The MADE Framework: Multimodal Software for Affective Education

Reza GhasemAghaei, Robert Biddle, Ali Arya
Computer Science
Carleton University
Ottawa, Canada
Reza.GhasemAghaei@carleton.ca, Robert.Biddle@carleton.ca, Ali.Arya@carleton.ca

Abstract: This paper proposes a framework for multimodal educational systems, considering the affective strategies. The ability to communicate emotionally and cognitively plays an important role in human-computer interaction (HCI) and education. The challenge is how theoretical models of HCI can inform affective multimodal education.

INTRODUCTION

The view of multimodal systems needs to evolve as the world is becoming increasingly computationally enabled. New forms of interaction such as gesture and speech are now becoming common, and interactions considering cognition and emotion are beginning. The growing interest in multimodal interface design is inspired largely by the goal of supporting more transparent, flexible, efficient, and powerfully expressive means of HCI. Multimodal systems process two or more combined user input modes—such as speech, pen, touch, manual gestures, gaze, and head and body movements—in a coordinated manner with multimedia system output. They are a new class of interface that aim to recognize naturally occurring forms of human language and behavior, and which incorporate one or more recognition-based technologies (e.g. speech, gesture, vision) (Oviatt, 2012). Multimodal HCI seeks to combine multiple sensing modalities in a coordinated manner to provide interfaces that are powerful, flexible, adaptable, and natural. In order to accommodate a wider range of scenarios, tasks, users, and preferences, interfaces must become more natural, intuitive, adaptive, and unobtrusive. This is a primary motivation for developing multimodal user interfaces (Turk, 2005). However, an increasing interest for design perspectives in learning could be noticed during the past decade (Kress, 2012). There seems to be a need for a new conceptualization of learning in multimodal interface design by increasing *affective* and *cognitive* concepts. Nobody denies the role of affect in learning. Certainly teachers know that it plays a crucial role, recognizing it under intuitively understood headings like motivation, emotion, interest, reward, and attention. Research has demonstrated, for example, that a slight positive mood does not just make you feel a little better but also induces a different kind of thinking. The need for a more precise theory is being driven today by growing efforts to build technologies that interact with learners — motivating, engaging, and assisting them in challenging new ways (Picard, 2004). HCI systems that can sense the affective states of the human (e.g., stress, inattention, anger, boredom, etc.) and are capable of adapting and responding to these affective states are likely to be perceived as more natural, efficacious, and trustworthy. Emotion is intricately linked to other functions such as attention, perception, memory, decision-making, and learning (Jaimes, 2007).

This research focuses on multimodal interaction, and particularly on using multimodal software for affective education. We created a framework representing theories of multimodal interaction based on *multiple sensory* modalities and *quasi-sensory* modalities, and introduced a compact model of affective multimodal systems. We are considering both cognitive and affective strategies in this multimodal framework, to increase affective and cognitive aspects of users in a multimodal environment. We are focusing on educational applications.

- We have reshaped the three domains of *Bloom's taxonomy* (Bloom, 1956) and we are considering the multiple sensory and quasi-sensory modality domains to help the affective and cognitive domains.
- We have developed a new framework based on principles for multimodal design that considers affective and cognitive aspects of learners while interacting with a multimodal system.

This framework is about both teaching and learning, as teaching is all about facilitating learning. It is for system designers and instructors, who are creating and using educational technology that considers affective and cognitive processes of the learner. The strategies are for the instructor who is responsible for the affective aspects. We as system designers are trying to help the instructor accomplish their approaches by supporting those strategies in the design. The instructor strategy is to help the learner learn through affect. The overall goal of this paper is to address the role of affective strategies in multimodal interaction. To that end, we set out to answer the following research question: What principled framework would be appropriate and would support multimodal software for affective education?

Therefore, the intention of this paper is to contribute to this body of work with the potential to impact on the broader study of design and evaluation of multimodal environments. Furthermore, our investigation was foundational. We required an increased understanding of basic cognitive and affective communication in the context of multimodal HCI. It was also our hope that this research could help to lay the groundwork for specific applications in education. Our main claim is that issues of affect in multimodal systems have not been addressed for software design for education. There are four different elements to consider: affect, multimodality, education and software design. Research has been done that outlines each of these elements: for example, the circumplex model of emotion by Russell (1980) (models of affect); Chang et al. (2010) created a multimodal system using affective touch called *The Haptic Creature* (affect and multimodality); Hede and Hede (2002) addressed learning that involves simultaneous interaction with multimodal media elements (multimodal design for education); Gelderblom and Kotzé (2008) provide guidelines for designing technology for young children and what we can learn from theories of cognitive development (software design for education). However, no clear connection between all of these elements has been made. The hope of this paper is to make these connections by focusing on the input and the output. We are not creating a technical package or a toolkit. We are focusing on a user interaction design and evaluation work considering all these aspects.

