Relevance of the cultural dimensions in affective-cognitive behavior during interaction with an intelligent tutoring system

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Abstract.
Cultural Dimensions, as stipulated by different theoretical perspectives such as Hofstede's, are normally not considered to define student models. These cultural dimensions consist of traits that can be attributed to students and include both cognitive and affective characteristics. Some dimensions indicate students' ability to represent an effect in the affect which may be useful to predetermine affective models. This research project hypothesizes that students' cultural dimension may indicate affect tendency during the use of Intelligent Tutoring Systems (ITS). The methodology consisted of determining students' cultural dimensions, cognitive achievement, and analyzing affective responses (self-reported) when the student used the ITS on an individual way. The results suggested that there are affective behaviors associated to a Hofstede cultural dimension (Power distance index). The implications of these results are that some cultural characteristics may predict students' affective behaviors employing an ITS for mathematics. Additionally, affect models could be used to predefine affective-cognitive scaffolding.

Keywords: affective-cognitive states, cultural dimensions, intelligent tutoring systems, secondary education.

1.1 Introduction

The technological tools are current elements that contribute to the teaching- learning process of students at different educational levels, which are shown with contents of topics specialized in some areas.

These tools are designed so that users (students) have innovative elements, however, when referring to the adaptation of the tools to the user, there are several problems in the interaction, since they are not fully developed to adapt to the particular needs or characteristics of each user [1].

However, these reasons have not precluded several researches to identify some relevant characteristics that impact on learning with technology such as collaboration [2], cultural dimensions [3], learning styles [4], motivation [5, 6], affect [7–9] and among others. The aim of this study is to analyze whether students' cultural dimensions are related to both affect and knowledge during interaction with the intelligent tutoring system.

In this research, we focus on individual student factors used in all the interaction with an Intelligent Tutoring System (ITS) for mathematics when they acquire knowledge about variables (numerical and categorical) and the way they represent them. To do this, there are characteristics that are affected by the environment where the student works in a learning process, such is the case of cultural dimensions. Since students' cultural dimensions traits lies in that teaching instructed in the classrooms and the learning environment.

In the association of affection and cognition, particularly, there are several studies applied with technology [10–13], that allude that the affection presents predominant tendencies in the learning process (negative, neutral and positive) [8], which can be regulated for the student to acquire either greater or better knowledge.

On the other hand, the importance of culture in education shows contrasts that impact the cognitive process [14, 15]. Cultural dimensions are divided into five dimensions described by Hofstede, these dimensions alone represent influential factors in society as the Power distance, Uncertainty avoidance, Individuality, Masculinity and Long term orientation [3, 16].

In Mexico's basic education system, it is considered that an environment conducive to learning must indispensably contemplate the recognition of influential physical, affective and social factors in cognitive achievements in an individual and group manner [17], making relevant the study of the characteristics of the students, as well as their behaviors in the classroom.

Considering the above is done the following research question: What cultural dimensions are present and how these influences the acquisition of knowledge and the affect of students during the use of a ITS?

The research focuses on identifying associated cultural behaviors that give indication to be able to define the students' profiles, and thus provide elements considering their cultural and affective characteristics during the interaction with an intelligent tutoring system.

2 Methodology

This work was performed at the secondary school "Federal N. 2 Julio Zárate" in Xalapa, Veracruz, Mexico for four days. It was considered to be a simple random sampling (n=50 students) of five groups (N=110 students) in the first year on 2017 of secondary school with 62% of female and 38% of male with an age range of 12 to 14 years old.

The materials used consist of the intelligent tutoring system "Scooter tutor" [18, 19] in the non-reactive version (without Scooter agent), the two isomorphic tests of learning employed on similar experiments [18], the standardized questionnaires of cultural dimensions [16], the self-report of the affective states, and props. The evaluation was guided under the standards of the Belmont report [20].

Standardized learning tests are isomorphic measuring instruments designed to evaluate students' knowledge of the development of scatter plots before and after interaction with the intelligent tutoring system. To calculate the level of knowledge (test scores) of students, points are obtained in percentage by standard terms of evaluation defined by the system creator [18] and these tests measure the cognitive achievement in such a way as to identify the increase obtained by the students. Achievement is calculated with the following equation:

Cognitive Achievement=Score of Post_test - Score of Pre_test

The registration of affective self-reports is given through a booklet, which presents the five most relevant states in a learning situation with technology [8]. This is through the issuance of student judgments about their affective status at intervals of every 8 minutes during the two sessions of interaction with the ITS. The records of affective trials are composed of images with random faces (emoticons) referring to the states of boredom, frustration, confusion, concentration and the absence of affec- tion of the neutral state. The affective measure reported is given in terms of proportions of cases through interaction, and they are distributed in negative (boredom and frustration), neutral (absence of affection) and positive (confusion and concentration) tendencies.
Cultural dimensions test stated by Hofstede [3] employed in this research is obtained through an adaptation of the instrument of the 1994 version [16], this consists of 20 items with five to six categories of ordinal scale type Likert. In addition, each item is weighted in an equation per dimension providing a representative score of the level, either low (*Index<=33 points*), normal (*33 points>Index<66 points*), or high (*Index>=66 points*). These dimensions present different representations such as Power distance that is defined as the extent to which the less powerful members of community within a society expect and accept the power other person or Uncertainty avoidance is as the extent to which members of community within a society feel threatened by uncertain, unknown, ambiguous or unstructured situations. On the other hand, in Individualism a person is expected to take care of himself and his immediate family, just as Masculinity represents a society in which social roles of gender are clearly different and Long-term orientation represents a society that encourages future re- wards-oriented virtues, particularly adaptation, perseverance and savings.

