

# Change in mathematics teaching practices through an international teacher exchange program \*

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## Cambio en prácticas docentes de matemáticas en un programa internacional de intercambio de maestros

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## Mudança nas práticas de ensino de matemática em um programa internacional do intercâmbio de professores

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## Abstract

Changing mathematics teaching practices among elementary and secondary teachers was studied across two groups of teachers, one from Guatemala and the other from the United States. Teachers participated in the International Teacher-to-Teacher Exchange program that offers teachers in the two countries an opportunity to explore each other's cultures and mathematics teaching methods, for the purpose of changing instructional practices. Researchers examined individual action research plans, implementation, reporting strategies, and perceived changes in teachers. Concerns Based Adoption Model instrumentation was used to determine stages of concerns and levels of use of the Action Research innovation. Results of document analysis, interviews, and observations indicated that five of six teachers changed practices with variance across the group, with only four changing practices in mathematics. All teachers reported they benefited from the exchange and noted that the changes they made were a direct result of the experiences gleaned from the exchange.

*Keywords:* mathematics, teaching practices, CBAM, action research.

## Resumen

El presente estudio se enfocó en el cambio de las prácticas docentes en el área de matemáticas en dos grupos de maestros de enseñanza primaria y secundaria, uno de Guatemala y otro de los Estados Unidos. Los docentes participaron en un programa de intercambio de maestros que les dio la oportunidad de explorar las culturas y métodos de enseñanza de las matemáticas respectivos. En sus centros educativos de origen los docentes, durante un periodo de seis meses, implementaron un plan de acción investigadora orientado a promover el cambio de métodos pedagógicos. A fin de determinar las etapas de preocupación y el nivel de uso de la acción investigadora, el estudio utilizó instrumentación basada en el Concerns Based Adoption Model. El análisis de documentos, entrevistas y observaciones indica que cinco de los seis maestros participantes cambiaron sus prácticas docentes, aunque con variaciones entre unos y otros. Todos los maestros declararon haberse beneficiado del intercambio y expresaron que los cambios fueron un resultado directo de las experiencias obtenidas durante el intercambio.

*Palabras clave:* matemáticas, prácticas docentes, CBAM, acción investigadora.

## Resumo

O presente estudo focalizou-se na mudança das práticas docentes na área de matemática em dois grupos de professores do ensino primário e secundário, um da Guatemala e ou outro dos Estados Unidos. Os docentes participaram de um programa de intercâmbio de professores que lhes deu a oportunidade de explorar as culturas e os métodos de ensino das matemáticas nas respectivas instituições. Em seus centros de ensino de origem os professores, por um período de seis meses, eles implementaram um plano de ação investigadora orientada para a promoção de câmbios de métodos de pedagógicos. Com o fim de determinar as fases da preocupação e o nível de utilização da acção de pesquisa, o estudo utilizou instrumentação baseado no Concerns Based Adoption Model. A análise de documentos, sondagens e observações indica que cinco dos seis professores participantes mudaram suas práticas de ensino, embora com variações entre uns e outros. Todos os docentes declararam que se tinham beneficiado com o intercâmbio e disserem que as mudanças foram um resultado direto das experiências obtidas durante o intercâmbio.

*Palavras-chave:* matemáticas, práticas docentes, CBAM, acção investigadora.

## Introduction

The latest school enrollment projections in the United States are indicative of a major shift in the ethnic, cultural, and linguistic makeup of the student population in grades K-12. According to data from the U.S. Department of Education, the period between 2011 and 2022 will experience a six percent decrease for Whites and a 33 percent increase for Hispanics (Hussar & Bailey, 2013). This trend will exacerbate the current ethnic mismatch between teachers and students. Today, only six percent of teachers are Hispanic, although Hispanic students account for almost one-fourth of the student population (Feistritzer, 2011). Some authors have mentioned this disparity as a possible contributor to the high dropout rates among Hispanics (Lofstrom, 2007). In particular, the academic attainment of students of Guatemalan origin in the United States has been found to be lower than the Hispanic population overall (Brown & Patten, 2013).

Statistics on students' success in mathematics in the country of Guatemala, as reported by the World Bank (2004), Guatemalan government (2012), and *Empresarios por la Educación* (2014) indicate low levels of performance throughout the country, particularly among indigenous children in poverty. Besides, when compared to other countries' mathematics performance on The Infant Mortality and Morbidity Studies [TIMMS] (2012) and PISA (Institute for Educational Studies, 2014) reports, Guatemala is not included.

However, internal Guatemalan sources (Avivarra, 2014) show how Guatemalan students perform far below students in both TIMMS and PISA reports when compared to other countries in the world, including Latin American countries. The findings indicate that teacher preparation, access to resources, and instructional spaces contribute to the gap. Many Guatemalan students who immigrate to the United States bring these mathematics performance levels as part of their educational portfolio.

