# Socio-culturally Adaptive and Personalized Collaborative learning environments

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**Abstract:** There was a growing interest in the development of CSCL (Computer Supported Collaborative Learning) environments over the last decade. Despite the plethora of tools available, they ignore the cultural differences between learners. In fact, especially, in the case of distant learning, these environments may bring together learners from different socio-cultural backgrounds that have acquired different socio-cultural values and behaviors and developed different needs, points of view and learning styles. Thus, CSCL environments need to be socio-culturally adapted to each learner's culture. The main goal of this paper is to emphasize the need of socio-cultural aware collaborative learning, to present our proposed ontology-driven adaptation approach to meet this need, its operationalization and its experimental validation. Results and limits are discussed at the end of the paper.

**Keywords:** CSCL, user profile, adaptation and personalization, ontology, design patterns.

## 1. Introduction

There was a growing interest in the development of CSCL environments over the last decade. Despite the plethora of tools available, they ignore the cultural differences between learners as they are dedicated to learners from dominant cultures (Economides, 2008). These environments may bring together learners from different cultures that have acquired different socio-cultural values and behaviors and developed different needs, points of view and learning styles (Economides, 2008). Thus, CSCL environments need to be socio-culturally adaptive to each learner's culture (Economides, 2008; Blanchard, 2007). Socio-cultural Adaptation may ensure learner satisfaction, consequently enhance their motivation to learn in an intercultural group by resolving potential socio-cultural conflicts emerging during intercultural communication, and thereby improve interaction and learning.

The main goal of this paper is to emphasizes the need of socio-cultural aware CL (section 2) and presents the proposed ontology-driven adaptation approach to meet this need (section 3). The use of ontologies allows us to build a socio-cultural user profile which will be used to adapt dynamically the functionalities of CSCL environments to the socio-cultural specificities of each learner. At the group level, the use of design patterns for cross-cultural collaboration allows us to handle and resolve intercultural communication and collaboration conflicts. The operationalization, where the design and implementation challenges are discussed, followed by the experimental validation is given and discussed in section 4.

## 2. Is Socio-cultural awareness a necessity for collaborative learning?

Since the early design phase of a CL system, instructors and designers should be aware of the socio-cultural diversity of learners (Economides, 2008). In fact, according to (Henri and Lundgren-Cayrol, 1998; Blanchard, 2007), in classroom CL context, teachers have noted that the learning goal of the collective activity is not always equally achieved by all the learners. Looking for the reasons of such observations, we have found that this is due to the difference in affordance appropriation. This difference is explained by differences in personalities, social contexts, behavior patterns, learning styles and motivation degree which are all culturally sensitive. Therefore, it is important that such tools ensure equal opportunities to learning for all learners by taking into account their cultural differences (Henri and Lundgren-Cayrol, 1998; Blanchard, 2007; Economides, 2008)

## 2.1 Culture definition

Culture has many definitions. After the review of a collection of fifteen most influential definitions of culture (e.g. Tylor, 1871; Hofstede, 1980), we were able to identify the following specifications of culture (Ouamani et al., 2012): Culture is a set of characteristics that affect ways of acting (explicit behavior patterns, language, customs, laws, etc.), thinking (standards,beliefs, ideology) and feeling (values, character traits, cognitive styles) of individuals in a group that distinguish them.
Socio-cultural differences are measured through the use of national culture models which are composed of a set of socio-cultural dimensions that translate standard behavior patterns. A comparative study (Ouamani et al., 2012) of the six most influential models (e.g Hofstede, 1997; Hall, 1990) allowed us to define five common socio-cultural factors (Ouamani et al., 2012) that have been used in the course of our thesis work: power distance (values: hierarchic/Linear), belonging (values: collectivism/individualism), relation with environment (values mastery/harmony), attitude toward time (values: polychromic/monochromic) and Risk and uncertainty avoidance (values: Universalism/Particularism).

## 2.2 Socio-cultural impacts on individuals

The impacts of socio-cultural factors were demonstrated on individuals: 1) on behaviors (Linton, 1977), 2) on communication (Hall, 1976), 3) on cognition (Nisbett and Norenzayan, 2002), 4) on motivation (Gurleyik, 2012), 5) on emotion expression, perception, understanding, management and using and (Miyamoto, 2011), 6) on learning (Valiente, 2008).

## 2.3 Socio-cultural impacts on collaborative learning

We have carried a deep study (Ouamani, 2015) of research works (e.g. Economides, 2008; Valiente, 2008) within Educational Sciences and CSCL research domains that focused on and demonstrated socio-cultural impacts on collaborative learning domain. This study allowed us to extract and define the following domain variables classes which are socio-culturally sensitive. These variables (describing the communication process, the collective activity control, the system support, the group composition and homogeneity) take two values depending on the type of culture as shown in Table 1.