PROPOSED FRAMEWORK

In this section we develop the proposed framework; first, we describe the education domain; next, the learning objective and cognitive affective strategies; after, the multiple sensory and quasi-sensory modalities; and finally, clarify the roles and stakeholders of the system. We propose a theoretical framework showing the connection between affective, cognitive, and multimodal aspects, called MADE (Multimodal Affect for Design and Evaluation). In this framework we are looking at cognitive and emotional aspects. We have learning objectives, affective strategies, cognitive strategies and multiple sensory and quasi-sensory modalities for educational applications. Our goal is to come up with an HCI framework for multimodal systems to support education. It will be used to help the learner to learn and engage more.

Education Domain

Now we explain the role of the education and introduce Bloom’s taxonomy. In support of a learning objective there are a number of cognitive strategies and affective strategies. Bloom's taxonomy breaks learning objectives for students into three domains that are cognitive (mental skills, knowledge, e.g. rules of the road), affective (growth in feelings or emotional areas, attitude or self, e.g. teaching affective driving to teenagers in terms of driving safety) and psychomotor (manual or physical skills, e.g. physical skills in driving a car) (see Table 1). The main goal of Bloom's taxonomy is to motivate educators to teach across all three domains and provide students with a more holistic education. According to Simpson (1972), the psychomotor domain includes physical movement, coordination, and use of the motor-skill areas. Development of these skills requires practice and is measured in terms of speed, precision, distance, procedures, or techniques in execution.

Bloom’s Taxonomy 1956
Cognitive: mental skills (Knowledge)
Affective: growth in feelings or emotional areas (Attitude or self)
Psychomotor: manual or physical skills (Skills)

Table 1: Bloom's Taxonomy (Bloom, 1956).

There are systems that involve psychomotor learning. But we are not focusing on the psychomotor learning. There could be a part in our model about psychomotor, except we are not addressing that kind of learning here. In the following three subsections we will explain the cognitive strategy, the affective strategy and the multiple sensory and quasi-sensory modalities: see Table 2. Later we are going to connect them together and detail the proposed interactive system.

<table>
<tr><th colspan="2">Learning objective</th></tr>
<tr><td>Cognitive strategy
Scaffolding
Situated cognition
Cognitive tracing
Enactive learning
Formative feedback
Embodied cognition</td><td>Affective strategy
Emotion
Humour
Social
Cultural
Personality</td></tr>
<tr><td colspan="2">Quasi-sensory modalities
Narrative
Persuasion</td></tr>
<tr><td colspan="2">Multiple sensory modalities
Visual
Auditory
Tactile</td></tr>
</table>

Table 2: Domains in the proposed interactive system.

Learning Objective and Cognitive Strategy

Cognition is distributed over a system of people and tools. Cognition has been described in terms of specific kinds of processes that include: attention, perception, memory, learning, reading, speaking, listening, problem solving, planning, reasoning, and decision making. It is important to note that many of these cognitive processes are interdependent: several may be involved for a given activity. When you try to learn material for an exam, you need to attend to the material, perceive and recognize it, read it, think about it, and try to remember it (Rogers, 2011). Cognitive strategy is going to be informed by what the learning is – some sorts of cognitive strategy will suit some sorts of learning strategy.

Here we give some aspects of the cognitive strategy. We are considering *scaffolding*, which is an aspect of the proposed framework. It can help the learner to do things in a certain kind of way such that he/she learns the basics of how they work and then the help he/she takes will go away; Figure 1 illustrates this. In educational applications, scaffolding is typically faded over time to increase student independence (Rowe, 2010).

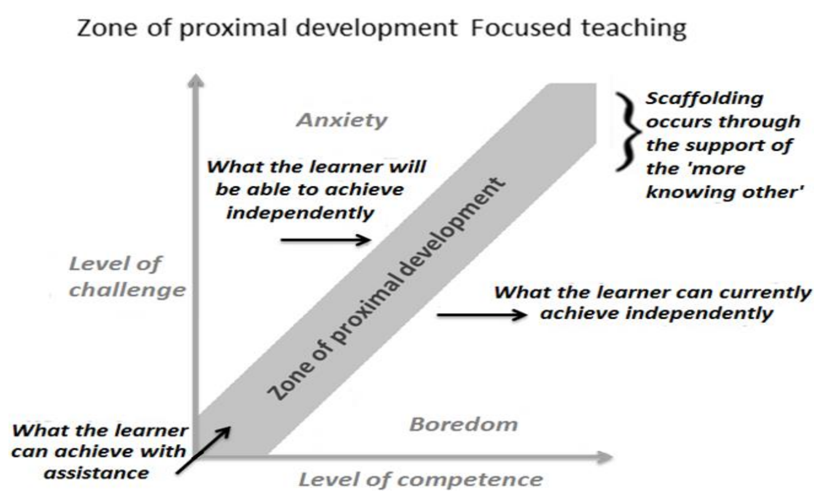

Figure 1: Bruner's theory builds on the work by Vygotsky. A learner's level of actual development is scaffolded to the level of their potential development. Scaffolding is a specific type of teacher (or more knowledgeable other, MKO) support that helps the learner achieve a task that they would not be able to achieve without assistance; assistance provided just at the time of need, which is designed to help the learner work with increasing independence (Wilson, 2008) (interpreting the work of Bruner).

