INTRODUCTION

With improvements in network technologies and systems’ scalability, more and more globally-distributed applications are available. Opportunities for people from varying societies to play, exchange, confront, cooperate or learn synchronously have multiplied, resulting in many technology-mediated intercultural interactions. Furthermore, with globalization, software creation and distribution is no longer confined within borders; it can be developed anywhere and distributed everywhere around the world.

Various researchers (Hofstede, 2001; House et al., 2004; UNESCO, 2007) point out that culture can have a profound impact on the way people physically interact with their environment and peers, as well as on their cognitive reasoning, such as interpretations and affective reactions they have when faced with specific terms, symbols and situations. In order to better take learners’ specificities into account, research in e-Learning definitely needs to improve its consideration of such an issue.

Modern societies have a growing need for highly specialized education and traditional educational systems have a difficult time providing solutions. E-Learning applications could become an important part of such solutions. This said, systems developed in a particular cultural setting and distributed around the world without taking into account variations in users’ cultural backgrounds pave the way for potential misunderstanding and failure of adequate teaching. This issue is particularly complex because the representation of the domain to be learned in e-Learning systems frequently reflects the cultural values of a given author, and these may greatly differ from those of e-learners of a different cultural background.

How might learners’ cultural background be adequately taken into consideration? How can content displayed to learners be culturally adapted? How can the most suitable strategies of interaction in accordance with learners’ cultural specificities be selected? These are some of the questions that will be addressed in this chapter.
After a brief overview of the findings of previous research on cultural awareness in e-Learning systems, especially in the sub-domain of Intelligent Tutoring Systems, we discuss a generic modular architecture for designing culturally-adaptive e-Learning systems. We then describe a rule-based process for culturally selecting culturally appropriate pedagogical resources and propose a method to determine the most culturally suitable pedagogical strategy. Finally, we investigate the potential of ontology engineering for dealing with several relevant issues when developing Culturally-Aware Tutoring Systems.

BACKGROUND

In order to clearly understand some of the problems we are facing when designing globally distributed e-Learning applications, let us begin by giving a brief introduction to intercultural education. According to UNESCO’s guidelines (2007), intercultural education should:

- Respect “the cultural identity of the learner through the provision of culturally appropriate and responsive quality education for all”,
- Provide “every learner with the cultural knowledge, attitudes and skills necessary to achieve active and full participation in society”,
- Provide “all learners with cultural knowledge, attitudes and skills that enable them to contribute to respect, understanding and solidarity among individuals, ethnic, social, cultural and religious groups and nations”.

Indeed, there are many reasons to take culture and learners’ cultural differences into consideration within e-Learning systems, and as such, discuss the development of adaptive e-Learning systems aimed at providing intercultural education. Following are some examples of important e-Learning elements that have been proven to be culturally-sensitive.

Culturally-Sensitive Elements in e-Learning: Examples

In the field of adaptive e-Learning, Emotional management has been growing in importance (Conati, 2002; Chaffar, Frasson, 2004). It appears that there are strong links between culture and emotional behaviour. According to Scollon and his colleagues (2004), the frequency with which someone feels positive or negative emotions is culturally dependent. Categorizing an emotion as positive or negative can itself, in some cases, depend on cultural background (Kim-Prieto, Fujita and Diener, 2004). Learners’ emotional behaviour can also greatly vary accordingly (Ekman, 1972; Elfenbein, Ambady, 2003, Mesquita, Frijda & Scherer, 1997).

