Cultural factors linked to collaborative learning in Intelligent Tutoring System in the Domain of Mathematics

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Abstract. The integration of technology into education requires a thorough analysis of the elements necessary to adapt it to the teaching-learning process, based on appropriate contextual analysis. This article presents the initial identification of elements or variables for the conceptualization of a collaborative model used in a mathematics Intelligent Tutoring System, deployed for secondary school students. Two exploratory studies were undertaken, the first to determine how students will be assigned to collaborative activities as to optimize the learning experience, and the second to identify the elements that influence collaboration and the extent to which collaboration is linked to cultural issues. The main contribution of this paper is to show the results of the second study, in which it was found that the association between collaborative and cultural elements, allow to improve the student's learning gains in collaborative activities use an Intelligent Tutoring System.

Keywords: Collaboration, Cultural Dimensions, Intelligent Tutoring System.

1 Introduction

Socials and cultural factors fundamentals to collaborative learning in technology mediated environment, allow that students improved their learning experiences and get greater benefits in it. To do this, the scales that Hofstede [1] suggest as cultural dimensions, and social elements as organization, participation, dialog, role and responsibly they offer the support to do it.

In several investigations [2], [3], [4], [5] it has been observed that students when interacting with educational technology have the opportunity to increase their level of learning, in addition, if the technology can be adapted within this process of learning, this will provide the necessary assistance that the student requires [6].

On the other hand, the changes of models and educational modalities, lead to certain aspects of migration or improvement in the teaching learning process, one of these aspects is the role of students, their become more dynamic entities in charge of the construction of his own knowledge [7]. Another aspect is the interaction of the student

with classmates to carry out academic activities, this communicative and interactive process is given through collaboration where two or more people exchange opinions to create meanings. For this, there are adaptable and intelligent web-based education systems, called AIWBES [8], which adapt the user's preferences and knowledge, individually and in group, during interaction with this system. In this sense, social interactions that promote active and vicarious learning can also be carried out, where students can learn by directly doing exercises or observing activities that others do [9].

The relationship that some students may have with each other, allows each of them to include elements from different contexts, because although they live in similar environments, they may present different personalities, attitudes, knowledge and emotions to face similar situations, this difference is given for the culture that each one presents. Living in the family, at school, on the street, are what denote this difference in individual and collective behavior [10].

Unfortunately in Mexico it is a fact that the mathematics level is below the OECD average, results show that up to 57% of the students do not even reach the basic level of competences, that is, they cannot represent mathematically a Real-world situation, such as comparing the total distance between two alternative routes or converting prices to a different currency [11]. This is an alarming situation, due to this, the interest to include educational technology as a mathematics Intelligent Tutor System within the learning process in secondary school, but not only to include the tutor in this process, but also to adapt in the Intelligent Tutor System, collaborative and cultural elements that further promote student learning.

2 Collaboration in the educational process

Understand by collaboration to the knowledge construction process that originates in the social interrelation of people who share, compare and discuss ideas [12]. It is through this interactive process that the student builds his own knowledge [13].

Within the educational context, collaboration is an interactive form of learning where students must participate as equals, adding efforts, skills, knowledge, talents and competence that lead them to define a series of activities and tasks that allow them to reach their common goal.

By incorporating collaborative activities in the classroom, the teaching-learning process can be enriched, especially if the participation of students is more actively, generating in this way, the construction of their knowledge, fostering collaborative learning and improving the interpersonal relationships.

One of the important benefits of collaboration is the learning that can be obtained from this, when students participate in argumentation and negotiation activities, share and discuss ideas from each person's perspective and reach the consensus of the collaborative group [14]. Collaborative learning is a didactic technique that allows students to be guided in an educational environment, where they can interact with classmates and teachers, enriching the teaching-learning process to achieve their academic goals. In an environment of this type, students assume different roles,

responsibilities, share experiences, knowledge and must be engaged by participating in joint processes, for the solution of specific activities in favor of their learning.

However, not all forms of grouping students to work collaboratively, leads to the best outcome [7]. Adequate group formation and structured interactions are important elements to increase the possibility of having a beneficent collaboration in a pair students [14].

As the formation of work groups is analyzed to obtain learning benefits, it should also be studied whether collaborative elements hat influence the learning process of students. One of the collaborative components used as part of this experiment to measure the collaboration of students was the Collaboration Test [15], which consists of 12 multiple-choice questions of nominal scale, from which information is obtained with relationship to five subscales of collaboration such as organization, participation, dialogue, role and responsibility. This test was applied with the goal to understand the kind of collaboration the participants think they had during the interaction with their teammate in the collaborative activity. Each of these subscales included in the test collects information on some of the questions as shown in table 1.