Instructors or designers can lead activities to scaffold students to learn how to use or to learn to explain. We can ask them to explore a series of scaffolded activities that are intended to help students learn to explain, and closely observe them during this process. Explaining can be a learned skill. Generally, students' explanations can be too brief and incomplete, especially with younger participants. Often they need to learn and practice explaining. Scaffolds can facilitate "learning to explain," and it can prove to be useful. Initially users need step-by-step instructions about how to explain and what they are explaining. Gradually, scaffolding can fade away and users can become more autonomous (Salehi, 2012). Belland et al. (2008) developed some guidelines for the creation of evidence-based argumentation scaffolding: Embed scaffolds within a system, have students articulate their thoughts, constrain the problem space, consider motivation, make scaffolds explicit for students with less prior knowledge, and focus on the development of conceptual, strategic, and difficult procedural scaffolds.

Another cognitive strategy component we are considering in our framework is *situated cognition*. It is a theory that suggests learning is "naturally tied to authentic activity, context, and culture" (Brown, 1989). Also, this theory suggests that it is more difficult to learn from un-natural activities. For example, learning one's first language or a foreign language by immersion is widely held to be easier than learning languages from textbooks and vocabulary lists (Lui, 2009). Basically, it suggests that learning is strongly supported by a specific kind of environment and a specific kind of culture. If all knowledge is situated in activity bound to social, cultural, and physical contexts, we can consider the situated cognition. We would like our framework to support situated character of embodied thinking in complex culturally organized settings and social contexts (Hutchins, 2006).

The next cognitive strategy component we are considering is *cognitive tracing* which involves externally manipulating items into different orders or structures. It is useful in situations where the current state of play is in a state of flux and the learner is trying to optimize his/her position. This typically happens when playing games. In a classroom example, letting students know what they have studied in an e-learning package; an interaction diagram can be used to highlight all the nodes visited, exercises completed and units still to study (Rogers, 2011). When we are assessing student ability in a cognitive tutor system, the assessment is performed by observing each step the student makes and applying a technique called *model tracing* to identify which procedural skills the students are using to produce each step. Once these skills have been identified, an approach called *knowledge tracing* can be used to assess each student's latent ability in each skill. This assessment is based on how many opportunities the student has had to apply to the skill and how often they correctly apply the skill in these instances (Anderson, 1995).

Enactive learning is learning by doing and experiencing the consequences of your movement and actions, which provides information. Enactive learning involves learning from the consequences of one's actions. Thus, enactive learning includes testing learned mental models in an environment that provides feedback based on action. It emphasizes the role of self-modeling in a structured environment with controls and feedback (Gupta, 2010). Another aspect of a cognitive approach is using *formative feedback* defined as information communicated to the learner that is intended to modify the learner's thinking or behavior for the purpose of improving learning (Shute, 2007). It comes in a variety of types such as verification of response accuracy, clarification of correct answers, hints, etc. It can be provided at various times during the learning process. For example, immediately after an answer or with some delay. It may interact with other variables to differentially affect learning (e.g., learner characteristics, aspects of the task) (Shute, 2011).

Embodied cognition is an aspect of cognitive strategy. It is a cognitive science in which the mind, body and the environment interact, enabling learners to acquire or construct new knowledge (Cowart, 2005). It offers us new ways to think about bodies, minds, and technology and deeply depends on features of the physical body of the learner. This triad of influences affords learning in goal-directed, real time environments that engage the senses, perceptions and prior experiences (Kerka, 2002). *Embodied interaction* (EI) is a form of technologically-supported training activity created, implemented, and researched by scholars interested in investigating multimodal learning. Through engaging in EI activities, users build schematic perceptuomotor structures consisting of mental connections between, on the one hand, physical actions they perform as they attempt to solve problems or respond to cues and, on the other hand, automated sensory feedback on these actions (Abrahamson, 2011). The concepts of embodiment and the role of the body contribute to the meaning making process, a focus on multiple modes from body posture to gaze, to physical action and manipulation as forms of communication is critical. Embodiment in the context of this framework centres around the notion that human reasoning and behavior is connected to or influenced by our physical and social experience and interaction with the environment (Price, 2013).

In short, by considering these aspects of cognitive strategies: scaffolding, situated cognition, cognitive tracing, embodied cognition, enactive learning, embedded and formative feedback, we can increase the learner's mental skills.

