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Between Worlds: Students' Lived Experiences and Perspectives on Math, Science, and Technology Education Between Mexico and the United States

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BETWEEN WORLDS:

STUDENTS' LIVED EXPERIENCES AND PERSPECTIVES ON MATH, SCIENCE, AND TECHNOLOGY EDUCATION BETWEEN MEXICO AND THE UNITED STATES

by

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As the world becomes increasingly globalized, education systems are striving to meet the needs of students. With globalization comes high amounts of migration, and some students may experience education in two or more countries. Early exposure and success in science, math, engineering, and technology (STEM) education are thought to be vehicles for entering high-status careers. Through interviews with U.S.-Mexico transnational students, this study uses a qualitative, text-analysis approach to understand students' lived experiences and perceptions on STEM education between the U.S. and Mexico. Although these transnational students have the opportunity to foster bilingual and bicultural skills, results show students may experience material limitations and academic discontinuities, potentially affecting their future education and career trajectories.

Dedicated to

my loving parents, Gustavo and Viviana,

who worked so hard to provide their daughter with the American Dream.

Author's Acknowledgements

This thesis stems from a larger, collective study on transnational U.S.-Mexican students, led by Dr. Víctor Zúñiga of the Universidad de Monterrey and my adviser, Edmund T. Hamann, of the University of Nebraska.

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Chapter 1 : Introduction

STEM Education in a Transnational Context

All across the globe, the disciplines of science, technology, engineering, and math (STEM) have become the focus of much attention in education. The primary call for this attention has been the perception that a well-educated country in the STEM areas will lead in the future, both economically and technologically. One part of the promotion of STEM education has been a call for diversifying the fields by embracing and encouraging more women and historically marginalized individuals to enter these careers.

Various international measurements, such as the PISA and TIMSS examinations, strive to compare countries in science and math education, with the overt goal to improve the quality of education for all students. However, can these measurements be used to compare transnational students who have moved between countries? Does measuring STEM skills of a student in a Mexican school who was previously in a U.S. school accurately measure where credit (or blame) should go for that student's success? Does the Mexican school deserve credit? Does the American one? Transnational students stand at an interesting crossroads (Ensor & Godziak, 2010). Their experiences in two or more countries during the course of their education and development lead them to learn and navigate among different cultures and languages. On the other hand, they may experience fragmentation and vulnerabilities in their education, including STEM education, due to the possibility of discontinuity in curriculum and pedagogy. While exams such as the PISA and TIMSS can provide a quantitative comparison of science and math education between countries, this study is a step towards understanding the lived experiences of transnational students to provide a qualitative comparison. Specifically,

this study examines interview data from U.S.-Mexico transnational students in order to determine their perception of STEM education between the United States and Mexico. Transnational students between the U.S and Mexico may be bilingual and bicultural, and have necessary intercultural skills which are seen as valuable in a globalized world. However, their academic skills, including STEM education, are varied. This may lead transnational students to be unprepared or feel unwilling to enter high-status STEM careers. Educationally, where does this leave transnational U.S-Mexican students? This is a challenge for both the United States and Mexico: What is the best way to educate transnational students and how will their experiences shape their futures?

Who are the children?

The demographics of U.S-Mexican transnational students are varied. Distinctions must be made between those with binational school experiences who are currently in the U.S. and those currently in Mexico. Profiles of transnational or bicultural children differ between the two countries, as well as within both, and each country has a variety of institutions documenting who is presently enrolled in school. I begin here with a summary of demographic information regarding foreign-born and native-born children in both countries.

In the United States, in 2010, individuals who self-identified as Hispanic or Latino/a made up 16.4% of the total population. Of these, 65% were from Mexico or claimed Mexican ancestry. This meant that, per the most recent count, about 10.6% of the U.S. population identified as Mexican-American (U.S. Census Bureau, 2010), although some may prefer other labels, such as Chicano or Latino (Taylor, Hugo Lopez,

Hamar Martinez, & Velasco, 2012; Oboler, 1995). In 2010, there were approximately 17 million Hispanic or Latino/a children under the age of 18 in the United States. Therefore, in the most recent census, approximately 4% of the total U.S. population were Mexican-American children (U.S. Census Bureau, 2010). These children live in neighborhoods all across the country, but are not equally distributed (Hamann & Harklau, 2010). Most attend school, but unfortunately, education attainment rates for Hispanics and Latino/as remains much lower than the national average. The high school dropout rate for 16-24 year-old Hispanics and Latino/as is 15.1% and remains the highest of all race/ethnicity categories in the United States (National Center for Education Statistics, 2012).

Most individuals who identify as Hispanic or Latino/a were born within the United States. Many are second or third generation, and some trace their ancestry to before the Mexican-American War, when the United States took the territories of California, Arizona, and other parts of the southwest from Mexico (Acuña, 2010). Individuals born outside of the United States and who migrate to the United States are sometimes referred as 'first-generation' or 'foreign-born.' As a subset of this group, those who are born abroad but who move to the United States as young children and who enroll in all or most of their schooling in the U.S. are sometimes called 'Generation 1.5' (see works by Linda Harklau and Sarah Benesch).

In the 2010 census, about 40 million individuals in the United States identified as foreign-born[1], or about 13% of the U.S. population. Of these foreign-born individuals, about 53% were from Latin America. Mexico was by far the most common country of

origin with 29% of foreign-born individuals calling Mexico their birthplace (U.S. Census Bureau, 2010). Mexican families[2] in the U.S. tended to be larger than families headed by U.S. born individuals, with an average of 4.7 people per household and they are more commonly multi-generational. In fact, 85.2 out of 1000 Mexican women aged 15-50 years had given birth in last 12 months, compared to only 51.5 out of 1000 U.S.-born women in the same age group. Also, 77% of Mexican family households had children under the age of 18 during the time of the 2010 U.S. Census. Unfortunately, 46% of Mexican-born children under the age of 18 lived below the poverty line in the United States, as compared to the 21% of native-born children (U.S. Census Bureau, 2010). The high rates of poverty among Mexican children could affect their lives in many ways, including education and health, although research in this area varies and is ongoing.

Similar to the United States, Mexico has a mix of immigrant groups within its population. While Mexican immigrants in the U.S. make up less than a third of America's foreign-born population, individuals from the United States make up the majority of immigrants in Mexico. In 2000, it was estimated that individuals born in the United States make up almost 70% of the Mexican foreign-born population. Also, over 50% of foreign-born individuals were children under the age of 14. Within age groups, 4.6% of 0-4 year-olds and 3.3% of 5-9 year-olds in Mexico were born in the U.S. (Instituto Nacional de Estadística, Geografía e Informática, 2000). These are the most

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[1] "Foreign-born" refers to anyone who is not a U.S. citizen by birth, and in the U.S with or without documentation. Hence, individuals from the U.S., Puerto-Rico, and other territories, or individuals born abroad to at least one parent who is a U.S. citizen are considered "native-born."

[2] "Mexican families" here means than the head-of-household was born in Mexico. The household may include U.S.-born individuals. On the other hand, if the household had Mexican-born individuals, but the head-of-household was U.S. born, then the household was considered "native-born."

recent statistics available on US-born children from Mexico's census agency and these percentages may no longer be accurate. In the last 10 years, the number of U.S.-born children in Mexico could have changed and been influenced by such factors as the United States' immigration enforcement and economic recession during the 2000's. These factors led to a decrease in US employment opportunities for Mexican immigrants and a large scale movement back to Mexico (Zúñiga & Hamann, 2009).

However, taking a close examination of these statistics clearly shows that the United States and Mexico share not just a border, but also a "culture of migration" between them (Kandel & Massey, 2002). Both countries have significant foreign-born populations from the other country and migrants or family members may move between countries, possibly without the intent of settling permanently (Zúñiga & Hamann, 2009). Some may form or maintain families on either side of the border. Although migration has traditionally been the domain of young men traveling without their families, in the last two decades, children and wives have become large participants in this culture of migration (Richardson, 1999; Zinn & Wells, 2008). This has meant increases in the student-age population, both those born in Mexico and those born in the U.S. to Mexico-born parents, who are likely to move between the U.S. and Mexico.

Children moving between borders can become bilingual and bicultural, and will likely learn how to navigate both cultures, although some children may not feel part of either culture (Hamann & Zúñiga, 2011). They may experience complex family living situations and attend school in both countries. However, both the United States and Mexico have been ill-equipped to adequately educate these transnational children. This is not just regarding school completion rates, but also in terms of mastery of curriculum

content since schooling in one country has rarely been aligned with that in the other. This paper now turns to the domain of inter-related fields of science, technology, engineering, and mathematics, which countries around the world, United States and Mexico included, have identified as crucial to the economic competitiveness in the 21st century, both domestically and internationally (Partnership for 21st Century Skills, 2010).

What is STEM Education?

The disciplines of **S**cience, **T**echnology, **E**ngineering, and **M**ath have been given the collective, short-hand notation STEM. While there is no official definition for STEM or the respective sub-fields to include, its usage is common. The U.S. Department of Homeland Security's Immigration and Customs Enforcement (ICE) limits the definition to physical sciences, math, statistics, engineering, computer and information sciences, and some environmental sciences. The National Science Foundation expands the definition to include agriculture, social sciences, economics, political sciences, and health sciences (Wasem, 2012). There is even a push to expand STEM to STEAM, adding 'Arts' to the original four (Robelen, 2011). At first, the acronym STEM had been used to identify skilled workers and students for immigration purposes to the United States, and the United States remains the leading country to host international students in STEM fields (Wasem, 2012). The term STEM has since entered the language of various other disciplines, including education and economics. A large, skilled populace in STEM fields leads to innovation, technological eminence, and a strong economy (Shapka, Domene, & Keating, 2006; Engler, 2012).