Human motivation is also subject to cross-cultural variations. To illustrate, Elliot and Bempechat (2002) have pointed to several research initiatives that highlight cultural differences when dealing with students’ motivation for achievement. Furthermore, many different theories discuss the causes, dynamics and consequences of human motivation per se, and within almost all of the proposed frameworks, cross-cultural variations have been reported. For example, in the Self Determination Theory (Ryan, Deci, 2002), which has been shown to be especially relevant in academic settings (Reeve et al., 2004), research indicates that autonomy support, or the need for someone to see his/her behaviour as self-endorsed, is a cross-cultural way of enhancing or maintaining the motivation of people. However, methods used to fulfill this psychological need and their degrees of efficiency are subject to cultural variations (Chirkov et al, 2003; Levesque et al, 2004; Chirkov, Ryan and Willness, 2005). Finally, and in direct relation to e-Learning, Lim (2004) has shown that motivation for online learning activities is culturally-sensitive.
According to several studies (Triandis, 1995; Hofstede, 2001), national cultures can more or less favour/recognize/encourage the development of collaborative attitudes. As a result, strong assumptions are made to the effect that a culture’s collaborative or individualistic orientation has an impact on how members of this culture generally react to given pedagogical strategies. In trying to validate these assumptions, Blanchard and Frasson (2005) have interviewed people from several countries on their preferences in view of individual or collaborative learning activities. Data resulting from their preliminary evaluation seems to reflect Hofstede’s national scores of the individualism/collectivism dimension that reflects the orientation and interest of a nation towards individualist or collectivist attitudes. Biggs (2001) also strongly advocates putting more concerns when adapting Western educational practices and strategies to the rest of the world.

Other elements that appear to be culturally sensitive in terms of e-Learning include rewards allocation, or how teachers reward students and the reaction students have to these rewards (Fischer and Smith (2003), stress caused by academic tests (Cassady, Mohammed and Mathieu, 2004), and references (for example, public figures, historical facts, artefacts) used to illustrate lessons or to describe the environmental context of learning.

Considering culture in e-Learning leads to designing “Culturally-Aware Tutoring Systems” (CATS), an innovative and quickly expanding area of research in e-Learning. We propose two varying approaches to categorizing CATS: Acquisition-Oriented CATS, or systems trying to teach intercultural skills to learners, and Adaptation-Oriented CATS or systems trying to understand the cultural profile of learners and adapt to it. Following is a brief overview of studies related to such CATS.

**Acquisition and adaptation-oriented CATS: an overview**

**Acquisition-Oriented CATS.** One of the most prominent works in Acquisition-Oriented CATS should probably be attributed to Johnson and his team at Alelo Inc (Johnson, 2007) in view of their Tactical Language and Culture Training System (TLCTS). The first version of this system was used by the US army to teach soldiers the basics of Arabic language and culture before sending them to Iraq. TLCTS has been developed as a 3D serious game that provides situational learning to users by confronting them with embodied pedagogical agents that can both express cultural gestures and “understand” a specific foreign language within a cultural 3D environment. New versions of the game enable training related to other areas of the world (Afghanistan, French-speaking Africa, etc.) and should be adapted for use in business. Lane and his colleagues (Lane et al., 2007; Lane, Hays, 2008) are working on a somewhat similar system named Elect-Bilat. Theirs teaches interpersonal and intercultural skills by focusing on narrative interaction within a 3D serious game. Among other things, they have rightfully pointed out that culture remains an ill-defined domain, which Ogan, Jones and Aleven (2006) also mention in their research which consists in helping students acquire cultural knowledge and intercultural competence by engaging them in activities of target-culture film viewing. Among other things, their online system uses video clips that can be paused when pre-selected culturally-interesting moments occur (Ogan, Jones, Aleven, 2008). At such moments, discussion related to cultural differences can begin.

**Adaptation-Oriented CATS.** Expressing some kind of cultural intelligence can be seen as the main objective of Adaptation-Oriented CATS. Cultural intelligence is defined by Earley and Mosakowski (2004) as a “seemingly natural ability to interpret someone’s unfamiliar and ambiguous gestures the way that a person’s compatriots would”. Cultural intelligence is considered to have three facets:

- A cognitive facet (the head): the ability to get knowledge about foreign cultures,
- A motivational/emotional facet (the heart): the motivation and confidence to be able to adapt to foreign cultures,
- A physical facet (the body): the ability to adapt actions, behaviours and demeanours according to foreign cultures.

Based on these facets, Blanchard and his colleagues (Blanchard, Razaki, Frasson, 2005; Blanchard, Frasson, 2007) have proposed a system architecture in order to adapt displayed multimedia contents according to the cultural profile of a learner and to culture-related rules. This work will be extensively discussed later in this chapter.