Table 1. Subscales in collaborative test.

Subscale	Question
Organization (S1)	Q1, Q6, Q8
Participation (S2)	Q3, Q4, Q5
Dialogue (S3)	Q2, Q3, Q5, Q9, Q12
Role (S4)	Q6, Q7, Q8, Q11
Responsibility (S5)	Q10, Q11

3 Cultural dimensions

The social behaviors observed in different countries are influenced mainly by thoughts and customs of the own culture [16]. Geert Hofstede is a research sociologist who explains the discrepancy between the behavior of different cultures, through a theory called cultural dimensions, this theory offers a panorama to examine how cultural values affect the behavior of people to act in a or another way.

The cultural dimensions of Hofstede are indicators that show the behavior of a complete society, not a single individual, however, this does not mean that one culture is better than another or has more value, but that the behavior of each is different from the other or not, according to the region [16], even within the same culture, there can be several subcultures which make up a global culture [17] within which can be observed different behaviors and opinions.

The first dimension to which Hofstede refers is the power distance index (PDI), here we can see how the members of a society, question or not, to the people who have the highest hierarchy, that is, in a society with great power distance, the members of a

society do not question those who have higher levels, however a society with low power distance, each person has equal power between members of a group or community.

A second dimension is individualism (IDV) versus collectivism, in which it is observed if the members of a society are integrated in a group, or the link between one person or another is weak, that is, he prefers to make individual decisions and focuses only on the "me" and not on the "us".

Another dimension is masculinity (MAS) versus femininity, which refers to the way in which roles are distributed in society through gender. In a highly masculine society people are driven by competences and results, they are ambitious. Within society with low masculinity or femininity, people are more focused on building good relationships and ensuring a high quality of life for all.

The uncertainty avoidance index (UAI) refers to the way in which people feel in unfamiliar situations, in cultures with strong UAI, people avoid risks and unexpected situations since you are creating stress and anxiety. People with low UAI are more tolerant in unexpected situations, they are more relaxed and flexible.

People with long term orientation (LTO) encourage to be thrifty and to invest, respect traditions and fulfill social obligations such as respecting their elders and people of different ranks, on the contrary, those with short term orientation are encouraged to spend and want to make immediate profits, these people believe that the status between members is not important, unless they can get some benefit from them.

Although Hofstede's work has been done to know the influence of culture on the values that people have at work, and that their research gives an idea of what other cultures are like, and which factors are predominant in the organizational scope, its results have prevailed over time and its dimensions have been used even in the educational field, adapting the questionnaire to be applied to students [16].

The Hofstede cultural dimensions test consists of 20 questions, four questions for each of the five dimensions, the purpose of this test was to find some element that intervened positively in the results of the students.

4 Intelligent Tutoring System

The beginning of Intelligent Tutoring Systems gave rise to the moment when Artificial Intelligence (AI) was being worked on to imitate natural intelligence through the creation of machines that could achieve a human thought, these systems have been an important part in the area of IA in Education to create an environment of instruction that resembles a teacher in his teaching process.

These Intelligent Tutors Systems began to be developed with the purpose that knowledge could be imparted in some intelligent way to guide and assist a student in their learning process, so that they sought to emulate the behavior of a human tutor who could adapt to the behavior of the student, identifying the way in which this can solve a problem to provide the cognitive help required, when required and tailored to the student.

Intelligent Tutors Systems by their own nature were created to be used individually, however, it has been shown [18] that students in Mexico work collaboratively, even when it is an Intelligent Tutor, they get up from their places to ask questions to their classmates and complete their activities.

There is an Intelligent Tutor System for the area of mathematics called Scooter the Tutor [19], which teaches students to solve scatterplots and assists them with the necessary help and feedback so they can understand the subject and continue to solve exercises. This Intelligent Tutor System will be taken to include a collaborative model that helps secondary school student's work collaboratively in their math activities to benefit their results.

This Intelligent Scooter Tutor System is a desktop system tested on Windows 95 to Windows 8 operating systems, however, it is being migrated to a web system to be compatible with any browser and operating system, in order to students can use the system in the school, or remotely from your personal computer or mobile device.

