useful support for the students themselves and at the same time for the teacher. Three of the students interacted with the GSR sensor and through biofeedback they launched self regulation reactions. The teacher through the GSR measures had a further support to realize his students' feelings and reacted adaptively.

8 FUTURE WORK

It is intended to repeat collaborative learning activities with GSR measurements applied to more student groups. It must be reported that there was an initial skeptical attitude towards the use of the GSR sensor by many of them. But after the described activity this attitude has been weakened. Also it is intended to add more emotion detection techniques in order to have more accurate emotion sensations. The emotion monitoring will be embedded into the collaborative tool being accessed by significant permissions. A new role will be introduced as emotional moderator assigned to an appropriate member of each group. An embedded to the collaborative tool intelligent agent will give support to each student in order to regulate his emotional state and to the group moderator to adaptively react. The teacher will monitor through a real time protocol the emotional state of his students.

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