Learning Objective and Affective Strategy

The following concepts illustrate affective strategy. According to Picard (2004), who coined the term *affective computing*, HCI can be considerably improved when multimodal systems are aware of their user's feelings and can react adequately. We discuss how emotion may play an important role in multimodal systems especially in terms of learning better. In a learning environment, people are sometimes reluctant and do not have enough time to learn something, because they get distracted, feel disconnected and not engaged. Therefore, in the design of this educational system, we also need to take into consideration the affective aspects. The emotional aspects and functional aspects combine to re-function the framework. The circumplex model of emotion was first developed by Russell (1980) who proposed an emotion model based on the two dimensions of arousal and valence. Kort et al.'s emotion model (2001) was built on Russell's circumplex model to create a learning companion that keeps track of what emotional state the student is in and from that, decides what help he/she needs. They proposed an affective model of interplay between emotions and learning; a four quadrant learning spiral model in which emotions change when the learner moves through the quadrants and up the spiral. It is well known that students' results can be improved with the right encouragement and support. Figure 2 shows this model, which attempts to interweave the emotion and the cognitive dynamics of the learning process.

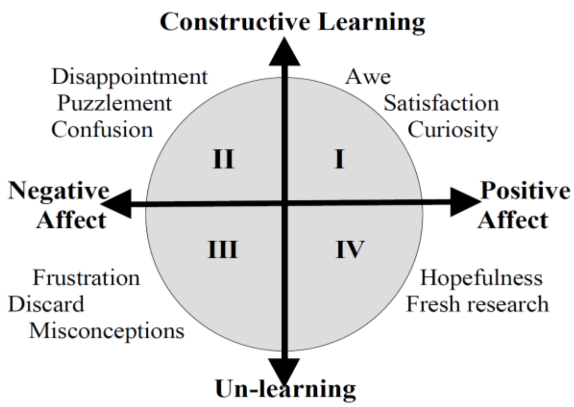

Figure 2: Kort's model relating phases of learning to emotions (Kort, 2001).

Emotion plays an important role in learning, since the affective strategy is very powerful. Emotion is an information processing system in the brain/mind that evaluates the world, determines what is good or bad, safe or dangerous, and it takes precedence over cognition most of the time, as puts the learner at a frustration level that prevents cognitive strategies from occurring. It is seen as an embodied process, involving both body and mind. In a sense, emotion processes have to play the role of bridging the dualism gap between mind and body. A learner's cognitive abilities depend on his/her emotions. Emotions can be used in the learning content to increase learner's attention and improve the memory capacity (Frasson, 2010). Picard (2004) has mentioned that one basic approach is to observe a person's patterns of behavior via sensors such as cameras, microphones, or pressure sensors applied to objects the learner is in contact with (mouse, chair, keyboard, etc.), and then use computers to associate these patterns with probable affective state information. Examples of emotion in HCI and affective computing systems directed at the learning field include for example, the work of Kapoor and Picard (2005). They have described the architecture of a proposed system and have focused on a scenario where children try to solve puzzles on a computer. In their framework, features are extracted and sent to a multimodal pattern analyzer that combines all the information to predict the current affective state. Another application in this learning area from Picard's group is a leap chair with pressure sensors classifying nine postures a student can have related to affective states associated with a student's interest level. These systems reactively decide what the learner needs in terms of both the content and the form of learning.

Another paradigm of an affective strategy in our framework can be *humor*. Humor plays a very important role in human-human interaction such as education, mediating the teacher-student relationship, and as a way where etiquette problems are resolved without conflict (Mishra, 2004). Instructors use humor to assist learning, to create a cheerful atmosphere, and to get and maintain students' attention. Humor can create a positive and energized atmosphere that is conducive to learning. Instructors can use humor to promote critical thinking and creativity (Rieger, 2014). It can make learning more engaging, as well as fun. According to Vandaele (2002) the three main theories of humor are superiority, relief and incongruity. Relief theory is the theory of humor resulting in laughter and mirth that comes from a release of nervous energy. From the perspective of the incongruity theory, people laugh at things that are unexpected or surprising. The proposition of the superiority theory is that we laugh about the misfortunes of others and we are better than others. Humor is a social phenomenon and we rarely laugh when we are alone. It has an essential function in relieving stress in learning situations, which diminishes students' anxiety or frustration, being an effective way to diffuse student anger and hostility. According to Dormann and Biddle (2009) many educators believe that humor creates a pleasant learning climate by increasing interaction and diminishing pressure in difficult environments, making the teacher more approachable, reducing the distance between the teacher and students, both offering and augmenting support. Teachers have a more satisfying experience, motivating learning, helping building language skills, and improving class atmosphere by the use of humor.

As previously mentioned, *formative assessment* is strongly assisted by an affective teaching strategy. For example, we can use it when we are doing an activity with the students. The teacher walks around the class, and says: "Oh, you are not quite there yet". In other words, doing an assessment, gives you immediate feedback to help you improve. Therefore, we need to have a strong affective strategy which brings trust.