It is important to mention that this test does not present an adequate validation and reliability [21], however, it is necessary to observe the internal structure by dimension and the biases in the answers.
The experimentation included the application of the tests and the interaction with the ITS. There were four experimentation stages during the mathematics class.

1. *Initial test*: This stage consisted of an explanation of the topic “Scatter plots” (10 minutes), the first learning test (20 minutes) and other questionnaires (20 minutes) in the classroom.

2. *Interaction I*: In this phase, the student first performed the interaction with the intelligent tutoring system for 40 minutes in the media classroom and self-reported affective states in interruptions during the lapse of 8 minutes.
3. *Interaction II*: In the same way that in the stage Interaction I, the student worked with the intelligent tutoring system for 40 minutes in the media classroom and self-reported affective states in interruptions during the lapse of 8 minutes.
4. *Final test*: The student was given the Post-test on a 20-minute period in the media classroom, as well as the cultural dimensions test (15 minutes) and participants were thanked for their participation in the research (5 minutes).

3 Result

The preliminary findings in the interaction with the intelligent tutoring system present relevant characteristics to influence the affective-cognitive student behavior. It is significant to mention that the analyzed information did not assume the assumption of normality, the test score (pre-test and post-test) was measured in percentage points and worked with affective tendencies (negative, neutral and positive) and the results were assessed with nonparametric statistical techniques in R [22] and just considering the cases of positive achievement (*Cognitive Achievement* > 0).

The comparisons (pre-test) between the five groups, showed no significant differences (*K−W chi−squared=3.64, p-value=0.45*). However, all groups showed a high proportion (more than 60%) of neutral affective states during the initial time of interaction with the intelligent tutoring system. In addition, it was observed that all groups in the performance showed *42.75* average proportion score of the positive affective state and *25.75* average score of the negative states and differences by group in the proportion of affective tendencies.

On the other hand, it was observed that only one dimension showed the existence of significant difference *(p-value<0.05)* between the groups of the Power distance (PDI), showing that group 1 manifests a normal level *(mean=34.0, sd=40.30)* to differences of the other groups (see Figure 1-A) and a general average lower (*mean=2.9, sd=49.48*) than the all groups and much variation with respect to their average value. In addition, high levels (*Index>=66 points*) on average identified of Uncertainty avoidance (UAI), Individualism (IDV) and Masculinity (MAS) and normal average index in Long-term orientation (LTO). (see Table 1)

In the same way that significant differences were identified *(p-value<0.02)* between the pre-test and post-test and not in the post-test by group (*K−W chi−squared= 5.94, p-value=0.20*). Moreover, the post-test had a significant association (r_s*=0.323, p-value=0.02*) with the positive affective states, moreover the positive affect with Cultural dimension of the Power distance index (r_s*=0.326, p-value=0.02*).

Nevertheless, it showed a significant difference per group related to the proportion of positive affective states (*K−W chi−squared=10.74, p-value=0.02*), negative states (*K−W chi−squared=18.19, p-value=0.001*), neutral affective states (*K−W chi−squared=11.75, p-value=0.01*) and the Power distance index (*K−W chi−squared=9.07, p-value=0.04*), the results also presented that the some groups with the lowest index (*Index<=33 points*) for Power distances showed less representation in the positive trend of affective states and only the group 2 high proportion of negative trends. (see Figure 1)

