Introduction

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Introduction

When we step into a meeting, or attend a lecture, can we genuinely leave our emotions at the door? Can we magically dissociate our decision-making processes from the effects of boredom, interest, anxiety, delight, anger or pleasure? Do we not experience utter joy and elation when a much anticipated grant gets funded? Do we not clench our fists and cry out in anger when we feel that a reviewer has treated us unfairly? It is clear that as complex human beings, emotions intersect every aspect of our lives. They bias every decision, influence every action, impact every memory, and govern every social interaction.

Neuroscientists have shown that a person with full cognitive abilities intact, but lacking normal emotional responses, is incapable of making decisions that are essential for life. While popular wisdom and folklore has often argued for the separation of emotion from reason, we now understand that this is neither realistic nor desirable. Affect and cognition weave together to form our experience and behavior as we engage in everyday activities. Simply put, we are affected by affect.

Learning at deeper levels of comprehension, problem solving, and high stakes testing are similarly affected by affect. We experience negative emotions (such as irritation, frustration, anger, and sometimes rage) when we experience failure, make mistakes, and struggle with troublesome impasses. We also experience positive emotions (such as delight, excitement and eureka) when tasks are completed, challenges are conquered, insights are unveiled, and major discoveries are made. These trajectories of positive and negative affective states presumably lead to different learning outcomes. Affective states (emotions, feelings, moods) such as engagement, flow, and curiosity presumably promote learning while frustration, boredom, and lack of self-confidence inhibit learning.

Given the pervasiveness of affect in learning activities, our ability to make significant advancements in developing effective educational interventions will rely on understanding the intricate dance between affect, cognition, and motivation. Once we have a better grasp on the impact of emotions, either as facilitators or in-
hibitors of learning, we will have made significant progress towards improving the efficacy of our interventions. This book is particularly focused on technological interventions, where computer programs deliver individualized instruction in a manner that is sensitive to learners’ affective and cognitive states. The book does not attempt to cover the full breadth of affective phenomena described, for example, in the Handbook of Affective Sciences (Davidson, Scherer, & Goldsmith, 2003), but rather focuses on affective phenomena that are directly influenced by, or are influential to learning, and generally, within the time span of a specific learning activity. It is also important to note that the term affect is used quite generally in this book and encompasses feelings, prototypical emotions, moods, affective traits, and affect-cognitive amalgamations such as confusion, interest, and engagement.

Understanding the complex interplay between cognition and emotion and developing effective interventions to regulate student emotions is a highly interdisciplinary endeavor that spans psychology, education, computer science, engineering, neuroscience, and artifact design. Highlighting cutting edge research from these fields to understand student affect coupled with the practical goal of developing learning environments that coordinate affect and cognition to promote learning is the major goal of this book.

Learning, Affect, and Technology in Close Relationships

Figure 1 presents a triangle with three entities and three interactions that are relevant to this book. Different lines of research have contributed to understanding different parts of this triangle. The top-left circle in the triangle represents research on human affective phenomena (Dalgleish & Power, 1999; Lewis, Haviland-Jones, & Barrett, 2008). Deciphering human emotions is one of the great unanswered questions about human nature and has been at the core of theoretical and empirical research for over a century (Darwin, 2002; Ekman, 1992; Lazarus, 1991; Russell, 2003; Scherer, Schorr, & Johnstone, 2001; Tomkins, 1962). Contemporary theories view emotions as expressions (Darwin, 1872; Ekman, 1992), embodiments (Barrett, Mesquita, Ochsner, & Gross, 2007), outcomes of cognitive appraisals (Ortony, Clore, & Collins, 1988; Scherer et al., 2001), social constructs (Keltner & Haidt, 2001), and products of neural circuitry (Damasio, 2003; Davidson, 1998; Panksepp, 2000), and some recent attempts have been made to integrate these views (Russell, 2003).

Research linking emotions and human activities has provided evidence on how emotions affect cognitive processes (e.g. Lane & Nadel, 2002), including memory, attention, deliberation, and action selection (Bower, 1981; Isen, 2001; Mandler, 1976). Our impetus here is on learning activities (the top-right of the triangle) including problem solving, text comprehension, test taking, etc. (Schutz & Pekrun, 2007), and we focus on the many ways these activities are affected by emotion (Link 1).
The development of technologies that compute affect, the third entity in Figure 1, is primarily in the purview of computer science, engineering, artificial intelligence (AI), and human-computer interaction (HCI) research. Emotions were not a substantial topic of research in these fields until the last decade, until Rosalind Picard coined the term ‘affective computing’ (Picard, 1997) in her influential 1997 book. Inspired by the inextricable link between emotions and cognition, the field of Affective Computing (AC) aspires to narrow the communicative gap between the highly emotional human and the emotionally challenged computer by developing computational systems that recognize and respond to the affective states (e.g., moods, emotions) of the user.

