Multimodal Software for Affective Education: UI Design

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Abstract: This paper focuses on interaction design for multimodal software in affective education. We suggest how multimodal systems can help us, and give a proposal for how to design the systems. These are demonstrations of how the MADE framework can be applied to well-known design techniques. Our goal is to come up with human-computer interaction (HCI) design guidelines for systems to support affective education. We propose the adaptation of personas from Goal-Directed Design process and propose adaptation of the Usage-Centered Design process for multimodal education.

INTRODUCTION

The main idea in this paper is to adapt well-known design methods to the *MADE* (Multimodal Affect for Design and Evaluation) framework for educational software. We as system designers wish to design an HCI system and we need to answer the following questions: how might the MADE framework be leveraged for design, and what are the methodologies to design the system? This is principally intended for system designers. For example, system designers have to work with teachers regarding the learning objectives and what affective and cognitive strategies they might use to get those learning objectives. We suggest what multimedia systems might support those affective strategies and how they could be built into a system. The multimodal system supports these two different parts, affective and cognitive strategies. Therefore, the question is, because we design the system, how should we do it – what is the principled way to design it. The design methodologies and usability tests are recognized as important milestones in the development of interactive applications such as multimodal systems. We adapt the design methodologies to the framework that are *goal-directed design* (GDD) with an adaptation of *personas*, and an adaptation of *usage-centered design* (UsageCD) for multimodal education. We will explain them in detail in the next section.

BACKGROUND

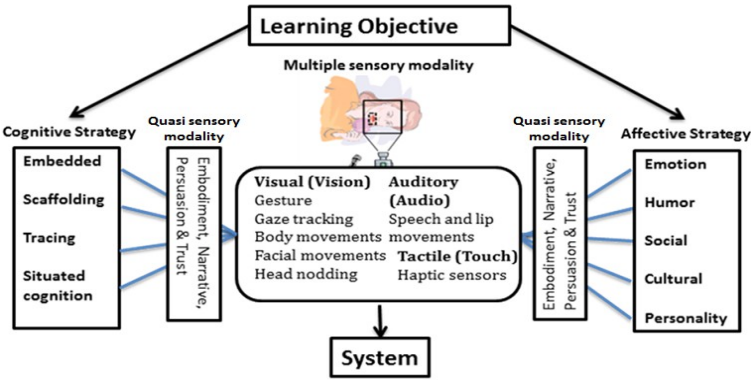

Figure 1: The proposed MADE framework.

MADE Framework

In the MADE framework we look at cognitive and emotional aspects of learning. We created this framework to represent theories of multimodal interaction based on *multiple sensory modalities* (visual, auditory or tactile) and *quasi-sensory modalities* (e.g. narrative or persuasion) and introduced a compact model of affective multimodal systems. We considered both cognitive and affective strategies in this multimodal

framework to increase affective and cognitive aspects of users in a multimodal environment. We focus on educational applications. We have reshaped the three domains of Bloom's taxonomy for learning (Bloom, 1956) and considered the multiple sensory and quasi-sensory modality domains to help the affective and cognitive domains. We developed a framework based on principles for multimodal design that considers affective and cognitive aspects of learners while interacting with a multimodal system. Figure 1 shows our MADE framework that has affective and cognitive strategies and uses multiple sensory and quasi-sensory modality domains to help and support these two strategies.

The learning objective controls the metrics, cognitive and affective strategies, and the linkages. These strategies will inform the teacher, student and educational technologies.

Goal-Directed Design

GDD is the first design methodology we considered: it was created by Cooper et al. (2007) and is an interaction design methodology; it includes personas as practical interaction design tools to create high-tech products. According to the authors, GDD is a process that follows six phases: research, modeling, requirements definition, framework definition, refinement, and support. The *research* phase employs observation and contextual interviews providing qualitative data about users of the system. In the *modeling* phase, behavior and workflow patterns discovered through analysis of the field research and interviews are synthesized into domain models (information flow and workflow diagrams) and user models (personas). In the *requirements definition* phase, design methods are employed by teams. During the *framework definition* phase, designers make the overall system concept. The *refinement* phase proceeds similarly to the framework definition phase; however, increasing the focus on detail and implementation. The *development* support answers developers' questions during the construction process (Cooper, 2007), (Dumeez, 2013).

