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Psychological Behavior of English Learners Utilizing a Cognitive Tutor in an Online Pre-Calculus

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PSYCHOLOGICAL BEHAVIOR OF ENGLISH LEARNERS UTILIZING A COGNITIVE TUTOR IN AN ONLINE PRE-CALCULUS COURSE

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The educational landscape is becoming a digital learning environment. Students in today's digital world draw from multiple sources of information; from hypertext, videos, social media, to video games and internet searches (Luke, 2005). English Learners, individuals learning two languages at once, who use software written in English have a passive relationship with the computer when software is not in their native language. They feel that this educational software belongs to another culture. This paper will present findings from a study with English Learners' engagement in a fully online pre-calculus course. The authors utilized Cultural-Historical Activity Theory to describe how English Learners' created authentic bilingual learning environments and improved their self-efficacy for mathematics.

INTRODUCTION

According to Lev Vygotsky (2012), humans learn through discourse and social contact; in online environments, this could be through email, course forums, texting, webinars, and blogs (Harasim, 2012). Griffiths et al. (1994) opined that cultural and language adaptation of software for non-English cultures could be beneficial. These researchers felt that software written in a student's native language could benefit students socially, educationally and financially. Translating math software can be yet another tool for oppressed students to create equitable learning opportunities.

Studies which investigate translanguaging, best practices, and literacy in teaching mathematics for English Learners are numerous in the educational literature (Esquinca, 2011; Moschkovich, 1999; Moschkovich, 2007; and Remillard, & Cahnmann, 2005; Tahar et al., 2010). Self-efficacy and learning attitudes research is also an area studied in great depth (Canfield, 2001; Di Martino, & Zan, 2010; Freeman, 2012; Muilenburg & Berge, 2005; Reed, Drijvers, & Kirschner, 2010; Rivera, & Waxman, 2011; Spence, & Usher, 2007; Tahar et al., 2010). As more universities are offering more and more online mathematics courses, the necessity to study how English Learners engage with technology in a mathematics class and how this affects their self-efficacy is significant. This mixed-methods study focused on how English Learners utilized their digital practices to create equitable bilingual educational environments in an online pre-calculus course.

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THEORETICAL FRAMEWORK

Bandura (1977) defined self-efficacy as a belief in one's ability to perform at a certain level. Students with a higher self-efficacy were found to have better test scores and achieved greater success in their mathematics classes (Freeman, 2012; Kitsantas, Cheema, & Ware, 2011; Rivera & Waxman, 2011). These studies implemented factor analysis on student surveys and questionnaires to quantify and measure self-efficacy and attitudes towards mathematics. Rivera and Waxman (2011) found that self-efficacy influenced English Learners' resiliency in a mathematics classroom. A positive self-efficacy had a positive effect on the math course, whereas a negative self-efficacy had a negative effect.

Moschkovich (2007) found that language was an important aspect of positive attitude and self-efficacy. Students were found to improve mathematical conceptual knowledge when they were allowed to use their preferred language. When a Latin@ immigrant performs basic arithmetic calculations, they mentally perform these calculations in the language of instruction, which for many was in Spanish (Moschkovich, 2007). Moschkovich (2010) opined that mathematics researchers should be more concerned with how language use relates to mathematical learning than "with making subtle distinctions among different language practices" (p. 130). Using language in learning mathematics may be far more evident in an online environment, where a student may have to find the meaning of mathematical terms and vocabulary by searching the internet.

Cultural-Historical Activity Theory (CHAT).

Socioculturalists, Vygotsky, Rubinshtein, Leont'ev, and Luria, are credited with developing Cultural-Historical activity theory (CHAT), also referred to as Activity Theory (Blunden, 2010; Engeström, Miettinen, & Punamäki, 1999). Yrjö Engeström developed what is considered the third-generation of CHAT, in which the unit of analysis is a network of activity systems and the inherent tensions that arise in the learning process (Blunden, 2010; Engeström et al., 1999; Engeström 2001). In activity theory the unit of analysis is the activity by which the subject is mediating tools or artifacts in the realization of a goal; the goal is referred to as the object (Engeström et al., 1999; Lantolf, Thorne, & Poehner, 2015; Yamagata-Lynch, 2010). The activity in which the subject engages is additionally influenced by the procedures which govern the social community in which the subject resides and by the tasks, or roles, of that community (Engeström et al., 1999; Yamagata-Lynch, 2010). Activity theory is consistent with ethnographic studies that focus on behavior and activity to describe and explain human experiences.

METHODOLOGY

This study utilized an embedded-exploratory design where findings emerged from the analysis of qualitative data which was supported by findings from quantitative data (Creswell & Clark, 2007). The embedded-exploratory methodology utilized in this study provided the researchers access to the lived experiences and digital practices of several English Learners participating in an online pre-calculus course over three semesters. An IRB proposal was submitted and approved for this study. This study was conducted in an online pre-calculus course over four semesters, from 2014 through 2016. Through a CHAT framework, the author employed an embedded-exploratory design to analyse qualitative data supported by quantitative data.

