The Mathematics Educator
2002, Vol. 6, No.2, 95-112

Does Language Make a Difference: A TIMSS-R Analysis

Leah Nillas
Illinois State University, Normal, Illinois, USA

Abstract: *This paper investigated the relationship between language and mathematics achievement. Data from TIMSS-R of 6601 Filipino 7th graders were analyzed. Mathematics achievement of students who took the English version and the Filipino version of the test were compared. Results showed that students who took the English version test performed significantly better than those who took the Filipino version test in five content areas. There was a significant but weak relationship between students' self-concept of language and mathematics proficiency and their achievement. Results suggested an investigation of the teaching and assessment practices in a bilingual classroom to identify language-related practices that contributed to students' mathematics achievement.*

There has been an ongoing debate as to the effects of teaching mathematics in a second language to students' learning of mathematics (Clarkson & Galbraith. 1992; Dawe, 1983; Gee, 1982; Jones, 1982; Saxe, 1988; Taole, 1981; Watson, 1988). A number of authors have studied conceptual issues related to mathematics achievement of bilingual students or those who have learned mathematics in their second language (Cocking & Chipman, 1988; Moscovitch, 1996; Tsang, 1988; De Avila, 1988). Specifically, a substantive number have studied the performance of bilingual students in mathematics (Conde, 1998; Ebert, 1985; Ferro, 1983; Myers & Milne, 1988; Valladoloid, 1991). In line with this interest, this study investigated the relationship between language and mathematics achievement. The investigation was conducted using Cummins'(1981) theory and Cocking and Chipman's (1988) mathematics learning model. It analyzed studies done across cultures that have English as the second language. In the discussion, the terms *bilingualism* and *bilingual students* are used to respectively refer to the teaching and learning of mathematics in the second language and to those students who are taught mathematics in a second language.

The poor performance (29% lower than the international mean) of the Filipino students in the recent TIMSS-R study posed several issues concerning the teaching and learning of mathematics in the country. For a country like the Philippines where mathematics is taught in English, second language concerns about the use of a second language in test taking are common. Educators hypothesize whether it could have been better for the Filipino students to take the test in the Filipino language, the country's national language, like other Asian countries such as Chinese Taipei, Indonesia, Japan, Korea, Malaysia, and Thailand. Thus, the TIMSS-

R Philippine report (UP-NISMED, 2000) suggested a comparative study on the achievement of those who took the English and the Filipino versions of the test to determine any significant difference on students' mathematics achievement. In this context, this study was inspired by this need to quantitatively analyze the effect of the use of the two languages, English and Filipino, to students' mathematics achievement. With this in mind, a comparative analysis between the use of language and students' mathematics achievement was deemed necessary to establish and determine any significant relationship.

Cummins' Theory

Cummins (1981) suggested that it was important for bilingual students to be competent in their first language as well as in their second language to learn mathematics better. His theory centered on two hypotheses. These were the *threshold hypothesis* and the *developmental interdependence hypothesis*.

The threshold hypothesis

This hypothesis centered on the idea of balanced bilingualism. It visualized two environments: the *subtractive environment* and the *additive environment*. Subtractive environment was where the second language replaced the students' first language. On the other hand, additive environment was where the student learned the second language by adding it to his or her competently learned first language. It considered students who were competent in both their first and second languages as *balanced bilinguals*. Studies showed that balanced bilinguals who learned their languages in additive learning environment had cognitive advantage over monolinguals or those who have learned mathematics in the first language. Dawe (1983) proved and supported this hypothesis. In his study, he examined the ability of bilingual Punjabi, Mirpuri, Italian, and Jamaican students to reason deductively in mathematics. He found that students' first language competence was an important factor in their ability to reason in mathematics in English as a second language. His study supported Cummins's hypothesis that a beneficial form of bilingualism could be achieved based on adequately developed first language skills. Similarly, Clarkson and Galbraith (1992) supported this hypothesis. In their study of sixth grade Papua New Guinean students, Clarkson and Galbraith showed that the students' level of competence in their first language, Pidgin, significantly influenced their mathematical performance. Like Dawe, they strongly proved Cummins' threshold hypothesis.