Internationally, math and science are often core subjects in a country's K-12

curriculum (Schmidt, et al., 2001), although STEM education in the broadest sense is rarer. In the United States, most K-12 schools have a variety of computer classes, primarily teaching basic keyboarding and word-processing skills. In Mexico, if funding allows, schools may also teach basic computing skills, but access to equipment and expertise varies widely. In both countries, few K-12 schools teach engineering or have pre-engineering programs. While science and math are often part of the core curriculum, extensive STEM education is limited (McLaughlin, 2002).

Around the world, STEM education manifests itself in a variety of ways. Some have proposed international measures in order to understand the differences between countries and curriculum, particularly in STEM. For instance, the Trends in International Mathematics and Science Study (TIMSS), which is actually a collection of several studies done every few years, includes an exam administered to students in the fourth grade, eighth grade, and in the final year of secondary school in participating countries. Students are tested on math and science ostensibly to compare the strength of their country's education system.

Arguably, there are different and equally successful ways to teach the STEM fields and countries employ a variety of strategies (Cogan & Schmidt, 2002). For example, in a study done by Schmidt, et al. (2001), the researchers compared the TIMSS data from 1999 to countries' curricula, including textbooks, standards, and teacher implementation. In eighth grade mathematics, several countries such as the United States, Norway, and Hungary, indicated that all 26 TIMSS topics were part of the content standards for eighth grade. However, Japan indicated that only 8 of the 26 TIMSS topics were part of their eighth grade standards (Schmidt, et al., 2001). Japan's eighth graders

scored fifth out of all 38 participating countries (Mullis I. V., et al., 2000). Japan has a different sequencing of topics in mathematics, such that some TIMSS topics are taught in earlier grades. This topic sequencing works well for Japan and is an effective mathematics curriculum when compared internationally on the TIMSS. This indicates that there is no "right" way to teach students STEM subjects, although possibly misguided research continues to try to find a "best" way (Schmidt, et al., 2001).

A child who remains in one school district in one country their entire life is more likely to follow a continuous, sequenced curriculum (although exogenous shocks like changes in content areas standards can affect this). However, if a child moves between districts or between countries, curriculum sequencing is likely to be interrupted. Which country should get the credit (or blame) for how a transnational student fares on their math and science achievement? With the migration of children between Mexico and the United States increasingly more common, how might a transnational child navigate different strategies and curricula? The effect of migration on a student's STEM education has been little considered and its relation to life-long success also remains unknown.

Why should we study transnational children?

In an increasingly globalized world, it is important for students to gain the skills and attributes needed for success (Hugonnier, 2007). Globalization creates a need for intercultural skills, including cognitive, digital, emotional, and social skills that cross country borders and cultures (Süssmuth, 2007). When each country has its own education system, curriculum, and pedagogy, can we be certain that children are learning

the skills necessary for the future? How do they learn what they might need somewhere else?

Preparation for a globalized society can be further complicated by the mobility of children and families. Although, some might argue that those who adeptly negotiate two systems are likely better ready for globalization than those who have only negotiated one. A transnational child, having moved between multiple educational systems, may experience fragmentation in their education, such as curriculum sequencing, but also gain beneficial bilingual and bicultural skills. When children migrate from one country to another, how can we be sure that they have developed the skills necessary to be good citizens and well-adjusted individuals (Zúñiga & Hamann, 2009)? Can we ensure a child's success, when it has been shown that early math achievement can lead to higher career aspirations and goals (Shapka, Domene, & Keating, 2006)? Are there other routes to equally high aspirations or ways to assure successful early education, even for the mobile? Transnational children can be educationally vulnerable, but they may also be a vanguard. By studying their experiences, we may discern what works, what doesn't work, and what we can do to improve the well-being for all children.

Chapter 2 : Literature Review

According to Suárez-Orozco & Sattin (2007), globalization is an "ongoing process of intensifying economic, social, and cultural exchanges across the planet" and it involves an "increasing integration and coordination of markets, of production, and of consumption" (p. 7). As a characteristic of globalization, individuals are displaced due to economic change, war, and other processes. Migration, once thought to be uni-directional, has become increasingly more circulatory, meaning individuals are more likely to move between countries and remain mobile, sometimes returning to homeland (Guo, 2010; Richardson, 1999). Today, children are more mobile than any time in history (Suárez-Orozco & Suárez-Orozco, 2001). With the unprecedented penetration of schooling all over the world, children are also more likely to have school experience in more than one country than ever before (Vandeyar, 2011).

Immigration and Education

The United States and Mexico have a long history of migration (Castañeda & Massey, 2012). Nonetheless, a child who attends school in both the United States and Mexico will experience a different curriculum sequence. For example, in the United States, it is common for students to study science at a high school level in the following order: Biology, Chemistry, and Physics. However, according to the *Mapa Curricular* (Curricular Map) from Mexico's *Secretaría de Educación Pública* (Secretary of Public Education), students in Mexican schools study science in the following sequence: Biology, Physics, and Chemistry (Secretaría de Educación Pública, 2011). Although this

is not likely the discontinuity, a student who migrates between countries could experience physics twice, but never chemistry, or vice versa. At a minimum, with the absence of coordination from individuals involved, we could expect discontinuities and fragmentation in the development of a students' science knowledge.

Similarly, sequencing in other curricular areas may also be fragmented. Mexico has consistently scored lower on the PISA (Programme for International Student Assessment) than the United States. The PISA measures 15 year-olds' performance in math, science, and reading in participating OECD (Organization for Economic Co-operation and Development) countries and its partners. However, in Mexico, post-9th grade education has not been mandatory until President Calderón signed a decree in July 2012, which gives Mexican states 10 years to make the final three years of high school (*bachillerato*) universal (Cruz, Educación Media Superior ya es obligatoria en México, 2012). In contrast, at least some high school is required in the United States. For many students in Mexico, ninth grade is the last grade they will attend, and if students move to the United States afterwards, their education will have been interrupted. Moreover, the quality of the final years of obligatory schooling in Mexico is often low, particularly in rural areas, where *telesecundarias* offer coursework by video when there is no local teacher with requisite content knowledge (Telesecundaria: Students and the Meanings They Attribute to Elements of the Pedagogical Model, 2006). However, Mexico has set out to improve its enrollment in secondary school. Between 2000 and 2009, enrollment in school for 15 year olds in Mexico rose from 52% to 66% (OECD, 2010).

Although the United States and Mexico share a border, their cultures are distinctly different. Mexico's 19th century dictator Porfirio Díaz allegedly once summarized the

relationship as such: “Poor Mexico, so far from God and so close to the United States.” Children who migrate between the United States and Mexico must navigate between different social norms and languages. In the United States, some schools provide transitional coursework for students from other countries, often called English-language learning or ELL, for short. These programs are intended to teach students English by taking English-acquisition classes with other non-English speakers, sometimes in conjunction with English-submersion classes which include English-speaking peers. Along with learning English, students gradually learn social norms and American culture, but their acquisition of the latter is not measured as a requirement for their placement in ‘mainstream’ classes.

Moreover, many times the English-acquisition classes take the place of core classes such as math, reading, and social studies. English-learners may lose a year or two of the core curriculum, and then be academically behind their English-speaking peers. Hamann, Zúñiga, and Sánchez García (2010) found that transnational students in Mexico were more than three times as likely to have repeated a school year than their classmates’ whose schooling had been entirely in Mexico, indicating that transnational students are more likely to have lost some content knowledge from moving between countries. An alternative to traditional ELL coursework is bilingual education, where students are taught core classes in both their native language and English. Advocates (Spener, 1988; ASHE Higher Education Report, 2011) for bilingual education argue that it builds off of students’ current language-acquisition and does not put students at a disadvantage compared to native-speaking peers. Given its complexity, it is not surprising that the effects of migration on literacy and education are still being studied.

Achievement in STEM

In the United States, achievement in science and math varies greatly across the country, between income levels, and between cultural and ethnic groups (ASHE Higher Education Report, 2011; Lee & Buxton, 2010). In 2007, fourth graders in the United States placed 11th on the TIMSS for mathematics achievement, out of 59 participating countries (Mullis I. V., et al., 2008). However, when schools were broken down by free and reduced lunch eligibility (a common measure of poverty or income level in the United States), schools with less than 10% of their students on free and reduced lunch would have ranked third among the other 58 countries (Taylor J. , 2010). Similarly, all schools with less than 25% of students on free and reduced lunch would have placed fifth in the rankings (Taylor J. , 2010). However, schools with 50% or more of their students on free and reduced lunch, indicating some of the poorest communities in the United States, would have ranked 21st (Mullis I. V., et al., 2008). These results indicate a stark difference between income and math achievement in the United States.

Science and math achievement gaps between ethnic groups also exist. Traditionally, white and Asian students outperform black, Hispanic, and other minority students in academic areas within the United States. On the TIMSS 2007 math test, eighth-grade white and Asian students in the United States scored 32 and 48 points respectively higher than the average of all the countries. However, on the same test, black and Hispanic students scored 44 and 26 points, respectively, *below* the average. Similar results occurred on the TIMSS 2007 science test, where white and Asian students scored 37 and 29 points above the average and black and Hispanic students scored 59 and 34 points below the international average (Dalton, 2011). This achievement gap remains

even on domestic measures, such as the National Assessment of Educational Progress (NAEP) mathematics assessment. On the 2011 assessment, 4th grade black and Hispanic students scored 224 and 229, respectively. However, their white and Asian/Pacific Islander peers scored 249 and 256, respectively, again indicating a significant achievement gap between ethnic groups in the United States (National Center for Education Statistics, 2012).