We also have to consider the *social* approaches in learning. Leaning happens in a specific context or as a social activity. Learning happens through the interaction of individuals, artifacts, tools and the environment (Connery, 2009). In interactive learning environments, animated interface agents play an important role. Mishra and Hershey (2004) described pedagogical software agents, a paradigm for teaching and learning based on research in the areas of animated interface agents and interactive learning environments which draw upon human-human social communication scripts by embodying observable human characteristics, such as the use of gestures and facial expressions, to increase student engagement and motivation. Mishra and Hershey explained other related work done at the Center for Advanced Research in Technology for Education at the University of Southern California, which developed pedagogical software agents that exhibit a variety forms of etiquette, for example politeness, expressiveness, and empathy for the purpose of promoting learning in interactive environments. They described STEVE (Soar Training Expert for Virtual Environments), which was developed by Rickel and Johnson (1997), an autonomous pedagogical agent that provides training in virtual environments, both in individual and team settings, and focuses on issues such as tracking a student's cognitive and affective states, tracking learner-agent interaction as a social relationship, and managing interaction to improve communication effectiveness.

Multiple Sensory and Quasi-Sensory Modalities

How do the learning objectives, cognitive strategies, affective strategies, multiple sensory and quasi-sensory modalities relate? We start with the learning objective. We have the two affective and cognitive strategies, and we implement these two through the multimodal system, relating the multiple sensory and quasi-sensory modalities domain to these strategies. The idea is that the multimodal system will support these two strategies (see Figure 3).

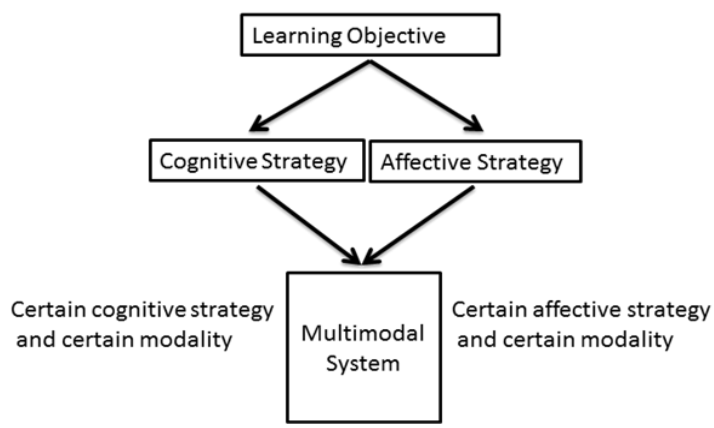

Figure 3: Learning objective, cognitive, affective strategies and multiple sensory modalities.

HCI is expanding towards natural modalities of human expression. Using multimodal gestures, voice, body movements, and other affective and cognitive interaction techniques can change the way computers interact with humans (Mourão, 2013). For example, multi-sensory techniques are used to assist a student in his/her learning. By using a multiple sensory teaching technique, the instructor can help a student to learn through more than one sense. The human senses are: sight, touch, hearing, smell, and taste. The input modalities of many computer input devices can be considered to correspond to human senses: cameras (sight), haptic sensors (touch), microphones (hearing), olfactory (smell), and even taste. Many other computer input devices activated by humans, however, can be considered to correspond to a combination of human senses, or to none at all: keyboard, mouse, writing tablet, motion input (e.g., the device itself is moved for interaction), galvanic skin response, and other biometric sensors. The reason we connect the learning objective to cognitive strategy, affective strategy and multimodality is because the learner is cognitively and emotionally involved in the learning process through multiple sensory devices.

Affective feedback can be used to guide learners toward emotional states that are conducive to learning and promote motivation. Cognitive support encompasses discreet and overt techniques for prompting learners toward taking desirable actions. Cognitive supports are likely to be most useful for users who are off-task, confused, or have low self-efficacy with regard to their ability to successfully progress through the learning environment. Cognitive and affective strategies can be delivered in several ways, such as conversational interactions between the instructor and the learner using different sensors such as facial expression sensor, pressure mouse, blood pressure measurement system, eye detection, posture analysis seat, etc.

In our framework we are looking at cognitive and emotional aspects. We have a learning objective, affective strategies, cognitive strategies, multiple sensory modalities and quasi-sensory modalities for educational applications. While interacting with the world, people employ their sensory modalities; they may also need to employ some quasi-sensory modalities (e.g. narrative-based HCI, or persuasive technology) while interacting with a supportive technology. When teaching, we want to have a cognitive and an affective strategy. We basically want to choose a sensory modality that collects both cognitive strategy and an affective strategy. Cognitive strategy is going to be informed by what the learning is, because some sort of cognitive strategies suits some kinds of learning objectives. When building software, affective and cognitive strategies are important in identification and role-play. For instance, a software that helps children learn about pollution, showing a small amount of poison can affect a large amount of water which can affect all kinds of different animals, or focusing on the town someone lives with people and animals, etc. that he knew about, can make it different and can be personal. Therefore, regarding the identification, making children identify the problem, e.g. if it is a pollution in California, it can be not important for someone living in Ottawa, but if pollution is part of our city, it becomes important for us. And the role-play can be a pollution officer or police investigator.