Two confluent circumstances are surrounding Guatemalan children, in Guatemala and the United States, involve teachers of mathematics. In Guatemala, teachers are generally underprepared, work in challenging situations, and have few resources, rendering underserved children. In the United States, the academic gap, based on ethnic origin and the ethnic divergence between teachers and students, contributes to lowered performance in mathematics among Hispanic immigrant learners. For the sake of students' mathematics learning, in both settings, a change in teaching attitudes and practices was warranted.

Hall and Hord (2010) note that change is a process that requires support, encouragement, and understanding on the part of change facilitators. When these three elements are applied, the likelihood of change occurring and sustaining increases considerably. Additional findings revealed that change in education occurs by implementers (teachers), rather than by those who design educational inno-

vations (administrators). They point out that change is based on teachers' personal perceptions of the change as well as their commitment to using the innovation in some form of fidelity. Change facilitators serve as sounding boards, encourages, and support personnel, who seek to provide whatever is necessary for teachers to embrace change and see it through. The result of Hall and Hord's work was the Concerns Based Adoption Model (CBAM), a method for assessing change in educational environments.

This study shows the influence of an international teacher exchange program, a facilitative change entity, on the instructional practices of six teachers, three in the United States and three in Guatemala. The underlying assumption of this facilitator-supported program was that the teachers' participation in the exchange would result in changed practices in all six classrooms. In the United States, it was assumed that the program would result in an increased awareness of and a desire to implement a more culturally relevant pedagogy. In addition, the study sought to ascertain whether being part of the teacher exchange encouraged U.S. teachers to change and think not only in terms of student achievement but also to help students "to accept and affirm their cultural identity" (Ladson-Billings, 1995, p. 469) while at the same time support students in developing a positive mathematics identity through the use of culturally relevant practices (Leonard, Brooks, Barnes-Johnson & Berry, 2010). In Guatemala, it was assumed that tea-

chers would change their practices to be more student-centered, hands-on, and engaging, with less emphasis on test scores and homework. The purpose of this study was to examine whether an International Teacher-To-Teacher Exchange program (ITTTE) between Guatemalan and U.S. mathematics teachers would affect change in instructional practices across both sets of teachers.

## Questions

- Question 1: What was the effect of the ITTTE on the Guatemalan and American mathematics teachers' change in teaching practices?
- Question 2: How did American and Guatemalan mathematics teachers' concerns about and levels of use of the innovation (changed mathematics instructional practice) evolve after participating in the ITTTE?

## Design

The design was a multiple case study. Case study methodology examines individual cases (people, classrooms, schools) and when several are included in one study (multiple cases), the findings across all case studies are used to determine trends in the case (Stake, 2005). In consequence, this paper provides a thick description of the activities of six teachers during their participation in the ITTTE program. To this effect, a considerable amount of time was spent on site with the teachers, including two weeks in the summer of 2014 during

the stay in the Guatemalan city of Antigua, as well as monthly visits with U.S. teachers during the 2013-14 school year. This allowed the researchers to be “personally in contact with activities and operations of the case, reflecting, and revising descriptions and meanings of what is going on” (Stake, 2005, p. 450).

This study used the CBAM (Hall & Hord, 2010) to study the mathematics instructional changes teachers underwent based on their participation in the ITTTE project. The two main components of the CBAM are concerns about and use of the innovation. Three instruments that inform concerns and use are the Stages of Concerns Questionnaire (SoCQ), the Innovation Configurations (IC) map, and the Levels of Understanding (LoU). They will be described in the methods section of this article.

## Related literature

### Concerns based adoption model

CBAM, created across over a decade of study of change in education, was analyzed for use in measuring change in educational settings and found to be an effective tool regarding curricular and instructional innovations (Anderson 1997). Tunks and Weller (2009) applied CBAM tools in the study of elementary and middle school teachers who were changing their mathematics instructional practice to include algebraic thinking. The use of the three tools, the Survey of Concerns Questionnaire (SoCQ), the Innovation Configuration

(IC) map, and the Levels of Use (LoU) matrix, revealed that teachers’ instructional practices changed when they embraced the vision of the innovation, and used the support systems available from change facilitators in the project. Chamblee, Slough, and Wunsch (2008) studied mathematics teachers’ use of graphing calculators in the classroom and employed the SoCQ. The authors found that teachers were at the Impact stage of concern. Christou, Eliiophotou-Menon and Philippou (2004) also used the SoCQ when they surveyed six hundred mathematics teachers about the use of a new textbook. The results showed variance in response based on years of service. Newer teachers shared more personal concerns, whereas veteran teachers’ concerns were in the categories of task stages. Khoboli and O’Toole (2012) applied CBAM methodology in a study of teachers engaged in action research that led to changes in instructional practices from teacher-centered to student-centered. The CBAM tools served to inform researchers about when and if changes were occurring among teachers in the various projects, including action research projects.

