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EXPLORING LEARNERS' EMOTIONS OVER TIME IN VIRTUAL LEARNING

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ABSTRACT

Time constitutes an important factor influencing every process related to e-learning. Along these lines, we need to study how students manage time in their learning processes. We need to know if they feel that they have enough time to carry out a learning activity or whether they feel stressed and frustrated by the lack of time. We are also interested in what kind of emotions they express and how these emotions evolve over this period of time. Our work focuses on studying the nature and role time plays in the affective states learners experience during a long-term e-learning process. Our methodological design shows the type of data we need to collect, which methods are more suitable for analysing this data in order to detect and interpret the learners' emotions across time.

KEYWORDS

Affective learning, emotions, time factor in affective learning, virtual affective agent/tutor, affective management.

INTRODUCTION AND RATIONALE

According to Demeure et al. (2010), time is an important variable in the analysis of teaching-learning processes that take place in e-learning and, more specifically, in CSCL contexts. Moreover, one of the main concerns in the educational field is that of making knowledge more meaningful and long-lasting. The e-learning process has to be an active process where technologies must serve as tools to support knowledge building and skill development in students by taking into account the students' specific, cognitive and emotional characteristics and skills that can facilitate and complement this process (Silva et al, 2006). In long-term virtual learning practices, it is important to investigate what kind of emotions students express and how these emotions evolve over this period of time. On one hand, we need to determine the factors that lead students to remain in the same negative affective state for a certain period of time, as this can lead to a significant reduction of the quality of learning and even withdrawal from studies. On the other hand, we need to study how students manage time in their learning processes. We need to know if they feel that they have enough time to carry out a learning activity or whether they feel stressed and frustrated by the lack of time. In this regard, we will establish a methodological design that shows the type of data we need to collect and which methods are more suitable for analysing the data in order to detect and interpret the learners' emotions across time.

An exhaustive analysis of all the data regarding the emotions students transmit is crucial for detecting and interpreting various types of emotions and anticipating the emotional states that students may experience at particular points in their learning process. Once we have completed our analysis, we need to develop a way of reacting to mediate and regulate students' e-learning processes. Affective pedagogical agents or tutors have been widely used in e-learning environments in a variety of ways (Beale & Creed, 2009; Frasson & Chalfoun, 2010). This study will lay the foundations for the design of an affective virtual agent/tutor able to intervene and mediate in students' e-learning processes, providing them with an appropriate affective feedback that will guide, advise and help them according to their needs and feelings. In order to achieve those challenges, this article will focus first on making a comprehensive and critical analysis of the state of the art of computer-based affective learning in relation to the time factor (i.e. evaluating important research work on the analysis of affective interactions, emotional feedback, affective tutor, etc.). Secondly, based on this analysis, we present our research questions. Thirdly, we describe our own proposal for explaining how we will address this issue in relation to the time factor and the advantages and innovations our proposal can offer regarding other proposals. Here we describe our approach at a conceptual design level.

BACKGROUND RESEARCH

During the past decade, emotion has emerged as a vital element of the learning process but many questions about emotional management in education remain unanswered. In his research, Pekrun (2005) recognises the lack of knowledge of the occurrence, frequency and phenomenology of emotions in different learning environments, and especially in e-learning. The emotional relationship with new tools and learning content are new research areas of particular interest to e-learning (Ekflides, 2006). The educational experiments being carried out in virtual learning environments require a redefinition of the agents involved (teachers and students), the spaces where educational activities are

conducted, time and learning sequences (Perez, 2002). The teaching process involves preparing the teacher to generate an effective dialogue with/and among participants, by encouraging active learning and knowledge building through collaboration, by knowing how to identify feelings and emotions and by controlling and providing appropriate models of expression (Ibarrola, 2000). Emotional aspects play a fundamental role in the user's interaction, because they affect cognitive processes. In other words, the user's affective states have an influence on how well that person solves rational problems. More specifically, emotions affect attention and memorization, as well as the user's performance and assessment (Brave & Nass, 2002). In this section, we study students' emotions from several perspectives, such as time management, the relationship between time and affectivity, and technology use, both at individual and group level.