These differences in achievement are still being studied, and the complex interplay between poverty and ethnic identity remains a mystery. Some argue that, for historical reasons, minority groups in the United States are more likely to live below the poverty line and this attributes to their academic success (Spener, 1988). In 2011, only 9.8% of non-Hispanic whites lived below the poverty line. In contrast, 12.3% of Asians, 25.3% of Hispanics, and 27.6% of Blacks lived below the poverty line (DeNavas-Walt, Proctor, & Smith, 2012). Unfortunately, poverty among minorities remains a barrier for achievement in the STEM fields for minority students. This may be due to several factors, including lack of funding in low-income area schools and the practice of "tracking" lower-income students into non-college bound courses (ASHE Higher Education Report, 2011).

However, achievement in low-income and minority students can be improved. Studies show that parental involvement, bilingual education, culturally relevant teaching techniques (pedagogy), and early exposure to STEM careers helps improve achievement among historically disadvantaged groups (ASHE Higher Education Report, 2011; Nasir, Hand, & Taylor, 2008; Hamann, Reeves, Baurain, & Valenciano, 2008).

In Mexico, academic achievement in STEM fields is also varied. The PISA in

2009 considered students' socio-economic status through indicators of parents' education level and possessions. By adjusting the mean of OECD countries to a value of zero and standard deviations of one, Mexico displayed one of the largest variations on the PISA socio-economic index (OECD, 2010). For Mexican students between the 25th and 75th percentile on socio-economic status, the PISA socio-economic scale ranged from -2.25 to -0.25 standard deviations from the average of OECD countries. About 58.2% of students in Mexico fell below the -1.0 standard deviation, indicating that most students in Mexico live significantly below the international average regarding socio-economic status. Schools in Mexico were just as varied, with scores as low as -3.9 for rural schools and scores above 1.0 for some private schools (OECD, 2010). These values indicate that Mexico has a large portion of its student population in a disadvantaged socio-economic position, as compared to the other OECD countries. Regarding achievement, students of Mexico's rural public schools (some of the most economically disadvantaged schools), tended to do poorer on the PISA than students of urban public and private schools[3]. However, just as the Effective Schools movement recorded in the United States (Edmonds, 1979), income-level is not a definitive factor since about one in three affluent private schools scored below the OECD average and some economically-disadvantaged public schools scored above the OECD average (OECD, 2010).

Other factors also influence the achievement of Mexican students on the PISA. For instance, Mexico has one of the lowest GDP per capita of the OECD countries, and

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[3] In the context of transnational students, rural Mexican areas have a higher proportion of participation in transnational migration. This study's data set largely comes from rural schools. By extending the results on the PISA, the transnational students in the study are likely attending schools with lower-than-average PISA scores.

therefore has limited resources for education. Interestingly enough, Mexico spends about 22% of its public budget on education, which is the largest proportion among OECD countries, where the average is 13.3%. However, this still only provides schools with 2,165 USD per pupil each year, which is below the 7,572 USD per pupil average in the OECD countries (OECD, 2010). While Mexico values education, its resources are limited when compared internationally. Also, the education level of parents in Mexico is much lower than other OECD countries. Only about 16% of 35-44 year olds in Mexico have experience in upper secondary (high school) or higher education (OECD, 2010). This may be influenced by the fact that mandatory school attendance until 9th grade was not placed into law until 1992. Only recently has Mexico pushed for mandatory high school (*bachillerato*), which will be implemented over time and reach national coverage in 2022 (Cruz, 2012). Regardless, both the United States and Mexico face a lot of challenges in providing a globally competitive STEM education for all their students.

Student Attitudes and Academic Success

While oftentimes the goal of schooling is to provide students with the academics needed for their futures, school is also a social place where students learn cultural and social norms. Academically and socially successful students flourish best when schools foster caring relationships between teachers, administrators, and students (Valenzuela, 2009; Pitts, 2011). When schools have high expectations and an atmosphere of success, students will live up to those expectations (ASHE Higher Education Report, 2011). Similarly, when teachers and administrators show genuine interest in a student, the student is more likely to feel welcome at school (Suárez-Orozco, Suárez-Orozco, &

Todorova, 2008). Reciprocally, when a student cares about school, they are more likely to succeed in academics (Valenzuela, 2009), including in the STEM areas (ASHE Higher Education Report, 2011).

In the United States, Latino/a students have a variety of attitudes towards school (Flores-González, 2002). Primarily, the distinction lies with generational status. Latino/a students who are first-generation immigrants to the United States (born outside the U.S.) tend to have more positive attitudes towards teachers and schools (Suárez-Orozco & Suárez-Orozco, 2001) and describe better relationships with teachers than native-born Caucasian children (Peguero & Bondy, 2011). However, U.S.-born Latino/a students collectively have more negative attitudes towards school and poorer relationships with teachers (Suárez-Orozco & Suárez-Orozco, 2001; Peguero & Bondy, 2011) than both first-generation Latino/a and native-born Caucasian peers. As previously mentioned, these attitudes may affect their achievement in a variety of subjects, including STEM. When examining just Mexican-American students, the first-generation students tend to have the highest levels of achievement in math and science, relating to their school attitudes. On the other hand, the second-generation students tended to have the lowest achievement of the Mexican-American identified students, and the third (or greater) generation students were somewhere in between (Crosnoe, Lopez-Gonzalez, & Muller, 2004).

This difference in generations has led some researchers to believe that immigrants to the United States are experiencing a segmented assimilation model (Peguero & Bondy, 2011). The segmented assimilation model concludes, with each successive generation in the United States, individuals of certain backgrounds do not accept, resemble, and/or are

not welcomed into the native culture. This model echoes facets of John Ogbu's cultural ecology framework for explaining some student groups' comparatively weak educational performance (Hamann, 2004) and contrasts the conventional assimilation model, which has been historically used to understand assimilation of European immigrants to the United States (Spener, 1988).

To complicate matters further, children who migrate away, but later return to their native country may engage in complex educational experiences. For instance, a small but significant population of Mexican immigrants to the United States eventually return to Mexico (Hamann, Zúñiga, & Sánchez García, 2006; Zúñiga & Hamann, 2009). In some *municipios* (municipalities) in Mexico, children who once lived in the U.S. account for about 8% of the student population (Zúñiga & Hamann, 2006). These students with transnational experience are more likely to repeat a grade (Hamann, Zúñiga, & Sánchez García, 2010). However, they are also more likely to aspire to continue their education by going to a university (Hamann, Zúñiga, & Sánchez García, 2010), an indicator of higher achievement and aspirations. It is therefore unclear and perhaps bifurcating in how transnational experience affects academic and life-long success for these students. It seems to be alternatively both an advantage and a disadvantage, with more factors than just mobility and attitudes explaining different educational trajectories.

Global Perspective on Education

As the world becomes more globalized, through international markets, modes of communication, and immigration, education needs to stay at the forefront of academic inquiry. Immigration between the United States and Mexico places both countries in a

critical position for educating their youth. Both countries must accept that children will have varied experiences, both socially and academically, when migrating between them. Regarding immigration, globalization calls for culturally responsive education. Culturally responsive education is curriculum and pedagogy that builds from and upon a child's existing culture. This may include bilingual education, multicultural or ethnic studies, and teaching culturally relevant knowledge and skills (Nasir, Hand, & Taylor, 2008). This includes STEM instruction that builds on cultural 'funds of knowledge' (Gonzalez N. , 1995; Gonzalez, Moll, & Amanti, 2005).

Globalization has also led to an increase in international comparison in education, including several standardized tests such as the PISA and the TIMSS. Multitudes of individuals from around the world are involved in the creation, translation, quality assurance, analysis, and critique of these and other measures. The official intent of these examinations is to evaluate the strengths and weaknesses of various education systems. While tests can provide a glimpse into a country's STEM achievement, a comprehensive comparison requires examining all aspects of education systems. This includes education expenditures, curriculum, pedagogy, teacher preparation, social and cultural factors, parental involvement, and much more.

The wealth of a country and the amount a country spends on education has some influence on the achievement of students on international measures. However, income alone does not explain the differences between countries (OECD, 2010). For example, Norway spends almost twice as much per student than New Zealand. However, New Zealand outperforms Norway on the PISA assessment in all areas (reading, math, and science). Similarly, individual income level may or may not have an influence on test

performance, as described previously in Mexican public and private schools.

Curricula in STEM education also vary greatly between countries (Schmidt, et al., 2001). Countries teach topics in a variety of sequences, and even mathematics, which can be seen as relatively linear in its progression, can be taught effectively in a variety of sequences (Cogan & Schmidt, 2002). In a study conducted by Schmidt, et al. (2001), textbook coverage and curriculum standards had only a moderate influence on achievement on the TIMSS. However, teacher autonomy and teacher preparation had a much greater influence on achievement. This indicates the complexity of curriculum and pedagogy on student achievement.