Action research conducted by classroom teachers has resulted in changed practices, attitudes, and relationships with students (Bradley-Levine, Smith & Carr 2009; Colucci-Gray, Das, Gray, Robson & Spratt, 2013; Feldman & Weiss, 2010; Haggarty & Postlethwaite, 2003; Ross & Bruce, 2012). Authors found that when teachers were empowered to conduct action research, supported by university personnel, change occurred. However,

when university personnel led the research, teachers showed greater reluctance to change (Li, 2008; Postholm, 2009). The studies tracked changes that were mandated by administrators and outside personnel other than teachers. Action research was used as a means of assisting teachers in dealing with the change.

Some researchers noted specific changes in mathematics teaching practices. Bonner (2006) found that when bilingual teachers used action research to study their instructional practices they noted that they began to value student reasoning after their practices were more student-centered. Students also reported higher levels of competence and confidence in doing mathematics problems. Liljedahl (2010) found that mathematics teachers changed practices when engaged in open discussions with other mathematics teachers regarding conceptual understandings of mathematics as related to how students report their conceptual understanding. In multiple cases, mathematics teachers, when engaged with other mathematics teachers in think tanks, willingly changed tried and true practices. Huillet *et al.* (2011) found that when mathematics teachers engaged in action research, in an attempt to change practice, teachers whose limited mathematics knowledge were revealed experienced a resistance to change. They also found that some knowledge bases were not developed fully, rendering change unrealized. These studies of change in mathematics teaching resulting from action research varied with the implication that if instructional change

affected student learning, the likelihood of teacher change was heightened.

### International teacher exchange

The growing number of students with diverse racial, ethnic, linguistic, religious, socio-economic, and cultural backgrounds in schools today has placed new demands on teachers, who are now expected to apply elements of a multicultural education in their instruction (Pérez & Torres Guzmán, 2002). However, understanding the cultural nuances that students bring to schools requires an active engagement in field experiences beyond the classroom (Lupi & Batey, 2009). International and intercultural field experiences have the potential “to prepare teachers to address the challenges associated with teaching children in a global age” (Cushner & Brennan, 2007).

Culturally responsive teachers, as proposed by Villegas and Lucas (2002), benefit from their participation in initiatives that broaden their cultural understandings (Alfaro 2008). These experiences have long-lasting effects regarding the global perspectives gained by the participants (Batey & Lupi, 2012) and the value of cross-cultural practices (Lee, 2009; Willard-Holt, 2001). Among these are “professional and personal changes, such as an increased confidence and a better appreciation and respect for differences of others and other cultures” (Pence & Macgillivray, 2008, p. 14). Other benefits of international teaching experiences

include an increased interest in global issues and a complete understanding of their role as educators (Dunn, Dotson, Cross, Kesner & Lundahl, 2014).

These studies of exposure and experience do not address levels of change in teachers' practice following the international engagement opportunities discussed. In essence, there are no indicators that the elevated perceptions of culture led to changed instructional practices. Consequently, this study attempted to fill the gap in this area by examining the outcomes of teacher exchange programs on participating teachers about changed mathematics teaching practices of teachers from both the United States and Guatemala.

## Method

### History of ITTTE project

The ITTTE project was born out of years of observations of mathematics teaching in the United States and Guatemala. In these observations, it was noted that concerns differed among teachers in both countries. The Guatemalan teachers' instructional practices were teacher-centered and predominantly based on lectures. The American teachers experienced difficulties relating to their Hispanic students, and this distance resulted in a low academic motivation for students. The connection between both was immigrant students. This prompted a study of mathematics teaching in Central America since many students migrate from this region to the

United States. A six-month ethnographic study was conducted in Guatemala in 2011 (Tunks, 2012). Daily observations showed that teachers taught as they had been taught for decades, in route, teacher-centered manner. There were no support systems available for students whose understanding of mathematics was limited. Based on this study, it was determined that both populations of teachers had needs and contributions to make to each other. The assumption was that both could benefit from living, attending school, and engaging socially with each other, in each other's settings.

### Subjects

The participants were six teachers, three from Guatemala and three from Texas. The years of teaching experience ranged from six to twenty-five. The grade levels taught ranged from fourth through high school. Teacher preparation ranged from three years of post-middle school observation and teaching (Escuelas Normales in Guatemala) to master's degrees from U.S. universities. Several teachers taught only mathematics while others taught multiple subjects. Five of the participants were women. The Guatemalan teachers' primary language was Spanish, and the U.S. teachers' was English.

