The Role of Emotions in the Design of Personalized Educational Systems

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Abstract

Research on modelling affect and on interfaces adaptation based on affective factors has matured considerably over the past several years, so that designers of educational products are now considering the inclusion of components that take affect into account. Emotions are considered to play a central role in guiding and regulating behaviour by modulating numerous cognitive and physiological activities. This paper[1] introduces a new model in the field of adaptive hypermedia, which integrates cognitive and emotional parameters and attempts to apply them on a web-based learning environment. Our purpose is to improve learning performance and, most importantly, to personalize web-content to users' needs and preferences, eradicating known difficulties that occur in traditional approaches. The specific article emphasizes on the emotional aspect of our model, since it presents results of our efforts to measure and include emotional processing parameters, by constructing a theory that addresses emotion and is feasible in Web-learning environments.

1. Introduction

Web personalization is the process of customizing the content and structure of a Web site to the specific needs of each user by taking advantage of the user's navigational behaviour. Being a multi-dimensional and complicated area a universal definition has not been agreed to date. Nevertheless, most of the definitions given to personalization [1, 2, 3] agree that the steps of the Web personalization process include: (1) the collection of Web data, (2) the modelling and categorization of these data (pre-processing phase), (3) the analysis of the collected data, and (4) the determination of the actions that should be performed. Moreover, many argue that emotional or mental needs, should also be taken into account.

One of the main challenges in Personalization research is alleviating users' orientation difficulties, as well as making appropriate selection of knowledge resources, since the vastness of the hyperspace has made information retrieval a rather complicated task [4]. Adaptivity is a particular functionality that distinguishes between interactions of different users within the information space [5, 6].

A system can be classified as personalized if it is based on hypermedia, has an explicit user model representing certain characteristics of the user, has a domain model which is a set of relationships between knowledge elements in the information space, and is capable of modifying some visible or functional parts of the system, based on the information maintained in the user model [7, 8, 6]. In further support of the aforementioned concept of personalization, when referring to information retrieval and processing, one cannot disregard the top-down individual cognitive processes [9], that significantly affect users' interactions within the hyperspace, especially when such interactions involve educational or learning, in general, goals.

Consequently, besides "traditional" demographic characteristics that commonly comprise the user model in personalized environments, we believe that a user model that incorporates individual cognitive and emotional characteristics and triggers corresponding mechanisms of adaptivity, increases the effectiveness of web- applications that involve learning processes.

2. User preference characteristics

This is the new component / dimension of the user profiling defined above. It contains cognitive and

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emotional processes that could be described as user "perceptual preferences", aiming to enhance information learning efficacy.

User Perceptual Preferences could be described as a continuous mental process, which starts with the perception of an object in the user's attentional visual field, and involves a number of cognitive, learning and emotional processes that lead to the actual response to that stimulus [32].

This model's primary parameters formulate a three-dimensional approach to the problem [33] described below:

3. Cognitive processing efficiency

The cognitive processing parameters [10, 11] that have been included in our model are:

i. *control of processing* (refers to the processes that identify and register goal-relevant information and block out dominant or appealing but actually irrelevant information)

ii. *speed of processing* (refers to the maximum speed at which a given mental act may be efficiently executed), and

iii. *working memory span* (refers to the processes that enable a person to hold information in an active state while integrating it with other information until the current problem is solved)

iv. *visual attention* (based on the empirically validated assumption that when a person is performing a cognitive task, while watching a display, the location of his / her gaze corresponds to the symbol currently being processed in working memory and, moreover, that the eye naturally focuses on areas that are most likely to be informative).

We measure each individual's ability to perform control/speed of processing and visual attention tasks in the shortest time possible, with a specific error tolerance, while the working memory span test focuses on the visuospatial sketch pad sub-component [12], since all information in the web is mainly visual.

4. Cognitive style

Cognitive styles represent an individual's typical or habitual mode of problem solving, thinking, perceiving or remembering, and "are considered to be trait-like, relatively stable characteristics of individuals, whereas learning strategies are more state-driven…" [13]. Amongst the numerous proposed cognitive style typologies [14] we favor Riding's Cognitive Style Analysis [15], because we consider that its implications can be mapped on the information space more precisely, since it is consisted of two distinct scales that respond to different aspects of the Web. The imager/verbalizer axis affects the way information is presented, whilst the wholist/analyst dimension is relevant to the structure of the information and the navigational path of the user. Moreover, it is a very inclusive theory that is derived from a number of pre-existing theories that were recapitulated into these two axises.