Studies investigating potential variations in learners’ perceptions according to their socio-cultural profile can be seen as a first step towards cultural intelligence. For instance, Johnson and his colleagues (2005) have discussed the interest of using the Politeness Theory (Brown, Levinson, 1987) as a strategy of interaction between pedagogical agents and German or US students. Baylor and Kim (2004), for their part, have demonstrated that adding socio-cultural criteria such as ethnicity to the design of pedagogical agents had an effect on learners’ appreciation of those agents.

Much research related to Human-Computer Interaction could also be applied within ITS to equip them with cultural intelligence. For instances, Nazir and her colleagues (2008) have proposed an affective model based on personality and culture-related data of users; Huang and his colleagues (2008) are working on culturally-adaptive conversational agents, whereas Rehm and his colleagues (2008) are investigating cultural differences in non-verbal communication in order to enrich interface responses.

We now take a closer look at a possible methodology for dynamic cultural adaptation based on a generic architecture of Adaptation-Oriented CATS. This is a refined and updated version of a previously presented methodology (Blanchard, Frasson, 2007).

## DESIGNING ADAPTATION-ORIENTED CATS

### Design requirements for Adaptation-Oriented CATS

In order to correctly adapt to learners’ cultural specificities, an adaptation-oriented CATS should necessarily have the two following abilities (Blanchard, Frasson, 2005):

- **Understanding**: the system should be able to translate a learner’s behaviour/feeling/result with regards to learners’ cultural specificities;
- **Adaptation**: the system should be able display different interfaces and/or to start different learning strategies with regards to learners’ cultural specificities.

Kashima (2000) mentions two currently coexisting approaches to culture in cross-cultural psychology. A culture can either be seen as (a) “a process of production and reproduction of meanings in particular actors’ concrete practices or actions or activities in particular contexts in time and space”, or (b) “a relatively stable system of shared meanings, a repository of meaningful symbols, which provides structure to experience”. From our perspective, a major distinction between the two definitions is the way a culture is seen as a static (a) or dynamic (b) system. Both these definitions can present advantages for e-Learning activities and should be considered when designing Adaptation-Oriented CATS.
The first definition (a) could underline cognitive assessments that are used to better understand and explain learners’ reactions in a specific context, whereas the second definition (b) could be used when explaining variations in learning results, practices and behaviors between cultural clusters. Accepting this dual definition implies that two kinds of cultural data would have to be considered:

- **Static cultural data** obtained from readings in the cross-cultural domain. For instance: *pride can be considered a positive emotion for a learner of a Western country.* A potentially valuable source of information to this effect is research on systems of values (Kirkman, Lowe, Gibson, 2006);

- **Dynamic cultural data** obtained by analyzing system use by learners. For instance: *French learners prefer to work collaboratively.* This implies developing efficient methods for analyzing learners and group of learners’ activity as well as methodologies to culturally categorize learners.

**Modular architecture for Adaptation-Oriented CATS**

The fore-mentioned requirements have been taken into account in designing the modular architecture presented in Figure 1.

![Figure 1. A modular architecture for Adaptation-Oriented Culturally-Aware Tutoring Systems.](image-url)
In the proposed architecture, the design of Adaptation-Oriented CATS is centered on a Culturally Intelligent Agent (CIA) that is made of two modules: a Cultural Transcription Module (CTM – for the understanding aspect) and a Cultural Action Module (CAM – for the adaptation aspect).

The Cultural Knowledge Base (CKB) is the other main element of this architecture. As mentioned in the previous part, both static and dynamic data can coexist there. Several strategies are possible for storing and organizing cultural information: from classical rule-based modules (Blanchard, Frasson, 2007) to modules based on contextual ontologies (Blanchard, Mizoguchi, 2008; Allard, Bourdeau, Mizoguchi, 2008, Savard, Bourdeau, Paquette, 2008). Cultural data can be used to explain/describe learners (for instance, “members of cultural group X are collaborative”) or to explain in a more or less generic manner how the system should act with learners (for instances, “collaborative activities have to be encouraged for members of collaboration-oriented groups”; “usage of resource R has to be particularly encouraged when dealing with members of cultural group X”).