## Settings

### Guatemala

The private school where the three Guatemalan teachers taught is on several acres of land, set off from the town of

Antigua, Guatemala. The school caters to both foreign and Guatemalan students, pre-kindergarten through high school. The classrooms are set up with a white-board, desks in rows and few teaching materials other than a dry erase marker and eraser. Following the first year of the project, the school created a mathematics laboratory, with mathematics manipulatives, overhead projector, tables and chairs. Each mathematics teacher, K-12, uses the mathematics lab for 45 minutes each week. There are approximately between 20 and 30 children in each classroom.

### United States

The two public schools (one elementary/primary and one middle school) are set in Denton, Texas, a rural/urban district north of the Dallas-Fort Worth Metroplex. The classrooms vary, with two of the three organized in tables and chairs, and a flexible environment for exploring mathematics ideas. The third is formatted in desks in rows. All three classrooms are equipped with multiple sets of mathematics manipulatives, document cameras, computers, graphing calculators, laser technology, and a myriad of communication devices ranging from graph paper to individual white boards. Classroom size ranges between 23 and 35 students.

## Instruments

### Survey of concerns questionnaire

The instrument includes thirty-five stem statements that examine respondents'

personal perceptions of the innovation, in this case, the use of action research to change mathematical instructional practices. The range of responses to the thirty-five items, from irrelevant to very true for me now, leads to a profile of teachers' perceptions that classify them as either self, task, or impact directed. The respondent reads a stem statement using the four categories of 0–irrelevant, 1–not true of me now, 2–4–somewhat true of me now, and 5–7–very true of me now. The items are sorted by stages of concerns: 1–unconcerned, 2–information, 3–personal, 4–management, 5–consequence, 6–collaboration, and 7–refocusing. Five items relate to each of the seven stages. The ratings across the five items for each category are compared to a percentile score sheet. What results from the analysis of data is a concerns profile for each person. The profiles are charted individually, signifying the percentile rank of each stage, for each person.

### Innovation configuration map

An IC map is a tool developed to include configurations of an innovation, in this case, the configuration of action research. The components of frequency (implementation of action research plans), fidelity (level of implementation), and reporting (electronic data collection) indicated the categories of behaviors tracked during observation of electronic and personal data collection. Each component was further delineated by variances of observed use within each component.



Table 1. Stages of concern

Dimension	Stage	Expression of Concern
Impact	6 Refocusing	Ideas that might work better
	5 Collaboration	My practice related to others' practice
	4 Consequence	Effect of the innovation on learners
Task	3 Management	Time spent preparing resources
Self	2 Personal	Affect on me
	1 Informational	Need to know more
	0 Awareness	Unconcerned

Source: Tunks & Weller (2009).

Table 2. Innovation configuration checklist (ICC matrix)

Component 1: Frequency (Implementation of Action Research plan)
Variance of Performance
1. Daily
2. Weekly
3. At least twice a month
4. At least once a month
5. Occasionally
Component 2: Fidelity (Level of implementation)
Variance of Performance
1. All aspects
2. Some aspects
3. A few aspects
4. Other actions not in research plan
5. Plan not related to original AR plan`
Component 3: Reporting (electronic data collection)
Variance of Performance
1. Every month
2. Bi-monthly
3. Every three months
4. In one entry at the end of project
5. Data unrelated to project

## Levels of Use Matrix

The LoU matrix has eight levels and seven categories. The eight levels include: 0–non-use, I–orientation, II–preparation, III–mechanical, IVA–routine, IVB–refinement, V–integration, and VI–renewal. The seven categories include: knowledge, acquiring information,

sharing, assessing, planning, status reporting, and performing. The matrix serves as a tool by which information from observations and interviews can be combined to create a profile of behaviors indicating the use of the innovation, in this case, changed mathematics teaching practice, based on teachers' implemented action research plans.

Table 3. Levels of use (LoU) inventory

Level	Description of Level	Behavior Indicators
0	Non-use	No interest, taking no action
I	Orientation	Taking the initiative to learn more
II	Preparation	Has definite plans
III	Mechanical	Making changes to better organize
IVA	Routine	Established pattern of use
IVB	Refinement	Making changes to increase outcomes
V	Integration	Making deliberate efforts to coordinate with others
VI	Renewal	Seeking more effective alternatives

Source: Tunks & Weller (2009).

## Data Collection

### Survey

Survey of concerns was administered to all teachers, in English for the U.S. teachers and in Spanish for the Guatemalan teachers, at the end of the six-month action research implementation.

### Observations

Teachers were observed implementing action research plans. The observation method for five teachers included distance observation, primarily based on

teachers' reporting in an electronic portal (Dropbox). The reports chronicled the implementation of each action research plan, by each teacher, with a frequency of reporting varying among teachers. One teacher, whose plan included using more Spanish words when teaching, was observed with an observation protocol that tallied word usage by the teacher and students. Data in Dropbox were reviewed for variance of frequency of implementing the action research plan, fidelity to action research plan of changed mathematics teaching practice, and reporting frequency in Dropbox. Observations were mapped on the IC

Map for each teacher at the end of the project. Data from the IC Map were interpreted and mapped onto the Levels of Use matrix.