We prefer the construct of cognitive rather than learning style because it is more stable [16], and to the extent that there is a correlation with hemispherical preference and EEG measurements [17, 13], the relationship between cognitive style and actual mode of information processing is strengthened.

5. Emotional processing

In our study, we are interested in the way that individuals process their emotions and how they interact with other elements of their information-processing system. Emotional processing is a pluralistic construct which is comprised of two mechanisms: emotional arousal, which is the capacity of a human being to sense and experience specific emotional situations, and emotion regulation, which is the way in which an individual is perceiving and controlling his emotions. We focus on these two sub-processes because they are easily generalized, inclusive and provide some indirect measurement of general emotional mechanisms. These sub-processes manage a number of emotional factors like anxiety boredom effects, anger, feelings of self efficacy, user satisfaction etc. Among these, our current research concerning emotional arousal emphasizes on anxiety, which is probably the most indicative, while other emotional factors are to be examined within the context of a further study.

Anxiety is an unpleasant combination of emotions that includes fear, worry and uneasiness and is often accompanied by physical reactions such as high blood pressure, increased heart rate and other body signals [18] [19].

Accordingly, in order to measure emotion regulation, we are using the cognominal construct of emotion regulation. An effort to construct a model that predicts the role of emotion, in general, is beyond the scope of our research, due to the complexity and the numerous confounding variables that would make such an attempt rather impossible. However, there is a considerable amount of references concerning the role of emotion and its implications on academic performance (or achievement), in terms of efficient

learning [22]. Emotional intelligence seems to be an adequate predictor of the aforementioned concepts, and is a grounded enough construct, already supported by academic literature [23, 24]. Additional concepts that were used are the concepts of self-efficacy, emotional experience and emotional expression [25].

6. Incorporating and measuring emotional factors in Web-based learning environments

6.1 Theory and questionnaires

Anxiety is a complex term and in order to measure it accurately and validly (measure the kind of anxiety we are interested in), it has to be adapted to our research. For this reason we included in our model not only a general anxiety measure (Stait-Trait Anxiety Inventory (STAI) test [20] but a situation-specific measure of anxiety as well (i.e. educational). emotions as well. [26] Still, since we are interested also in his emotional state during the Web-based learning procedures, real-time monitoring of anxiety levels (current anxiety) would also provide us useful indications. This is done by a self-reporting instrument (e.g. by giving the user the possibility to define his anxiety level on a bar shown on the computer screen).

Since our research examines learning process and how to improve performance through a personalization system, the situation-specific measure of anxiety that we are interested in is test anxiety.

Test anxiety has been defined as one element of general anxiety composed of cognitive processes that interferes with performance in academic or assessment situations [21]. It includes both cognitive and physiological activity [20]. Its two components are worry and emotionality. Worry is the cognitive concern about performance and emotionality is somatic reactions to task demands and stress [27]. Test anxiety research has shown a relationship between anxiety and performance [28].

For the construct of emotion regulation we used a 10-item questionnaire that we developed based on the theories of emotional intelligence, self-efficacy, emotional experience and emotional expression.

On the basis of the research conducted by Goleman [23], as well as Salovey & Mayer [24], who have introduced the term, we developed an emotional control scale which consists of: (a) The self-awareness scale, (b) the emotional management scale, and (c) the self-motivation scale.

6.2 Sampling and procedure

All participants were students from the University of Athens; The part of the study concerning emotional processing was conducted with a sample of 92 students. 35% of the participants were male and 65% were female, and their age varied from 17 to 22 with a mean age of 19. The environment in which the procedure took place was an e-learning course on algorithms; the factor of experience was controlled for. The sample was divided in two groups: almost half of the participants were provided with information matched to their Perceptual Preferences, while the other half were taught in a mismatched way. We expected that users in the matched condition would outperform those in the mismatched condition.

In order to evaluate the effect of matched and mismatched conditions, participants took an online assessment test on the subject they were taught (algorithms). This exam was taken as soon as the e-learning procedure ended, in order to control for long-term decay effects. The dependent variable that was used to assess the effect of adaptation to users' preferences was participants' score at the online exam. At this point, it should be clarified that in the matched condition, Users with moderate and high levels of anxiety receive aesthetic enhancement of the content and navigational help and in the mismatched condition users with moderate and high levels of anxiety receive no additional help or aesthetics.