The international comparison of countries and education systems has led some countries to become internationally acclaimed. For example, Finland, which consistently has performed highly on the PISA and other measures, has inspired documentaries, media reports, and education reform across the globe. Some cite Finland's secret to success as stemming from two main parts: little to no standardized testing and highly qualified teachers in a competitive job market (Sahlberg, 2012; Kain, 2011). This may seem like a paradox: Finland has few standardized tests, yet outperforms countries on international standardized measures (i.e. PISA and TIMSS). While it may seem tempting to follow in the footsteps of one or two high achieving countries and copy aspects of their education system in order to improve our own, there is a risk to over-generalization or the assumption that what works one place will, unmodified, also succeed somewhere else. Each country has its own cultural and social influences, which makes it different from other countries. Instead of copying what some have deemed as countries of success, some have argued that countries should reflect inward and use domestically high-

performing schools or systems as models (OECD, 2010). There is, perhaps, some middle ground: using both internationally high-performing countries and nationally high-performing schools as models for domestic education reform.

In a globalized world, transnational children are placed in a unique position. Having experiences in two or more countries promotes unique values and experiences. Transnational children often develop bilingualism and biculturalism, which as Süssmuth (2007) explains, may put transnational children at an advantage regarding social and intercultural skills for a globalized future. However, if such favorable outcomes can ensue, it does not mean that they automatically will. Indeed, as previously mentioned, Hamann *et al.* (2010) found for transnational students in Mexico, such students were more than three times as likely to have repeated a grade than their mononational classmates.

Ultimately, there is still a need to understand the experiences of transnational students in a globalized context. In a time where international comparisons are paramount and inescapable, we need to increase our understanding of the similarities and differences between education systems. How can we determine the inequalities in education? Are there some inequalities that should concern us more than others? Does achievement in math and science increase the likelihood of entering high-status careers for students in all countries, not just the United States? From a student's perspective, how do experiences in different countries shape their academic aspirations, life-skills, and citizenship? The voices of transnational children are diverse and their experiences are varied. This study attempts to bring forth those voices and experiences, which are often unheard and untold, to better understand the STEM education of transnational

students between the United States and Mexico.

Chapter 3 : Purpose of the Study

This paper forms part of a much larger, mixed-methods study. The larger study is funded by the *Consejo Nacional de Ciencia y Tecnología*, Mexico's national science foundation. By using survey data and interviews, the larger study examines the educational experiences of Mexican students and, in particular, transnational students. Within the scope of the larger study emerges this paper. The primary research question driving this paper is how transnational students perceive the similarities and differences between U.S. and Mexican schools, particularly regarding science, math, and technology. Engineering education, while part of STEM, is not often taught in either U.S. or Mexico's primary or secondary curriculum. However, science and math are core subjects in both countries, and technology classes (such as keyboarding or word-processing) are common as well. For this reason, this study focuses on science, math, and technology education and will use the term STEM to refer to these subjects.

All students in this study have lived in both the U.S. and Mexico, and were enrolled in *secundaria* (middle school) in Mexico during the interviews. By using the interview data, this study's focus is to provide a comparison between curricular, pedagogical, and institutional dynamics from the viewpoint of the student. While it may be possible to simply compare U.S. national standards with Mexico's national standards to provide an overview of similarities and differences, sometimes the delivered curriculum can deviate substantially from the official curriculum (Cortina, 2011; Schmidt, et al., 2001). Instead, the current study wishes to engage in a deeper, personal, phenomenological approach. The intent is to discern how the students' lived experiences and their developed perceptions with STEM education may influence their future

aspirations.

Chapter 4 : Methodology

Research Strategy

Qualitative research. A largely qualitative, text-analysis research strategy was used for this study. A qualitative design allows flexibility when a topic is new or has never been addressed (Creswell, 2009). As previously stated, very little research has been done on the experiences of transnational students, especially regarding attitudes and STEM education. Most of the prior research relies on survey data to gauge attitudes (Suárez-Orozco & Suárez-Orozco, 2001; Bybee & McCrae, 2011). However, a deeper level of understanding is desired with this study in order to understand a specific and eclectic group of children. Lastly, the possible variables and complexities that may attribute to student perception are not well understood. A qualitative strategy lends itself better to the study due to many affected and unknown variables.

Collecting student voices. One of the primary challenges of this study is the collection of student voices and maintaining their authenticity. Transnational students are a traditionally marginalized group and have rarely been granted a voice in research (Kitchen & Civil, 2011). Latino/a studies sometimes focus on a deficit perspective, where the problems and issues immigrant students face are at the focus. If a student has an accent or mixes languages, they may be labeled as "limited English proficient," instead of viewing their potential bilingualism as a resource in education. Oftentimes, schools do not add to a transnational student's current knowledge. Instead, Latino/a students may face a "subtractive schooling," where they must leave their old culture and language in order to assimilate and succeed in their current education (Valenzuela, 2009).

In order to empower transnational students, this study takes on a naturalistic

paradigm. The naturalistic paradigm stems from the ecological framework from Bronfenbrenner (1989), on studying learning in a cross-cultural context. Ecological approaches to education research are concerned with understanding the complexities of social, cognitive, and physical dimensions of individuals and their interaction in various contexts, such as family, churches, and schools (Moschkovich, 2011). Ecological approaches recognize that an individual's learning takes place in many settings and that context matters. By using a naturalistic paradigm, this study employs principles from anthropology, sociology, and cultural psychology, as well as previous transnational research. This study approaches the experiences of transnational students as complex and multi-faceted. A naturalistic paradigm acknowledges cultural relativity, where individuals are studied in their own terms and contexts before compared to other systems. As stated by Maschkovich (2011), "relativism allows us to move from deficiency models of learners to exploring their reasoning in terms of potential progress, a move that is especially relevant to research with learners from nondominant communities" (p. 7). Using the naturalistic paradigm, this study seeks to empower transnational students by learning from their complex and diverse experiences.

Similarly, careful consideration has been taken during translations in order to maintain authenticity of student voices and experiences. Interviews with students sometimes changed between Spanish and English. To describe and understand the original intent of the language and discourse of students, bilingual Spanish-English speakers (including some native speakers of both languages) were used at each stage of the study (during interviews, transcriptions, and analysis). Similar to the students, the collective group of researchers also had a diverse set of experiences, including living,

working, and/or studying in Mexico, the United States, or both. The collaborative effort of several very different individuals helped to maintain the authenticity of students' experiences without losing components in translation.

Data Collection

Prior collection. In the first phase of the larger study, surveys were distributed using a stratified random sample to schools in four states in Mexico. All students in sampled classrooms were given the first survey, which asked demographic and educational biography questions, including whether the student had lived or attended school in the United States. If a student identified U.S. experience on the first survey, the student was given a second survey with extended questions regarding their experiences in the U.S. In the Mexican state of Puebla, some students who completed the second survey were purposefully chosen for a follow-up interview. The selection for interviews was based on a convenience sample, where interviewers with limited time designed itineraries to visit as many of the identified transnational students as possible.

Interviews were led by a team of researchers and audiotaped. Interviews were open-ended and, by the student's choice, conducted in Spanish, English, or a combination of both languages. The interviews usually began with a series of demographic questions, such as age, school grade, and where and how long a student lived in the United States. The purpose of these introductory questions was to confirm and clarify questions from the written survey and reintroduce the student to the research topic. The interviews continued with various questions about school experiences, such as favorite subjects, interactions with peers, and structural differences. The intent was to elicit conversation

with the student about comparisons between U.S. and Mexican schools. The interview protocol did not include any specific questions regarding STEM education, but many students broached the topic.

Role of the Researcher. As the researcher of this study, I was not directly involved in the data collection (surveys, interviews, or transcriptions). However, my advisor was involved in the original data collection and my role has been primarily to analyze the interviews, looking for the specific sub-topic of STEM education. I was provided the interview data for several reasons. First of all, I am bilingual/bicultural (having been born in Argentina) and was capable of analyzing transcripts primarily in Spanish but that alternated and frequently code switched into English. Beyond this issue of language comprehensibility, my expertise lies in math and science education through my teaching certificate and my graduate studies. I am well positioned to consider how a relatively brief math reference might actually connect to a much larger topic (e.g., how a reference to multiplication struggles in the U.S. likely connected to third and fourth-grade math education). Furthermore, I am interested in the cross-cultural, cross-national, and globalization perspectives on science and math education. The interviews are an opportunity to glimpse into the lives of students who have experienced education in different countries, and to further compare the strengths and weaknesses of the education systems in the United States and Mexico in a global perspective.

While being bilingual meant I was better positioned to read and interpret the transcriptions than a non-native Spanish speaker, during the course of the analysis, certain cultural and linguistic differences between my own country (Argentina) and Mexico became evident to me. For instance, the term *batallar* came up several times in

the interviews. The word *batallar* means "to struggle" in the Mexican variety of Spanish and it was often used in the context of students struggling in certain classes. However, in Argentine Spanish, the term *batallar* is more often used to mean physical fighting (punching and kicking). The reader can imagine my obvious surprise when, from my first interpretation, I thought that a student was "fighting in their math class." In truth, the student had said that they were having difficulties succeeding in their math class, but my initial interpretation reminded me of the diverse linguistic differences between Spanish-speaking cultures.

However, these minor linguistic differences were not detrimental to the overall analysis process. My bilingualism was a great strength due to occasional language switching within the interviews. My own experiences as a child growing up with Spanish in the home and English at school caused me to occasionally language switch, similar to the students in the interviews. Understanding transcribed interviews was not difficult for me, and in some places, I understood why students would switch from one language to the other to say a certain word or phrase. Some words or phrases did not have an equivalent in the other language. These small nuances gave me an advantage since I had also grown up bilingual and bicultural like the students.