Analysis of the multilayered qualitative data through an activity theory lens illuminated the complex relationships English Learners developed between the mathematical content, their academic language proficiency, and online sociocultural environments. English Learners were able to make cognitive connections between prior knowledge learned in their native language, Spanish, and new topics learned in English. However, tensions arose with English Learners' attitudes towards learning new material in English and their self-efficacy. These tensions lead the authors to develop an activity system diagram to fully describe English Learners' digital learning environments.

SETTING AND DATA SOURCES

Data was gathered from one demographic survey, two self-efficacy surveys, weekly course forum questions, weekly logs with screen shots, email interviews with focus groups, and face-to-face interviews with two key-informants, in an attempt to understand the digital practiced of English Learners participating in an online pre-calculus course.

FINDINGS

An activity system was developed by the authors of this study to explicate English Learners' mediation of the translation capabilities in an intelligent tutoring system and an online translator (Figure 1). English Learners made meaning of English vocabulary and mathematical lexicon by mediating the software translation capabilities and online translators. Figure 1, articulates the complex actions of English Learners within a sociocultural educational environment. English Learners followed course procedures (Rules), were engaged in the online pre-calculus course (community), and were meaning consumers while mediating the online translators (mediating artifacts). Figure 1 displays the six components of Engeström's (1999) activity system with arrows to indicate the tensions between each component that were encountered in the online pre-calculus course. These tensions were the unfamiliar Spanish dialects or translations English Learners encountered.

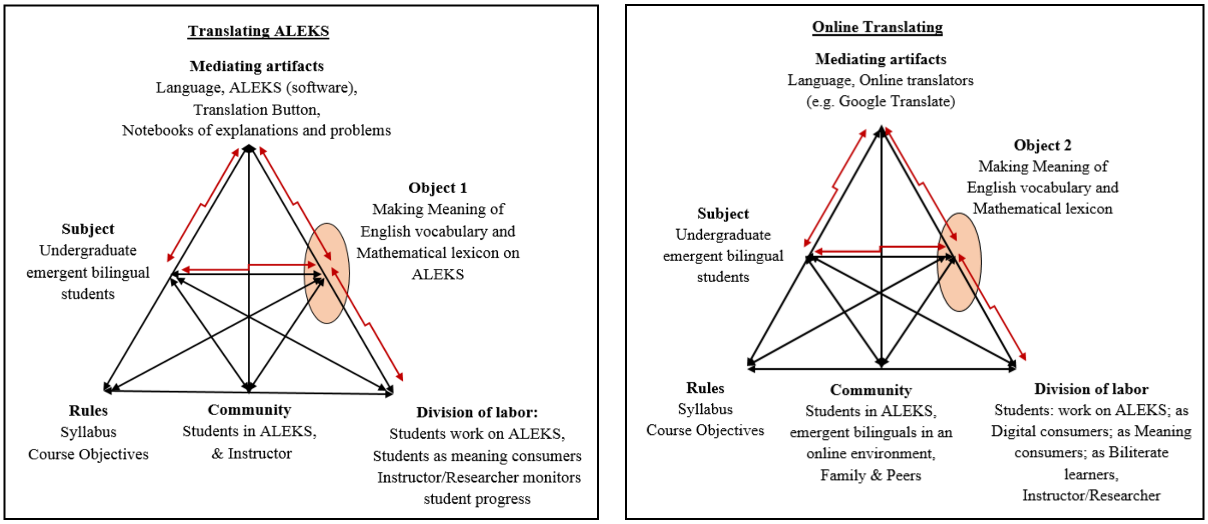

Figure 1. Activity system for translating online software and mediating online translating software with tensions depicted by red arrows.

A two-way multivariate analysis of variance was conducted on the Mathematics Self-Efficacy Survey (MSES) pre- and post-surveys (N=13) with the two independent variables being the MSES survey scores and translating the software. A representative group of ten English-dominant students was used to compare with emergent bilingual key informants. The analysis showed that there was no statistically significant interaction nor a correlation between the MSES scores and whether a student translated the software with their self-efficacy, the dependent variable ($F(18,5)=0.316$, $p=0.968$; Wilks' $\Lambda=0.468$). A two-way multivariate analysis of variance was also conducted on the Mathematics and Technology Attitudes Scale (MTAS) pre- and post-surveys (N=13), with the two independent variables being the MTAS and whether a student translated the software or not. The analysis showed that there was no statistically significant interaction between self-efficacy, the dependent variable, with mathematics and technology and whether a student translated the software or not, $F(20,2)=0.326$, $p=0.961$; Wilks' $\Lambda=0.039$). There was, however, a statistical correlation between translating the software and individual survey items. The findings discussed next result from descriptive analysis.