## Interviews

Teachers were interviewed individually for 30-45 minutes, at the end of the six months of the action research project implementation. The interviews were based on the action research plans submitted, the actions taken, and the results for both the students and teachers. The interviews were unstructured but followed the IC map configurations of frequency, fidelity, and reporting. Also, teachers were asked to describe their experiences in the project overall, with a request for additional suggestions for improvement. The interviews were recorded digitally and uploaded into a computer assisted qualitative analysis package. Using an inductive approach

(Lewins & Silver, 2007), codes were grouped into categories, which led to the appearance of themes. Interviews were interpreted and mapped onto the Levels of Use Matrix.

## Action research plans

These were collected from each teacher before the beginning of the Action Research phase of the study. Teachers provided explanations of the following regarding their mathematics instruction: 1) student-centered problem/need noted in the classroom, 2) a plan of action to address the problem/need, 3) data collection and data analysis which were collected in a shared online site. The teacher action research plans varied by the teacher, as each chose research based on problems they observed either in their teaching or students' performance in class.

Table 4. Teachers' Action Research Plans

Teacher	Action in Action Research Plan
Teacher 1	Use 25 words and/or phrases common in Spanish in my classes. Enhance students' cultural self-awareness.
Teacher 2	Share my experiences about the Guatemala Exchange program. Encourage students to bring artifacts or information about their culture. Adopt a more relaxed attitude in school. Show empathy for the cultural and linguistic struggles of my students. Incorporate the Guatemalan teachers in my classroom environment.
Teacher 3	Incorporate artifacts of culture into several lessons, encouraging students to share elements of their cultures. Use currency exchange rates to reinforce multiplication and division. Highlight how different cultures have contributed to mathematics.

Teacher	Action in Action Research Plan
Teacher 4	Move from concrete to abstract learning. Use a student journal.
Teacher 5	Use the math lab to apply daily life concepts to mathematics. Collect feedback from games, songs, collages and student reflections. Make a math toolbox with scissors, rulers and calculators for each student. Assess students once a week for at least three application problems. Make mathematics fun and related to the environment. Share my experiences with other colleagues.
Teacher 6	Use technology. Use manipulatives. Move from concrete to abstract learning. Allow student initiatives and engagement.

## Results

This section presents the results of the study regarding the two research questions. The questions were:

- Question 1: What were the American and Guatemalan teachers' perceptions of the influence of the ITTTE on their mathematics teaching practices?
- Question 2: How did American and Guatemalan mathematics teachers' concerns about and levels of use of the innovation (changed mathematics instructional practice) evolve after participating in the ITTTE?

### Question 1

This question was answered examining the data from the IC matrix and the exit interviews conducted with the teachers. The first allowed us to place the teachers' observed behaviors during

the six months of implementation of the action research plans in the categories of frequency, fidelity, and reporting. The analysis of the interviews was based on grounded theory, with themes emerging as the data was collected and analyzed. Using an inductive approach, two main themes were identified: 1) Teacher perception of participation in the ITTTE program and 2) Teacher perception of change.

#### *Teacher perceptions of participation in the ITTTE program*

All teachers had a positive perception of their participation in the ITTTE program. During the interviews, some emphasized the effect of working with teachers from another country:

T2: The evidence is there in the culture of my classroom, in the feeling of my classroom, when you walk in there, it is just such an open environment.

T3: I think we learned a lot from the other teachers, taking their methods and applying them in our classrooms.

Teacher 5 remarked the change she experienced in the way she taught mathematics. When asked if she taught mathematics differently after participating in the teacher exchange, she replied:

T5: Yes, playing, sharing, with more activities.

This teacher moved from a teacher-centered instruction to allowing students to use manipulatives and implementing hands-on activities. Teacher 2 agreed with the significance of the exchange, observing the importance of sharing this experience with teachers from another country.

### *Teacher perceptions of change*

All teachers had been asked to design and implement an action research plan containing an innovation or element of change. Five of the six teachers (T1, T2, T4, T5, and T6) expressed satisfaction about the impact of change, including a sense that their participation in the program had fulfilled their expectations:

T4: How can I help [other teachers at the school]? Disseminating what I have learned and helping the mathematics teachers to replace their instructional methods for new ones, assisting them to have an open mind toward other instructional approaches. Now, I adapt my instruction to the needs of the student.

The change was also perceived as vital because it affected their students in critical ways. Speaking about how participation in the ITTTE program had changed her classroom environment, one teacher expressed the following:

T2: it made it be a place where they would be proud of who they are, proud of being different, and confident. It enabled me to make connections with students who are hard to reach, even non-Hispanic students.