Current data collection. A total of 29 transcribed interviews were given to me in a Microsoft Word document. From this Word file, I was able to use the Find/Search feature to look for key words. This text-analysis approach is similar to other linguistic research methods (see Santa Ana, 2002; Brier & Hopp, 2011). I looked for science, math, and technology related words and word segments in both Spanish and English, such as *science*, *math*, *ciencia*, *compu-*, and *tecn-* within the transcribed

interviews (see **Table 4.1**). When I found a valuable quotation related to school, I read a few lines before and after the quotation in order to gain some context for it. I copied blocks of text, including the quotation and enough of the lines before and after to determine context, and moved the block quotes into a Microsoft Excel file. From there, each quote was given a specific number value between 1 and 5, depending on the topicality of the quote. For instance, a 1 indicated that the comment was "in passing, only marginally related to school." A 5 indicated the comment was "about school, with great detail, and discussed differences between U.S./Mexico." An intermediate score of a 3 would imply that the quotation was detailed, but did not directly compare the U.S. and Mexico (see **Table 4.2**). Each quote was also matched with demographic information about the student, such as years in the U.S. and grade, and this information was further included in the Excel file.

In the final stage of analysis, I carefully read and re-read the quotes, while taking notes on some of the reoccurring topics. Using my notes, I organized the quotations into several emerging themes regarding STEM education. I created a Microsoft Word file with tables of concatenated quotes. Each theme was given a table, and quotes were color-coded based on their 1 through 5 quality scale (see **Table 4.2**). At this point, interview participants were also given an ID number and a pseudonym to protect their identity. Each table included the ID of the participant, the original quote, and my own comments on the quote (see **Table 4.3**). Some significantly detailed quotes included several themes, and I created a final table of "synthesis of themes" quotations. This final table included a separate column to identify the two or more themes associated with the quote (see **Table 4.4**).

Table 4.1 Raw number of hits from various search terms. Note, not all of these hits counted as a quote because words may have been repeated within a conversation or were unrelated to STEM education. Only key words or word segments with results are listed.

Word or word segment	Number of total hits
ciencia	*8*
biología	*3*
química	*11*
físíca	*1*
science	*18*
biology	*1*
chemistry	*1*
matem-	*41*
math	*16*
tecn-	*11*
compu-	*45*
Total	*156*

Table 4.2 Quality Scale values, colors, and descriptions.

Color	Quality Code	Description Type
White	1	In passing, only marginally related to school
Light Gray	2	In passing, slightly more detail about school.
Dark Gray	3	About school with greater detail (i.e. content, pedagogy), but no discussion about the differences between US/Mexico
Purple	4	Greater detail discussing school/individual & sparks some conversation between US/Mexico
Blue	5	About school, great detail, and discusses differences between US/Mexico

Table 4.3 An example of a theme table. The theme table includes the student ID number, the original quote, and my research comments (usually a summary, translation, or interpretation).

ID	Quote	Comments
3	Oye y este, y en cuanto a las materias que llevaste aquí que se te hacían más difíciles ¿cuáles fueron? R: Matemáticas y español.	The student says math and Spanish were the hardest when he came to Mexico
2	So far, speaking of the subjects you're taking here, what subject is hardest? --All of them besides English and little bit of math. --Are hard? --the rest like Spanish and science and Formación Cívica y Ética. All of those Are hard.	The student thinks science is hard in Mexico, and math is a little easier. (contrast math and science)

Table 4.4 An example of the synthesis table. The theme table includes the student ID number, related themes, original quote, and my comments. Note the color scheme changes: white and gray, from **Table 4.3**, refer to 1 and 2 on the quality scale respectively. The purple background in this table refers to a 4 on the quality scale.

ID	Themes	Quote	Comments
10	Favorite Subjects Technology & Resources	Pues pensando en las varias materias, ¿cuál es tu favorita? --Química. --...¿cuáles otras materias?, ¿otras ciencias también?, ¿la Físíca o la Biología, o nada más la Química? R: -Nada más la Química. --Ok. (…) ¿o hay maestro de Química aquí? --No hay maestro de Química. En el libro trae experimentos, y de ahí los sacamos, incluso hoy vamos a hacer uno, y como no trajeron los demás el material, se va a hacer para mañana.	The student says she likes Chemistry, then goes on to talk about how Chemistry is done in Mexico… Students sometimes bring in materials to do the experiments.

Validity and reliability. Validity and reliability are important while conducting any research. In order to maintain consistency within my qualitative study, I will employ several strategies:

1. *Clarify bias* – In my analysis, I will be sure to be upfront about the biases I bring as a researcher. As previously mentioned in the *Role of the Researcher* section, I am a math/science educator and a Spanish/English bilingual speaker. I will include reflections of the codes and themes based on my background.
2. *Discrepant information* – I will include any and all contradictory or unexpected information that comes to light during the analysis. Validity in qualitative research depends, in part, on approaching the issue from all angles (Creswell, 2009).

Ethical issues. There are a few ethical issues that I will take into consideration while conducting the research. First of all, the research is intended to bring to light the experiences of a small population of individuals. These individuals may have experienced prejudice (Moschkovich, 2011). In the United States, Mexican-Americans are historically and currently under fire due to illegal immigration. While the rate of illegal immigration has stalled in the last few years (Castañeda & Massey, 2012), there is still a negative perception regarding Mexican-Americans. I will take extra care not to continue this perception nor use it against the students in the research. The primary intent of using a naturalistic paradigm (see **Research Strategy**) is to move away from a deficit perspective and bring to light the voices of a historically marginalized population.

To further protect the identities of students, I will also use pseudonyms when

referring to students and locations within this paper. This will maintain their responses as anonymous. Lastly, in order to keep the data safe, it is kept on my personal computer and on the web service Dropbox.com behind different passwords. This will keep the information safe for as long as it is needed.

Chapter 5 : Results and Analysis

Descriptive Data

Overall, a total of 29 interviews were conducted, including four interviews with teachers, over a collection of ten audio-tapes. Some interviews included multiple transnational students to maximize the number of students interviewed. Of the 29 total interviews, 22 interviews mentioned STEM education through the keywords search (about 76%). Only one teacher commented on STEM education. Therefore, 21 student interviews out of 25 total student interviews mentioned STEM education (84%).

A collection of 43 quotes were collected and the vast majority (63%) received a quality value of 1 or 2 ("in passing, only small details about school"). Many of these quotes reference favorite or least favorite subjects in school. A small percentage of conversations (5%) were exceptionally long and detailed about STEM, receiving a 5 on the quality scale.

As noted by the small number of detailed quotes, the greatest limitation to this study is that the interview protocol did not elicit any specific curriculum, pedagogy, or institutional questions about STEM education. Conversely, this is also a strength of the study because students volunteered the comments and, presumably, were less likely to say what they thought the interviewers wanted to hear. Most importantly, the examined data shows that transnational students could be important sources of information on STEM education in both countries and may offer better ways to synchronize it. For more information on the limitations of this study, see the **Limitations** at the end of this paper.

Themes

During analysis, quotes divided into six emerging themes:

1. Difficult/easy subjects in U.S. and/or Mexico
2. Favorite subjects in U.S. and/or Mexico
3. Differences in curriculum and/or pedagogy
4. Differences in courses and/or sequencing
5. Differences in technology and/or resources
6. Future career and/or educational goals

A detailed analysis will follow on each of the above themes, including the number of quotes from each quality value (1 through 5) and a discussion of key differences between the United States and Mexico as noted by the experiences of the transnational students. Some very detailed quotes (receiving a 4 or 5 on the quality scale) include a combination of these themes. These quotes with multiple themes will be discussed in its own section.

Theme 1: Difficult/easy subjects in U.S. and/or Mexico. From the 21 student interviews, six interviews mentioned the STEM subjects students found more difficult or easier between the United States and Mexico. Four students discussed that they thought math was harder in Mexico, or they had a more difficult time with math class in Mexico. Only one student thought math was a "little" easier in Mexico.

Maricela, who spent five years in the United States, said that she was good at basic arithmetic (multiplication, division, etc.), but struggled with some more complex concepts in math now while living in Mexico. Natalia mentioned that all subjects seemed more difficult in Mexico for her, and in particular math class. She thought it wasn't

because of the language, but because all the classes were more challenging. Cristina spoke in length about her classes. She was one of the students that said math was difficult in Mexico, but she also thought math was hard in the United States because of long word problems, implying that she had difficulty reading them due to the language. However, Cristina thought science was easier in Mexico compared to the United States.

In contrast, Eduardo thought science, along with Spanish and *Formación Cívica y Ética* (Civics and Ethics), were hard in Mexico and math was actually easier. Eduardo's interview was mostly conducted (by his choice) in English. It is possible that Eduardo, having lived in the United States for about nine years, was more comfortable with English than Spanish. While Eduardo did not mention why he thought Spanish and *Formación Cívica y Ética* were more difficult for him, it is possible that Eduardo had more trouble with them due to language. However, math, while arguably may be taught with a significant amount of cultural influences (Nasir, Hand, & Taylor, 2008), could be more easily understood with less language-dependence and more numeracy skills.

Eduardo mentioned in another part of the interview that he thought science was difficult also in the United States. Unlike Spanish and *Formación Cívica y Ética*, Eduardo explains why he thought science was difficult, mentioning there were a lot of formulas in his science classes in the United States. This implies that Eduardo's science classes used math and formulas as part of the curriculum. While Eduardo thought math was easier in Mexico for him, he though science was difficult in both countries. It's possible that Eduardo's language strengths cannot entirely explain this difference, and instead can be explained by Eduardo's preference for subject areas, as we will explore in the next section.