Table 1: An excerpt of socio-culturally sensitive CL domain variable values (Ouamani et al., 2013).

| Variables | Values | |
|---|---|---|
| | Hierarchic and collectivist cultures | Egalitarian and individualistic cultures |
| Activity structure | Formal | Informal |
| Activity focus | Specific | General |

## 3. Ontology-driven adaptation approach

In order to consider the socio-cultural differences between learners when designing CSCL environments, we need first to model the socio-cultural knowledge about the learner and the CSCL domain and then use these models to adapt such environments at different levels: GUI (Graphic User Interface), Functionalities and content in addition to handling the intercultural communication problems.

## 3.1 Socio-cultural user profile

As we aim to propose a generic, shared and consensual model, understandable and usable by both humans and machines which allows not only the representation of socio-cultural knowledge but also inferential reasoning about it, we have chosen to use ontologies. An ontology framework composed of two ontologies is built:
- The first one, SocioCUltural Domain Ontology (called SOCUDO) is a generic core ontology that models the user related socio-cultural knowledge:

- The second one, Socio-Cultural Aware Collaborative Learning Ontology (called SCACLO) is a domain ontology that models socio-cultural knowledge of CSCL domain.

These two ontologies communicate together and share socio-cultural knowledge about "users" involved in collaborative learning sessions. In fact, the instantiation of SOCUDO triggers the instantiation of SCACLO for each user based on association rules (see Table 1) that associate SOCUDO concepts values to SCACLO concept values. The merging of the two instances results in the generation of the socio-cultural user profile. The detailed definition of the ontologies (hierarchy of concepts, relationships, etc.), the construction processes, and their validation are out of the scope of this paper (Ouaman, Bellamine Ben Saoud and Ben ghézala, 2014a). The ontologies are available at the following link[1] and their ORSD (Ontology requirement specification document) can be found at the following link[2].

## 3.2 Socio-cultural adaptation process

The socio-cultural user profile is managed and used by an adaptation process (Ouamani et al., 2016) which was implemented to operationalize the proposed ontology-driven socio-cultural adaptation approach. This process consists in two main modules: socio-cultural user profile management module and functionality adaptation module.

### 3.2.1 Socio-cultural user profile management module

It performs what follows: 1) socio-cultural data acquisition from the user by filling out a form, 2) The acquired data is processed to infer socio-cultural knowledge which is a SOCUDO instance for this user. 3) By applying association rules, connecting both ontologies, we get a SCACLO instance. 4) the two instances are then merged to get the socio-cultural user profile which is stored in the profile data-base to insure adequate personalization.

### 3.2.2 Functionality adaptation module

It is based on the application of suitable adaptation rules on the user profile socio-cultural knowledge. These rules match SCACLO concept values to adaptation tasks that need to be carried out by the system to provide socio-culturally adapted recommendations to participants of a collaborative session.

We have proposed and implemented two types of adaptation rules: "If condition then do action" and "On event do action". Each one matches one or more SCACLO concept values to one or more adaptations tasks (Table 2).

The definition of the second type of rules was based on the use of existing design patterns proposed by (Schadewitz, 2009) to handle intercultural collaboration (Table 3) These rules were validated by an empirical study (Ouamani, Bellamine Ben Saoud and Hajjami, 2016) we have conducted based on an online trilingual survey to verify two assumptions related to the accuracy and precision of these findings.

Table 2: An excerpt of the proposed adaptation rules for learners from hierarchic and collectivist cultures

| SCACLO concept values | Adaptation rules |
| --- | --- |
| Activity structure= formal | The activity statement provided to such learners are structured in different parts: problem desciption, questions, pedagogical resources. |
| Activity focus= specific | The activity statement provided gave accurate information and details about the problem, how to resolve it and the future solution |

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[1]    http://ontohub.org/repositories/socudo-scaclo/ontologies
[2]    https://www.academia.edu/23295514/SOCUDO-SCACLO_ontology_ORSD

Table 3: An excerpt of the proposed adaptations based on Schadewitz (Schadewitz, 2009) design patterns

| Problem/Situation | Adaptations |
|---|---|
| Concepts that have different meanings across cultures | The system provides a common library to store these meaning variations |
| Integration and participation problems occuring among participant | The system provides an activity and discussion summary mechanism. Thes summaries are stored in the common library. |

## 4. Operationalization and experimentation of the proposed approach

### 4.1 A case study : socio-cultural adaptive tool for collaborative argumentation tool

To operationalize the proposed solutions, we have developed a web based tool for synchronous collaborative argumentation called SCCo-ckeditor. To show how this tool operates, we have chosen the following scenario in which three users from three different nationalities (Tunisian, French, and American) are collaborating. First, the users should register to the system and provide socio-cultural data by filling out a form. This data is used to instantiate SOCUDO and then SCACLO and build his/her socio-cultural profile. Then, the socio-cultural profile is used to generate socio-cultural adapted interfaces. To ensure group awareness, the system use event notifications.

If the users choose different languages when registering to the system, they need to vote for a common language. Once done, the participants should click on the button "Start activity" which allows them to choose the activity. The system adapts the activity to the socio-cultural profiles of the users: For American participant, it displays it as a whole text bloc that explains the problem generally unlike Tunisian or French participant for whom, it displays a well-structured activity statement that presents the problem with a detailed description and clear questions.