Cooper's GDD process results in a solid user model and a comprehensive user plan. It is a powerful tool for answering questions such as who the users are and what are they trying to accomplish, or how users interact with the system and how the system should behave and deal with problems they may encounter. To create a system that must satisfy a variety of users is to use personas and design for specific types of individuals with specific needs. Personas are user models that represent a class or type of user of a specific interactive system. The components of GDD are persona, scenario and end goal.

The personas are rich descriptions of typical users of the system under development that the designers can focus on and design the product for. They do not describe real people, but are realistic and not idealized; they are models of the people who use the system. Each persona has a unique number of goals relating to the particular system under development. It also includes a description of the user's skills, attitudes, motivations, main points, tasks and environment. These personal, precise and credible details will help designers to see the personas as real potential users to design for (Rogers, 2011). Persona defines whom the story is about. A persona is an archetypal model that communicates research patterns about a type of user in the present. A persona is depicted as a specific person, but is not a real individual; they are synthesized from observations of many people. A scenario defines when, where, and how the story of the persona takes place. The scenario is a narrative that describes how a persona behaves as a sequence of events and would interact with software in a particular context to achieve their end goal(s). Scenarios are written from the persona's perspective, at a high level, and articulate use cases that will likely happen in the future. A goal defines what the persona wants or needs to fulfill. The goal is the motivation of why the persona is taking action. When that goal is reached, the scenario ends. End goal is an objective that a persona wants or needs to fulfill by using the system. The software aids the persona to complete their end goal(s) by enabling them to accomplish their tasks via certain features (Goltz, 2014).

Usage-Centered Design

In the second design methodology, UsageCD, it is not users who must be understood, but *usage*, which is how and for what ends software tools will be employed. UsageCD focuses on the work that users try to achieve and on what the system will need to supply via the user interface to help them accomplish it. UsageCD was introduced and developed by Constantine and Lockwood (1999). It is based on user intentions and usage patterns for user interface design. It analyzes users' roles that they play in relation to systems and employs abstract (essential) use cases for task analysis.

Now we explain the use cases and scenarios, and later the *essential use case*. Use cases focus on user goals. They were introduced in the book Object-Oriented Software Engineering (Jacobson, 1992), by focusing on the interaction between the user (actor) and a software system. It is precise and we can implement directly from it. UI design work must be done beforehand.

Scenarios are concrete stories concentrating on realistic and specific activities and traditional use cases contain certain assumptions including the fact of interacting with the technology, user interface and kind of interaction to be designed (Rogers, 2011). Constantine and Lockwood developed *essential use cases* (EUCs) in 1999, to compensate for the limitations of both scenarios and use cases. They are called essential because they represent the essence of the use case. The whole thing about EUCs is that they are in the higher level compared to the use cases. It does not say exactly "how" to build a system. It says "what" to use in our design. They represent a more general case than a scenario embodies, and tries to avoid assumptions of traditional use cases. An EUC has three component parts: a short, fully descriptive name; a name that expresses the overall user purpose or intention, plus a two-part narrative comprising the user intention model and the system responsibility model. The division between user intention and system responsibility can be helpful in conceptual design considering task allocation and user responsibility and system scope and what it can do (Constantine, 1999), (Rogers, 2011).

In short, in conventional (concrete) use cases consist of the user action model and the system response model, while in EUCs we have the user intention model and the system responsibility model. This EUC is often dramatically shorter and simpler than the conventional use cases for the same interactions because it contains only the steps that are essential and of intrinsic interest to the user (Constantine, 1999).