The developmental interdependence hypothesis

This hypothesis suggested that bilingual students' first and second languages acted on each other. It asserted that students' level of competence in one language was a function of his or her competence in the other language. Thus, exposure in one language contributed to the deeper conceptual and linguistic development of the other language. It further suggested that bilingual students' languages should be taken as one entity and that the development of students' one language was dependent on his or her other language. Clarkson and Galbraith contrasted this hypothesis. Instead, they advocated that bilingualism should not be taken as one-dimensional entity. They stressed that students' competence in both languages should be considered.

Cocking and Chipman's Factors Affecting Learning

Cocking and Chipman (1988) identified a model of how mathematics learning was affected by linguistic and nonlinguistic factors. Their model addressed the following factors: (1) students' entry characteristics, (2) students' opportunity to learn, and (3) students' motivation to learn. These factors were all extrinsic which formed part of a bilingual students' difficulty in learning mathematics and not inherently related to his or her being bilingual. This means that these factors were externally caused and were not due to the student's bilingual nature.

Students' entry characteristics

This factor referred to students' entry mastery in both language and mathematics. This included students' language and reading skills, learning ability, and conceptual understanding of mathematics. Studies (Han, 1998; Jones, 1982; Taole, 1981) showed how bilingual students' entry characteristics affected their learning. In her study, Han (1998) statistically showed that the Chinese language ability was a strong predictor of students' mathematics scores. She investigated the relationship between certain Chinese and English mathematical terms and students' understanding of the concepts represented by these mathematical terms. She found that some mathematical terms stated their underlying mathematical concepts more clearly than the other mathematical terms and that this clarity varied between the Chinese and the English languages. She found that there was a significant difference between the achievement of the English speaking students and the Chinese students and between the English speaking and the bilingual speaking students. Han concluded that the English and the Chinese languages were innately different in expressing mathematics ideas. Similarly, Taole (1981) comparatively analyzed the performance of South African students taught in a vernacular called Sesotho, in English, and in both Sesotho and English. He determined the effect of these three methods on students' achievement. His findings supported the hypothesis that a high level of proficiency in English, a bilingual students' entry characteristics, was a prerequisite for good performance in mathematics for students taught in English. Also, he found that the difference in English proficiency was statistically significant.

For bilingual students, semantics or language meaning might vary from one language to another (Jones, 1982). In his study of elementary Papua New Guinean students, Jones found that both the first and the second language students acquired different meanings of "more" and "less" in mathematical context. The students' level of mastery appeared to determine the nature of his or her response to questions requiring higher-level skills. Thus, for both the first and the second language English speakers, there appeared to be similar pattern of language development in acquiring the mathematical terms “more” or “less”. It was found that majority of students did not understand these terms and acquired them one by one with further language development and formal schooling. The results supported that understanding elementary mathematics concepts was built on students’ understanding of semantically related mathematical terms such as "more" or "less". This suggested that the relationship could seriously limit students’ ability to develop understanding of fundamental mathematical concepts and solve word problems. Again, this supported that students’ entry mastery affect mathematics achievement.

Students’ opportunity to learn

This factor referred to teacher's knowledge and training, and parent's assistance. This included variables such as time spent on task, quality of instruction, use of appropriate language, and parental or other people’s assistance. The factor might not be directly related to the language aspects of learning mathematics but encompassed the influence of appropriate use of language in the effective learning of mathematics. Studies (Bacon, 1983; Travers, 1988; Wang & Goldschmidt, 1999) proved that students’ opportunity to learn was a substantially significant factor in learning mathematics. In an attempt to show such significance, Travers (1988) identified findings from the Second International Mathematics Study (SIMS). He explored the limited opportunities given to eighth graders to learn mathematics. He used the SIMS model to report the findings that teachers’ coverage of mathematical content or what he called “opportunity to learn” was a significant variable for student achievement. This was an important finding, which addressed the reason why students had low performance on SIMS. Travers suggested that the low achievement of students could be attributed to the differences across mathematics classes in providing students the opportunity to learn mathematics. This meant that students had not been taught the content being tested. Also, he presented the dramatic differences in the quality of instructional practices or contexts in which students were placed.