- **As regards time management**, we need to study how students manage time in their learning processes and how this is related with their emotions. Zimbardo & Boyd (1999) propose the following paradoxes about how to manage time perception effectively: (1) Understanding relativity, (2) Consistent awareness and (3) Conscious effort. However, even if students are good at time management, this does not guarantee that they will achieve effective learning. For instance, Roy & Christenfeld (2007) suggest that people underestimate how long it will take them to complete future tasks. There are three facts that one should take into account: (1) the tendency to underestimate future duration, which disappears when the task is new, (2) the existence of similar bias in estimating both past and future durations, and (3) variables that affect memory of duration, such as level of experience of the task and the duration of the delay before estimation, affect prediction of duration in the same way. It appears that, at least in part, people underestimate future event duration because they underestimate past event duration.

- **As regards time and affectivity**, we want to identify what kind of emotions students express and how these emotions evolve over a period of time. It is necessary to know if the negative emotions that have been detected remain and turn into other negative (and possible more harmful) emotions through time and set time limits to make them change to more positive emotions. Both D'Mello et al. (2007) and Baker et al. (2007) have shown that students are most likely to remain in the same affective state over time in these environments and that certain emotional transitions are more likely than others. Likewise, McQuiggan et al. (2008) have shown that when transitions to alternate affective states did occur, they followed interesting patterns. Moreover, Feidakis et al. (2012) argue that time and emotions have to be taken into account in three stages when assessing a task: before the task, in real time and at deferred time.

- **At an individual level**, we will have to take into account the time perception of learners in relation to their time perspectives and their time management skills. It is necessary to know whether students feel that they have enough time to carry out a learning activity or whether they feel stressed and frustrated by the lack of time. In this sense, lack of time may be caused because the format of learning content or the development of learning activities cannot be adapted to each student's learning style (Alonso et al, 1994). Learning style constitutes an important precondition for the design of any learning process. In this sense, Bloom (1968) explored the Model of School Learning by concluding that, given sufficient time and quality teaching, nearly all students could learn. Johnston & Aldridge (1985) proposed

an exponential learning model, which included learner characteristics - specifically, aptitude and motive - as conditions related to learning achievement. Therefore, learning achievement can be predicted by a function of student characteristics and the time spent in learning. Demeure et al. (2010) argue that the major difficulty for individual learners is to balance all their professional, social, and academic activities.

- **At group level**, in Computer-Supported Collaborative Learning (CSCL) contexts, time is also an important factor in group work. Analysis of collaborative learning interactions requires a constant effort in trying to detect emotions through the application of a variety of methods, such as discourse and conversation analysis, analysis of feelings or opinion mining that allow non-intrusive automatic detection and extraction of emotions from student-created texts and dialogues. In this case, the teacher should apply an activity plan that takes time into account in terms of when it is suitable to proceed to emotion detection as well as when to provide dynamic recommendations and affective feedback, depending on the design and requirements of the collaborative activity concerned. Therefore, *with regard to group processing*, group formation needs time in order to establish the social norms to regulate member activities (Demeure et al. 2010). In this sense, the five stages of group development (orientation, conflict, cohesion, performance and dissolution) could be used to analyse temporal relationships in interaction, in terms of the succession of stages (Tuckman & Jensen, 1977). So, the teacher can influence or persuade learners by providing suitable affective feedback in order to regulate members' emotions in every planned stage. By doing so, group members can feel more confident through belonging to a community and they can even develop co-leadership skills.