USING THE MADE FRAMEWORK FOR DESIGN

In this section we illustrate the MADE strategy diagram and show how we adapt the two design methodologies to multimodality. As seen in Figure 2a, the teacher actor, the student actor and the developer actor are associated with the use cases. Each actor represents a role, so when e.g. Robert, who is the instructor, has to come up with and decide the learning objective, the cognitive strategy and the affective strategy, he has a monitoring role with the system as well. The developer's job is to take this model into the system. In the figure, the cloud is kind of a conceptual model, connected to the actual system. Therefore, the top layer is a kind of a cloud that has the learning objective, affective strategy, cognitive strategy and the multiple sensory modalities.

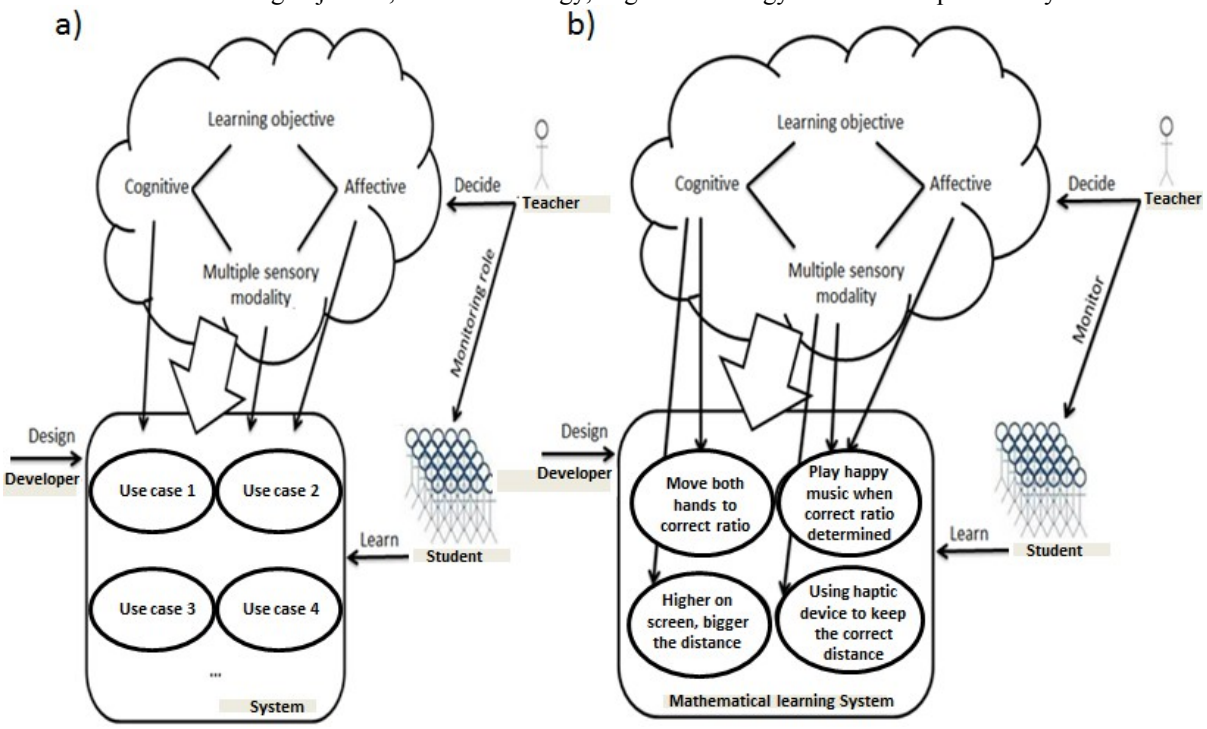

Figure 2: a) The MADE strategy diagram; b) The MADE strategy diagram specific to the mathematical learning system.

Figure 2b is the general version of the framework diagram that it has to be for a specific system. Abrahamson and Trninic (2011) explained an embodied-interaction design framework for mathematical

concepts. They demonstrated a mathematical imagery trainer. They train new kinds of imagery for the concept of proportionality. In this activity the learners who are grade four, five, and six, have to make and keep the screen green by moving their right and left hands in regard to a specific ratio and distance between their hands. We have taken this concept and applied it to our framework. It is for a mathematical learning system, which is a specific version of the framework diagram. The first and second use cases are "Move hand to correct ratio" and "Higher learner move hands, keeping the distance bigger" (cognitive strategies). The affective strategy and the multiple sensory modalities are "Play happy music when correct ratio is determined" and "Use haptic device to keep the correct distance".