These excerpts indicate that the teachers not only perceived their participation in the program as a fundamental element in their personal and professional development but also remarked on the impact of their change in their own students. This impact, according to Teacher T4, reached parents:

T4: I am pleased seeing that the children are learning with the new mathematic materials and knowing that parents are going to use these new mathematics strategies at home.

However, teachers also reported some limitations to the scope of change. These limitations related to the inability to implement certain aspects of the innovations outlined in their action research plans. For example, Teacher T3 remarked:

T3: I just didn't have that class time to be able to do that. I wasn't able to incorporate as many [cultural artifacts] as I wanted to.

In another instance, the demands of standardized testing were cited to justify the inability to implement the innovation. Teacher T5, when asked why the value blocks had not been used, replied:

T5: We are preparing the children for mathematics testing.

## Question 2

The CBAM instruments yielded data that addressed Question 2.

### *Survey of concerns*

Findings from the SoCQ indicated that teachers varied individually to some degree, but certain trends were noted. Four of the six teachers showed moderate concerns about being unconcerned with the innovation (20-50 percent range). However, two of the teachers showed a high (90-99 percent) concern about being unconcerned. Five of six teachers showed concerns about needing more information (40-70 percent), with one at the 99 percent in this category. All teachers peaked in the personal stage (40-99 percent). These data suggest that overall the teachers showed moderate to high concern with issues related to self as action researchers in the mathematics classroom. The concern for self was evident across all participants.

Regarding the task of conducting action research to change practice, teachers ranged from almost no concern (15 percent) to one teacher who registered at the 80 percent on the task concern. The other teachers fell in between these

two outliers, showing concerns within a range of 15-55 percent. The implication of these findings suggests that the teachers had concerns about how to manage teaching changes through the process of action research, but that they did not seem overwhelmed by the management of the project.

Impact aspects of the stages of concerns include consequence (concerns about students' learning), collaboration (working with others to work on the innovation), and refocusing (envisioning another approach, or projecting into the future). All six teachers showed the lowest concern for consequence (the effect of changed teaching practice on student performance), with scores ranging between 15-50 percent. The most prevalent concern across the group was about collaboration. The responses ranged from 50-99 percent in this category. The refocusing category was a mix of responses ranging from 10-90 percent, with pairs of teachers falling into three groups, two at the lowest end, two in the middle, and two at the top level. The implication of these findings for what teachers were concerned about regarding the innovation is that teachers were concerned collectively about working with others in completing the action research. Figure 1 shows that teachers trended upward with higher concerns about personal and collaborative issues related to conducting action research. Also, they all showed a downward trend in their concerns about how the action research related to student learning (consequence).

These results showed mathematics teachers who were at the early stages of concern, which Hall and Hord (2010) indicate is common when an innovation is first introduced. The use of action research to examine changed mathematics teaching practice concerned teachers personally, a common finding. However, teachers' concern about collaboration is an artifact of the ITTTE, since teachers were reliant on each other's expertise to bring about change in their classrooms.

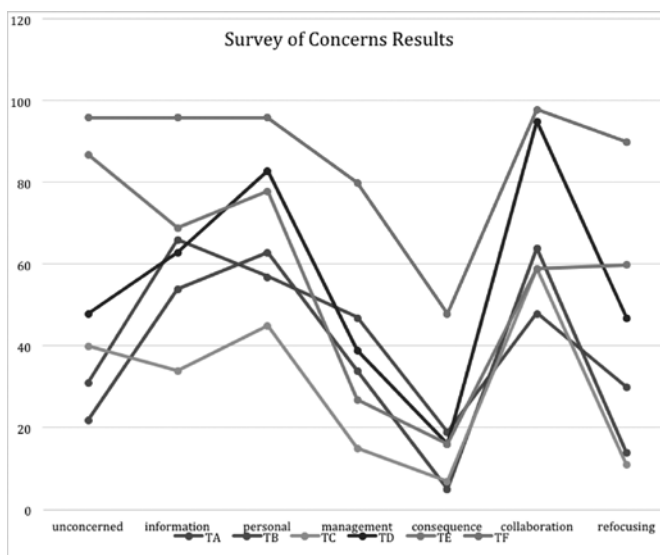
### *Innovation configuration*

Innovation configurations (IC) maps are representations of innovations or change in action (Hall & Hord, 2010) used as a diagnostic tool within CBAM. The IC Map of Action Research Innovation used for this study (Table 2) includes three components of the action research

plans designed and implemented by the participants as well as the variations of implementation. These three components are the frequency of the implementation of the action research plan; fidelity of the implementation; and reporting of the data collection.

