Distributed Emotions in the Design of Learning Technologies

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Learning is a social activity, which requires interactions with the environment, tools, people, and also ourselves (e.g., our previous experiences). Each interaction provides different meanings to learners, and the associated emotion affects their learning and performance. With the premise that emotion and cognition are distributed, the authors suggest two principles for considering emotion in the design of learning technologies: use relational meanings around content; and think of emotion as providing resources for learning, design, and research. In this article, the authors discuss these principles based on how they are designing a 3D multiplayer game for learning Earth systems using dinosaurs and their fossils as conceptual and emotional anchors of learning.

Introduction

The learning sciences field develops, tests, and informs theories about how people learn by studying designs of teaching and learning, and in turn, strives to influence designs of effective learning environments in and out of school settings. The contributions from renowned scholars of learning sciences in *The Cambridge Handbook of the Learning Sciences* (CHLS) (Sawyer, 2006) imply the recent foci of the field. Topics of many articles are around the nature of knowledge and reasoning, the processes of conceptual change, the representations of knowledge, the designs that consider these knowledge entities, processes, and representations for learning, and the ways of studying such complex learning processes and outcomes in various contexts. Thinking, including learning, is a social activity, which requires interactions with the environment, tools, other people, and also ourselves (e.g., our previous experiences, personal interests, prior knowledge).

What is often neglected, especially in research on learning, is that like these thoughts there are emotions associated with the personal meanings of the interactions (Zembylas, 2005). In the CHLS, "emotional" engagement of learners, except motivation, is briefly mentioned only in the context of informal learning (Bransford *et al.*, 2006), from which we can infer that the field of the learning sciences in general has not paid very much attention to the emotional aspects of learning in the designs and studies of learning environments.

The relationship between emotion and cognition is a complex and difficult matter for psychological research. There was a view that emotion draws on different resources than cognition in our mental processing (e.g., Zajonc, 1980), and some recent studies still show that negative/positive emotions do not have much effect on the performance of complex problem-solving (e.g., Spering, Wagener, & Funke, 2005). As such, emotion has often been regarded as a separate phenomenon from cognition in psychological and educational research, until recently (Lemerise & Arsenio, 2000; Pekrun, Goetz, Titz, & Perry, 2002).

Some critical constructivist perspectives on cognitive theories have started to look for evidence for the links between cognition and emotion. Our cognition is working when eliciting and experiencing emotions; and, at the same time, our emotion activates and modifies cognitive processes. Especially, emotions could direct, sustain, or decrease our attention (i.e., cognitive resources) toward objects/events depending on individuals' perceived meanings of them (Pekrun *et al.*, 2002). The growth of cognition and the growth of emotion are also tightly linked because having emotions would mean having certain evaluative appraisals of, for example, a person, which indicate having knowledge about the person's characteristics (Zembylas, 2005).

In spite of the focus on the links between cognition and emotion, however, the assumptions about the links still overlook their interrelationship, focusing more on cognition. What research might then pursue is focusing on the development of sociocultural systems beyond reciprocity of how learners react to and influence the sociocultural aspects. During the interactions among people and the context, we could view cognition, motivation, and emotion of the sociocultural system as contributing to the development of each other (Meyer & Turner, 2002). Thus, they (i.e., people and contexts) are seen as interacting and developing as one system.

We pay attention to arguments for the interrelationship between emotion and cognition in our research:

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that is, these two aspects of our mind serve our every thought and action together. We concur that each interaction in a learning situation provides different meanings to learners and their sociocultural contexts, and the associated emotions affect their thinking, learning, performance, and development as a system. Martin and Briggs (1986) problematized the separation between cognition and affect, and made much effort to propose how affective objectives and strategies should be linked in the design and sequencing of instruction. In this article, however, we would like to expand these relationships beyond the prearranged instructional settings as to how learners could connect their learning and emotions with their personal resources, experiences, and environments. Although disentangling the intertwined temporal-causal relationship between cognition and emotion is almost impossible (Zembylas, 2005), the field of the learning sciences should consider emotional aspects of our thoughts and actions in the designs and studies of learning environments to better understand and support learning processes.

Distributed Emotion and Cognition, and Learning Design

If emotion and cognition are interrelated, then emotion and learning affect each other. Learners think and act according to their continuous (mostly unintentional) appraisal of the learning situations and contents (Eynde & Turner, 2006). Some aspects of learners' emotional relationships to the learning contents or situations, therefore, are embodied in learners' every thought. From this sociocultural perspective, thinking and actions are sociocultural, and so are emotions. Emotions are distributed among people (at various levels, such as classroom, community, and society), symbols, objects, and environments in a way similar to how researchers talk about cognition (e.g., Salomon, 1993).