- **As regards technology**, it is necessary to incorporate specific tools in the virtual classroom that will facilitate communication of both intentions and feelings at appropriate time intervals which can be easily recognized both by the teacher and the students. The latest research and development in the areas of artificial intelligence and robotics are reflected in the appearance of Intelligent Tutor Systems (ITS). As well as being educational programs, these simulate the behaviour patterns of a human tutor, aiming to improve learning in a field of knowledge. ITS are empowered with Affective Pedagogical Tutors (APT), which act as teachers and are able to interact with the student in human communication style (Beale & Creed, 2009). An APT's role is to solve problems, provide advice, guidance and emotional support in interaction with the student and to show contextuality, continuity and temporality. Learners experience a variety of emotions while interacting with a virtual tutor in the same way as in the context of traditional learning, when a human tutor can influence student emotions in order to improve efficiency in learning (Hargreaves, 2002). Similarly, a virtual tutor can be seen as a practitioner able to influence emotions in the learner. Moreover, these emotions will strongly influence their cognition (Isen, 2000). An APT can be invaluable when students do not recognize that their actions are inappropriate or simply not optimal. In such a case, a virtual tutor can intervene with the appropriate advice. In other circumstances, they may encounter situations that are unfamiliar due to insufficient knowledge, so they might benefit if they have someone to guide them, answer their questions and show them the right process. As such, several types of environments have been designed and evaluated (Table 1) and several types of effects have been detected (Table 2).

Table 1. Different types of virtual environment with APTs.

Types of virtual environments with APT (Affective Pedagogical Tutors)	
Embodied Agents	An embodied agent can be defined as a digital, visual representation of an interface, often taking a human form (Cassell, 2002). Affective issues such as empathy, self-efficacy and motivation have been implemented in various forms in a very broad range of different virtual environments. Because of their strong life-like presence, animated teaching agents can capture students' imaginations and play a critical motivational role in keeping them deeply engaged in a learning environment's activities (Lester et al. 1997). Indeed, one of the main goals of an ITS is to be able to recognize and address the emotional state of the learner and react accordingly through the presence of the pedagogical agent. Examples: Affective tutor (Kapoor, 2007), AutoTutor (D'Mello et al, 2005).
Narrative Learning Environments	Narrative has been an important way of transmitting knowledge across generations, and is innate in human nature. Narrative is also a valuable vehicle for structuring knowledge and helping us in the process of creating meaning. By applying a narrative approach, it is possible to achieve an application that may help learners by illustrating phenomena and procedures and by motivating them to stay engaged and immersed in learning tasks. In addition, narrative learning environments can facilitate activities associated with learning, such as role-playing and exploration, reflection and idea sharing that use different pedagogical strategies and affect the context of narration. Examples: Crystal Island (McQuiggan and Lester, 2008), FearNot! (Aylett et al. 2005).
Subliminal Learning	According to Chalfoun and Frasson (2008), emotions, especially motivation and engagement, are widely related in various cognitive tasks. A large body of work in neuroscience and other fields leads us to believe that simple to complex information can be learned without perception or complete awareness of the task at hand (Dijksterhuis and Nordgren 2006). In fact, the existence of perceptual learning without perception has been neurologically proven and accepted (Del Cul et al. 2007). In a recent work, Chalfoun and Frasson (2008) have suggested an increase in performance when using a subliminal teaching Intelligent Tutoring System.

Table 2. The most characteristic effects detected in virtual environment with APTs

The most characteristic effects detected in these environments
• ***Person Effect*** **(Lester et al, 1997):** The presence of an agent in an interactive environment, though not encouraged, can have a positive effect on the perception of the educational experience for the student. The time factor was not taken into account in these works. Examples: *Herman the Bug* (Lester et al, 1997); *Steve* (Johnson & Rickel, 2000); *AutoTutor* (Graesser et al, 2008).
• ***Proteo Effect*** **(Yee & Bailenson, 2007):** Students can learn because they are motivated by the characteristics of their avatars and they want to be like them. In this case, the role of the agent is not authoritarian, but fundamentally emotional/social support. Research on this effect is more focused on immersion in the 3D environments of educational games. This line of research does not take the time factor into account and it remains open without conclusive results in the literature. Examples: Troublemaker (Aimeur & Frasson, 1996); Jake & Jane (Arroyo et al, 2009).
• ***Protégé Effect*** **(Chase et al, 2009):** Students make a greater effort to learn how to teach their avatar than on their own learning. The focus of these agents is based on the "Learning by Teaching" paradigm; this means the student learns to teach the agent technical issues or concepts. The time factor was not taken into account in this work either. Examples: Betty (Biswas et al, 2009).