As a corollary to this finding, Wang and Goldschmidt (1999) addressed the issue of equity in the curriculum in terms of course work measures. In their longitudinal study of U.S. immigrant students, they explored the assumption that bilinguals students were self-directed by their schools into less demanding courses which reduced their opportunity to master core subjects in the curriculum. They investigated the relationship between U.S. immigrant students' mathematics achievement and their opportunity to learn in terms of course taking and how this relationship differed by their English-language proficiency and immigrant status. They found that immigrant students and those with limited English proficiency (LEP) performed lower than native-born students did. Their analysis also showed that students' course taking patterns varied across their language proficiency, immigrant status, and ethnicity and had an effect on mathematics achievement. Students' socioeconomic differences affected their achievement but were of lesser importance than other related factors. This showed that there was an important interplay between students' opportunity to learn mathematics and their mathematical proficiency. This led Wang and Goldschmidt to stress the importance of assessing curriculum equity in providing equal opportunity for bilingual students to learn mathematics.

Curriculum equity required equity in quality instruction. Quality instruction required competent and skilled teachers. In this context, Bacon (1983) showed how skilled and trained teachers could provide bilingual students the fair opportunity to learn mathematics in their second language. His study on Cherokee Indian students showed how effective bilingual instruction was influenced by the facilitation of trained bilingual teachers. As a result, he found that Cherokee Indian students who received bilingual instruction scored significantly higher on reading achievement subtest than those without bilingual instruction. However, there was no significant difference between four years and five years bilingual instruction in mathematics achievement. Bacon proved that linguistically deprived Cherokee Indian children needed to receive bilingual instruction in order to improve their reading and mathematics achievement and this required skilled bilingual teachers.

Students' motivation to learn

This factor referred to students' expectations for rewards, their mathematics attitudes, and parental, peer, or cultural values. Studies (Hatano, 1982; Lester, Garofalo, & Kroll, 1989) showed how students' motivation to learn extrinsically affected mathematics learning. In particular, the Japanese culture was known to support and place a high value on students' mathematical understanding. Hatano (1982) discussed studies which showed the relationship of strong Japanese cultural support on the development of Japanese students' mathematical understanding. His discussion indicated that Japanese children preferred mathematics than other academic subjects. Moreover, a significant number of Japanese families paid to send their children to private schools for advanced mathematics training. This strong cultural and family support on students' mathematical development had a direct bearing on Japanese students' mathematics achievement. Thus, results from international tests showing exemplary performance of Japanese students in mathematics as well as in science showed how cultural and parental support for mathematics development significantly affects students' mathematics achievement. Furthermore, self-perception and perception of mathematics were also connected with students' performance in mathematics (Lester, Garofalo, & Kroll, 1989).

Effects of Bilingual Instruction

In response to the growing need to prove the claim that bilingual instruction affected students' mathematics achievement, many researchers (Conde, 1998; Ebert, 1985; Ferro, 1983; Linde, 1984; Myers & Milne, 1988; Valladoloid, 1991) conducted studies that linked bilingualism to students' mathematics achievement. In his study with Capeverdean bilingual students, Ferro (1983) showed that teaching in Capeverdean and English gave better results in mathematics achievement than teaching entirely in English or a mixture of Portuguese and English. Consistent with Linde (1984), his study found that there was no significant difference in the mathematics achievement mean scores between males and females. Also, he found that interaction between content and the three forms of instruction was not statistically significant. Combined factors such as sex, age, grade, time in school, English or Portuguese reading skills, aural comprehension in English, Portuguese, or Capeverdean, and Portuguese or Capeverdean fluency, did not predict mathematics achievement. However, his findings proved that students taught in Capeverdean/English were expected to increase their achievement more than those given the entirely English or Portuguese/English instruction.