Particularly, technological capabilities of interacting with other learners within a virtual space (or a mixture of virtual and physical) provide another dimension of distributed thinking and sharing feelings. In classroom situations, learners' efforts in certain subject areas are often intertwined with emotional relationships with the teacher and peers (Meyer & Turner, 2002). At the same time, learners constantly process social cues and select their attentions in relation to their personal and social goals, which affect their mood and emotions (Lemerise & Arsenio, 2000). Group level emotions form and evolve as the members work together, and the distributed emotions can improve or impede overall performance of the system, and vice versa (Norman, Ortony, & Russell, 2003). In the design of learning technology, we should consider how interaction mechanisms might affect learners' emotions and how emotions are distributed within the technology to improve the group level performance.

We, therefore, aim to consider distributed emotion and cognition as the premise of our design process. To explore, develop, and evaluate distributed emotion in design and research of learning technologies, we consider two principles: (1) use relational meanings around content; and (2) think of emotion as providing resources for learning, design, and research. The principles below are theoretical but intuitive in the sense that we all have our own emotional experiences. In the next two sections we briefly describe the main ideas about them; we then discuss examples from our design effort.

Relational Meanings

Meaningful learning affects learners' emotion and cognition. This is in line with how Wenger (1998) describes the negotiation of meanings and identities in multiple levels of communities (e.g., classroom, school, local and global society), and how Scardamalia (2002) discusses deep embedding of learners' ideas in the larger conceptual structures and the practices of a knowledge-building community. Learners might have positive emotions toward interesting content for the sake of it, but more often they respond to relational meanings around the content (Planalp, 1999). For example, one might be fascinated by how the human body reacts to viruses, but it is more likely that we want to learn about symptoms of a viral infection when there is a chance to be infected. The concern for science education, for a similar reason, is that only a few learners relate to the science subjects in a manner that they provide meanings, inspirations, and worldviews beyond the classroom work (Kozoll & Osborne, 2004). Learners' emotional and cognitive engagement in an activity is equivalent to their meaningful interpretations of the activity and acting on it (Eynde & Turner, 2006). Technology has vast possibilities to open doors to relational meanings of various levels of concepts. In our design efforts, we should consider what kinds of meanings we want learners to create within a larger conceptual structure, beyond textbook content, and how the interactions allow learners to bring their personal meanings to the learning activities with technology.

Emotions as Resources

Emotions can be associated with learning concepts when they are relevant to learners' direct or indirect life experiences, and can supply the best resources to accomplish learning goals (Zhu & Thagard, 2002). Emotions of learners, therefore, can provide resources both for them to engage in activities and for researchers to better understand how people learn. For learning environments, it then becomes very crucial to design objects, interactions, and contexts that would help learners bring forth their emotional resources. As mentioned above, emotion provides resources for

learners to direct cognitive resources (i.e., attention) to a particular object/event (Pekrun *et al.*, 2002). This can happen by learners' taking emotional cues both from the interesting content and from the environment (e.g., emotions of teacher and peers, or relational meanings beyond the content itself).

For research into learning designs, emotion that learners express through their conversations and actions might provide more reliable information about their learning processes than reasoning represented in them (Zhu & Thagard, 2002). The studies on how people learn using emotional and cognitive resources could be on multiple levels. On an individual level, learners' emotional expressions can be examined to understand their appraisals of learning situations at hand and their relevant actions. On a group level, the collective emotions are important indicators of learning, as a system of learning improves its performance in a distributed manner. In larger contexts, classroom norms and practices, school or community level rules and values, and local community could be examined to understand how learners might direct their emotional and cognitive resources to learning situations (Eynde & Turner, 2006).

Designing Around Meanings and Emotions

Voyage to the Age of Dinosaurs (VAD) is a 3D multiplayer game prototype for learning Earth system science. We propose to develop a learning environment where learners could find personal as well as societal/global meanings around Earth system science, thus supporting conceptually and emotionally engaging learning experiences. When people interact with the context, the relevant cognition and emotion develop and contribute to the development of each other. Perception and understanding of the Earth also develop in such manners, and people of all ages develop their personal ideas and feelings about the Earth's phenomena. Lee (1999) and Tsai (2001), for example, studied children's knowledge about natural disasters (hurricanes and earthquakes, respectively) in regions that recently experienced deadly occurrences. The studies indicate that many students developed preconceptions about the causes of natural disasters based on their worldviews within social and cultural contexts, especially beliefs about supernatural forces. At the same time, these students undoubtedly would have developed certain emotions around such natural phenomena, which is not typically studied in conjunction with research on preconceptions. The meanings in relation to the Earth system are in the context, values, beliefs, and artifacts of the lived environments and the people who live together; nonetheless, the classroom learning about our Earth does not occur in the manner that considers such developed and developing emotions together with cognition.