RESEARCH QUESTIONS

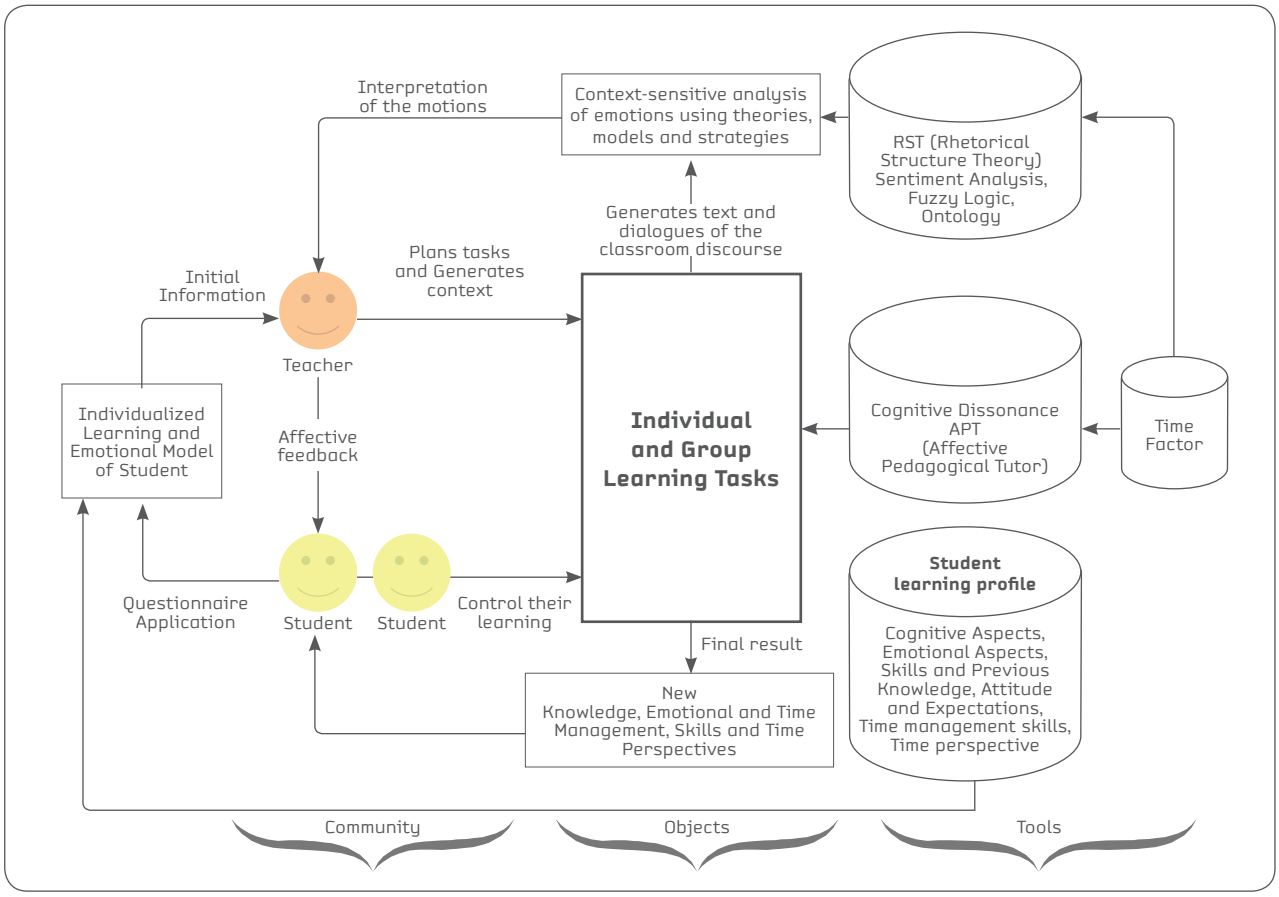
Based on the analysis made of the literature described in the previous section, we proceeded to identify the following research questions that still remain open and for which we will try to provide some effective answers in our current and future work:

- **(Q1)** How do students manage time in their learning processes? How can we know if they feel that they have enough time to carry out a learning activity or whether they feel stressed and frustrated by the lack of time?
- **(Q2)** What kind of emotions do students express and how do these emotions evolve over a certain period of time? How do negative emotions turn into other (and possible more harmful) negative emotions over time? What time limits should we set to make them change to more positive emotions?
- **(Q3)** What are the factors that lead students to remain in the same negative affective state that is considered detrimental and dangerous for a certain period of time, leading to a significant reduction in the quality of their learning, failure and even withdrawal from studies?
- **(Q4)** How can we detect and interpret various types of emotions and anticipate the emotional states students may experience at a particular moment of their learning process?
- **(Q5)** How can we make students react in time, guide them and help them in an appropriate way so they can come out of a negative affective state and move into a more positive one?
- **(Q6)** How should a virtual tutor manage time with the aim of providing feedback at the right time, intervening and mediating in the students' e-learning processes, providing them with appropriate affective feedback that will guide, advice and help them, depending on their needs and feelings?

A CONCEPTUAL EMOTION ANALYSIS MODEL

In today's student-centred constructivist learning environments, where students develop their learning processes over time, teachers' work is highly demanding. To provide an effective answer to the above questions, we are proposing an emotion analysis model at a conceptual level which integrates an extension of learning and linguistic theories with a variety of methods and tools. Our approach is based on the Activity Theory (AT) (Engeström et al., 1999), which provides a theoretical framework to understand and analyse a phenomenon, find patterns and make inferences through interactions that describe those phenomena. AT provides a conceptual framework (Barros et al, 2004) to situate social and technological elements of a system in the same unit of analysis, called activity. In our case, we apply an extended AT scenario which consists of making several participants (teacher and students) cooperate and interact with specific objects (such as text and dialogue) through the use of specific tools (APTs, emotion analysis tools) to carry out goal-oriented activities. According to Barberà (2010), the "temporal dimension in e-learning is considered as a real tool which is always present and which spreads out into the planning and implementation of online education". In this sense, we include the time factor as a tool within our definition of the AT for providing both teacher and students with more control and flexibility in the development of their respective tasks. That is, with regard to resources and tools, they decide how and when to use them. In this way, the time perspective and time management both become an issue and a fact in planning and carrying out learning tasks, while they play an important role in the establishment and evolution of the emotional state of the learning community. Adequate time management is a necessary factor in facilitating and

Figure 1. Graphic Representation of the Emotion Analysis Model based on an Extended Activity Theory Scenario.



enhancing the teaching-learning processes. Let us now briefly explain the components of the architecture of our conceptual Emotion Analysis model which is based on an extension of AT with emotional information and time factor (Figure 1).

In this context, emotion can be used to initiate actions that direct the student's attention to the cognitive goal that needs to be completed. At this point it is important that the teacher's feedback takes time into account. Without being obsessive or abusive, it will consider the duration of the student's learning process in three ways: the time needed to carry out an activity, the time the student has available, and the moment the tutor considers that he/she has to intervene with cognitive and emotional feedback. Concerning the tools used in our framework, first, the building of a robust student learning profile is an important component of our model. The resulting student profile enables the teacher to establish the content format, develop activities and choose the settings for using methods such as Project-based Learning, Problem-based Learning or Case-based Learning.