Theme 2: Favorite subjects in U.S. and/or Mexico. Many students spoke of their favorite and least favorite subjects to study in school. Out of the 21 interviews, 13 students mentioned STEM when asked about the subjects they liked and disliked in school. Eight students said math was their favorite subject in Mexico, the US, or both countries. Four students said they liked some kind of science class, with some students specified whether they preferred natural or physical sciences. Only one student specifically stated that she didn't like math at all, and preferred Spanish, English, and history classes.

Math seemed to be a popular choice among the students interviewed, although the reason is unclear. Octavio mentions that he likes math, but struggles with his geography class because the book is confusing to understand. Eduardo, who had previously mentioned that science was difficult for him, stated that math was his favorite subject. However, in Mexico he only "kind of" liked math because it was taught differently, implying pedagogical differences between Mexico and the US. On the other hand, Sierra also mentioned that math was her favorite subject in Mexico, but she thought learning math, science, and technology came more easily to her than other subjects.

Two students specifically mentioned enjoying chemistry, the most out of all the types of sciences. One of them, Fernando, went on to mention that he used to not like "computers" class in the US, but enjoys it more now in Mexico. However, another student Ignacio said he liked science classes in general, but enjoyed it more in the United States because they conducted easier experiments. Lastly, Selena said she liked studying natural sciences like biology in Mexico, and went on to talk about her interests in studying polar bears in the future. Unfortunately, details are unclear about why students

enjoyed science more in one country over the other, but it may come down to personal preference. Some further details emerge when we examine differences in curriculum, pedagogy, and resources.

Theme 3: Differences in curriculum and/or pedagogy. Curriculum refers to material taught, including topics and concepts, whereas pedagogy refers to how the curriculum is taught, specifically presentation and activities. There are two major variations on curriculum: intended and implemented. The intended curriculum refers to what is officially to be taught, including textbook materials and national, state, and local standards. On the other hand, the actual implemented curriculum may differ from the intended curriculum (Schmidt, et al., 2001). Pedagogy may play a role in on the implemented curriculum. Pedagogy can differ greatly between countries, even if the intended curriculum varies less (Kitchen & Civil, 2011; Schmidt, et al., 2001). The students in the interviews were aware of differences in both curriculum and pedagogy between the United States and Mexico. A total of seven students spoke about curriculum and pedagogy, including two individuals who spoke about specific and detailed differences between the US and Mexico ("4" on the quality scale).

The girl Paz spoke of how her math teachers in the United States would help when she needed it. This comment implies a difference in pedagogy, where teachers in the United States more readily assist students one-on-one. However, other students spoke of how there were more problems, and especially more word problems, in math in the United States. Camila said she is doing much better in Mexico because she used to have difficulty with the word problems in the United States. This shows a difference in curriculum between the United States and Mexico.

Eduardo, whose favorite subject is math, discussed how he tried to use some of the strategies he learned in the United States to solve problems in his current math class. However, sometimes he would get the problem wrong. Although it is unclear whether Eduardo was using a strategy incorrectly or if his teacher in Mexico took off points because he was not doing the problem as assigned, Eduardo does mention that math is taught differently between countries. Eduardo's comments shed light on some possible pedagogy differences that could influence learning for transnational students.

Lastly, Ignacio mentioned that he liked science better in the United States because they conducted easier experiments. Ignacio states that "over there they already have it all planned." This likely corresponds to more teacher preparation time to set up experiments and more resources for experiments. It's also possible that lab inquiry in the United States is more guided and teacher-directed than in Mexico. Natalia, another student who went to a different school than Ignacio, mentioned that her school in Mexico did not have a science teacher, so students were required to read the book and conduct the experiments with their regular teacher supervising. While this form of self-directed learning can be effective for some students, Ignacio says that in Mexico he has trouble reading what to do for the experiments.

Theme 4: Differences in courses and/or sequencing. The differences in courses and sequencing could affect a students' interests, attitudes, or educational attainment. A total of 4 students spoke about course offerings. The most notable difference students mentioned about courses between the United States and Mexico was that there was a larger variety of courses to choose from in the United States. For instance, Eduardo discussed how his day in his Atlanta school would have up six or seven

periods a day. He would move between a type of English-language learning class centered around reading and math, then language arts, followed by science, and so on. At the end of the day, he would have a rotation of classes, including drawing, PE, and Spanish class. However, in Mexico, each day is a different subject for Eduardo. The teacher would tell the class what they were going to be working on during that day, and the students are not aware before coming to school.

Similarly, Sierra mentions how the school day in the United States was a little longer and had a larger variety of classes, such as art and music. She says they have a computers class in her Mexican school, but she enjoyed the options she had at her school in the United States.

From student comments, it seems that the rural schools the students attended in Mexico focused mostly on core curriculum and courses, such as math, language arts, science, and social studies. On the other hand, the schools in the United States (many of them likely urban schools) had more options for course work, including a variety of electives. When it comes to technology education, this may be a difference in the amount of resources schools, and some students even made direct comments regarding the differences in resources.

Theme 5: Differences in technology and/or resources. Out of all the other emerging themes, the differences in technology and/or resources had the most detailed conversations, and seemed to be a primary focus when students were asked about how their U.S. school differed from their Mexican school. A total of nine students discussed the amount of technology and resources, especially regarding their science and technology classes. Two students discussed in such great detail, that their discussion

merited the only two block quotes with a quality value "5." All quotes from students showed stark and enduring differences between the U.S. and Mexico.

For example, Natalia said students did experiments out of their science book, as mentioned in the previous pedagogy and curriculum theme section. She went on to mention that students have to buy their own materials, so they have to wait to do the experiments until all the students have brought the necessary supplies. Teresa elaborated on the same subject. She mentioned students also have to buy many of their own supplies, such as pens and crayons for projects. Recently, her class was studying the Periodic Table of Elements, and students had to purchase chemicals from a nearby store, such as "*cloro*" (chlorine).

The other students mentioned differences in technology between the United States and Mexico. Ricardo, Sergio, and Salvador all said there were a lot of things their school in the United States had that their school in Mexico did not, including televisions, computers, and a library. Leandro said he would like to put a computer lab in his school in Mexico and his school in the United States used computers all the time. Maricela said she learned how to use a computer in the United States, and she wishes she had one now because she would do her homework on it. Cristina said she used the computers in her classes in the United States. Her family had a computer in their home (in the U.S.) where she could do her homework. However, the only computers at her secondary school are the ones some of her teachers have, but there are none available for the students to use. On the other hand, the elementary school in her community did have computers for students. Cristina said there are three internet cafés in the community and they are cheap enough for her to afford if she wanted to do her homework or keep in touch with family

in the United States.

Sergio summarized students' overall comments regarding resources in a poignant way: the schools in the United States are larger, have more teachers, and have more technology for both students and teachers. These discrepancies in resources, particularly in the 21st century where technology skills are critical in a globalized economy, students in Mexico are at a disadvantage. Transnational students who have had experience in the United States will have some experience with technology and computers. While more resources do not guarantee a better education, the OECD recommends Mexico take steps to upgrade school infrastructures to similar levels within the country and equitably distribute resources among schools (OECD, 2010). This will ensure that all schools have computers and necessary science lab equipment at some basic level.

Theme 6: Future career and/or educational goals. Only four students spoke of STEM careers or educational goals, although these discussions were sometimes linked to other topics such as favorite subjects. Maricela said she wanted to become a lawyer, but her interests in biology may lead her to a science career path. She had mentioned earlier in the interview that she helped others in the class with science homework during study time. Fernando, who used to not like computers class in the U.S., but enjoys it now in Mexico, said he wanted to study computers in the future. He hoped to return to the U.S. to continue his education. Leandro said he wanted to be a doctor, and thought learning math was going to be important for being a doctor. Leandro had previously mentioned that he enjoyed math class and thought that all students should be able to do basic arithmetic before graduating.

Selena was quite talkative about her future aspirations. She said she enjoyed

learning natural sciences, like biology, and wanted to learn more about polar bears. She had tried reading about polar bears in books, but couldn't find a lot of information. She hoped to be a scientist someday to study polar bears.

Combination of Themes. Six total block quotes fell under the heading of several themes. These quotes were more involved and gave greater insight on the differences between the U.S. and Mexico from the student perspectives. All of the "combination of themes" quotes emerged from discussions stemming from Theme 1 (Difficult/easy subjects in U.S. and/or Mexico) and Theme 2 (Favorite subjects in U.S. and/or Mexico), oftentimes as the interviewers asked for elaboration on subject matter. As a summary, two students discussed how their future career goal is influenced by their favorite subject in school (connection to Theme 6). Another two students discussed how differences in pedagogy and curriculum influenced their opinions on STEM subjects (connection to Theme 3). Finally, two students spoke about how their favorite subjects were influenced by the technology and resources between the U.S. and Mexico (connection to Theme 5). Each of these students will be discussed further.

Two students, Selena and Leandro spoke about how their favorite subjects in school were related to their future career interests. Selena said she enjoyed her Natural Sciences class in Mexico. When asked by the interviewers if she had thought about being a scientist in the future, Selena said yes and wanted to study polar bears because she found them interesting. While she couldn't find a lot of information about polar bears, perhaps due to limited resources in her rural school, her curiosity encouraged her to keep searching. On the other hand, Leandro said he liked his math class in both the United States and Mexico. He thought math was important to know for his future because he

wanted to be a doctor. He told the interviewer that he thought math was important for all students to know, and teachers should make sure students understand basic arithmetic before graduating. Leandro's comment about students having some basic computational skills reflects one of the curricular philosophies behind global education.