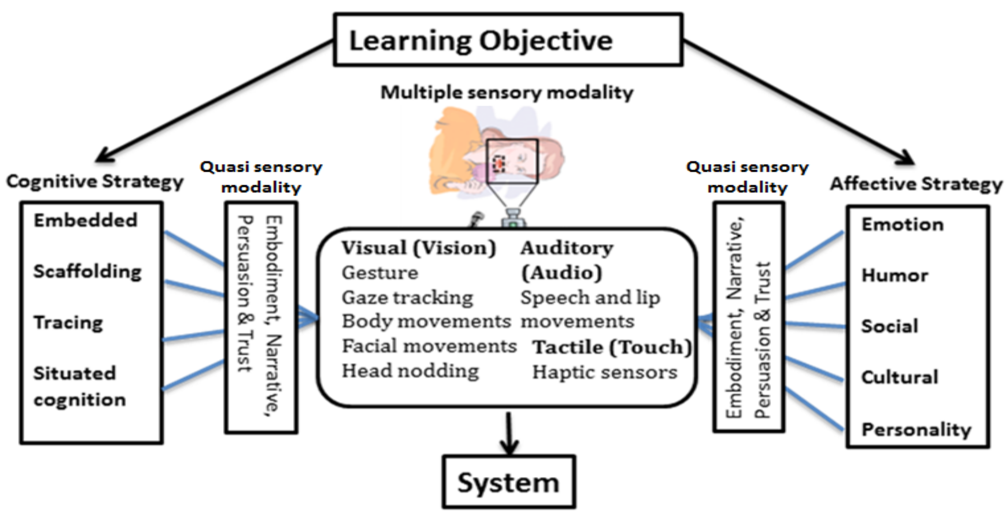

Figure 4: The proposed MADE framework.

The learning objective controls the metrics, cognitive and affective strategies, and the linkages. These strategies then inform the instructor, student and educational technologies (see Figure 4). We are proposing a framework by using affective and cognitive strategies and using multiple sensory and quasi-sensory modality domains to help and support these two strategies. Consequently, we developed a novel framework for the design of multimodal educational software inspired by Bloom's taxonomy, incorporating the multiple sensory modality domain. We have reshaped the three domains of Bloom's taxonomy and we are considering the multiple sensory modality and quasi-sensory modality domains to help the affective and cognitive strategies (see Table 3). These two domains are just a particular way of hoping that it supports those two strategies. The only thing we are leveraging from Bloom's taxonomy is the fact that there are these different aspects of a learning system that we have to accommodate. Therefore, the domains of educational activities or learning are shown in table 3.

Bloom's Taxonomy 1956	**MADE Taxonomy 2015**	
Learning domains:	**Learning domains:**	
Cognitive: mental skills (knowledge)	**Cognitive:** mental skills (Intellectual capability. i.e. knowledge, or 'think')	**Multiple sensory modality:** visual, auditory or tactile and **quasi-sensory modality:** e.g. narrative or persuasion
Affective: growth in feelings or emotional areas (Attitude or self)	**Affective:** growth in feelings or emotional areas (Feelings, emotions and behaviour, i.e. attitude, or 'feel')	
Psychomotor: manual or physical skills (Skills)		

Table 3: Comparing Bloom's Taxonomy with MADE Taxonomy.

The MADE framework can be used by the teachers in a classroom to help students learn and engage more. The affective feedback is supplementing the teacher. It can have cameras and sensors to check when learners get unhappy and it can go slowly or give learners messages. Alternatively, it can provide that information to the real teacher, and he/she can come and check on the student. The system helps the teacher recognize the problem and it is safer than it going unnoticed. The teacher might not notice the student needs help but with this multimodal system it will become possible. Our goal is to reduce cognitive load and improve communication by developing richer communication interfaces and model human-like sensory perception and communication patterns.

Roles and Stakeholders – Teachers, Students, Technologists

To explain the effect of role, we will consider the example of a teacher and a learner. Here we have a teacher who has a lesson plan with both cognitive and affective strategies. We will explain the roles and stakeholders and who are the target users of this framework. The technologist or the HCI person when designing the system has to consider supporting the teacher as well as thinking about the roles and stakeholders who are teachers, students and technologists. This is the plan which we are suggesting: the steps are planning, setting learning objectives (affective strategy and cognitive strategy), monitoring and integrating (interpretation, retrospective and review). Teacher interpretation is the way something is explained or understood to the learner. Retrospection is looking back on or dealing with past events or situations. We consider Figure 5 as an example of the role of the system in relationship to the teacher.