Cultural awareness for the purpose of cultural adaptation is obtained as follows:

First, several parameters of the user (i.e. the learner) are monitored through a Human-Computer Interaction module. Depending on its level of embedded technology, this module can monitor various activities coming from the learner, from mouse and keyboard activities to physiological stimuli (Blanchard, Chalfoun, Frasson, 2007). Gesture and speech recognitions are also being considered in several research projects (Johnson, 2007; Rehm et al., 2008). Data are then processed by the Cultural Interpretation Module (CIM) that uses cultural information contained in the CKB to dialog with the Student Model Module in order to update the model of the learner.

The CIM is also in charge of providing information on the behaviour of users to a Cultural Model Module (CMM). The CMM is in charge of eventually detecting and extracting particular, sometimes unpredicted behavioural patterns expressed by learners of a specific cultural group. Data mining and machine learning techniques are naturally being considered for this purpose. When such detection occurs, information is then stored as dynamic cultural data referring to the related cultural group of users. A possible example of dynamic cultural data could be: “given learners’ behaviour analysis, when using the system, learners that are members of cultural group X appear to be competitive”. When dynamic and static cultural data provide opposite information, dynamic cultural data are privileged because they are more reality-based than theory-based.

Interaction between the specific student model of the learner and the CMM leads to determining membership of the learner to different cultural groups; this will be further elaborated later in the discussion.

Once the specific cultural model of the learner has been updated, the Cultural Action Module (CAM) can use it jointly with information contained in the CKB in order to determine how to use the specific database of the system. In the case of e-Learning systems, mainly stored data are related to the domain to be learned as well as pedagogical methods.

The final result of this inter-module process is culturally-adapted interaction with the learner. This adaptation could lead to an evolution of the Human-Computer Interface (physical facet of cultural intelligence). For example, the interface could display pictures related to a given situation, reflecting how it occurs in the specific original cultural context of the learner. The cultural adaptation could also consist in a specific attitude of the system (cognitive and emotional/motivational facets of cultural intelligence). For example, the system could manage learner’s emotions in a manner coherent with his/her cultural practices. The following part
gives a detailed description of a rule-based process for cultural adaptation, within the framework of the fore-mentioned modular architecture.

**A rule-based example of a process for cultural adaptation**

The original objective of the process presented in Figure 2 is to propose a method for determining the most suitable resources to be displayed to a learner in a given learning situation in order to take into account his/her cultural specificities.

![Diagram showing a process for cultural adaptation](image)

**EXPLANATIONS:**
- **Representation of cultural specificities of a resource**
  - Cultural Interest Scores of a resource for group A
  - Cultural Interest Scores of a resource for group B

- **Representation of “learner L”’s cultural specificities**
  - Attribute Weight Vector for learner L
  - Membership Score related to group A for learner L
  - Membership Score related to group B for learner L

- **Cultural Knowledge Base**
  - Rule 1
  - Rule 2
  - Rule 3
  - Rule 4
  - Fact 1
  - Fact 2
  - Fact 3
  - Fact 4
  - Fact 5

- **Resource Base**
  - Type T resources related to concept C

**Figure 2. A process for cultural adaptation.**

This process is based on cultural information stored as facts and rules. Several points are managed in this process, including the representation of cultural groups, the representation of an individual’s cultural specificities, the representation of the interest of using a given...
resource with people with a certain cultural background, and the dynamic evolution of all those representations according to interaction within the system.

**Modelling cultural groups.** In Figure 2, two cultural groups A and B are considered. As previously mentioned, this process is grounded on a knowledge base of cultural rules. An Attribute Weight Vector (AWV) is associated to each cultural group. An AWV is a set of weights that are associated to attributes used to illustrate the various characteristics of learners that can be considered by the system. “Collaborative attitude”, “Competitive attitude”, “Risk taker”, or “Conservative attitude” are examples of possible attributes. Weights are initialized according to cultural knowledge base rules. For instances, one rule could express that *being from Western countries positively correlates with “Competitive Attitude”*. Some rules can also illustrate positive or negative correlations between attributes. AWV are dynamic structures: weights associated to attributes will evolve after the original initialization to better fit users real behaviour. Dynamically-deduced rules will be used for such purpose.

Each weight consists in a value between 0 and 1. If, in the AWV of a cultural group G, the weight of an attribute is near 0, the related attribute is not a good categorizer for members of G. On the other hand, if the weight of an attribute is close to 1, members of G will tend to reflect this attribute.