Two other students spoke about how curriculum and pedagogy influenced their opinions on subject areas. Cristina thought math was more difficult in the United States because the curriculum included more word problems. She said that sometimes their homework would be only five problems, but they would be much more difficult. She was doing much better in her math class in Mexico. This shows that differences in curriculum between countries could result in a variety of achievement levels. Cristina, who is a capable math student in Mexico, struggled in her class in the United States. Perhaps it was a language barrier, but under the philosophy of globalization, Cristina should be viewed as dual-language or Spanish-dominant. In the United States, her abilities in math could have been more accurately assessed if she had been given the option between Spanish and English word problems.

On the other hand, Eduardo said his favorite subject was math, but preferred it in the United States. He spoke mostly in English during the interview, so he may have not encountered the same difficulties as Cristina with the prevalence of word problems in the United States. Also, the curriculum in the United States varies substantially between states and school districts. On the other hand, in Mexico, there is a national curriculum. Eduardo's curricular experiences in the U.S. might vary from Cristina's. Regardless, Eduardo says that in Mexico, they teach different strategies for solving math problems, and sometimes Eduardo tries to use the strategies he learned in the U.S. but he gets the

incorrect answer. While it's not possible to discern from his interview whether Eduardo was using the correct strategy and getting the wrong answer, or he was using an incorrect strategy, or if his teacher in Mexico did not recognize the strategy, it's important to note Eduardo's perception between Mexico and the United States. He says that math is "different" in Mexico, specifically "they teach you different *[sic]*." His comment directly implies a pedagogy difference between Mexico and the United States. While pedagogy is largely influenced by culture, transnational students are between cultures and culturally-influenced pedagogy may be less or more effective for some students. With this in mind, globalization encourages pedagogy to be influenced by the student and the student population, from the "take what they already know" as a base point for teaching. Even in the United States, where student populations are oftentimes more diverse than in other countries, the student-centered approach to pedagogy is not commonly implemented (Valenzuela, 2009).

Lastly, we return to Ignacio and Natalia, two students who spoke about the differences in resources and technology between the United States and Mexico. Ignacio, similar to Eduardo, liked science class both in the United States and Mexico, but said he liked in more in the United States. Ignacio said that, in the United States, students did more experiments, they were more planned out, and there were more resources available. Natalia mirrors Ignacio's comments by stating that she likes chemistry, but discusses how students must bring their own materials for experiments and there is no teacher for chemistry. As mentioned before, the differences in resources were the most notable differences students commented about regarding the U.S. and Mexico. While Ignacio, Natalia, and other students did not seem adversely affected by the resources, the

distinction is clear to them. As electronics and computer-related skills become more prevalent in a globalized world, transnational students such as Ignacio and Natalia likely have a distinct advantage over students who have remained in Mexico their whole lives because they have had more access to a larger variety of technology hardware and software during their time in the United States.

Major Findings

Quotes were coded by quality of the details and descriptions, with a "1" meant an in-passing comment about STEM, while "5" meant about school, great detail, and discussed the differences between US/Mexico. Of the 43 quotes about STEM education, only two merited the "5." The major distinction about these two quotes was that both '5-quality' quotes were detailed conversations about technology and resources.

The first high-quality quote is from Cristina. Cristina spoke at length about how technology affected her schooling in Mexico compared to the United States. Cristina used to do school work on computers in the United States, but now has to pay to use the community's internet cafés. She said there are computers in the elementary school, but the secondary school she attends in Mexico does not have access for students (only teachers). In the United States, it is commonplace to see computers at all public schools and libraries, free to use (although paid often through local tax dollars). Due to Cristina's experiences in the United States, the difference in access to technology is staunchly apparent. She says that it is common to go to the internet café to do homework, and fortunately, it is affordable for students. However, compared to the free access available the United States, Cristina feels a little disappointed. Cristina's comments about access

to technology and computer classes reflect what many of the transnational students said about technology: there was simply more available in the United States.

The second high-quality quote is from Teresa. Similar to Cristina, Teresa spoke at length about the resources available in her U.S. and Mexican schools. Teresa spoke about her science class in Mexico and how students had to buy materials for science experiments at the local store, along with most other school supplies such as crayons and paper. This made it difficult to conduct experiments in her Mexican school, compared to her school in the United States. In the United States, it is uncommon for students to purchase their own science materials. On the other hand, students are often still required to purchase at least some basic materials such as notebooks, folders, paper, and pencils. The amount and types of materials students must purchase in the United States varies greatly between schools. However, in Mexico, students must purchase most of their own materials because schools do not provide them. This includes textbooks, along with other school supplies (McLaughlin, 2002).

In summary, transnational students commented on how their U.S. schools had more computers, computer classes, and materials for science labs. To students who have lived in the United States, material poverty (material limitations) in Mexican schools seemed to be a major disadvantage. The OECD's recommendation to Mexico to provide equitable access to technology and resources by upgrading facilities and distributing wealth to rural community schools could help improve the skills of future Mexican students. These students will face a world more infiltrated by electronics and they can only be ready if they have the opportunity to learn and use the ever-changing technology.

A small group of students (7 of 21) spoke about pedagogical and curricular

differences between Mexico and the United States. This was perhaps the second most noteworthy analysis from student interview data (where some quotes merited a "4"). Both curriculum and pedagogy may be heavily influenced by culture (Nasir, Hand, & Taylor, 2008; McLaughlin, 2002; Schmidt, et al., 2001). A transnational student stands between two cultures, and sometimes considering themselves as both or neither culture and nationalities (Zúñiga & Hamann, 2006; Hamann & Zúñiga, 2011). Beyond the complications that may arise from curricular or grade-level course sequencing, which may interrupt transnational students' education pathways, these students remain vulnerable populations as both the United States and Mexico often fail to see students for what they "have" instead of what they "have not" (Suárez-Orozco, Suárez-Orozco, & Todorova, 2008; Valenzuela, 2009). Instead of taking advantage of a transnational students' biculturalism and bilingualism, perfectly oriented for intercultural skills within a globalized context (Süssmuth, 2007), schools in both countries increasingly label students as "deficient" and focus attention on "deficiencies" (Spener, 1988; Moschkovich, 2011; Kitchen & Civil, 2011). Focusing time and attention on remediation may lead to a loss in educational growth, hence forth refered to as "academic poverty" – a loss of intellectual and social capital from educational discontinuties, which could affect future educational and career aspirations.

From student interviews, the effects of academic poverty were not as obvious. Students mentioned that, due to their low English proficiency, they struggled with word problems in math while in the United States. Some students said they did better in math than in other subjects while in Mexico. One student mentioned it took her about three months to get used to the subject material in Mexico. According to her, language was not

an issue, but the subject material was actually harder in Mexico. Some students spoke of attending bilingual classes while in the United States, such as Santiago, who stated that his math class was in Spanish. According to Santiago, his other classes were in English. Some researchers (Kitchen & Civil, 2011; Spener, 1988) have argued that bilingual programs, where students take courses in both their native language and in the language of acquisition, helps use students' "funds of knowledge." The "funds of knowledge" is information and knowledge students currently have or mastered (see Gonzalez, 1995). Bilingual programs can help bilingual students maintain proficiency or keep pace with their native-language peers, as compared to English-Language-Learning (ELL) programs.

Another concern with academic poverty with transnational students is the limitations on technology and resources may limit their STEM education. Since various students spoke of lacking the materials necessary for science classes, the students may be lacking instruction and education in valuable scientific inquiry, a key component for in a globalized 21st century world (Guo, 2010; Partnership for 21st Century Skills, 2010). This may lead to a perceived academic poverty if transnational students return to the United States and wish to enter post-secondary education in a STEM subject. The competitive nature of post-secondary education in the United States could, unfortunately, push out transnational students if they are deemed "unprepared" because of their prior educational experiences. Fortunately, some post-secondary colleges and universities in the United States place high value on international students because of their intent on maintaining a multicultural experience for their students. This may mean that transnational students could be offered scholarships or financial aid for attending a post-secondary institution, but if their STEM education is weakened by some level of

academic poverty, they may still struggle in their post-secondary education.

As a summary, the interviews from the small collection of transnational students in Puebla led to some meaningful discussions on STEM educational experiences between the United States and Mexico. Most notable were references to technology and resources for STEM education and, to a lesser extent, the pedagogical and curriculum differences between the two countries, as experienced by the transnational students. Both could strongly influence the academic poverty of these students and affect them in future endeavors, whether they enter STEM fields or not. If the intent of education within a globalized context is to prepare students for futures unimagined, what can be done to improve STEM (and general) education in both the United States and Mexico, especially for transnational students, but also for all students?

Chapter 6 : Discussion

Implications for Students

The intent of this study is to locate transnational students' perspectives in relation to a number of larger frameworks, such as STEM education, transnational mobility and academic achievement, globalized education, and so on. Specifically, this study focuses on the experiences and perceptions of U.S.-Mexico transnational students and STEM education, through primarily a qualitative lens. We return now to questions that have motivated and driven this study: How can we determine the inequalities in education? Are there some inequalities that should concern us more than others? Does achievement in STEM increase the likelihood of entering high-status careers for students in all countries, not just the United States? From a student's perspective, how do experiences in different countries shape their academic aspirations, life-skills, and citizenship? We start by examining the implications of this study for students, and what can be done to improve transnational student achievement, success, and motivation within STEM education.

