# Culture-Oriented Factors in the Implementation of Intelligent Tutoring Systems in Chile

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**Abstract.** With the aim of assessing the use of intelligent tutoring technology for math teaching in Chilean public schools, an experimental study was performed in the period 2013-2014. Although it was a successful experience in terms of number of participants and learning outcomes, it was not achieved without a number of difficulties which could be explained by focusing on the cultural challenges encountered in the endeavor. In this paper we explore the impact of cultural dimensions such as: organizational strategies and structure; organizational culture; pedagogical processes, human resources, and technology deployment. We characterize each one of these aspects by means of a qualitative study of the implementation process, involving tasks such as planning and technical support, class observations, interviews, and support to teachers in the classroom and lab. As a result, we propose a Diagnostic Chart which could help in the identification of pre-conditions to be solved at an earlier stage of the implementation phase.

**Keywords:** Intelligent tutoring experimentation; teaching strategies; country-specific developments; evaluation of CAL systems

## 1 Introduction

We describe a qualitative study focused on cultural issues encountered in the implementation of intelligent tutoring technology for Chilean public middle schools (5th to 8th grade in a K-12 system)[1]. The experimentation was carried out during two academic years (2013, 2014) and one of its objectives was to understand the challenges faced by teachers, students and authorities when engaged in the change of their teach-

[1] By implementation we refer to the complex endeavor of introducing new strategies and technology into the teaching-learning processes. This includes development and adaptation of software tools, planning, training, demos, on-line and field support.

ing-learning strategies by means of intelligent tutors[2]. The long range vision is to improve math learning in public education for underserved populations.

Based on the literature and the experimentations' findings, we have identified culture-oriented critical factors to be dealt with when implementing an intelligent tutoring system environment in the math class. From this characterization we construct a Diagnostic Chart which could help identifying pre-conditions to be solved at an earlier stage of the implementation process.

The implementation endeavor includes the development of a pedagogical framework that, considering scarce technological resources, takes advantage of personalized student-centered activities in the computer lab and collaborative-constructivist strategies in the classroom. Even though the ultimate goal has been to improve math learning among students, the core methodology has focused on the teachers: they provided training for teachers and implemented teaching support tools. In the training courses, the new technology-based strategies were socialized, situated and adapted to local contexts. We wanted to make sure teachers felt motivated and are willing participants-leaders of the required change process. After training, we provide constant support and follow-up of the implementation in the classroom and lab.

The focus is on the tools and support activities needed by teachers to adequately implement the new technology-enhanced teaching strategies. This involves substantial change in the teacher's attitude, motivations, activities, and plans. The teachers need training, time and support for studying and planning the new classroom-lab strategies. It involves major changes in planning, instructional design and the teaching processes itself; it is a complex task. We have identified that once the basic technology issues are resolved (computer labs with one functioning PC for each student, reliable local area networks, client software correctly installed, sufficient Internet access to the servers, and effective technical support), there are several cultural-organizational drawbacks that work against a successful implementation. Most teachers complain about the extra effort required for the process.

To understand the particularities associated with setting up a class on an intelligent tutoring environment, we first describe the technology and its strategies.

### 1.1 Cognitive Tutor Technology

Following the theoretical principles developed by Anderson [1], [2], a personalized digital learning system known as a Cognitive Tutor (CT) was built at Carnegie Mellon University and is maintained and operated by Carnegie Learning Inc.[3] In this software, each student has a personalized "problem-solving" space, with just-in-time feedback and detailed tracking of his or her progress [3]. CT follows a personalized self-paced approach, allowing students to sequentially tackle progressively more difficult tasks. It tracks students' progress in real time as they answer questions, ask for

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[3] Cognitive tutoring technology is a trademark property of Carnegie Learning Inc.

help and solve problems. It provides personalized feedback and hints when errors are made in key points [4].

Cognitive tutors have shown considerable potential, and evidence in the literature indicates that they are effective in improving mathematics and science problem-solving skills [5], [6]. Specific mathematics cognitive tutors have been used in large school systems (primary/secondary level) in the United States, including Los Angeles and Chicago, as well as in rural areas [7].

### 1.2 Cognitive Tutor Strategies

The main objective of the CT software is to provide each student with a unique, enriched environment where he/she can interact with the system by solving specific problems. Multiple graphical representations can be explored by the student for creative thinking practice [8], [9], [10].

The software presents a problem and the student is requested to work towards the solution. Instead of jumping to the final answer, the software provides step-by-step scaffolding [11]. This divide-&-conquer strategy asks specific questions, from easier to more complex, so that the student can advance at his/her own pace in the solution of the problem.

The first question in each problem presented to the student is always related to the appropriate reading of the problem narrative. The next questions (posed by the software) guide the student towards the solution of the problem[4].