An important issue needs to be taken into consideration when dealing with the concept of cultural groups. Members of a cultural group aren’t necessarily alike nor do they express/endorse in the same manner all the behaviours related to their culture (Sharifian, 2003). In other words, culture doesn’t have a uniform impact on the individual members of their associated cultural group. An AWV of a cultural group describes tendencies within this group. Though it can be used to suggest several attitudes that can be adopted towards a learner, it cannot be used to clearly predict what the reactions of each member of the particular group will be. To this effect, individual modelling of learners’ cultural specificities as well as their level of endorsement to specific cultural influences are needed.

**Modelling learners’ cultural specificities.** Elements that need to be considered to represent learner cultural specificities are illustrated in the explanations of Figure 2.

As previously mentioned, cultural groups are described by an AWV. In a similar manner, each learner model within the system has a personal AWV made with the same set of attributes used for cultural groups (pas clair). Similarly also, associated weights represent how learner attitude and behaviour relate to each attribute.

Membership Scores (MS) are determined to illustrate the strength of the relation between the learner and each of the cultural groups defined in the system. MS are basically a distance value between the AWV of the learner and the AWV of the targeted cultural group. Thus, in Figure 12, given the fact that two cultural groups A and B are defined, personal MS.A and MS.B are dynamically computed in each student model, using the following formula:

$$MS.G = \sum_{i=1}^{n} \frac{1 - |L.AWV_i - G.AWV_i|}{n}$$

(formula a)

In formula a, n refers to the number of attributes in AWVs of the system, L.AWV_i is the weight associated to attribute I for learner L whereas X.AWV_i refers to the weight associated to the same attribute within the AWV of cultural group G. According to this formula, MS.G for each learner has a value between 0 and 1. If the MS.G of learner is superior to a given (arbitrarily determined) threshold, the system considers the learner as a member of G. Of course several thresholds could be determined to reflect various membership levels.
To summarize, this fore-mentioned methodology allows the representation of cultural specificities for each learner (i.e. AWV specific to each) as well as the cultural influences to which each is subjected (i.e. MS).

**Expressing the cultural interest of a resource.** Most e-Learning systems use “resources” as basic building blocks. In this case, resource refers to any kind of document, movie, image, multimedia file, used to transmit information related to the domain to be learned. Many of these resources are culturally-flagged because they are grounded in cultural references, practices, or illustrations. For instance, the architecture of cities, thus their appearance, differs from one country to another. Using badly culturally-selected pictures of cities to situate the action of a learning activity may appear unnecessarily exotic to some learners and, in some cases, it could even distract them from learning goals. In the same way, alcohol and specific food are well accepted and considered as symbols of celebration in some cultures whereas they are prohibited in others. Thus it is important to express whether or not it is appropriate to use a given resource with members of a specific cultural group. This is the aim of Cultural Interest Scores (CIS). CIS are dynamically computed for each resource to express whether it is suitable to use it with each of the cultural group, which means there are as many CIS for a resource as the number of cultural groups. CIS have a value between 0 (not suitable at all) and 1 (very suitable). If no value is mentioned, CIS of a resource are set at 0.5 for each cultural group. However, when adding a resource to the system, authors can mention explicitly that it should/should not be used with people with certain specific cultural attributes. Consequently, CIS of a resource transform according to results gained from analysis of learners: if it is determined that a learner of a given cultural group has had success in a learning activity after using a specific resource, then the CIS of this resource related to this cultural group is increased. If a learner has failed, the CIS is lowered.

**Dynamic evolution of learner’s AWV.** AWV are not static structures. As mentioned earlier, they are initialized according to rules and facts that are present in the Cultural Knowledge Base. But they also need to reflect learner activity. Hence, when an attribute is used by the system to adapt its interaction with the learner, the weight of this attribute is raised if the learner has success, but it is lowered if the learner fails in the activity.

**Dynamic evolution of cultural group’s AWV.** A cultural group is indeed a set of cultured individuals. The AWV of a cultural group reflect the general tendencies of its members. Thus its value depends on the evolution of AWV of members of this group. The system frequently retrieves the AWV of learners who are members of a cultural group (i.e. their MS is higher than a given threshold) to update the AWV of this cultural group. The new AWV will be obtained by computing the average weight for each attribute within the members of the cultural group. The computation of this new AWV results in change in MS of learners. For instance, if a member of a cultural group G has atypical attitudes and results compared to other members of G, distance between his personal AWV and the AWV of G will rise. At one point, the value of MS.G for this learner will be lower than the determined threshold. Thus this learner will no longer be considered as a member of G by the system.