Regarding the first element (frequency of implementation), five of the six teachers fell in the higher end of the spectrum with an implementation of the innovations that were either daily or weekly for the six-month period encompassing the action research plans. One teacher, however, only implemented the plan occasionally in this same time frame. It is important to note that the three Guatemalan teachers listed as part of their innovations the use of manipulatives with the students. This use of hands-on activities to learn mathematics was

Figure 1.



carried out in the salón de matemáticas or math lab. Teachers were assigned one day of the week to use this lab, moment when students used the manipulatives. However, our observations did not detect the use of manipulatives outside of the mathematics lab, which led us to believe that the use of manipulatives happened only during the weekly visit to the lab. However, during interviews, following the observations, one Guatemalan teacher showed researchers an extensive collection of manipulatives and described their regular use in her classroom.

In the case of the American teachers, their action research plans included innovations connected to the way they approached instruction, listing a series of changes ranging from using Spanish words and phrases to a change in tone and demeanor. Whereas not all the changes were implemented equally, two of the three American teachers had elements in their plans that they implemented daily. In the case of the third teacher, however, even the changes that she implemented most often were only put in practice occasionally.

The IC map provides us with a more clear depiction of the level of implementation in the next element, which refers to the fidelity with which teachers implemented their innovations. In this case, all six teachers appeared grouped in the middle to high end of the range, with four of them having implemented some aspects of the plan and two others having implemented a few aspects of their plans. The plans appeared to have

fluctuated throughout the six months of implementation, rendering fidelity to the original plans somewhat minimal.

The final component of the IC map is the reporting of the data collection. In this case, four of the teachers appeared grouped in the low end of the range, with two teachers reporting no data and two others reporting data in one single entry at the end of the project. Higher in the range, are two teachers who reported data on a bi-monthly basis. From the latter two, one of them reported the data after the observations carried out by the researchers in her classroom while the other sent e-mails with updates on the innovations.

### *Levels of use*

A third tool used to analyze the extent to which teachers implemented the innovations is the Levels of use (LoU) matrix. To plot the teachers' level of use of the innovation two factors were considered. One was data collected from the interviews with the teachers, and the other, data from the IC map.

Most noticeable in the LoU matrix is that most of the teachers were at a user's level. Only one teacher (T3) fell into the category of non-user of the innovation. This teacher was still at a stage in which she was gaining an understanding of the influence of the international experience in her teaching practices. Having being exposed to the international experience, she cited elements in her instruction that she desired to change and was aware of the processes involved in that change. At the



same time, however, she cited logistical issues that she was unable to overcome (e.g. timing of the change). A second teacher (T1) brought about change at the mechanical level but did not focus change on mathematics instruction, rather on the linguistic infusion of the Spanish language into all exchanges in the classroom.

The other four teachers were categorized as users in the LoU. The graphical representation of the levels of use, representing types of behavior and patterns in the process of change, indicated two clusters within the level categorized as routine. The first of these clusters occurred in the category of knowledge. This category is described as knowing both the short and long-term requirements of the innovation while using the innovation with minimum effort or stress. Teachers were asked to implement the action research plan in the second year of their experience in the ITTE. Consequently, they had already traveled to Guatemala and the United States respectively once before and had seen their counterparts implement the teaching practices that they wanted to change in their own teaching. This eliminated some of the stress or uncertainty inherent to change.

The second cluster observable in the LoU at the level of routine happened in the category of performing. Here, teachers used the innovation smoothly with minimal management problems and little variation over time. The data from the observations and the interviews coincided to place four of the six teachers in this category that, again, points to a

level of comfort with their respective changes that allowed them to implement such changes without major difficulties.

Changes in the performance of mathematics teaching practices were noted among four of the six teachers, three in Guatemala and one in the United States. One Guatemalan teacher (T3) changed mathematics instructional practice by including more manipulatives in her elementary classroom to teach operations. These manipulatives included: dice, playing cards, base-ten blocks, fake Guatemalan money (Quetzals), and games. She also brought her students to the mathematics lab once each week, but found that the students were grasping the concepts better with manipulatives, so began using manipulatives in her classroom on all other days of the week, outside of lab time. Her performance as a teacher changed from lecture to experiential learning across the six weeks, although the practice was at the mechanical level because the teacher expressed difficulty in implementing experiential learning due to the pressures of testing.

Two of the Guatemalan teachers (T5/6) applied a quasi-experimental design to provide mathematics instruction differentially to two classes, for three months. The upper-elementary teacher (T5) brought group A to the mathematics lab once weekly for eight weeks, where the students worked through algebraic thinking mathematics concepts using manipulatives, in an open, shared environment. Group B received standard lecture format on the same day, on the

same concept. Means for pre-test (Group A 46/64, Group B 52/63) showed no significant differences between groups in either administration. Concerning performance, these data show a lecture-based teacher changing mathematics teaching practice, in an action research format, from lecture to experiential learning.