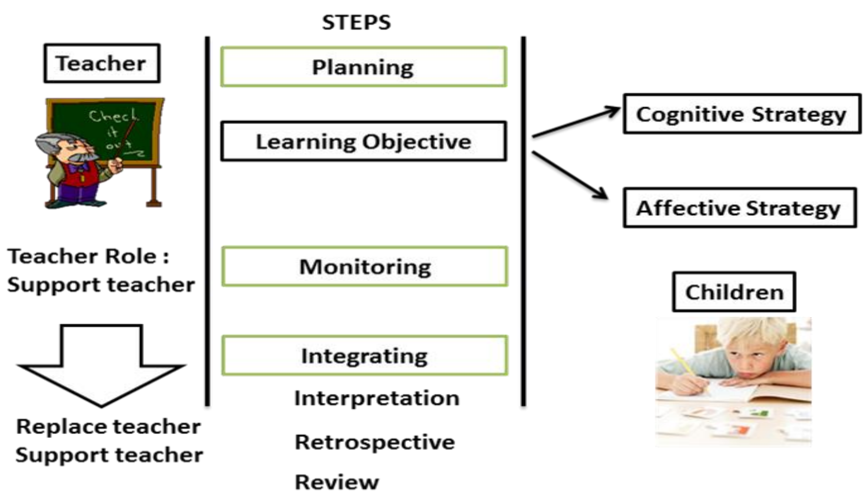

Figure 5: The role of the system in relationship to the teacher.

From the teacher's point of view, the first step is in terms of worksheets, blackboard, etc. The teacher has some learning objective, which is something that essentially most teachers have. For example, novice teachers make lesson plans for every class they teach. Lesson plans outline the learning objectives and what the students should be able to do. Since we are following Bloom's approach, there is a cognitive strategy (how the teacher is explaining the materials) and an affective strategy (how to make it fun and help to bring enthusiasm). We will describe how to follow it through and then figure out if we have been successful. Novice teachers write a report on what was successful or not, and then review it with a mentor and figure out what could have been improved. In the school, teachers will propose some new things that will be approved by the head of the department, and later, how to intend transforming it for the affective education. Then, there is the established education theory that requires input from the teacher (see Figure 5).

This framework is about both teaching and learning, as teaching is all about helping learning. It is for system designers and instructors, who are creating and using the educational technology that consider affective and cognitive processes of the learner. It should be the instructor who determines the affective strategies to be used. It is these strategies the instructor uses to leverage affect to help learning. We as system designers are trying to help the instructor accomplish their strategies by supporting those strategies in the design. The instructor's strategy is to help the learner learn through affect. We are creating an environment that considers both affective and cognitive methods in the learning process. Regarding the age of the learner, currently our focus and objective is post-secondary and adult learners. We hope that it will be true for everyone, and eventually be true for children.

CONCLUSIONS

In this paper, we introduced MADE, a multimodal affective framework for design and evaluation of multimodal user studies. We described how a theoretical framework could be useful for evaluating multimodal user case studies by considering affective strategies, cognitive strategies, and multiple sensory and quasi-sensory modalities. We explained the connection between them. Multiple sensory modalities are coming to help both the affective and the cognitive strategies for implementing the learning objectives. The interactions between multimodal, affective, and cognitive strategies creates an environment as a way to assist teachers and students to communicate and interact through these multiple modalities to engage and increase the learning aspects. The aim is to optimize student engagement and learning, e.g. by using a narrative-based presentation. This paper ended with summarizing the contributions of this research, comparing Bloom's Taxonomy with MADE Taxonomy, and explaining roles of teachers, students and technologists. It concluded that affective strategies can indeed facilitate learners' understanding and learning through the employment of multiple sensory and quasi-sensory modalities which augment learners' rhythmic cycles of engagement and reflection.

REFERENCES

Abrahamson, D. & Trninic, D. (2011) *Toward an embodied-interaction design framework for mathematical concepts*, IDC.

Anderson, J. R. & Corbett, A. T. (1995) *Cognitive Tutors: Lessons Learned*, The journal of the learning sciences, 4(2), pp. 167-207

Belland, B. R., Glazewski, K. D. & Richardson, J. C. (2008) *A scaffolding framework to support the construction of evidence-based arguments among middle school students*, Education Tech Research Dev, 56, pp. 401–422.

Bloom, B.S., Engelhart, M.D., Furst, E.J., Hill, W.H. & Krathwohl, D.R. (Eds.), (1956) *Taxonomy of Educational Objectives – The Classification of Educational Goals – Handbook 1: Cognitive Domain*. London, WI: Longmans, Green & Co. Ltd.

Brown, J. S., Ollins, A. & Uguid, P. (1989) *Situated Cognition and the Culture of Learning*, Educational researcher, Vol. 18, No. 1, pp. 32-42.

Chang, J., MacLean, K. & Yohanan, S. (2010) *Gesture Recognition in the Haptic Creature*, EuroHaptics.

Cowart, M. (2005) *Embodied Cognition*, Retrieved from http://www.iep.utm.edu/embodcog/.

Dion, C. (2007) *Laughter and humour in second-language learning and teaching*, Doctoral Dissertation, Université de Montréal, Quebec, Canada.