The student gets feedback (positive or negative points in a roster of skills to be achieved) whenever he/she answers questions within a problem. This immediate feedback is continuously represented via a "skill-o-meter" in the interface of the tutor [12]. Based on the "skill-o-meter" we have developed a web-based tool that provides teachers with a complete view of students' progress, both at an individual and full class scale. The teacher knows at any time where individual students are standing and thus can give them reinforcement on topics of struggle [13].

## 2 Experimental Study

The broad objective of the study is to understand how the culture-oriented challenges, that may be an obstacle for the implementation of an intelligent tutoring system in schools, can be characterized to detect deal-breaker barriers at an early stage of the implementation. We state that dealing with these obstacles is a condition sine qua non to successfully engage teachers, school authorities and students in an intelligent tutoring environment, hence the importance of achieving this goal.

The key questions are: Which are the culture-oriented challenges that can be identified during the experimentation? Which are the critical factors that can be deduced from the cultural challenges? Are there verifiable achievement indicators that can be

[4] There is extensive literature with thorough description of CT technology ([2], [4], [6], [7], [8]).

linked to those challenges? How can these indicators be arranged into an evaluation instrument to be used as a guideline for teachers and school authorities in the process of setting up an intelligent tutoring implementation?

### 2.1 Methodology

Building from experiences in USA, the Chilean initiative seeks an important innovation: the definition and application of new teaching strategies that, based on the CT technology, are adapted to the local educational context. This starts with the negotiation of change strategies with the district and school authorities. It follows with the involvement of teachers in training and instructional design blended-courses (90% of work is on-line) based on the CT. It culminates with the implementation of the technology-supported strategies in the math classroom.

At an early stage, we decided to work with public Chilean schools (totally or partially dependent of Municipalities) which enroll the largest percentages of vulnerable students and present the lowest learning results. These are the students with most diminished education opportunities explained by the lack of household economic resources. Once the schools were selected and authorities had committed their support, we provided training for teachers to engage them in the new strategies and technologies. Teacher involvement was the most critical issue in the implementation plan. The training goal was to achieve high motivation and strong commitment of the teachers towards the new technology-based strategies. However, a common denominator that plays against this goal is a dramatic lack of time for innovations on the part of the teachers. We also checked the technological infrastructure at the schools, providing support and solutions when needed[5].

In addition to the definition of the pedagogical strategies, we took an English version of the software content and, considering cultural and contextual differences, transformed it into a Spanish version. Even though the underlying theory and structure of the software tool remains the same as in the English version, contents and exercises were localized to the local culture. Finally, we have conducted activities to collect the data needed for constructing the Diagnostic Chart.

### 2.2 The Sample (2013-2014 Implementation)

In general, the selection of the participating districts was a difficult process. It is obvious that without full support and involvement of the district authorities, implementation was impractical. There were some initially invited districts that were necessary to discard due to their lack of real involvement. All schools within a district were invited to participate, but only a few of them decided to experiment with the CT technology.

During the implementation process, a number of treatment schools dropped out for different reasons: problems with infrastructure, lack of involvement in training, reluc-

[5] Even though the technological infrastructure of public schools in Chile is generally adequate, in some cases we needed to provide local servers and networks due to low connectivity.

tance toward teaching changes, and lack of support from school authorities. Due to the training process most participating teachers were enthusiastic and willing to adopt the new strategies and technology. Some teachers (about 20% of initial participants) didn't have enough time to complete the training. The later ones constituted drop-outs from the implementation and in some cases the school as a whole could not participate. Table 1 shows the total number of participants separated by geographic location (Villarrica is mainly a rural area.)

**Table 1.** Total number of participants by geographic location

| | Schools | Teachers | Courses | Students |
|---|---|---|---|---|
| Santiago | 17 | 36 | 76 | 2915 |
| Villarrica | 5 | 7 | 14 | 340 |
| Others | 4 | 6 | 8 | 95 |
| TOTAL | 26 | 49 | 98 | 3350 |

### 2.3 Culture-Oriented Challenges

Culture-oriented challenges continue to be a significant obstacle in the adoption of new technologies for the classroom and lab as means of improving teaching practices [14]. Based on the literature and best practices in industry [15], in our experimentation we have identified a number of these challenges, which rise up as significant barriers to be dealt with in the implementation of intelligent tutors[6]. We have grouped them in 5 categories or dimensions: (1) Pedagogical processes (teaching & learning); (2) Organizational strategies and structure; (3) Organizational culture (teacher's attitudes towards change and technology); (4) Human resources (teachers' skills and knowledge; student attitudes); (5) Technology acquisition and deployment.

A characterization of these dimensions can be obtained by a series of questions to be answered during the study (i.e., observations, interviews, empirical data analysis), as follows.