**Unsupervised determination of new cultural groups.** The system will frequently run an unsupervised technique such as Kohonen’s Self Organization Map, to determine new cultural groups. Learners’ AWV will be used as entries. Results will be clusters of learners with slightly similar AWV. If this cluster has enough members and if its AWV is sufficiently different from the AWV of already existing cultural groups, then this new group will be introduced in the system. Related MS will be determined for each learner. CIS linking resources to this new group will be initially set at 0.5.
Culturally selecting resources. The process of cultural adaptation presented in Figure 2 refers indeed to the process of selecting the most culturally suitable resource. It is thus implied that there is more than one possible resource to illustrate a given concept. This system is based on the notion of cultural templates (Blanchard, Razaki, Frasson, 2005; Blanchard, Frasson, 2007). A cultural template is a descriptive file where general information (that is not culturally flagged) is mixed with Tags for Cultural Adaptation (TCA). A TCA refers to a concept and the type of resource that is needed to illustrate it. For instance, “IMG:CITY” is an example of TCA that expresses that a culturally-suitable image of the concept of “city” should be displayed. Basically, TCA are inserted in the skeleton of an HTML page. Once the cultural adaptation is performed, the result is an HTML page where multimedia resources are selected according to the profile of the learner watching it.

Following are the details of the process of selection illustrated in Figure 2:

a) The request for finding a type T resource for a concept C to be displayed to learner L is initialized.

b) The system computes all MS of learner L.

c) The system retrieves CIS of all existing resources of type T related to concept C. For each of those resources, using previously computed MS, a Cultural Interest Score for learner L (CIS.L) is determined, using the following formula:

\[ CIS.L = \sum_{i=1}^{n} (MS.G_i \times CIS.G_i) \]  

(formula b)

In this formula, \( n \) is the number of currently existing cultural groups, \( MS.G_i \) is the Membership Score of learner L for the cultural group \( G_i \) and \( CIS.G_i \) is the Cultural Interest Score of the resource for the cultural group \( G_i \).

d) The chosen resource, i.e. the one with the biggest CIS.L value, is displayed to learner L.

To summarize, this process is used to answer the question of “what” has to be presented to a learner in order to take his cultural specificities into account. Based on that, a short methodology is proposed in the next part to answer the question of “how” this should be presented: this point discusses the culture-based adaptation of the pedagogical attitude (i.e. the selection of the most culturally-suitable pedagogical strategy) within an Adaptation-Oriented CATS.

A methodology for culturally selecting pedagogical strategies

The methodology used to determine which strategies should be used with a learner, according to his cultural profile, is directly inspired from the previously described process for the selection of culturally-relevant resources.

When a pedagogical strategy is defined within the system, it is more or less linked to any of the existing pedagogical attributes i.e. each attribute is associated with a value \( \omega \) that expresses the strength of its importance for the strategy (the sum of all \( \omega \) equals 1).

Furthermore, a cultural rule may be specified by the author for any strategy. Depending on the cultural specificities of a learner (for instance, the learner is from a Western country), the rule determines a multiplier \( \sigma \). For example, the resulting \( \sigma \) should be 0 if the learner has some cultural specificities that result in the proscription of the related strategy. But if this strategy is particularly relevant given the learner’s cultural profile, \( \sigma \) could be set to 1.5, 2, 3 or even
more. If there is no specified cultural rule, $\sigma$ is set to 1. Figure 3 describes a method for obtaining the Cultural Interest Score (CIS) of a strategy $S$ for a learner $L$.