Now we describe the proposed adaptation of personas from GDD and the proposed adaptation of UsageCD for Multimodal Education.

Proposed Adaption of Personas from Goal-Directed Design

We take the established GDD methodology and adapt it to our purposes by adding learning objectives, affective and cognitive strategies and multiple sensory modalities. Here we explain how to adapt them in a multimodal system. Cooper et al. (2007) have provided examples of personas. Personas can be useful in developing a better view of the user, are part of GDD, and are useful in developing a better view of the users.

The personas in the educational multimodal system and the instructor and the learner, who want to be able to do things by: using the system, achieve their goals, and undertake meaningful activities using the multimodal system that the design will show. The overall goal is that MADE supports design of multimodal systems. We create the personas so that we can envisage whom we design for and to allow and imagine ourselves to see or experience something from someone else's point of view and from a user's position. Therefore, it is important to create several different personas for our new multimodal system because different types of people will use it. Although we focus on affective outcome, we can never completely ignore the cognitive ones because if the cognitive ones in fact do not work, then the affective strategies are pointless. For example, in a primary school in an arithmetic class, teachers might provide a lot of affective strategies such as little stories or cartoon characters. Those are very nice to help multiple sensory and quasi-sensory modalities, but that does not help the cognitive strategies such as "how to add numbers, columns, etc". If teachers don't have a cognitive strategy for teaching arithmetic, no affective strategy will help them to succeed.

We specify whether there are e.g. genius students who always want to be challenged with extra materials, or very hesitant, insecure students who need to have confidence, since all of these will effect affective strategies. However, the critical thing is that those personas should have elements that put tension to affective learning. Then, a system designer will know how it is to be supported. With personas we consider: behavior patterns, goals, skills, attitudes, environment, and some fictional personal details to bring the persona to life.

For a multimodal educations system, personas are developed to explore the various needs of people with different needs. In our example the personas are fictional. To ensure comprehensive coverage of our framework we defined a better learning environment according to the affective and cognitive strategies with the help of the multiple sensory modalities. We use three personas: one unconcerned student, one student whose parents would like him to become an engineer, and finally, one more inclined student who has a reading disability (dyslexia). The first scenario introduces the reader to Sarah, an unconcerned student who likes to listen to music when studying. Next, we assume the role of Sarah's classmate Oliver. His parents pressure him to become an engineer and therefore he feels pressure that makes pressure on him and he worries about it. Lastly, Mike has a learning disability. Therefore, they for example, would need more engagement and persuasion to learn by taking into consideration the affective and cognitive strategies. These personas are shown in Figures 3. Figure 3a shows first learner persona (Sarah). She prefers to listen to music, dance and go clubbing and does not have the passion to study and concentrate in the classroom. The instructor has to encourage her with affective strategies such as humor, emotion, and use theories of cognition such as embodied interaction with using multiple sensory modalities such as funny sound effects and pleasing interfaces to provide more engagement, attention and pleasure. Figure 3b shows second learner persona (Oliver). He worries about his future to be an engineer because of his parents. He likes to be relaxed and have fun, and is not very ambitious. He is afraid of not being successful. The instructor has to encourage him with affective and cognitive strategies like humor, emotion and use persuasive learning techniques and multiple sensory modalities such as encouraging videos and haptic devices to bring more motivation. Figure 3c shows the third learner persona (Mike). Mike has a disability called Dyslexia that can effect his learning. He does not feel confident and fears making mistakes. He worries other students make fun of him. Instructors have to encourage him with affective and cognitive strategies like humor, emotion, persuasion learning, and use multiple sensory modalities such as

haptics and encouraging videos to show in the classroom – but the details are a matter for the teacher, not the system designers.