Regarding curriculum, Ebert (1985) determined the effects of the Immersion Bilingual Mathematics Institute (IBMI), an immersion program designed to accommodate Hispanic linguistic, cultural and learning preferences, to the Mexican-American seventh graders' mathematics achievement. He found that the IBMI produced statistically significant gains in the students' mathematics achievement. His study showed that the Mexican-American seventh graders' mathematics achievement levels were significantly lower than their Anglo-American counterparts and the implementation of the IBMI could reduce the difference between Mexican-American and Anglo-American seventh graders' mathematics achievement level. Likewise, in his longitudinal study with Hispanic students, Valladoloid (1991) determined the effect of bilingual instruction on students' academic achievement as they progressed through a bilingual program. He found that Hispanic students' skills in mathematics across grade levels significantly improved. However, he found no improvement across grades between the groups for either English reading or language. Similarly, Conde (1998) investigated the influence of receiving instruction in two languages, English and Spanish, on the performance of students enrolled in the bilingual immersion program. The 4-year performance of the English/Spanish bilingual students was compared with a comparable control group. The data showed that the English/Spanish group performed significantly better than the control group for reading comprehension, mathematics computations, and applications along the four years. The group's mean percentiles on these three measures were significantly higher than those of the other groups. Conde concluded that receiving instruction in two languages did not negatively affect the performance of bilingual program students on tests taken in English. Furthermore, he found that this particular design of the bilingual program enhanced Hispanic students' general performance on standardized tests.

In a comprehensive study, Myers and Milne (1988) investigated the effects of students' home and primary language on the mathematics achievement of various groups of language minority students. They used two conceptual models, which measured the language spoken at home and students' primary language, to investigate the importance of intervening mechanisms to increase achievement. These two models were analyzed to estimate the structural relationships among background variables affecting mathematics achievement. It was found that there were significant differences between the mathematics achievement of various languages groups and that of monolingual English students. The results for the home language model showed that the bilingual groups had significantly higher achievement scores on at least one mathematics test than the English monolinguals and the non-English monolinguals had significantly lower scores than the English monolinguals. Myers and Milne's analysis of the cross tabular results of the primary and home language showed that more students from any of the home language groups relied on English than on the major non-English home language. The intervening variables in the home language models were found to be more effective at mediating the effects of home language for some groups than for others. Results from the primary language model showed that only the primary language and gender were considered as independent variables. Specifically, they found that students who claimed both Spanish and English as primary language had greater achievement deficits than students who claimed Spanish as a primary language.

Moscovitch (1996) on the other hand studied the interaction aspect of a bilingual conversation. She explored how Latino students construct mathematical meaning during bilingual, Spanish and English, conversations. She addressed general questions on the nature of mathematical talk as well as questions specific to the learning of mathematics during bilingual conversations. She considered two frameworks for describing mathematics learning and its relationship to language. The first framework called a “discontinuity” model was used to examine mathematical expressions in Spanish and English while the second framework called “situated” model was used to analyze two bilingual mathematical conversations. She found that the “discontinuity” model clarified multiple meanings in mathematics conversations and provided analysis to describe mathematics learning in two languages. However, she added that this model had certain limitations on reducing mathematics discourse to technical vocabulary and failing to consider situational resources. On the other hand, she found that the “situated” model broadened and included more aspects of the learning situation than the "discontinuity" model. Thus, she suggested that the "situated" model could be used to generate different questions and show how everyday context and students' first language be used as a resource for learning mathematics.

To quantitatively investigate the relationship of language on students' mathematics achievement (Cummins, 1981) and determine some mathematics learning factors

(Cocking & Chipman, 1988) affecting achievement, the following research questions were addressed:

1. Do English and Filipino test takers significantly differ in overall mathematics achievement?
2. Do English and Filipino test takers significantly differ in achievement on specific mathematics content areas?
3. Do students' self-concept of language and mathematics proficiency relate to their mathematics achievement?

Method

The TIMSS-R used the TIMSS framework, methodology, and instruments used in 1994-96. However, certain modifications were adopted which involved newly constructed items replacing the released items in the TIMSS achievement test. The sample consisted of the upper grade level of 13-year olds, which came from 150 schools of each participating countries (UP-NISMED, 2000).