Figure 1. A dinosaur and volcanic steam in the sky.

In our design, we use dinosaurs and their fossils as conceptual and emotional anchors of learning to enrich the relational meanings and provide meaningful experience to learners. We are assuming that emotions pertinent to concepts, storyline, and game play are distributed to the various objects/events in the game, by capitalizing on learners' technological and aesthetic capacity. Such emotions (e.g., those pertaining to volcanic eruption) develop with the players' existing emotion and cognition around the relevant concepts. In other words, emotions are linked to particular objects, events, and people, as Pekrun and colleagues (2002) have discussed. In VAD, players teleport to the early cretaceous period after carrying out multiple quests in the present day, Lioaning, China. They are to capture dinosaurs alive in the context of supporting one of two rival paleontologists. The past world environment, for example, features a volcanic mountain, which provides an interesting context for learning (see ***Figure 1***). As an environmental object with reoccurring events, it could represent: a potential threat to dinosaurs and players; simulated volcanic activities with volcanic materials; and a source of rock formation and fossilization.

Depending on players' existing ideas and feelings about them, volcanoes could mean danger, fatality, and nature's violence. The events of eruptions are indicated by tremors and sounds, which could raise relevant emotions (based on their understanding of such indicators). The provided volcanic gas map can inform the potential fatality of players themselves. Conceptually (also in relation to the scenario of VAD), simulated volcanic materials represent sources for the present world's rocks and fossilization of dinosaurs. In the following, we discuss what kinds of relational meanings we consider for the design of VAD, and how we try to learn from learners' emotions by working with them as design partners.

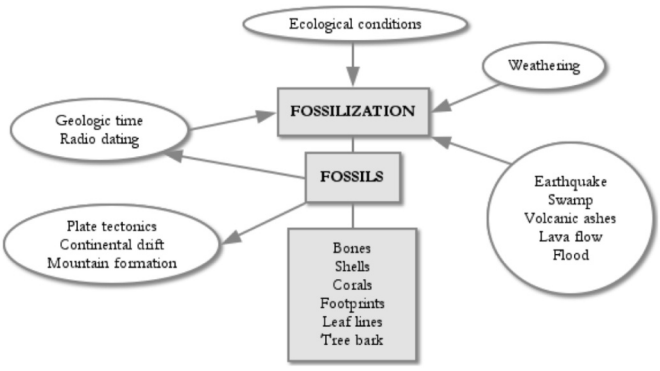

Figure 2. Fossils and earth processes.

Figure 3. Study and sketch of Dilong.

Enriching Relational Meanings: Paleontology

In the design of VAD, we consider the relational meanings around the Earth science concepts, especially in relation to dinosaur fossils. One might ask why students learn about the Earth system with dinosaurs when learning about dinosaurs is not part of the national curriculum. We propose that fossils and the fossilization processes of dinosaurs embody the Earth's dynamics and history. Fossils are formed (and exposed) because of Earth's materials, weather/climate, and structure/dynamics. Fossils thus provide relational meanings and evidence, not only of ancient life and the Earth's history, but also of processes such as the movement of tectonic plates. ***Figure 2*** illustrates the relationships we considered among various Earth's processes/events in relation to fossils/fossilization.

The fossils found by paleontologists are those with hard substances. Among them, dinosaur bones are the biggest that can bring to light various Earth processes, as these are traces of prehistoric living creatures. To remain as fossils in thousands of years after its lifetime, a creature would have lived in certain environments and died in certain ways. For example, a dinosaur that became trapped and died in a swamp may be fossilized with all its bones in good shape and place. Fossils also suggest the Earth' plate tectonics in that the many fossils are exposed when plates formed mountains. The concepts such as plate tectonics, earthquakes, and mountain formations might be interesting to some learners due to their inherent characteristics; nonetheless, learners may find them more meaningful because of how they affect our lives and affected the lives and traces of such intriguing creatures as dinosaurs. We approached the learning of Earth's processes focusing on dinosaurs and their fossils for these reasons.

Placing the learning experience in the larger structure of practices and concepts, experts' knowledge and practices from the disciplines such as geography, geology, and paleontology should be embedded in the designs. First of all, the objects, landscape, and characters in VAD are being designed to imply certain aspects of paleontological and geographical contents beyond aesthetic value or the preference of an artist. For example, dinosaurs' appearance and movements, their skin/feather colors, textures, and so forth reflect the research of paleontologists, as well as artists' imaginations (see ***Figure 3***). Second, the activities in the VAD reflect the certain gadgets and practices of paleontologists, such as finding fossil sites and carefully digging and excavating fossils. In this case, various rocks and their compositions become much more meaningful because of their relevance to the fossils and fossil sites. We hope these relational meanings can bring personal meanings for the learners to the various concepts.