Gelderblom, H. & Kotzé, P. (2008) *Designing Technology for Young Children: What we can Learn from Theories of Cognitive Development*, ACM SAICSIT.
Gupta, S., Bostrom, R. P. & Huber, M. (2010) *End-user training methods: what we know, need to know*, ACM SIGCPR.
Hede, T. & Hede, A. (2002) *Multimedia effects on learning: Design implications of an integrated model*, In S. McNamara and E. Stacey (Eds), Untangling the Web: Establishing Learning Links, ASET, Melbourne.
Hutchins, E. (2006) *Imagining the Cognitive Life of Things*, The Cognitive Life of Things: Recasting the boundaries of Mind symposium organized by Colin Renfrew and Lambros Malafouris at the McDonald Institute for Archaeological Research, Cambridge University, UK.
Jaimes, A. & Sebe, N. (2007) *Multimodal human–computer interaction: A survey*, Journal Computer Vision and Image Understanding, Elsevier.
Johnson, W. L. & Rickel, J. (1997) *Steve: An animated pedagogical agent for procedural training in virtual environments*, ACM SIGART.
Kapoor, A. & Picard, R. W. (2005) *Multimodal Affect Recognition in Learning Environments*, MM'05.
Kerka, S. (2002) *Somatic/Embodied learning and adult education*, Retrieved from http://www.calpro-online.org/eric/textonly/docgen.asp?tbl=tia&ID=155.
Kirsh, D. (2013) *Embodied cognition and the magical future of interaction design*, ACM TOCHI, Special issue on the theory and practice of embodied interaction in HCI and interaction design.
Kort, B., Reilly, R. & Picard, R.W. (2001) *An Affective Model of Interplay between Emotions and Learning: Reengineering Educational Pedagogy-Building a Learning Companion,* Proc. Int'l Conf. Advanced Learning Technologies, ICALT '01.
Kress, G. & Selander, S. (2012) *Multimodal design, learning and cultures of recognition*, Internet and Higher Education 15, Elsevier, pp. 265–268.
Lui, J. & Su, Z (2009) *Situated Cognition/Learning Theory*, Retrieved from http://etec.ctlt.ubc.ca/510wiki/Situated_Cognition/Learning_Theory.
Mishra, P. & Hershey K. A. (2004) *Etiquette and the Design of Educational Technology*, Communications of the ACM.
Mourão, A. & Magalhães, J. (2013) *Competitive Affective Gaming: Winning with a smile*, MM '13.
Oviatt, S. (2012) *Multimodal Interfaces*, The Human–Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications, Third Edition, CRC Press.
Picard, R. W., Papert, S., Bender, W., Blumberg, B., Breazeal, C., Cavallo, D., Machover, T., Resnick, M., Roy, D. & Strohecker, C. (2004) *Affective learning – a manifesto*, BT Technology Journal, Vol 22 No 4.
Price, S. & Jewitt, C. (2013) *A multimodal approach to examining 'embodiment' in tangible learning environments*, TEI 2013.
Rieger, A. (2014) *Energize Your Classroom with Humor*, Effective Teaching Strategies.
Rogers, Y., Sharp, H., & Preece, J. (2011) *Interaction Design: Beyond Human-Computer Interaction*, John Wiley & Sons.
Rowe, J. P. (2010) *A Framework for Narrative Adaptation in Interactive Story-Based Learning Environments*, In Proceedings of the Intelligent Narrative Technologies III Workshop, ACM INT3, Monterey, CA, USA.
Russell, J. A. (1980) *Circumplex Model of Affect*. J. Personality and Social Psychology, pp. 1161-1178.
Salehi, S., Kim, J., Meltzer, C. & Blikstein, P. (2012) *Process pad: a low-cost multi-touch platform to facilitate multimodal documentation of complex learning*, In Proceedings of the Sixth International Conference on Tangible, Embedded and Embodied Interaction, TEI, Stephen N. Spencer (Ed.). ACM, New York, NY, USA, pp. 257-262.
Shute, V. J. (2007) *Focus on formative feedback*, Research report, ETS.
Shute, V. J. & Tokac, U. (2011) *Formative feedback*, Florida State University, Teacher Training Workshop.
Simpson, E. (1972) *The classification of educational objectives in the psychomotor domain: The psychomotor domain*, Vol. 3, Washington, DC: Gryphon House.
Turk, M. (2005) *Multimodal Human-Computer Interaction*, Real-Time Vision for Human-Computer Interaction, Springer.
Vandaele, J. (2002) *Humor mechanisms in film comedy: Incongruity and superiority*, Poetics Today, 23(2), pp. 221-249.
Wilson, S. (2008) *Components of Cognitive Apprenticeship: Scaffolding*, Retrieved from http://etec.ctlt.ubc.ca/510wiki/Components_of_Cognitive_Apprenticeship:_Scaffolding, ETEC510 Design Wiki, Technology-enhanced Learning Environments.