Participants

The Philippine sample was composed of 114 public schools and 36 private schools. These schools were selected by stratified random sampling with region as stratum. In each school, a first year class was randomly chosen. There were 6601 seventh graders, 47% were boys and 53% were girls. With this large number of cases, $n(6601)$, this study was statistically very powerful (1.0). Among the participating schools, only 10% of the principals opted to have their students take the Filipino translation of the tests. Thus, a smaller number of students took the Filipino version of the test (n = 593) against those who took the English version of the test (n = 6008). The sample had mean age of 14.1, an average that was less than the international mean age of 14.4. With this sample, girls performed relatively better than the boys. Students, in general were weakest in the areas of measurement and algebra. However, their self-concept in mathematics was at a medium level (77%) and had high level (59%) of positive attitude towards mathematics. Academically, they were far behind their international counterparts in all areas of mathematics covered in the test. Furthermore, they had been taught more on computational skills, took mostly multiple-choice tests, and relied heavily on textbook in learning mathematics (UP-NISMED, 2000).

Instruments and Materials

This study used data collected from the TIMSS-R assessment test, which consisted of achievement as well as background data. In TIMSS-R, each student was given an achievement test booklet and a student questionnaire. There were eight booklets for the achievement test. However, each student was asked to answer only one booklet. Each booklet required 90 minutes of response time. All instruments and materials were translated in English and Filipino.

The achievement test consisted of 162 items, which consisted of questions on fractions and number sense (61), measurement (24), data representation, analysis, and probability (21), geometry (21), and algebra (35). The questions were multiple-choice tests (77%) and free response (23%). The multiple-choice items were scored a point each while the free response items were scored using a double-digit scoring rubric. This scoring system used two-digit codes. The first digit designated the correctness level of the response while the second digit, combined with the first, represented a diagnostic code identifying specific types of approaches, common errors, or misconceptions of students who took the test (Gonzalez & Miles, 2001). In order to ensure reliable scoring of free-response items, TIMSS conducted intensive training for the personnel in-charge of scoring the free-response items. The TIMSS achievement tests covered the entire span of curricula from the beginning through the completion of the secondary school. The tests were developed through an international consensus process which involved inputs from mathematics, science, and measurement experts.

Student Questionnaire covered items on educational resources at home, peer pressure, out-of-school study time, self-concept and attitude towards science and mathematics. Not all of the students responded to all of the mathematics and science items. In order to ensure broad subject coverage, TIMSS used a rotated design that included both mathematics and science items. Thus, students were tested in both science and mathematics, which were grouped into clusters.

Design

TIMSS used the "plausible value" methodology to estimate students' proficiency in mathematics. Estimation was required since the students answered not all of the questions. This meant that the students answered a fraction of the total items in the assessment tests. This estimation or "plausible value" was based on students' response on the test items and background questionnaire (Gonzalez & Miles, 2001). The total mathematics achievement of students and each of the five specific mathematics content areas were given five plausible values for different data analyses.

In order to answer the research questions of this study, re-analysis of the TIMSS-R data was conducted. Specifically, data on mathematics achievement of Filipino students who have taken the English and the Filipino versions of the test were compared. The data used were the computed means of the five plausible values for the total mathematics achievement as well as its content areas namely: fractions/number, measurement, data representation, geometry, and algebra. Each plausible value was in itself valid for data analysis. However, it was more powerful and reliable to use the means of the five plausible values in order to cover all possible estimates of students' achievement results.

Procedures

The means of each five plausible values for mathematics achievement and the content areas, namely fractions/number, measurement, data representation, geometry, and algebra, were computed using the SPSS Transform and Compute Command. With these computed means, mathematics achievement of students who took the English and the Filipino were quantitatively compared. Statistical analyses were conducted to generate quantitative results for the mean comparison. Specifically, one-way ANOVA was used to determine the significant difference or no significant difference of the mean achievement of the two language groups. On the other hand, the independent t-test was employed to compare the specific means of each of the five content areas for each group. Finally, a correlation analysis (Spearman-rho) was used to determine the relationship between students' self-concept of language and mathematics proficiency and their mathematics achievement. All procedures used the SPSS program to perform the required statistical analyses.

Results

Specifically each data analysis provided statistical results that addressed the three research questions of the study: (1) Do English and Filipino test takers significantly differ in mathematics achievement? (2) Do students significantly differ in achievement on specific mathematics content areas? (3) Do students' self-concept on language and mathematics proficiency relate to their mathematics achievement?

On English and Filipino Means

Students who took the English version of the test performed significantly better than those who took the Filipino version of the test. Table 1 showed this result.