Link 2 encompasses affect-sensitive or affect-aware technologies. These systems are being developed in a number of domains including gaming, mental health, and learning. In addition to developing systems to help users regulate their emotions, technology has also been used to learn about emotions. Similar to how a physician uses technology to diagnose disease (e.g., a stethoscope to monitor the heart), neuroscientists, for example, have used fMRI and other techniques to understand the neural circuitry that underlies emotion (Dalgleish, Dunn, & Mobbs, 2009; Davidson, 1998; Immordino-Yang & Damasio, 2007; Panksepp, 1998). Finally, learning activities can be paired with technology, independent of affect, as is usually the case. This is illustrated by Link 3 in Figure 1. This link includes research in the areas of computer supported learning, e-learning, intelligent tutoring systems (ITS), and artificial intelligence in education (Biswa, Leelawong,
The focus of much of this research is on designing technological interventions to promote more effective learning outcomes. Intelligent tutoring systems take this goal a step further by developing interventions that are sensitive to the cognitive states, knowledge levels, and learning styles of individual students.

This book, and the series of which it is part, focuses on exploring links between affect and learning with technology. In particular, this edited volume brings leading researchers whose work combines the three entities described above: student affect, learning activities, and technology. Each of these three entities is important in providing an accurate and detailed account on affect and learning. If the learners’ affect is not taken into account, and the research assumes learning as a ‘cold’ cognitive process, the understanding of the learning phenomena is limited; this is aptly demonstrated by extensive multidisciplinary evidence presented throughout this book. If basic research on affect and learning is not considered in the development of technologies, researchers might end up developing affect-aware tools that have little impact, or worse, a negative effect, on learning. Finally, technology can also be used to advance basic research on affect and learning by providing tools to monitor the dynamic rollercoaster of student emotions that arise, morph, and decay during learning. In summary, an interdisciplinary position that integrates research from all three entities is the most promising way forward.

Aims and Scope

The last decade has seen an explosion of basic research on affect and learning, as well as technological advances in monitoring and responding to emotions, in order to heighten motivation and engagement, boost self-efficacy, and optimize learning. While much of the traditional research in affective computing is focused on building technologies that recognize and adapt to affective states, it is important that this focus is expanded. In addition to innovative technologies having the potential to adapt to user emotions, they can also be used to inform our understanding of the emotional processes and affective dynamics that underlie learning activities.

Existing methods for studying the impact of affect within real-world activities are fundamentally difficult, since they depend on the subjective judgment of the subjects themselves, or third party experts and novices. They require the laborious manual collection of data, often by experts that are costly and a limited resource. Much of the research described in this book is aimed towards the development of objective methods to model the enormous variety of affective features in human behaviour, language, and physiology. Rather than relying only on data collected before and after an activity, these models would use the micro behavioural information that can be collected with different type of sensors and video cameras.

This book is designed to act as a catalyst to advance research in affective learning technologies by highlighting recent advances, discussing open problems, and
setting the stage for future research in this area. This book focuses on technological interventions that aspire to promote learning gains by responding to emotions, while simultaneously helping uncover some critical learning-centered affective phenomena. This edited volume brings together recent research in the area of affective computing with an emphasis on affect and learning. The "new perspectives" come from the intersection of several research themes including:

- Theories of affect, cognition, and learning
- Basic research on emotion, cognition, and motivation applied to learning environments
- Pedagogical and motivational strategies that are sensitive to affective and cognitive processes
- Multimodal human computer interfaces with a focus on affect recognition and synthesis
- Recent advances in affect-sensitive computer learning environments
- Design issues in the development of affect-sensitive learning environments
- Novel methodologies to investigate affect and learning
- Neuroscience research on emotions and learning

Overview of Contributions

The book is divided into three parts. In the first part, *Theoretical Perspectives*, the authors discuss the conceptual changes that are driving the renewed interest in affect and learning, and present theoretical perspectives of relevance to education and learning environments. The second part, *Case Studies*, features exemplary studies that span from basic research on affect and learning to state-of-the-art affect-sensitive learning technologies. The third part of the book, *Interdisciplinary Perspectives*, features diverse views related to affect and learning from cognitive load, creativity and design, and neuroscience, followed by a summative conclusion of current research in the field and possible avenues for future research.

The first three chapters present unique theoretical perspectives on affect and learning. Art Graesser and Sidney D'Mello (Chapter 2) begin by introducing theories that integrate cognition and emotion during learning. They emphasize the role of cognitive disequilibrium, confusion, and impasses in driving inquiry and promoting deep comprehension. In Chapter 3, Reinhard Pekrun provides a categorization of the emotions that arise in learning activities (called academic emotions) and describes a theory that relates these academic emotions with their antecedents and consequents. In Chapter 4, Benedict du Boulay tackles the very pertinent question of how to engage students who lack motivation by providing theoretically-grounded pedagogical strategies that can be implemented in computer tutors.

The case studies feature research projects, mostly from the ITS community, that address important questions on affect, learning, and describe novel technologies that monitor emotions while helping learners regulate their emotions. In particular, researchers have found it challenging to develop protocols and techniques
to collect ecologically valid data, an essential component for the design of affect-sensitive learning systems. Addressing this issue in Chapter 5, Shazia Afzal and Peter Robinson discuss approaches to collecting and annotating naturalistic affective data. Cristina Conati, in Chapter 6, discusses how causes and effects can be combined to model user affect in educational games. The goal here is to build affective user models with an explicit representation of the possible causes of an affective reaction, as well as its behavioral effects. In Chapter 7, James Lester, Scott McQuiggen and Jennifer Sabourin, examine a wide-range of issues emerging from systematic investigations of learner affect during interactions with narrative-centered learning environments.