6.3 Results

The results of experiments conducted within the actual learning environment, as we hypothesized, show that users with high or medium anxiety level, lacking the moderating role of emotion regulation, are in a greater need of enhancing the aesthetic aspects of our system and the provision of additional help, in order to perform as well as low anxiety users. Users with low anxiety levels focus more on usability aspects.

Table 1. Analysis of variance between emotion regulation groups and core anxiety means

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.316	2	2.158	18.554	.000
Within Groups	10.700	92	.116		
Total	15.015	94			

Table 2. Analysis of variance between emotion regulation groups and specific anxiety means

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.345	2	4.173	15.226	.000
Within Groups	25.213	92	.274		
Total	33.558	94			

Table 3. Multifactorial ANOVA (Factors - Core Anxiety, Application Specific Anxiety and Aesthetics)

Dependent Variable: Score %

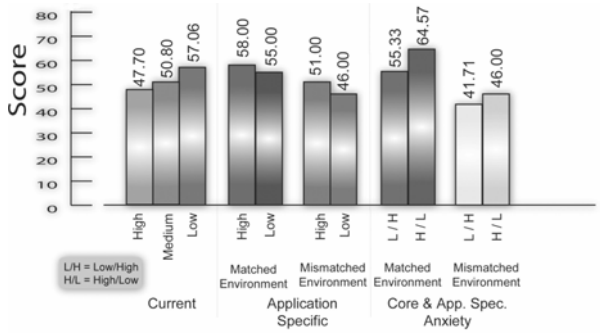
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
	(a)				
MatchedAesthetics	1097.361	1	1097.361	4.238	.043
core_groups * specific_groups * MatchedAesthetics	983.259	1	983.259	3.797	.055

(a) R Squared = .102 (Adjusted R Squared = .017)

All types of anxiety are positively correlated with each other and negatively correlated with emotion regulation. These findings support our hypothesis and it can be argued that our theory concerning the relationship between anxiety and regulation has a logical meaning. In tables 1 and 2 an even stronger relationship between emotion regulation and core and specific anxiety is displayed respectively. A statistically significant analysis of variance for each anxiety type shows that if we categorize the participants according to their emotional regulation ability, then the anxiety means vary significantly with the high regulation group scoring much higher than the low one. Finally, in table 3 we can see that the two conditions (matched aesthetics/mismatched aesthetics) are differentiating the sample significantly always in relation with performance. Participants in the matched category scored higher than the ones in the mismatched and additionally lower anxious (core or specific or both) scored higher than high anxious, always of course in relation to match/mismatch factor.

We also found that participants with low application specific anxiety perform better than participants with high specific anxiety in both matched and mismatched environments. Additionally, when a certain amount of anxiety exists, the match-mismatch factor is extremely important for user performance. Participants with matched environments scored highly while participants with mismatched environments had poor performance. Emotion regulation is negatively correlated with current anxiety. High emotion regulation means low current anxiety and low emotion regulation means high current anxiety.

Finally, current anxiety is indicative of performance, while high current anxiety is associated with test scores below average and low current anxiety with high scores. Graph 1 shows the scores that participants achieved in relation to each experimental condition.



Graph 1. Mean scores (performance) in each experimental condition

7. Conclusions

Undoubtedly, there is a question about the role of emotions, and their cognitive and / or neurophysiologic intrinsic origins [29]. Emotions influence the cognitive processes of the individual, and therefore have certain effect in any educational setting. Bibliographic research has shown that anxiety is often correlated with academic performance [30], as well with performance in computer mediated learning procedures [31]. Subsequently, different levels of anxiety have also a significant effect in cognitive functions. We believe that combining the level of anxiety of an individual with the moderating role of Emotion Regulation, it is possible to clarify at some extent how emotional responses of the individual hamper or promote learning procedures. Thus, by personalizing web-based content, taking into account emotional processing, we can avoid stressful instances and take full advantage of his / hers cognitive capacity at any time.

We intend to use all these methods of measurement controlling at the same time confiding or correlated variables like verbal ability (and / or IQ). We primarily aim to ground our hypothesis that personalizing web content according to the participants' emotional characteristics (an individual's capability or incapability to control his / hers emotions and use anxiety in a constructing way), is of high significance in optimizing computer mediated learning processes.

There are of course limitations in our approach, mainly due to the nature of the web content that often limits radically differentiated adaptation, and the

psychometric challenges of measuring a wide spectrum of human cognition and emotionality. The relationship between different dimensions of the model must be further investigated. Our future work includes the incorporation of physiological measurements of emotions and anxiety in our model, with the use of biometrical sensors.

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