# Observations of Collaboration in Cognitive Tutor Use in Latin America

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**Abstract.** Cognitive tutoring systems have proven to be effective at improving mathematics learning in economically developed countries, but little is known about how teachers and students use these systems in other cultures. We visited three Latin American countries and observed use of the Middle School Mathematics Tutor in a school in each country. We found that students in these classrooms tended to work more collaboratively than observed students in the United States, in particular engaging in more interdependently-paced work and conducting work away from their own computer. We discuss how cognitive tutors might be improved to be more adaptive to these environments.

**Keywords:** cognitive tutors, collaborative learning, cultural adaptation

## 1 Introduction

There is growing interest in how use of educational software varies across cultures [1]. In our work, we examine the cross-cultural generalizability of cognitive tutors, which compare student problem-solving to a model of behavior, and provide individualized hints and feedback. They have been demonstrated to be successful in classroom contexts [2], but this work has primarily been done in individualist settings. In fact, cognitive tutor design assumes, for the most part, that students are working at their own individual computers and proceed at their own pace. Based on classroom observation, these assumptions are generally met in use of cognitive tutors in American classrooms [3]. It is an open question to what extent the effects of these tutors generalize to collectivist cultures, where individuals are highly integrated into groups and pursue group goals [4]. Assumptions underlying their design (e.g., students work at their own computers and proceed at their own pace) may not be met.

Thus, we visited Brazil, Mexico, and Costa Rica, three countries that are substantially more collectivist than the U.S. [4], and observed student and teacher use of a Scatterplot unit of the Middle School Mathematics Tutor (CT) [3] in each setting. In this unit, students read problem scenarios and plotted two numerical variables on a graph. To do so, they took several scaffolded steps, including labeling axes, choosing a scale, plotting points, and answering interpretation questions. They received feedback on their answers, and could request a hint at any step. We installed the CT in an extant computer lab in each school, which had been donated by the government or a private foundation. These labs were generally unused, as teachers felt that they did not have appropriate educational software or enough time to prepare lesson plans that incorporated technology. Thus, most teachers were enthusiastic about using the CT, which they perceived as requiring little additional preparation, and serving as a good supplement to the exercise-based work that students typically did. All students used the Scatterplot unit for 80 minutes, translated into the local language of instruction. We observed around 100 students in Brazil (12 students per session), 600 students in Mexico (20 to 46 per session), and 90 students in Costa Rica (20 per session). For the most part, sessions were conducted by the students' own math teacher at the school.

## 2 Patterns of Use in Collectivist Cultures

One major element of cognitive tutor use in these Latin American countries was the interdependent pace of student work. For some CT sessions, particularly in Mexico and Costa Rica, the whole class worked at the same pace, led by the teacher guiding students step by step through the tutor. This approach was common during the first 30 or 40 minutes of the session, when students were unfamiliar with the tutor. The teacher would describe a single tutor step, wait as students executed the step on their own computer, and then give students the correct answer. As students acquired more expertise, teachers would instruct them to do a few steps on their own, and then stop the class to wait for everyone to catch up. During these sessions, students typically did not show exploratory behavior with the tutor; they would wait patiently for the teacher to say they could continue, and follow the teacher's instructions closely. As students moved into an individual work phase, their pace of problem-solving often remained interdependent, but in spontaneously formed groups of two or three people seated at adjacent computers. When one student successfully completed a step, they would inform the other group members of the correct course of action, who would then take the correct step and move on. Within any given group, it varied whether one person always took on the explainer role, or whether it switched as different members of the group were more successful at different steps. During this type of work, the teacher circulated around the classroom to help individual students and groups.

In addition to problem-solving interdependently, we found that students frequently helped each other while working on different problem steps, and thus much of their work did not occur at their own computers. Students interacted either from their own seats or by moving around the class. For example, students would frequently call across the room to ask a friend for help, and the friend would cross the room to give help. In some cases, help-related actions were less directed; a student might go from computer to computer looking for the answer he or she needed, or move around the room giving several classmates information about steps that he or she had solved. When probed on this behavior, students explained that everybody needed to finish, and that the performance of their class was important. Students said that they felt kinship with their classmates, given that they often had the same classmates for several years. Teachers encouraged these collaborative behaviors as they circulated around the classroom. The kinds of help students gave varied between settings. In general, help consisted of verbal content, a demonstration by physically taking control of another person's computer, or a combination of the two. The verbal content of help ranged from domain answers to technology-related help to full explanations, and appeared to be related to the prior knowledge of each collaborating student.

## 3 Augmenting Cognitive Tutor Design

In this cross-cultural project where we deployed one unit of the CT in schools in three different Latin American countries, we found that, compared to previous work on classrooms in the U.S., students worked more interdependently and spent more time doing work away from their own computers. One improvement to cognitive tutor design suggested by our observations involves modifying knowledge tracing algorithms to account for the possibility that certain students are problem-solving at the same pace. It may even be possible to determine over time which students' performances are linked, by tracking the timing of different students' steps. Students' collectivist behaviors also reflect an opportunity to actively encourage students to seek and give help at appropriate times during their problem-solving, from appropriate people. If a student is clearly struggling, the system could encourage them to go seek help from someone who has already mastered the relevant skill, and if students have mastered a skill quickly, they could be encouraged to help others who have not mastered it. Additionally, when students are judged to be receiving help, it may be effective to introduce scaffolding encouraging students to provide a self-explanation of the demonstrated problem-solving step. In general, regardless of the reasons for the differences observed, it will be productive to expand cognitive tutor design to be more adaptive to collaborative behaviors. If these behaviors are indeed common in CT use in these countries, having systems that can detect and respond to them would likely improve their effects. These behaviors are arguably a desirable way to use cognitive tutors [5], and should be fostered when they occur naturally.

**Acknowledgments.** Thanks to all the teachers who made this study possible. Thanks to Sofía Pachaco, Xareni Alvarez, Etmon Vega, and Ruth Wylie for their help.

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