Secondly, we endow the Affective Pedagogical Tutor (APT) with several roles. Firstly, there is the capacity to design and apply *cognitive dissonance strategy* in both the planning and implementation of learning activities which are carried out cooperatively. In particular, in the design of learning activities, both at individual and group level, our APT plans evaluation tasks with dissonance questions based on the "Learning by Teaching" paradigm (Biswas

et al, 2009). In addition, another role for the APT will be as a troublemaker classmate, i.e. a difficult student who sometimes gives incorrect answers in order to provoke cognitive dissonance, similar to the agent used by Aimeur & Frasson (1996). Here, it is important to study how the APT should manage time and know the moment when it should appear to play this role. As cognitive dissonance provokes "constructive conflicts" for students, it is more likely that several emotions will also appear and be openly expressed by students. For this reason, it is important that learning activities should be controlled by the APT with an appropriate time management strategy so that the "conflicts" can be resolved within a desired time interval and not leave space for unwanted negative emotions and situations among students. In particular, cognitive dissonance allows us to identify possible activating or inhibiting emotional causes and consequences, as well as its influence on students' emotional situations, behaviours, habits and behaviour modification, including their time management skills and their perception of time perspectives. Moreover, it allows us to know how students manage time in their learning processes. In this case, we need to know if they feel that they have enough time to carry out a learning activity or whether they feel stressed and frustrated by the lack of time. We are also interested in what kind of emotions they express and how these emotions evolve over this period of time. It is necessary to know if the negative emotions that have been detected remain and turn into other negative (and possible more harmful) emotions over time, and to set time limits for changing them to more positive emotions.

Thirdly, we need to find the best way to automatically detect and present the affective behaviours that participants show in their interactions in virtual spaces in order to label and display their emotions in an unobtrusive, relevant and non-intrusive way. To achieve this, we will apply an extension of Rhetorical Structure Theory (RST) and Sentiment Analysis (Liu, 2012), also taking the Time Factor into account. We are using these discourse analysis tools to analyse collaborative learning activities (such as the creation of a wiki and debates in forums or chats) in order to extract the emotional relationships between discourse units and provide a graphic representation of the emotional structure of discourse. Based on the time factor, we can determine how long students remain in the same negative affective state in their discourse and then we can search for the factors that have led to the situation. In this case, we need to specify a time limit after which continuation of this situation can be considered detrimental and dangerous, as it can lead to a significant reduction of the quality of learning, failure and even withdrawal from studies. An analysis of the emotional state will also take the context in which learning occurs into account. We understand as *learning context* all relevant information related to a student/group that participates in the learning activity. We will use ontologies as a computational approach to represent this context. Moreover, based on these context data and given that the emotional state is not a precise thing, the analysis will include machine learning techniques (such as fuzzy logic) to derive the emotional state as well as its relationship to the context and the learning outcome.

The application of the above tools provides important knowledge about when specific emotions arise and what causes them. Consequently, in response to the detection of students' affective states their occurrence over time, the tutor is able to provide appropriate feedback to make students react in time, guide them and help them in an appropriate way. This method helps students enhance their time perception, emotional safety and more effective and fruitful engagement in the learning experience. This is more evident when students

become capable of coming out of a negative affective state and moving into a more positive one at a particular moment in their learning process.

FUTURE WORK

In order to evaluate and analyse the effects of this model in the collaborative learning process, our future work will first focus on developing a full computational model and then designing and carrying out three experimental scenarios which will assess the validity of our model and provide us with appropriate answers to the research questions set above. In all three scenarios we will conduct a controlled experiment for which two groups are needed: an experimental group and a control group. This will be an important part of our research, as a controlled experiment is a highly focused way of collecting data and will be especially useful for us in order to determine emotional and behavioural patterns of cause and effect.

CONCLUSION

At each step of the learning process it is important that both emotion detection and emotional feedback take time into account. At a conceptual level, this study proposes a methodological framework for managing students' emotions, especially when carrying out cooperative tasks and where time management plays an important role in students' participation, behaviour and performance and is directly related to students' emotional states during the learning process. In this context, emotions can be used to initiate actions that direct the student's attention to the cognitive goal that needs to be completed. The ultimate aim is to provide an environment where students feel safe, comfortable, valued and confident that they will receive the help they need to achieve their goals. All in all, we consider time as an important factor to be taken into account and this is clearly reflected in the design of our integrated approach and Emotion Analysis Model which includes the provision of timely affective feedback.

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