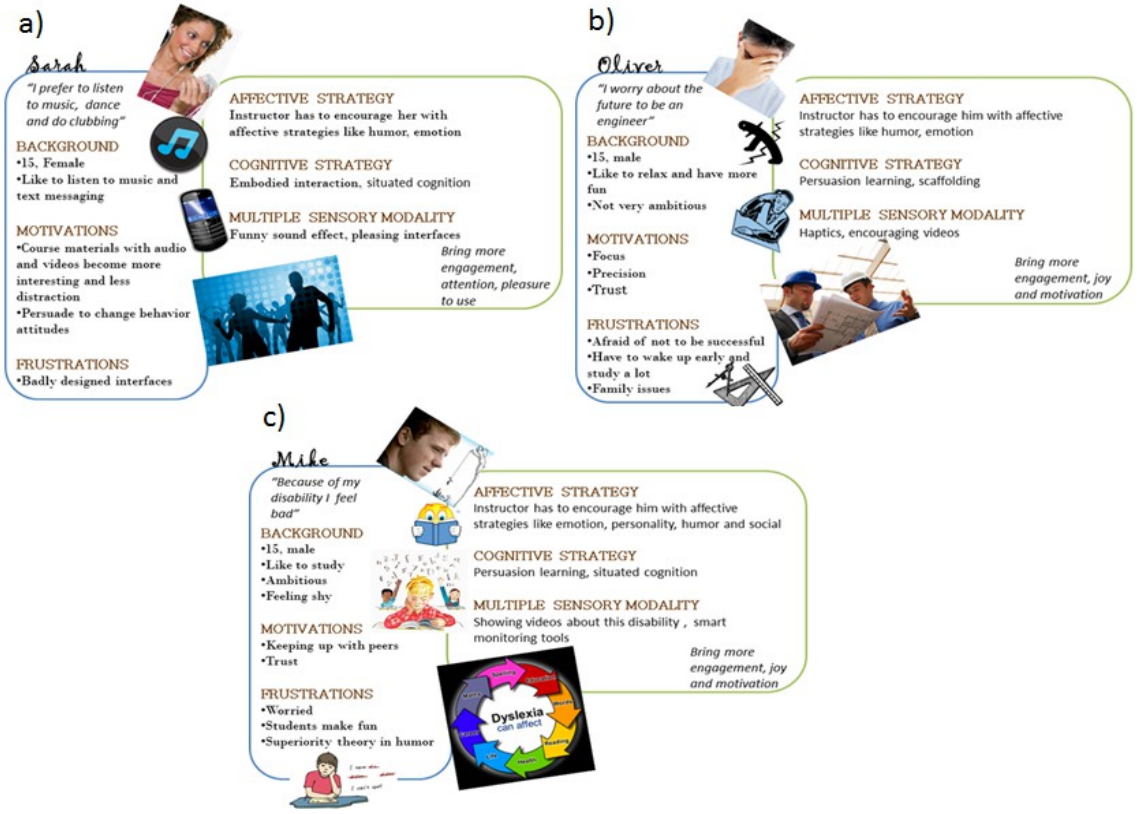

Figure 3: 1st, 2nd and 3rd learner personas for MADE educational scenario.

Proposed Adaptation of Usage-Centered Design for Multimodal Education- Essential Use Case

We now explain how to adapt UsageCD with learning objectives, affective and cognitive strategies and multiple sensory modalities. We describe essential use cases, and then give details of the adaptation.

The EUC captures the essence of the use case. That means you are supposed to document what the result is meant to be and not how you expect to accomplish it. The advantage of this is that then we can document the "WHAT" and leave it to the designer to come up with "HOW" (see Figure 4a). The whole idea of EUC is to focus on what the outcomes of the use case is meant to be. After, we have to see the different ways of implementing it. Therefore, the outcome of that use case basically should involve for example from the teacher, cognitive outcomes and affective outcomes.