**Figure 3. Methodology for obtaining $CIS_L$, the CIS of strategy $S$ for a learner $L$.**

Function used to obtain the CIS of a strategy $S$ for a learner $L$ is the following:

$$CIS_S = L \cdot \sigma_S \times \sum_{i=1}^{n} (L.AWV_i \times S.\omega_{AWV_i}) \quad \text{(formula c)}$$

In formula c, $n$ refers to the number of attributes in AWVs of the system, $L.AWV_i$ is the weight associated to attribute $i$ for learner $L$ whereas $S.\omega_{AWV_i}$ refers to the importance of attribute $i$ for the strategy $S$. Finally, $L.\sigma_S$ is the cultural coefficient obtained from the rule associated to strategy $S$, according to the profile of learner $L$. The selected strategy will be the one whose $CIS_S$ is the highest for learner $L$.

**FUTURE TRENDS**

Having access to cultural knowledge, and being able to efficiently use it are inherent and critical features for any CATS:

- *Acquisition-Oriented CATS* need cultural information to describe the intercultural skills to be learned and the culturally-related environments in which learning can take place (in cases of situational learning),

- *Adaptation-Oriented CATS* need cultural information to nurture their adaptation processes.

However dealing with cultural data necessarily raises several important concerns which we shall now address.

**Issues related to cultural data**

**Existing cultural data are not always reliable for educational use.** This is a major issue. Indeed, preeminent cross-cultural studies have mainly been developed for and within the context of leadership or business research (Hofstede, 2001; House et al., 2004). Legitimate concerns can be raised as to how (and whether) findings can be transferred and used within educational settings. Furthermore, there is no consensus on the reliability of these studies and their respective methodologies (Earley, 2006; McSweeney, 2002; Smith, 2006) even though many empirical studies discuss and “validate” their correctness and usefulness (Kirkman, Lowe, Gibson, 2006).
Representations of cultural data as well as the focus given to specific categories of cultural data vary from one research domain to another. All domains addressing cultural issues (sociology, psychology, management, anthropology, statistics, etc.) have particular ways of dealing with them. This can cause information consistency problems within CATS if data are obtained from several sources that don’t have a common method of formalization.

A given culture is too complex to be fully modelled. What cultural data are consequently sufficient to circumscribe a decent model of a given culture? How could acceptable results be obtained from a given model? These are crucial questions for the development of CATS.

Culture-related research/development may be biased by authors’ personal profile. It is well-known in cultural research that analysis of a culture by a person foreign to that culture may be biased by interpretation based on that person’s cultural values even if methodologies such as participant observation (DeWalt, DeWalt, Wayland, 1998) have been proposed to minimize such bias. As cultured agents, course authors and designers are prone to such cultural bias. In some cases, authors may simply not consider possible categories of behaviour because they may not be aware of their existence. One solution is that authors be members of the culture being modelled, which still raises the problem of ensuring authors’ objectivity. Because CATS are dealing with critical information on how people perceive the world (and thus how they will interact with it), reliability of data is especially important. This means that stereotypes, interpretations and propaganda must be proscribed, to the extent that this is possible. Furthermore, teaching intercultural skills within Acquisition-Oriented CATS should be based on learners’ original perception of the targeted culture (i.e. the understanding and appreciation of the targeted culture within the learner’s culture) in order to express how this differs from “reality.” For instance, teaching about French culture should differ according to whether learners are German or Japanese because they don’t necessarily share similar knowledge and beliefs about the French culture.

These are a few of the many issues that have to be considered when designing CATS (Blanchard, Mizoguchi, 2008). We now discuss how the use of techniques related to the domain of conceptual ontology engineering could lead to interesting solutions to better design CATS.

Conceptual ontologies for representation of cultural knowledge

According to the IEEE Standard Upper Ontology Working Group (SUOWG: http://suo.ieee.org/), an ontology “is similar to a dictionary or glossary, but with greater detail and structure that enables computers to process its content. An ontology consists of a set of concepts, axioms, and relationships that describe a domain of interest”. By “conceptual” ontology, we mean that the identity of a node (concept) is related to its parts and properties, whereas its semantic label is secondary (even if a correctly chosen label remains helpful) (see Guarino, 1998; Mizoguchi, 2003; Mizoguchi, 2004, Sowa, 1995). In other words, conceptual ontologies refer more to the philosophical essence of concepts than semantic-oriented ontologies.