The third Guatemalan teacher (T6), a secondary teacher, taught one algebra class in the mathematics lab, using manipulatives, group work, and open shared environment, to teach basic mathematics, an observed deficit in both algebra classes. The teacher reported that the methods for experiential learning were gleaned from his observation of the U.S. student-centered classrooms. The matched algebra class received instruction in the standard Guatemalan lecture format, with the teacher on the board, students in desk taking notes, and practice problems at the end of the lecture. A pre-test of basic computation was administered to both groups resulting in means of 47.5 for the control group and 35.25 for the experimental group. Post-test scores showed the control group showing a slight loss with a mean of 47; however the experimental group showed a mean of 42.81, a significant gain at the  $p < .05$  level. The teacher found that the changed practices affected students' learning and indicated in interviews that he now sees the value of the ITTTE due to the change in mathematics teaching practice that benefitted his students.

Finally, the LoU matrix showed one teacher (T2) at the level of refinement

of both the categories of sharing and assessing. This teacher reported in the interview having modified the initial change to maximize its impact on students. The modification was a direct consequence of the knowledge about the impact of the change on the students. This is a stark contrast from other teachers who were at the mechanical use level, focusing on the short-term impact of their change without reflecting on the long-term impact, which resulted in a superficial use of the change. This U.S. teacher used a transformational (Banks, 2003) approach to instruction by using Guatemalan found art, economics connections, engagement with the Guatemalan mathematics teachers to introduce mathematics concepts of transformational geometry, perspective, economics, and currency exchange. As a non-Hispanic, who has not noticeable Latina characteristics, she felt compelled to connect with her Hispanic students by using the inherent mathematics characteristics of artifacts to engage learning, as well as employing the inclusion of the Guatemalan teachers in her ESL classes as teachers who encouraged and engaged with Latino students. Data from the action research project, a survey of mathematics students' perceptions of the influence of the Guatemalan mathematics teachers' involvement in their classroom netted a positive influence with over 80% of the students who noted that the involvement with Guatemalan experiences influenced them positively. The teacher also found that Hispanic students, after engaging with

Guatemalan mathematics teachers, who spoke Spanish with them, and engaged in an extra-curricular mathematics experience with them, showed significantly higher pass rates on standardized tests than in previous years before the initiation of the action research.

### Conclusions and Recommendations

The first research question in this study asked about the effect of the ITTTE on the change in teaching practices of the mathematics teachers. Data revealed that teachers were able to change their practices. They were receptive to change when they thought that change would have a positive effect on their students. Not only were teachers open to change, but they also took the necessary steps to make that change happen. This was the case for all teachers in the study, even for one for whom the data did not support the idea that classroom practice change had happened.

The second research question addressed both concerns and levels of use that teachers had about changing their teaching practices. During the six months in which the action research plans took place, most teachers experienced difficulties with data reporting. This might have been in part due to difficulties understanding the idea of action research. Also, the day-to-day demands of teaching might have taken precedence over reporting data to researchers who were far removed from them. However, in spite of the problems reporting data,

all teachers agreed that the two-year cycle of the ITTTE facilitated the process of change. Teachers perceived the first year as one in which to become acquainted and familiarized with the host culture, school, and teaching practices. The second year brought a sense of understanding and empowerment and was recognized as the ideal moment to implement change.

The teachers' levels of use of the innovation, namely the change in mathematics instructional practice, are observed in the LoU matrix. This matrix showed that most teachers were at a level of implementation defined as routine. Their experiences in the ITTTE had allowed them to understand the benefits that change could bring to them as teachers and, very importantly, to their students. They were convinced that changing their instructional practices would be beneficial and, consequently, changed those practices.

Hall and Hord (2010) point out that teachers' change is a process and incremental, generally taking between 3-5 years to reach a high level of fidelity to the innovation. Understanding the change process, personal concerns, and levels of use of action research practices by mathematics teachers in two countries supported the premise of CBAM. Although the instrumentation (IC map, SoCQ, and LoU) provided a profile of the two sets of teachers as they underwent change, it is recommended that change facilitators (university personnel) follow recommendations outlined by Hord and Hall that detail how facilitators encoura-

ge change, once levels of use and stages of concern have been ascertained.

One recommendation is for change facilitators to examine their own change facilitator style. The Change Facilitator Style Questionnaire (CFSQ), a 30 item, Likert-scale instrument found in Hall and Hord (2010), could be issued to teachers in the change process to indicate how change facilitators perform. The results of the survey would provide change facilitators with information needed to foster change among teachers, toward higher levels of use and concerns within the Impact range. Change facilitators supporting the change in this situation should consider the insights of the CBAM methodology. Hall and Hord (2010) note that change facilitators provide supportive interventions necessary for change to occur. Researchers serving as change facilitators could potentially advance the levels of use and stages of concerns should they adhere to these.

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