Using Emotions as Resources

Emotions provide resources for learning, indicators of learning for researchers, and thus important information for design efforts. Our main design approach is to work with learners as our design partners. Learners' ideas and emotions can become generative resources for learning activities when we take them seriously. During our design workshops, learners' emotions were also their resources for engaging in learning and design activities as well as researchers' sources of understanding. For example, one of the workshops was about creating a scenario and a short film illustrating fossils and dinosaurs of the early cretaceous period. One member of a group (Tony) was especially interested in expressing the violence of volcanic eruptions. He did not stop looking for a material to illustrate lava flow. He finally realized and said:

> *I forgot I got lava. I remember I got poncho (taking pinkish-red disposable poncho pack and throwing it onto*

Figure 4. Shooting and the film of volcanic eruption.

the table. Irene picks it up and takes it out of the packaging). Big enough. Like that (taking poncho back and unfolding it). You can do this or not? Victor, Victor, after you know the brooooooosh (making sound of volcanic eruption) then everyone dies. And then somebody will throw tissue (throwing it up above the table with both hands). Very funny.

This emotional and cognitive engagement in illustrating the eruption with a poncho (see ***Figure 4***: top—shooting process; bottom—their film shot of two dinosaur props with the poncho flowing down) was shared by the group members. After a trial, Weilong, who was filming, commented on Victor's performance:

Weilong: Ok, Victor, you must make the shaking sound, then throw. You don't immediately throw, but very good. OK, very good.
Victor: How to make shaking?
Weilong: You make like krrrr…. (making sound of tremors)

The scenes on which students spent more time were especially parts where characters in their story (dinosaurs and paleontologists) would become emotional in some respects (e.g., discovering fossils, sudden attack of a predator). Even though we cannot engage learners in this kind of activity for all learning situations, we are designing our game considering the emotional and cognitive engagements of our student design partners. We hope our design provides (future) learners with a similarly engaging experience and shifts their role from passive recipients of knowledge to active meaning-makers, as they make meaningful associations through their explorations in VAD. The design elements they used and the emotions they expressed through their design (e.g., sudden happenings, urgency of situations), therefore, become our important sources for VAD design.

Conclusion

This article illustrates how emotion could be considered in the development of game-based learning environments. There are distributed cognition and emotion around objects, events, and players in the 3D environment that we intend to embody within conceptual and emotional elements related to the Earth science learning that we are unable to explain at length; and at the same time, learners are possibly unable to notice such multi-faceted aspects. As designers of learning technologies, we should consider how these distributed cognition and emotions might affect learner's emotions, thinking, and actions. In sum, with an intention to provide meaningful experiences for learners, we reviewed the following two principles for designing learning technologies:

- *Relational meanings:* Situating the learning experience in the larger structure of practices and concepts to embed experts' knowledge and practices.
- *Emotional experiences as resources:* Considering learners' emotional experiences as resources both for them to engage in activities and resources for researchers to explore learners' emotional resources.

We argue that emotion is crucial for the design of learning technologies, especially games. The motivation sparked from this game should then be maintained together with various other activities in and out of the classroom experiences, which is what Gee (2007) calls "Game design," with a big G, for the design of interactions around the game. □

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Playing Epistemic Games in Science and Mathematics Classrooms

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Education in the Knowledge Age calls for engaging students in creative work with knowledge. A major implication for research and design in the learning sciences is that the necessary shift is not simply technological or pedagogical, but essentially epistemological (Brown, 2007). In this article, the authors view such creative work with knowledge through the theoretical lens of *epistemic games* (Collins & Ferguson, 1993; Morrison & Collins, 1995). Epistemic games refer to strategic play with disciplinary knowledge in complex domains, and are based on the study of disciplinary communities such as Physical, Biological, and Social Scientists. The authors describe two instantiations of epistemic game play drawn from classroom interventions in science, *Ideas First* (Bielaczyc & Ow, 2007), and mathematics, *Productive Failure* (Kapur, 2008). The two research projects were funded as part of a comprehensive reform effort in Singapore schools toward 21st century education. Their analyses illustrate the design features of epistemic games in learning environments and discuss the implications of learning to play epistemic games.

Introduction

Education in the Knowledge Age calls for engaging students in creative work with knowledge. In advising the Singapore Ministry of Education on what is needed to achieve the necessary transformations, John Seely

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