One of the potential interests of conceptual ontology should be to determine trans-disciplinary core concepts of culture and the relations existing between them. This is the aim of the currently being developed Upper Ontology of Culture (UOC - Blanchard, Mizoguchi, 2008). According to the SUOWG, an upper ontology “is limited to concepts that are meta, generic, abstract and philosophical, and therefore are general enough to address (at a high level) a broad range of domain areas. Concepts specific to given domains will not be included; however, this standard will provide a structure and a set of general concepts upon which domain ontologies (e.g. medical, financial, engineering, etc.) could be constructed”.
The aim of UOC is consequently to identify major constituents to be considered when dealing with any kind of cultural issue. In other words, the UOC tries to elicit and define trans-disciplinary core concepts of culture and the relations existing between them. One has to clearly understand that the goal of UOC is not to directly capture cultural differences, but to capture the essence/structure of culture and culture-related elements, which in turn will be used to elicit/identify/collect cultural differences. Figure 4 describes a process leading to CATS development.

As shown in Figure 4, upper level concepts are identified, described and interconnected within UOC.

Some aspects/concepts of UOC could then be specialized within domain or task ontologies. For instance, let us suppose that nonverbal communication is determined as an upper level concept in UOC. This implies that essential parts and properties of this concept have been identified, as well as the relations this concept has to other concepts defined in UOC. This helpful information could ground the development of culturally-specialized ontologies such as French non-verbal communication or Japanese non-verbal communication.

Among concepts that the UOC tries to conceptualize (i.e. determining parts and properties for each of them) are context, contextual relation, culture, cultural entity, cultured agent, cultural heritage, history, communication method. Almost all of them can be specialized, which means there are variants of them. For instance, the UOC defines the concept cultural entity and its specializations (Figure 5).

A cultural entity is the association of a culture with its related cultural group. A cultural entity can have sub-entities (i.e. minority groups with their own culture).

There are three kinds (specializations) of cultural entities:

- Socio-cultural entities whose members are related to each other within a social structure, and whose history can be discussed. Civic nations, ethnic nations, area-related entities (for instance the citizens of a specific cultural entity)

Figure 5. The concept of Cultural entity and its specialization in UOC
city), companies and communities are specializations of socio-cultural entities.

- Quality-based cultural entities are virtually-created cultural entities, based on some shared qualities of their members. Such entities don’t have a real history. For instance, the entity associating soccer players with the shared culture related to soccer is an example of a quality-based cultural entity.

- Hybrid cultural entities. For instance, the entity related to “African-American” is based on a non-social criterion (the “African” criterion refers to people with very different socio-cultural origins and history, that share non-social attributes such as skin colour). However, African-American have organized themselves in the course of history and developed a social structure (it is sometimes referred to as a community).

Structures determined in the UOC and in similar initiatives linking researches on CATS and ontology engineering (Allard, Bourdeau, Mizoguchi, 2008; Savard, Bourdeau, Paquette, 2008) already hold valuable information to be used in processes aiming at providing cultural intelligence. Those structures also could be used as formalisms to improve the elicitation of cultural data, as guidelines for defining data structure to be used to represent various kinds of cultural knowledge and their specificities (artefacts, beliefs, norms, behaviours, traditions, rituals, references). Processes for peer-validating cultural knowledge could also profit from this shared cultural corpus.

CONCLUSION

Adaptation-Oriented CATS development is a very promising field that aims at humanizing computer-assisted education by considering the cultural background of learners as well as the cultural context of learning sessions. In this chapter, we have defined several important notions related to those systems. We have proposed an architecture as well as processes for bringing cultural intelligence in tutoring systems. We have reviewed how the use of ontology engineering techniques could help researchers on CATS deal with several inherent issues related to culture-related software, especially by providing structures and norms for dealing with the ill-defined domain of culture.

In addition to what we have discussed in this chapter, several other issues related to CATS design could be tackled. Ethical considerations, assessment of the quality of cultural data, distinctions and management of appreciations of members of a cultural group compared to perceptions of foreigners, are some of the many points that will necessarily have to be addressed in the future.

ACKNOWLEDGEMENTS

The author wishes to thank Claude Frasson, University of Montréal, and Riichiro Mizoguchi, Osaka University, for their precious insights and the fruitful discussions in relation to the various issues raised in this chapter. The author also wishes to thank Danièle Allard, Dalhousie University, for help in finalizing this chapter.

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