5 Methodology

In the methodological process to find which elements or variables have an important degree of significance for the elaboration of a collaborative model, several tests were applied to a group of students, such as the collaboration test which identifies in five subscales (organization, participation, dialogue, role and responsibility) [15], the degree of collaboration of the students after carrying out a joint activity and the Hofstede cultural dimensions test adapted for educational situations that identifies the influence of the culture in students in the secondary school No. 2 "Julio Zarate" in Xalapa, Veracruz, México, in relation to the power distance index (PDI) towards their teachers, uncertainty avoidance index (UAI) in a collaborative activity, individualism (IDV) versus collectivism, masculinity (MAS) versus femininity and long term orientation (LTO).

5.1 Study units

The subjects involved in the development of this project were 116 morning hours students constituted in five school groups 1, 2, 3, 4 and 5 of the first grade (equivalent to seventh grade in the United States) of the General Secondary School No. 2 "Julio Zarate" located in the city of Xalapa, Veracruz, Mexico.

5.2 Procedure

The study was carried out in four days during the 50-minute math class in the media classroom, this is a computer lab used by teachers and secondary students, the classroom has capacity for 50 students at the same time and it consists of 34 computer equipment available with Windows operating system.

On the first day of interaction was the thematic induction, in this case scatter plot in a time of 10 minutes, later a standardized pre-test was done to know what the student's initial knowledge was, this test was done in a time of 20 minutes, a learning styles Kolb test [20] was applied in a time of 15 minutes, this test was applied because in the first study it was found that the best way to associate students in a collaborative activity is grouping them according to the same learning styles, this association allows students to obtain higher learning gains, than if students with different learning styles will join in the activity. The participation of the students on this day was individually. Once the learning style tests were taken, they were evaluated by the researcher for the conformation of the work couples of the following day.

For the second and third day, with the Intelligent Tutoring System, the interaction was done in a collaborative way by students pairs previously defined, this was done in a time of 40 minutes.

On the fourth day of interaction, the standardized test (post-test) was carried out in a time of 20 minutes, then the test of collaboration to answer it in 10 minutes and the last the test of cultural dimensions in 15 minutes. The collaboration test was applied in order to know the type of collaboration that existed between students. The cultural dimensions' test to know if any dimension affected or not, the performance of students during their collaborative activity.

The activities and execution times of this study can be seen in table 1.

Table 1. Activities and execution times of the exploratory study.

No.	Activity	Day	Execution time in minutes
1	Induction scatter plots	1	10
2	Pre-test		20
3	Learning styles test application		15
4	Work teams formation		---
5	Collaborative activity with the STI Scooter	2	40
6	Collaborative activity with the STI Scooter	3	40
7	Post-test	4	20
8	Collaboration test application		10
9	Cultural dimensions test application		15

6 Results

The tests carried out during the experimental scheme were, the pre-test to know the initial student's knowledge in the scatterplot topic, the test of learning styles, so that the students could be put together in pairs according to their same learning styles, the test of collaboration to know the type of collaboration (organization, participation, dialogue, role and responsibility) that existed during the activity, the test of cultural dimensions to know if any dimension affected or not, the student's performance during your collaborative activity. As for the analysis performed in the tests that were applied

in the groups in the experiment, it was observed that there is no significant difference (*p-value=0.0866*) between the groups initially, presenting an equal knowledge in the pre-test, another aspect that was shown is that there is no an association between the learning styles and the groups evaluated (*p-value>0.05*), as well as the relationship between learning styles and the five sub-scales of collaboration measured during the interaction with the tutor. However, in the post-test it is identified that there is a significant difference between the groups (*p-value=0.02439*) as shown in Figure 1.