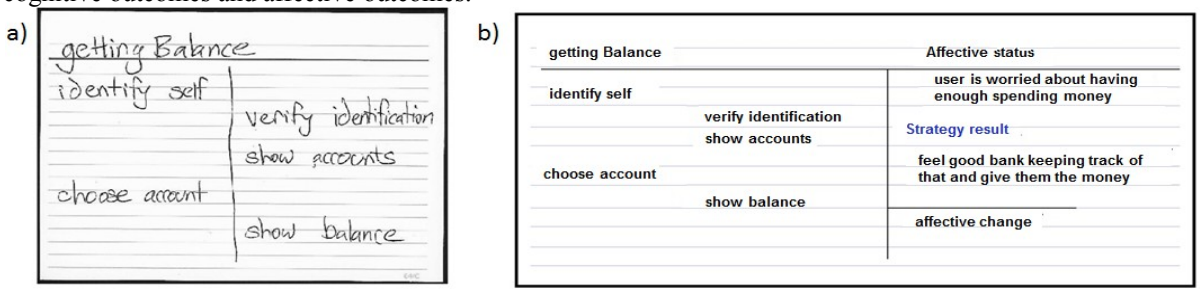

Figure 4: a) An EUC card (Biddle, 2001); b) An EUC card using the affective strategy.

EUCs might be extended to document the affective goal of use case and how we might achieve it for gathering information about multimodal education. We need to show which multiple sensory modality methods have desirable affects. For this use case there could be a cognitive goal such as the student will understand how

to add two one digit numbers, and an affective goal like they will find a rewarding experience. We know for instance that using sound has some beneficial effects; happy encouraging sounds and animation on the screen can come to our design to have emotional influence on the user. An EUC always has to start with goals of what is going to be accomplished at the end of use case. For instance, in the use case of depositing money in the bank, goals will be that at the end of the transaction the user's balance has gone up by that amount and the recording log.

We add the affective objective and people can decide how to achieve that affective objective. What we do here is different with the personas idea. The personas do not explain what we try to do; they just talk about the emotional characteristics of the user. Each use case will have an affective objective. We add a part called "Affective sidebar" to the EUC card in Figure 4b, and have a column in the right side. Our focus is education and not the banking, but here we bring an example of a banking situation. We want the users to feel good by saying the bank is keeping track of their money and it is doing good work for them as well as getting the cash out, which transmits a kind of affective messages. The bank's strategy is to be friendly, trustworthy and professional, and their intent is that they come up with a good feeling. With multimodal strategy we can play different kinds of music or video clips in the background.

The whole idea of EUC is that we only specify the essence of what is going to work, and then we try different alternatives to come up with that essence. Therefore, we could be talking about it in computer terms and the essence of enjoyment and fun. One thing that we know about the enjoyment and fun in multimodal systems is that we could be using funny sound effects, e.g. a happy sound. Therefore, now we have one possibility that will implement the EUC. There are other things we could be doing as well. We could have pictures with cartoon characters and we could personalize it. There could be a joke or similar things, which are testable alternatives. Of course, in a banking context, the affective goals would more likely be to inspire trust and a feeling of security, and perhaps optimism about saving.

CONCLUSIONS AND FUTURE WORK

This paper focused on user interaction (UI) design for multimodal software in affective education. In particular, the purpose of this paper was to describe a design approach for multimodal educational systems while considering the affective and cognitive strategies. The ability to communicate emotionally and cognitively plays an important role in HCI and education. Our main claim is that issues of affect in multimodal software have not been addressed for software design for education. The challenge is how theoretical models of HCI can inform multimodal affective design in education. For the design guidelines, we adapted well-known design methodologies to the MADE framework, and we proposed the adaptation of personas from GDD and propose adaptation of UsageCD and essential use cases for multimodal education. This paper makes significant contributions in UI design for affective education, and to the understanding of user experience and its effect in a multimodal system. In the future, we will apply these proposed design methodologies to some case studies to provide affective and cognitive aspects of the user. If the findings from the studies (that investigate the use of affective learning in multimodal software) are positive, our approach might increase the opportunity of students to better engage with their learning materials. It is hoped that the design methodologies proposed in this study may encourage educators to consider these methodologies in a teaching environment with having affective multimodal software for the purpose of delivering courses.

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