English Learners in this study developed confidence in their mathematical skills when they utilized their digital literacies to find solutions to the online practice problems. English Learners believed that they could master a computer program needed for school. Their self-efficacy in the use of smart devices also increased at the end of the semester. One Spanish-dominant participant reflected the sentiments of many participants when she stated: "I feel confident [with ALEKS, the online software] and look forward to what is next." English Learners utilized their digital meaning making strategies to show a marked improvement in their self-efficacy.

The MTAS showed that English Learners increased their self-efficacy on several key items while their English-dominant counterparts' self-efficacy decreased (Figure 2).

Translating the online software and utilizing online translators allowed English Learners to make meaning of English vocabulary and increased their attitude towards class required computer programs. English Learners developed agency in their mathematical education and increased their mastery of the mathematical topics through their digital practices. For English Learners, this translated to mastering any computer program required for school. Finally, English Learners developed a complex network of digital activities that allowed them to learn mathematics in both English and Spanish, leading to their belief that they do in fact have a mathematical mind (Item 9, Figure 2).

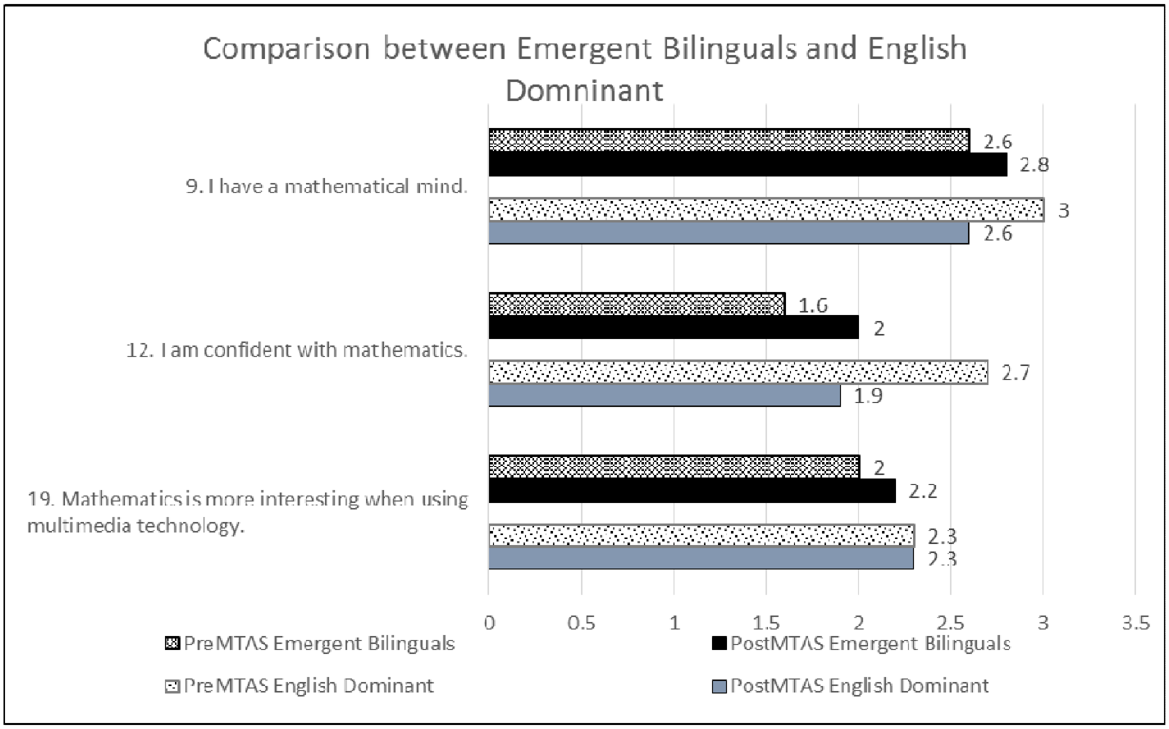

Figure 2. Bar graph showing English Learners increase in self-efficacy vs English-dominant participants' decrease or stagnation in self-efficacy.

SCHOLARLY SIGNIFICANCE

These findings contribute to the literature on English Learners' in several ways. The digital practices of English Learners' proved to be a complex sociocultural endeavor which they created and mediated. Translating software into an English Learners' native language allowed for participants agency in creating an equitable learning environment. Utilizing software translation capabilities and online translators gave English Learners an opportunity to make meaning of English lexicon and mathematical syntax. Researchers and practitioners of online mathematics courses may find that allowing students, in particular, English Learners, to mediate translation utilities may create a bilingual digital mathematics course in which English Learners can acquire academic mathematical literacy.

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