(1) **Pedagogical processes (teaching & learning):** Are the actual teaching processes adequate for improved learning? Are these processes student-centered or teacher-centered? Is the technology used to innovate (and improve) the teaching process or just to micro-improve a specific task (i.e., projectors for lectures, e-books for reading)?

(2) **Organizational Strategies and Structure:** Are the organization's structures and strategies adequate to motivate, lead and perform effective changes in the teaching processes? Is it feasible to implement changes in the classroom? Do authorities facilitate resources (equipment, time for training, planning, and implementation) to involved teachers?

[6] We focus here on "organizational" culture as opposed to "ethnical" culture. Notwithstanding, there are organizational issues that may be influenced by the local culture, such as dealing with scarce resources, poor planning and assessment, social unrest, vulnerable student communities, etc.

(3) **Organizational Culture:** Are teachers comfortable-satisfied with the actual pedagogical strategies? Are they committed to introduce changes for improvement? Using the CT technology, was it possible to change the classroom-lab processes? Were the resources assigned (by school authorities) adequate? Were there other critical factors? Do teachers perceive that the resources and support for innovation are adequate?

(4) **Human Resources:** Is the teacher's level of proficiency in the domain (math) adequate for teaching? Do teachers master the features present in the CT technology? Are the teachers confident on the contributions of technology for improved learning? Are they confident on the CT technology? What is the student's attitude towards learning, technology and math?

(5) **Technology Acquisition and Deployment:** Are there enough computers in the lab for a "one computer per student" strategy? Are there enough local area networks (e.g., Wi-Fi) to support the use of the new technology? Is there a sound Internet connection and Web services? Does the school have appropriate technical support?

# 3 Results and Discussion

Using assessment instruments such as interviews and surveys, during the experimentation we have identified specific factors for each dimension of culture-oriented challenges. These factors can be evaluated by means of achievement indicators. The set of dimensions, factors and achievement indicators provide a coherent characterization of culture-oriented challenges found in our study. What follows is a brief description of factors and indicators for each dimension.

## 3.1 Factors and Achievements for Culture-Oriented Dimensions

As shown in Table 2, within the "Pedagogical Processes" dimension we have identified two factors: teaching strategies and teaching tools.

**Table 2.** Factors and Indicators for Pedagogical Processes (Dimension 1)

| Factor | Achievement Indicator |
|---|---|
| Teaching strategies | Facilitates a student-centered process v/s teacher-centered. |
| Teaching tools | Use of technology tools<br>Use of other resources in the classroom (hands-on material, etc.) |

The "Organizational Strategies and Structure" dimension addresses school's organizational structure and strategies for teaching-learning innovations. In this matter, school's authorities have the main saying; they should be motivators and promoters of transformations in the classroom. If authorities are open to changes, it is necessary to verify the feasibility of these transformations. Table 3 summarizes factors and achievement indicators for this dimension.

**Table 3.** Factors and Indicators for Organizational Strategies and Structures (Dim. 2)

| Factor | Achievement Indicator |
|---|---|
| Authorities motivated towards changes | Interested in innovative pedagogical activities (with or without technology).<br>Comfortable with current teaching strategies.<br>Encourages teachers towards changes.<br>Values the use of technology for teaching-learning.<br>Positive evaluation of CT as a new learning strategies |
| Feasibility of implementation | Facilitates pedagogical innovations in the school.<br>Facilitates the use of technology in the classroom. |
| Resources for teacher | Provides enough time for planning activities.<br>Provides extra time for training activities.<br>Provides enough time for implementation.<br>Encourages school community involvement in innovation.<br>Provides resources. |

As part of the third dimension, organizational culture of a school, teachers are the most important agents of change and innovation in the classroom. Table 4 shows factors and achievement indicators for this dimension.

**Table 4.** Factors and Indicators for Organizational Culture (Dimension 3)

| Factor | Achievement Indicator |
|---|---|
| Teacher's motivation towards change | Open to innovative pedagogical activities (with or without technology).<br>Performs innovative pedagogical activities (with or without technology).<br>Feels pleased about current teaching strategies.<br>Encourages other teachers towards changes.<br>Values the use of technology and CT for teaching. |
| Feasibility of implementation in the school | There is enough time for re-planning learning activities.<br>There is enough time for attending training sessions.<br>There is enough time to carry out the implementation.<br>The school community is engage and supportive towards innovation.<br>There are resources to carry out the innovation activities. |
| Training in new contents, methods and tools | Interest in training.<br>Suggests training opportunities to his or her colleagues and school authorities.<br>Participates in training sessions (school authorities initiative)<br>Participates in training sessions (personal initiative) |

Within the "Human Resources" dimension, we consider teachers and students as shown in Table 5.