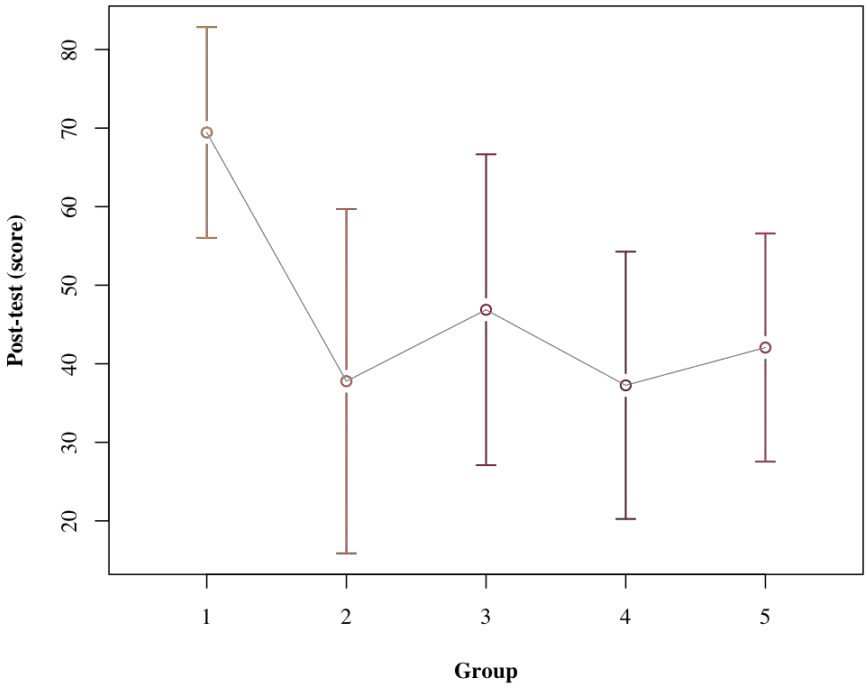

Fig. 1. Result of the post-test of groups.

In the analysis individually for each of the groups, it was found that the variables of both collaboration and cultural dimensions in some of its elements are related, that is, some behaviors are distinguished that do not occur naturally by themselves, but they are added with other characteristics, in this sense the collaboration is directly linked with characteristics of cultural dimensions or vice versa, this in benefit of the improvement of the result in the post-test of the students.

Of the five sub-scales, organization, participation, dialogue, role and responsibility evaluated in the collaboration test, and the five cultural dimensions defined in the Hofstede test, the power distance index 'PDI', uncertainty avoidance index 'UAI', individualism 'IDV' versus collectivism, masculinity 'MAS' versus femininity and long term orientation 'LTO' there was mostly an association between them in a particular way for each group.

In group 2 (G2) the relationship between UAI and Responsibility was observed with a value of *p-value=0.0498*, MAS with Participation (*p-value=0.0497*), as well as LTO with the same dimension of collaboration Participation (*p-value=0.0036*), in addition to MAS and role (*p-value=0.0024*). In group 3 (G3) the relationship between UAI and Organization was observed (*p-value=0.0307*). Group 4 (G4) showed relationship in UAI with Organization (*p-value=0.0102*), MAS and LTO with Responsibility with values of *p-value=0.0439* and *p-value=0.0001* respectively. On the other hand, group 5 (G5) only showed a relation of IDV with Conversation (*p-value=0.0054*). Group 1 (G1) did not present any relationship between cultural dimensions and collaboration sub-scales. You can see these results in table 2.

Table 2. Results of relationship of cultural dimensions and collaboration subscales.

	PDI	UAI	IDV	MAS	LTO
Organization		0.0307 (G3) 0.0102 (G4)			
Participation				0.0497 (G2)	0.0036 (G2)
Conversation			0.0054 (G5)		
Role				0.0024 (G2)	
Responsibility		0.0498 (G2)		0.0439 (G4)	0.0001 (G4)

Table 2 shows that the union of both elements, cultural dimensions and collaboration are present in the behavior of the groups, however, by themselves, they do not show any type of behavior, which indicates that both characteristics must be associated for obtaining better results.

With the results that are observed of the relationship between some cultural dimensions and some collaborative elements, the intelligent tutoring system to which the model going to include, should mediate this type of aspects. For example, if it is observed that the lack of responsibility is linked to the high student's uncertainty to work in a collaborative activity, then, we should include in the intelligent tutoring system, an element that explains more in detail, how to solve the exercise, with the goal to eradicate the student's uncertainty when they doing the activity. In this way, we would seek to eliminate or reduce the uncertainty so that the student is responsible in the development of their activity. Just as the system would be modified in this relationship, modifications would also be made for the other relationships between cultural dimensions and collaborative elements.

7 Conclusions and future work

It was observed that the group is a factor that affects the post-test, the learning style is an element that affects learning independently, that is, it is not linked to any cultural dimension or to any collaborative elements, and last, that the union of the collaborative and cultural elements must be associated to obtain better results.

As future works are the integration of variables for the formal definition of the collaborative model, considering the multiple linear regression approach to study the relationship between the variables of interest, to calculate the response variable through the estimation of the best linear predictor, in this case would be the post-test. Also the inclusion of it in a mathematics Intelligent Tutoring System and the evaluation of the model to check the predictions of it. All this will be done so that students can work collaboratively with an Intelligent Tutoring System to help them get better results in their math assessments.

An example of how it would be the inclusion of the model in the Intelligent Tutoring System is if the model predicts that the student would have a greater post-test if the student when doing a collaborative activity, will talk more with his classmate, then the Intelligent Tutoring System will have to include elements such as a forum, a chat, an editor, or any aspect that promote conversation in the collaborative activity. In this way, all the elements indicated by the collaborative model needed to improve the student's post-test would be added to the system.

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