This study, placed within the context of globalized education, shows the inequalities between education systems in the United States and Mexico can leave lasting impressions on transnational students. As previously mentioned, the most notable differences were with technology/resources and pedagogy/curriculum.

First of all, global education perspectives call for equal access to education for all students (Süssmuth, 2007; Guo, 2010; Hugonnier, 2007). This is obviously limited for transnational students between the United States and Mexico for a variety of reasons affiliated with technology/resources and pedagogy/curriculum. The first step could be to

improve allotment of resources in Mexican schools, as designated by the OECD (OECD, 2010). This would help the rural schools in Mexico, such as the schools attended by the transnational students in this study, to be better equipped with technology and would likely improve technology education for rural students. Another step could be to create or improve on bilingual programs in both the United States and Mexico. The students of this study spoke of difficulties because of language barriers in their education. The language barriers could slow down students' educational gains and result in a loss of important skill acquisitions. Since the United States and Mexico have such a long history of immigration (Castañeda & Massey, 2012), it is a bit of a surprise that both education systems are still relatively unprepared to support and nurture transnational students from either side of the border (Hamann, Zúñiga, & Sánchez García, 2006; ASHE Higher Education Report, 2011). Many students in the study spoke of struggling in school because of a variety of language and cultural differences. Global perspectives on education call for intercultural skills, at which transnational students are perfectly poised to succeed due to their bilingual and biculturalism. However, from the students' perspectives in this study, rarely was their biculturalism encouraged, supported, or built upon by the schools they attended. Only a couple students spoke of attending bilingual classes in the United States, while a handful more spoke of taking ELL or remedial courses. In Mexican schools, transnational students were occasionally called on to help with English class, but that was the extent of their bicultural acknowledgement.

While the intercultural skills of transnational students are largely ignored in their formal education, its effects on STEM education are unclear. Math and science seem the most affected, as students spoke of difficulty solving problems due to language or reading.

Some, however, thought math was easier because it did NOT require as much reading. Other students simply enjoyed math and science and were able to be successful in the classes regardless of other barriers.

Implications for Public Policy

Within the context of improving education for transnational students on both a local, national, and international level, the United States and Mexico could employ a variety of policies. Since immigration between the two countries is likely to remain well in to the future (Castañeda & Massey, 2012), pathways for success for transnational students should be a primary concern for educators. First of all, the idea that immigration is one-directional and students who move to one country will likely stay in that country for the remainder of their lives should be reconsidered. Transnational students are, by definition, cyclical migrants. They have moved between countries, sometimes staying only a couple months or a few years at each location. Both the United States and Mexico maintain education systems supportive primarily for students who will "stay for life," meaning they emphasize acculturation and language-acquisition. For transnational students, this may mean having to lose part of their other culture, only to return amidst it later in life. While it may be difficult to assess whether a student is a "settler" or a "sojourner" (for more information, see Zúñiga & Hamann, 2009), this should not be an argument against a quality bilingual and multicultural education. Both the United States and Mexico have to take many strides to improve their education of transnational and immigrant students within their borders, without the loss of social, cultural, and academic well-being.

Implications for Global Education

All across the world, students are consistently measured on their academic skills, both domestically and internationally. Two major international measures for STEM education include the PISA and the TIMMS. Countries, including the United States and Mexico, use these measures to quantitatively and qualitatively compare their educational systems. Both countries lag behind in science and math education globally. The United States employs a "breadth not depth" approach to curriculum, meaning students sometimes lack valuable critical thinking skills or the motivation to study in STEM fields (Schmidt, et al., 2001; Bybee & McCrae, 2011; Engler, 2012). In Mexico, the lack of resources, technology, and equipment in some schools means that students miss out on valuable scientific inquiry in a world where technology is rapidly becoming the norm (OECD, 2010; McLaughlin, 2002).

According to Süssmuth (2007), globalization will require a need for a variety of intercultural skills, including cognitive, digital, emotional, and social skills. While the transnational students in this study are perfectly poised to be future leaders of interculturalism, due to their movement between cultures, the education systems of the United States and Mexico may actually be stifling these students. On an international policy level, the United States and Mexico should discuss how best to align their education systems so transnational students moving between them would not lose topics, sequencing, course offerings, or skills. Since the United States and Mexico do not share a common culture or language, it's important to foster a mutual respect and offer all students chances to learn from either culture. All students could benefit from building intercultural skills, and transnational and immigrant students could be the inspiration

behind such an endeavor. Using the "funds of knowledge" that transnational students bring to the classroom could be a step in building mutual respect and better communication between Mexico and the United States. Unfortunately, the amount of stigmatization and currently held beliefs from populations on both sides of the border will be difficult to change.

Regardless, global education reform based on student success and achievement should be less motivated by "who is doing what?" and "who is doing it better?" and, instead, should focus on how students are acquiring the skills necessary to thrive in an unclear future, prevalent with international communication and collaboration. The current research within the context of global studies remains largely quantitative, using test scores, immigration statistics, and various economic measures. This study was an attempt to navigate away from the quantitative realm and bring the voices of the players, those truly affected by globalization, into the arena. These transnational students are possibly the most affected by the global education reform movement and their experiences show stark differences between two countries that share the tenth longest border in the world (Central Intelligence Agency, 2009). This study shows that the experiences of transnational students are just as valuable as a research tool for global studies, their voices having given us a glimpse into their lives, struggles, and successes in education between two different countries. Are these students ready to face the future? Possibly. Have their educations prepared them for a high quality life? Uncertain.

Limitations

There are several distinct limitations to this study. During the course of analysis,

I had to extrapolate information from the interviews regarding science, math, and technology education. These topics were not the focus of the interviews, and hence, not all students who were interviewed discussed their science, math, and technology experiences. Unfortunately, most of the quotations taken from the interviews were about whether students liked or disliked their math and science courses. Several students spoke of technology in either schools, but few made connections or comparisons between the U.S. and Mexico. There were only two in-depth quotations (given a "5" on my scale), out of a total of 43 quotes, regarding comparisons between U.S. and Mexican schools. This means that there is a very narrow and limited view in the study. On the other hand, this may be considered a strength of the study, as students were not led or asked specific questions about STEM education, so many may have felt free to speak their mind.

Another limitation is the amount of interviews available. The interviewers attempted to maximize their resources with the scope of limited time. This meant that not all students who did the original survey were chosen for interviews. While qualitative research methods focus on quality, not necessarily quantity of data, reliability is still an issue when interviews were not conducted on a specifically random occurrence. Some schools who participated in the survey may have had several students interviewed, while others had only one student, even if there were more transnational students within the school. This was primarily due to the time and travel restrictions of the researchers during data collection, and may have resulted in a possible loss of key student experiences.

A final limitation to the study is that I was not directly involved in the data gathering process. My responsibility was primarily on the data analysis, and more

specifically on STEM education. While I was able to circumnavigate the lengthy IRB (Institutional Review Board) process and obtaining permission from the Mexican secretary of education (*Secretaría de Educación Pública*), since these were completed prior to my analysis, a limitation arises from these circumstances. It meant the interview data was completely textual and I did not have direct experiences with the students. Specifically, the transcriptions did not include any voice intonations or non-verbal components, which are sometimes important in interpreting the meaning of speech. Also, since I did not have direct experiences within the Mexican schools, I had to research a lot of background information on the education system in Mexico. Between the textual data and the limitations in my own experiences, this may have led to false interpretations of data; although I took care to attribute meaning to only statements I could understand the intent clearly. Statements which emerged from the original keywords search were thrown out of the final data analysis if I could not adequately discern meaning, intent, and context.

Future Research

While this study expands the understanding of transnational students' educational experiences between U.S. and Mexico, more will be needed to provide a large and detailed picture within the framework of global, transnational, and STEM curriculum studies. This study could provide a background or framework for a future study, where specific questions are prepared in order to discuss curriculum and structural differences in STEM education between countries. An interview protocol could include a series of questions to extend the inquiry, such as "What was different about your science class in

the United States?" or "What types of resources would you like to see in your school in Mexico?" Questions could be developed to further explore the perceived differences between the U.S. and Mexico regarding technology/resources and curriculum/pedagogy (the two themes identified in this study as leaving the greatest impression on students). A possible further extension to this inquiry would be to develop focus groups or a small, longitudinal sample of transnational students. This may include how students' perceptions change over time, or how the perceptions of students currently residing in the United States are different from those residing in Mexico. It could be pertinent to include a greater discussion on the effects of perceptions and circular migration.

Another future, perhaps quantitative, study could include students' grades in order to compare STEM achievement. Some studies have looked into student achievement and attitudes for Latino students residing in the United States (Suárez-Orozco & Suárez-Orozco, 2001), but few studies exist of similar comparison in Mexico (Kitchen & Civil, 2011). Transnational research is also well poised for mixed-methods research, which can capture the experiences of students and its many facets.

Lastly, future research will need to delve deeper into the positive experiences encountered by transnational students: what can transnational students do to improve the intercultural skills of all students? Positive experiences of transnational students can help educators and policy makers make decisions on how best to educate a diverse group of students.

Overall, in our increasingly global and connected world, students should be provided with the opportunities for life-long learning and success, regardless of whether they migrate or remain in the same country their entire life. The future of our world

depends on the educations we can provide for children today. Will they be prepared to face the future with heads held high, and equality and fairness in mind? Only time will tell if the changes in education we make today will positively influence these students in the future. Regardless, we should continue to strive for a quality education for all.

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