**Table 5.** Factors and Achievement Indicators for Human Resources (Dim. 4)

| Factor | Achievement Indicator |
|---|---|
| Teacher's tech skills | Mastering technology, at a user level: Internet, desktop tools. |
| Teacher's attitude towards technology | Introduction of technology into the annual or semester class planning<br>Positive opinion towards the use of technology for teaching. |
| Teacher's self-perception towards math | Self-confidence on knowledge for domain area.<br>Masters the learning objectives of the grade he/she teaches. |

| Factor | Achievement Indicator |
| --- | --- |
| Teacher's mastery level of CT software (technology and contents) | Check the lessons in "student" mode.<br>Identifies fundamental strategies present in the CT software<br>Understands CT methodology for problem solving and scaffolding |
| Teacher's confidence with technology based strategies | Self-confidence on his/her technology skills<br>Comfort level regarding technology |
| Student's attitude towards technology | Interested in carrying out activities using technology<br>Positive opinion towards the use of CT in the math classroom<br>High level of comfort in using CT for math learning |
| Student's attitude towards math | Improved perception about math after using the CT technology |

Factors and achievement indicators for the "Technology Acquisition and Deployment" dimension are shown in Table 6.

**Table 6.** Factors and Indicators for Technology Acquisition and Deployment (Dim. 5)

| Factor | Achievement Indicator |
| --- | --- |
| Computers availability | Feasibility for adapting a one-computer-per-student strategy. |
| Internet connection and local networks | Sufficient Internet access and local area networks for full deployment of one-computer-per-student in a class. |
| Technical support | Permanent technical support staff for the lab.<br>Lab administrator present during lab sessions. |
| Exclusive dedication of technical resources | Technical resources used exclusively for educational purposes (as opposed to administrative). |

### 3.2 Diagnostic Chart

Following the dimensions, factors and indicators presented in the previous section, we have constructed a Diagnostic Chart of culture-oriented factors. With this tool we can pin-point those issues that seriously impact or endanger the feasibility of the implementation. Even though the chart is a result of our experimentation, it could be used in future studies to identify pre-conditions to be solved at an earlier stage of an intelligent tutoring endeavor.

**Table 7.** Diagnostic Chart Application: Critical Factors for Drop-Out Schools

| School | Culture-Oriented Factors that Constrained the Implementation |
| --- | --- |
| School 1 | **Dim 2:** Authorities (school principal and academic coordinator) were not motivated towards changing the actual teaching methodology.<br>**Dim 4:** Lack of technological skills among teachers. |
| School 2 | **Dim 2:** Authorities (school principal and academic coordinator) were not motivated towards changing the actual teaching methodology.<br>**Dim 5:** No enough computers; lack of a reliable Internet connection; lack of technical support. |
| School 3 | **Dim 2:** Authorities (school principal and academic coordinator) were not motivated towards changing the actual teaching methodology.<br>**Dim 5:** Lack of a reliable Internet connection and local networks. |
| School 4 | **Dim 5:** Lack of a reliable Internet connection and local networks. |
| School 5 | **Dim 3, 4:** Teachers not open to change. Teachers do not value the use of CT technology. |

We have used the diagnostic chart to assess the results of the experimentation with 26 schools in urban and rural areas. Out of 26 participating schools, 5 of them showed culture-oriented issues that endangered the implementation effort (resulting in drop-outs). These drop-outs and related inhibiting factors are shown in Table 7.

It could be inferred from Table 7 that the most frequent culture-oriented inhibitors (in our experimentation) are the ones related to “Technology Acquisition and Deployment” (Dim. 5), “Organizational Strategies and Structures” (Dim. 2) and “Human Resources” (Dim. 4).

# 4 Conclusions

Based on the analysis of culture-oriented factors encountered during our experimentation, we have constructed an instrument that helps identifying schools likely to drop out from an intelligent tutoring endeavor. Although the sample size is relatively small (5 out of 26 schools drop-out), observations in the field clearly highlight those factors which are critical in the implementation.

Cultural factors that had more impact on our experimentation (diminishing though the feasibility of implementation) are, in order of importance:

- Innovation is not facilitated by school authorities; no interest on innovative technologies.
- Lack of adequate Internet connection and local area networks.
- Lack of positive attitude towards changes (authorities and teachers).
- Teacher’s claim that there are not enough resources to implement.

It can be noticed that there were no cultural issues related to students. According to our surveys and interviews, all drop-outs were due to problems with infrastructure, reluctance toward teaching changes, and lack of support from school authorities. Despite the sense that change was difficult for the teachers and administration, the fact that 100% of non-drop-out teachers and authorities want to continue using the CT technology in the future is an encouraging result that shows motivation and willingness to change once the value of the new technology is established.

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