While collaborating, the system may detect inactivity or absenteeism. In this case, the system may propose help assistance (Tunisian or French user) or wait until the user request help assistance by himself (by clicking in a discrete button when the user is American). For an American user, the system provides synchronous communication tools and allows unlimited communication at any moment during the interaction unlike for Tunisian or French users for whom it provides asynchronous communication tools and limits the communication message number, size and time. All the socio-cultural adapted GUI of the our collaborative web application can be found in (Ouamani et al., 2014b)

### 4.2 Experimentation scenarios

Experimentations were carried out to assess both: 1) the accuracy of the proposed adaptation rules in predicting user preferences according to his/her cultural specificities. 2) the benefit of socio-cultural adaptivity: is the adapted version of the tool is better appreciated by the user than the standard version? Is it satisfactory? Can it increase efficiency of collaborative interaction and individual involvement in collaborative learning and subsequently improves the individual learning?

Participants were undergraduate students (same age, 7 females and 8 males) who have good language levels and computer science skills. Each tool test lasted 20 minutes and was carried out first with the standard version and then with the adapted one. They were asked to coproduce an argumentative text about smoking subject. Two surveys were distributed to participants to collect assessments, opinions and inconveniences after the test of each version (the two questionnaires are available in three languages) (Ouamani, 2015).

### 4.3 Evaluation criteria

The proposed surveys are composed each of 32 questions divided into different categories. Each question category is provided to verify the aspects related to the performance, the usability and user satisfaction. To verify the usability aspect, we have used the UTAUT theory (Unified Theory of

Acceptance and Use of Technology) (Venkatesh et al., 2003) (validated by (Oshlyanski, Caims and Thimbleby, 2007) across cultures). To verify the performance aspect, we have proposed 4 questions inspired from the work of (Reinecke, 2010). To verify the user satisfaction aspect, we have used the measurement scale proposed by (Hassenzahl and Tractinsky, 2006) and (Hassenzahl, 2010) that confronts the pragmatic perceived quality and the perceived attractiveness.

For all questions that ask for answers with a Likert scale, we have used Cronbach's alpha (Nunnally and Bernstein, 1994) to test internal consistency, to check the overall reliability and to detect incoherent answers (the test is considered consistent when the alpha value is close to 1). We have also used: 1) The kolmogorov-Smirnov test to verify the distribution of the sample, 2) The t-test to compare data. This test allowed us to assess the average answer for both versions to verify assumptions related to user satisfaction aspect and the benefits of socio-cultural adaptivity, 3) The correction (Benjamini and Hochberg, 1995) of the p values calculated by kolmogorov-Smirnov tests for each evaluation criteria, 4) Pearson correlation to test correlation between answers related to the usability and user satisfactions and general preference information in which each participant have to choose between the two versions and 5) The chi-square goodness of fit who had as input the variable "preferred version" with three levels of answers "PreferredAdapted", "PreferredStandard" and "Neutral" to categorize participant preferences

## 4.4 Experimentation results

An excerpt of results was as follows:
- The Cronbash's alpha (above 0.5) showed that for usability and satisfaction criteria, we have obtained values near to 1 (more than 0.5) for the two versions. This proves the validity of our test and the homogeneity of participants answers. However for the performance criteria, the values were close to 0 (0.2 for the two versions). This translates the divergences of participant answers.
- The Kolmogorov-Smirnov tests showed in most cases and for most of the evaluation criteria that we have normal data distributions for the two versions.
- The correction of p values for the different evaluation criteria had shown that the usability, the performance of the adapted version was better according to the participant answers. When comparing the participant answers for both the two versions; 56% of participants think they can work more efficiently with the adapted version, 66% of the participants find the adapted version more suitable, attractive, easy to use, understandable and user-friendly. 100% of participants choose the adapted versions as the best one. Participants had always accepted the system recommendations.

## 5. Discussion and limits

This paper tries to address a set of challenging questions. The first question is about the socio-cultural knowledge we can adapt to. To address this question and based on literature review of research studies on socio-cultural influence on individual, we have proposed an ontology that models this knowledge. The second question is about the CSCL components that can be socio-culturally adapted and based on literature review related to socio-cultural influences on collaborative learning, we have built an ontology that models these socio-culturally sensitive CSCL variables. To collect socio-culturally data needed to instantiate the two ontologies, the developed tool inquires the users and then uses the collected data to infer socio-cultural knowledge. Inferences are based on association rules modeling expertise and knowledge extracted from the same literature reviews. The remaining questions are about the impact of the socio-cultural adaptation, how socio-culturally adaptive and personalized CSCL environments may promote learning in real contexts and how learners of different profiles perceive socio-cultural adaptation, the results of our experiments validate the benefits of socio-cultural adaptivity. The adaptive collaborative environments developed had improved the efficiency and the satisfaction of participants belonging to the studied cultures. However, this performed set of experiments is limited: more time and collaborative efforts are required to test the tool within several cultures and with large samples to validate our assumptions across cultures.

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