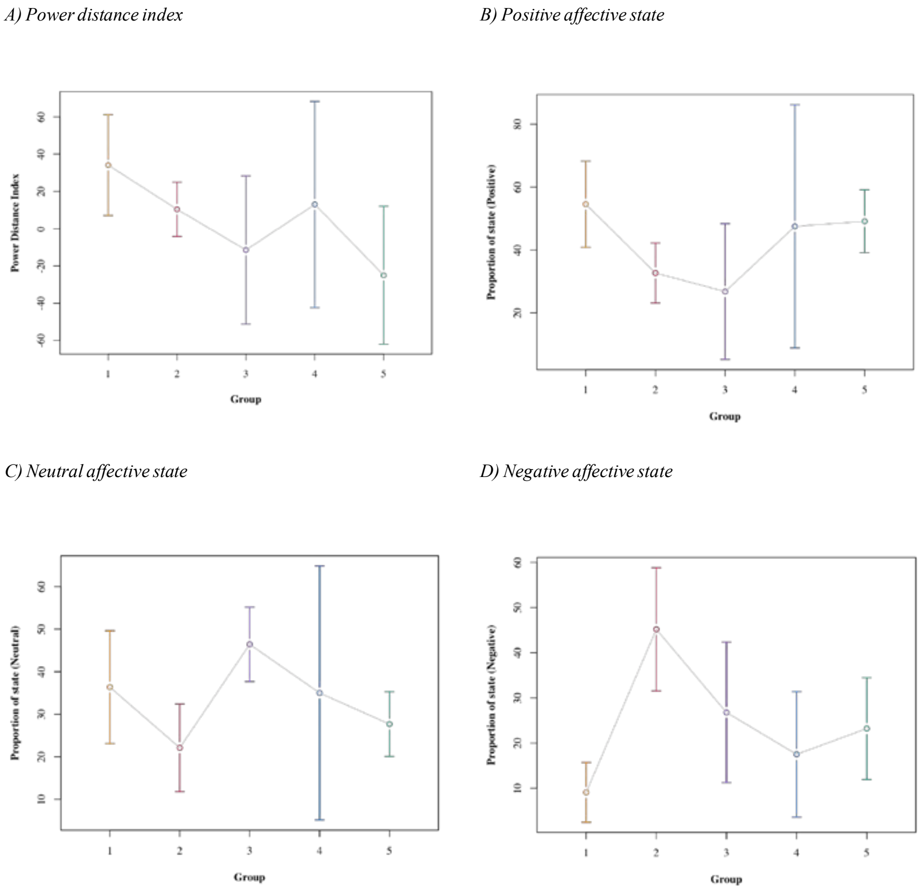

Figure 1. Comparison by group and characteristics (affect and Power distance index)

Figure 2 shows the Principal Component Analysis [23] represent 61.01% varia- tions of the behavior of the affective states association with the Cultural dimension and Learnings scores (pre and post-test), this identifies and confirms that the positive affective trends (AE-Positive) are oriented to Power distance (PDI) and the post-test presents a high association with the pre-test as well as with the Power distance index and positive states. Finally, the negative tendencies (AE-Negative) do not present any significant association with the learning scores when only considering students with a cognitive achievement.

Table 1. Descriptive statistics (Cultural dimensions)

	Cultural dimensions				
Statistics	**PDI**	**UAI**	**IDV**	**MAS**	**LTO**
Number of Observations	50	50	50	50	50
Median	5	92.50	82.5	75.0	40.0
Mean	2.9	83.80	73.8	72.8	43.6
Standard Deviation (n-1)	49.48	71.20	63.18	87.99	22.38
Coefficient of Variation	1706.486	84.96	85.61	120.87	51.34

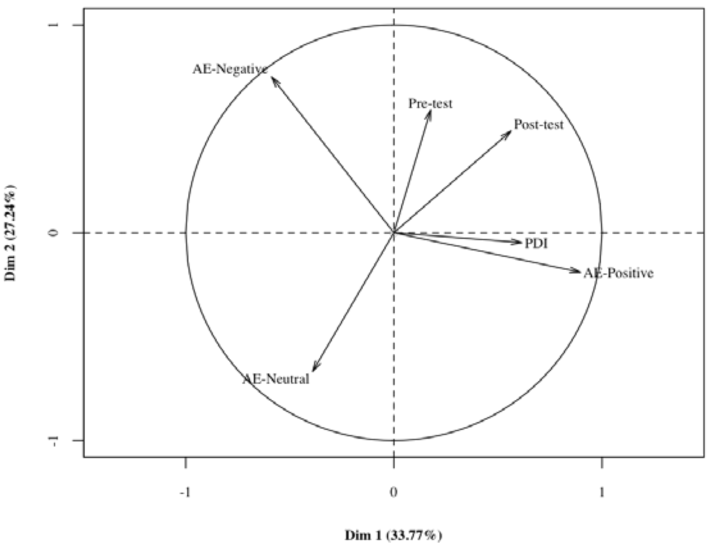

Figure 2. Representation of the characteristics in learning process

4 Discussion

This research project presents results suggesting different patterns of individual student' behavior, which were observed during the use of educational technology (ITS) for mathematics at the secondary level in Mexico. The exploration of independ- ent characteristics (cultural dimensions, affect and cognitive achievement) is relevant because it allows understanding the student profile in a preliminary way during the learning process mediated with technology, contributing with information about the cultural criteria of the student who is likely to affect the academic environment of Mexican students.

The results suggest that there are significant associations between the cultural dimensions (Power distance index) and cognitive-affective states. This can be explained as the positive affective behavior of students may be closely associated to power distance in normal level to obtain higher score in the post-test.

In particular, considering this dimension will allow Mexican students to demonstrate positive states conducive to learning math issues by setting aside levels of traditional academic hierarchy.

However, it is important to mention that the affective measurement of students during the use of technology can be considered as an exploratory measure of the affection that the student presents according to his/her judgement, however, this requires specialized metrics [19] or to measure awareness and regulation [10] of the same over their states.

As a future work, it is proposed to evaluate other characteristics that affect the cognitive process in order to elicit a model of the user who is able to react to factors that are not conducive to learning. This model will allow creating a motor of inference that provides before the interaction of the students a profile to identify if these requires the use of a common intelligent tutor system or one with affective elements of regulation for to increase cognitive achievement and improve the interaction.

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