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Affective states in computer-supported collaborative learning: Studying the past to drive the future

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ABSTRACT

CSCL investigates ways of promoting students' collaboration through technology. Although affective states and socio-emotional factors have an important effect on learning, few studies have classified and analyzed the results obtained by the scientific community to show their real impacts on in CSCL settings. The lack of a comprehensive overview and understanding of previous findings hampers the survey on research gaps, challenges and trends. This work addresses a systematic mapping of the literature for the summarization of results and discussion on research directions for the use of affective states and socio-emotional factors to support the development of intelligent CSCL environments. Six digital libraries were queried and 58 studies were deeply analyzed and categorized. Over 90% of the studies considered emotion and personality traits in the CSCL environment; most studies used personality recognition by questionnaires rather than automatic sources of inference; most technological approaches employed instruments to collect, analyze and/or represent emotions; and most papers that reported empirical experiments focused on “emotional awareness” and “interaction among students in a CSCL environment”. We have identified three main challenges to be addressed by the community in the next decade for an adequate incorporation of affective states in CSCL environments: emotional awareness, orchestration of students' interaction and group formation.

1. Introduction

Computer-Supported Collaborative Learning (CSCL) investigates the use of technologies in collaborative learning contexts for the promotion of students' interaction and collaboration, and maximization of their learning achievement (Stahl, Koschmann, & Suthers, 2006; Tchounikine, Rummel, & McLaren, 2010). To obtain positive results from collaboration in CSCL environments, researchers, such as Dillenbourg (2002) and Isotani et al. (2013), present some aspects that should be considered to better understand: (a) How students should be grouped, (b) How to improve learners' engagement and interaction in group work, and (c) What activities should be carried out by students to solve a problem. Examples of such aspects include: composition/size of a learning group, allocation of roles and resources, interaction patterns, tasks distribution, among others. Several studies have shown the benefits of their use for the

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creation of effective collaborative learning situations (Isotani, Mizoguchi, Inaba, & Ikeda, 2010; Kobbe et al., 2007; Strijbos & Weinberger, 2010). Nevertheless, Calvo (2009) highlights the lack of studies that investigate the impact of affective states to improve the potential benefits of educational collaborative environments mediated by technologies.

Jones and Issroff (2005) discussed the role of affect in three main areas of collaboration, namely collaborative learning setting, online communication, and development of socio-emotional skills. Feidakis and Daradoumis (2010) addressed the design of learning systems and environments as a path to better understand student's emotion/affection. In this context, *Affective Computing* investigates the way affective states are considered in computational systems for the *detection, representation* and *expression* of the user affect in machines (Picard, 1997). **Detection** recognizes the student's affective state through, for example, psychological questionnaires (e.g., Big Five) and automatic sources of inference (Picard, Vyzas, & Healey, 2001), such as facial expressions (e.g., video) and physiological signals (e.g., heartbeat). **Modeling** regards the development of techniques to be implemented in machines (e.g., affective models), so they can "understand" what is affect; and **expression** represents the way affective states can be used by computer applications (e.g., affective agent) for improvements in the interaction of students with the environment or adaptations of the interface according to a particular affective state.

Regarding the different definitions of affective state, emotion and related terms, occasioned by their application in different knowledge areas, such as Psychology, Neuroscience, Education and Computer Science, in this paper *affective state* will employ the Scherer (2000) definition which includes: **emotion**, intense affective state of short duration, and activated by evaluation of an event; **mood**, affective state which tends to be long and has no apparent cause; and **personality trait**, affective state relatively stable, predictable and is intrinsic to a person. In addition to Scherer's (2000) affective states definition, other factors, denominated **socio-emotional**, will be considered in this paper, aiming to analyze the emotional aspect of the social interactions among students in a group work (Kwon, Liu, & Johnson, 2014; Oksanen & Hämäläinen, 2012).

Although there are several findings related to affective computing, there is a lack of research that analyzes and summarizes their impacts, contributions and applications in CSCL environments. Most of literature reviews carried out to date on the field of CSCL focus on gathering evidences about: (i) the benefits of specific social interaction skills (Nussbaum, 2008; Scheuer, Loll, Pinkwart, & McLaren, 2010); (ii) how users' interaction/participation can lead to better learning (Malinen, 2015; Tenório, Bittencourt, Isotani, & Silva, 2016); (iii) how learning scenarios and pedagogical approaches have been designed to improve collaboration in small and large scale (Hei, Strijbos, Sjoer, & Admiraal, 2016; Manathunga & Hernández-Leo, 2015); and (iv) the role of computational technology to better support collaborative learning (Cruz & Isotani, 2014; Resta & Laferrière, 2007). The findings presented by these literature reviews show the maturity of several topics related to CSCL. Nevertheless, none of them focus their attention specifically to the role of affective computing in CSCL. An exception is a work that briefly summarizes how affective states are used in collaborative learning environments (Reis et al., 2015a). However, even in this work a more comprehensive understanding about the impact of affective computing on CSCL was not explored.

Thus, in order to contribute with the field, this paper presents a systematic mapping of the literature that investigates the affective states and socio-emotional factors used in CSCL. We are particularly interested in gathering evidences about what kind of affective states or socio-emotional factors are used to improve or understand collaboration; which instruments/methods are used to help the detection and expression of affect in CSCL; how technological approaches have been incorporated in CSCL environments to offer affective support; how much empirical evidence is available showing the benefits of affective computing in CSCL. Furthermore, we intend to analyze and categorize our findings to show some trends and challenges that can be used as an incentive for future research in an underexplored area to develop methods and intelligent CSCL environments that consider the affective states and/or socio-emotional factors to improve learning benefits and students' motivation.

The paper is organized as follows: Section 2 addresses the importance of elements related to affect (e.g., emotion, mood, among others) in the learning context; Section 3 describes the development process of systematic mapping; Section 4 presents and analyses the results; Section 5 discusses the challenges and trends; finally, Section 6 provides the conclusions.

2. What is the relevance of affect to learning?

Researchers from different areas (e.g., Education, Psychology, Neuroscience, among others) have discussed the relevance of emotion and other affective states to cognitive processes (Izard, 1984; Piaget, 1989; Vygotsky, 1994). According to Piaget (1989), affective aspects strongly influence the cognitive process and vice-versa. Izard (1984) stated positive emotions improve students' performance and negative emotions have an adverse effect; and Vygotsky (1994) supports intellectual, evolutive and affect elements cannot be dissociated from learning.

Over the past few years, affect has gained more importance and attention in the computing area, particularly in the context of individual learning (D'Mello et al., 2013; Hawkins et al., 2013; D'Mello, 2013; Sottilare & Proctor, 2012; Baker, D'Mello, Rodrigo, & Graesser, 2010; O'Regan, 2003). For example, D'Mello et al. (2013) described *flow/engagement*, *confusion*, *frustration*, and *boredom* as predominant affective states experienced by students during individual learning with educational technologies. According to authors, the frequency and persistence of such affective states depend on the learning context. In other study, D'Mello (2013) analyzed 24 papers that include four different learning contexts, such as intelligent tutoring systems, serious games, simulations environments, and simple computer interfaces, in most of them students work individually. The author identified 17 affective states experienced by students, the most frequent were *flow/engagement*, *confusion*, and *boredom*; while *curiosity*, *happiness*, and *frustration* were unusual to find. Finally, Baker et al. (2010) investigated the impact of affect and cognition on different learning environments where students learn individually (dialogue tutor, problem-solving game, and problem-solving-based Intelligent Tutoring System) and observed, *confusion* and *engaged* concentration were the most common states; *frustration* was the less persistent; and *boredom* was very persistent across learning environments.