There are a number of practical and challenging issues that arise when one attempts to engineer affect-sensitive learning environments. These systems must address the problem of integrating sensors that monitor multiple signals, such as physiology, facial expressions, and contextual cues. Some systems also need to automate the process synthesizing emotions via avatars or animated pedagogical agents. Importantly, all systems need to adapt their pedagogical and motivational strategies in a manner that is sensitive to each learner’s emotions, knowledge states, needs, and learning styles. In Chapter 8, Win Burleson presents his work on building an agent platform with classifiers that can recognize affect and drive the real-time behavior of a learning companion. Often emotional-intelligence capabilities need to be retrofitted on top of existing systems, introducing an entirely unique set of challenges. Sidney D’Mello, Blair Lehman, and Art Graesser describe, in Chapter 9, their work on the Affective AutoTutor, which is an affect-sensitive version of the influential dialogue-based AutoTutor system (Graesser et al., 2004). They also provide early evidence of the efficacy of affect-sensitivity in promoting learning gains, particularly at deeper levels of comprehension.

It is important to acknowledge that we are only beginning to understand how best to adapt an affect-sensitive tutor’s behavior to be responsive to learner affect. In Chapter 10, David Cooper, Ivon Arroyo and Beverly Woolf address this issue by describing actionable affective processing techniques and illustrating their use in affective learning companions. Their chapter also describes the deployment of affect-detection systems in classroom environments.

Most would agree that metacognitive processes are as important as affective and cognitive processes, and there is a paucity of research exploring complex interactions between affect, cognition, and metacognition. Although this is a challenging research area, it offers several opportunities for innovative discoveries to be made. Roger Azevedo and Amber Strain discuss these challenges and their own approach with the MetaTutor system in Chapter 11.

In addition to affect, motivation and engagement are equally important constructs that warrant serious consideration. Chapter 12, by Genaro Rebolledo, Rosemary Luckin and Benedict du Boulay, provide guidance on implementing a form of motivational scaffolding that adapts to learner affect. They focus on personalization (user modeling plus scaffolding) within a narrative supported learning environment. They also discuss their iterative development methodology that should inform the development of similar systems. Detecting engagement/disengagement, and adapting to it, is a formidable challenge addressed by
Kate Forbes-Riley, Diane Litman, and Heather Friedberg in Chapter 13. They present an approach for annotating student disengagement and its source during spoken dialogues with a computer tutor as an initial, yet critical step, towards this goal.

Generalizing the outcomes of so many different projects and platforms is quite challenging. To what extent do insights gleaned from one system generalize to another? This is a difficult issue to address since each research group tends to focus on a single system. In Chapter 14, Ma. Mercedes Rodrigo and Ryan Baker address this very issue by comparing the incidence and persistence of learners’ affective states during interactions with an impressive array of learning environments.

The third part of the book features interdisciplinary perspectives from researchers outside the Intelligent Tutoring Systems community, which constitute the majority of authors in this book. This section begins with a chapter by Slava Kalyuga (Chapter 15), who presents the cognitive aspects that underlie the expertise reversal effect. He presents an impressive synthesis of cognitive-load research with in multimedia learning environments and discusses how insights gleaned from this avenue of research can be applied to affect-sensitive learning environments.

Chapter 16, by Andy Dong, examines the representation of affect through language, with a particular focus on its three meta-functions in creative thinking and design: to help break stimulus-response bonds; to control the pacing and sequencing of actions; and, to evaluate situations according to beliefs and values. The chapter then discusses links between affect and creativity and their implications for building learning technologies.

Armed by emerging evidence from neuroscience, Mary Helen Immordino-Yang and Vanessa Singh (Chapter 17), construct an argument which claims that: a) emotion and cognition are inextricably bound and involve both the body and the mind, and b) learning is often accompanied by learners’ internalization of subjective interpretations of other people’s beliefs, and feelings, and actions.

Peter Goodyear’s chapter (Chapter 18) encourages us to revisit the underlying motivation and framing of our research field, where technology, learning and affect meet in interesting ways. It is known that affective phenomena are contextually-bound and situated in a social and physical world. Goodyear’s argument transcends the body of evidence pertaining to this interrelatedness and opens a discussion into the type of activities that affective computing should support. One important point is that a deeper understanding of learning cannot be achieved by reducing the rich social nature of human behavior (including learning) to the actions of isolated individuals, as is the case with most ITSs. Hence, it might be necessary to reconceptualize the role of learning technologies in order to meet 21st century outcomes, an activity that, in our view, should take place in an interdisciplinary forum such as the one advocated in this book.

We conclude the book (Chapter 19) by taking stock of the various threads of research on affect, learning, and technology. We emphasize significant accomplishments and suggest possible avenues that are particularly promising for future research.
References