Table 1

Comparison of Achievement Means by Language Group

Language	*M*	*SD*	*F*	η^2	*p*
English	348.45	86.74	58.02*	.009	.001
Filipino	320.60	63.90			

**p<.05*

The one-way ANOVA was used to compare the mean achievement between the English and the Filipino groups. A significant but weak $(\eta^2 = .009)$ difference was found, $F(1,6599) = 58.02$, $p = .001$. This result showed that there was a significant though weak difference between the average mathematics achievement of students who took the English and the Filipino version of the test. Those who took the English version of the test performed significantly better than those who took the test in Filipino.

On Mean Achievement on Different Content Areas

The performance of those who took the English version and the Filipino version of the test on five content areas was analyzed and compared in order to validate whether the higher performance of students who took the English version of the test was consistent across these mathematics content areas. In particular, results showed that students who took the English version of the test performed significantly better in all mathematics content areas. They significantly outperformed those who took the Filipino version of the test on questions about fractions/number, measurement, data representation, geometry, and algebra. Table 2 showed the statistically significant difference between the means of the English and the Filipino test takers across mathematics content areas.

Table 2

Means and Standard Deviation for Mathematics Content Areas

Content Area	*M*		*SD*		*t*	*p*
	English	*Filipino*	*English*	*Filipino*		
Fractions/Number	380.49	358.51	77.50	59.79	8.29*	.001
Measurement	357.23	338.01	78.33	63.17	6.90*	.001
Data Representation	407.86	394.47	51.72	44.80	6.84*	.001
Geometry	384.01	370.42	65.00	51.95	5.93*	.001
Algebra	348.96	315.88	98.14	73.47	10.11*	.001

*$p < .05$

An independent sample *t*-test was conducted on the average achievement of those who took the English and the Filipino versions of the test across the five content areas to determine whether the means of these two language groups were significantly different for each content area. This test was used since the cases were unrelated. Results showed the corresponding computed values for the mean and standard deviation of each content area. Using Levene's test, the data had computed values for fractions/number $(F = 58.17, p = .001)$; measurement

$(F = 38.04, p = .001)$, data representation $(F = 22.84, p = .001)$, geometry $(F = 28.73, p = .001)$, and algebra $(F = 69.38, p = .001)$. All corresponding probabilities were less than the significance level of 0.05. This indicated that the variances of the two groups were significantly different. Thus, in all cases, the results for not assumed equal variances were considered. In this data, the computed *t* statistics for the independent samples *t* test had corresponding $p = .001$, which was less than $\alpha = .05$. Thus, the null hypothesis was rejected. In other words, using $\alpha = .05$ two tails, the observed difference between the means of each content area for the English and Filipino samples were statistically significant. The results supported the conclusion that the English and Filipino groups significantly differ in achievement scores across all content areas. The English group outperformed the Filipino group in fractions/number, measurement, data representation, geometry, and algebra.

On Language and Mathematics Proficiency

There was a significant but weak relationship between students' self-concept on language $(\tau = .237,\ p = .001)$ and on mathematics $(\tau = .264,\ p = .001)$ proficiency and their mathematics achievement. Students' positive perception about their language and mathematics proficiency was related to high achievement. However, the relationship was not strong enough to be generalized. Table 3 shows this weak relationship.

Table 3

Correlation between Self-Concept in Language/Math and Math Achievement

Factors	τ	*p*
Do well in language	.237*	.001
Do well in mathematics	.264*	.001

**p < .01*

Discussion

Research studies discussed above clearly showed that learning mathematics in a second language was a complex process. Specifically, studies (Clarkson & Galbraith, 1992; Dawe, 1983) found that proficiency in the first language was essential in the development of students' mathematics understanding. Also, studies (Conde, 1998; Ebert, 1985; Ferro, 1983; Moscovitch, 1996; Myers & Milne, 1988; Valladoloid; 1991) on bilingual instruction showed positive results on students' achievement. Furthermore, a number of studies (Basurto, 1999; Han, 1998; Jones, 1982; Taole, 1981) identified curricular and instructional issues that affect the teaching and learning of mathematics in the second language. Specifically this study, investigated the effect of language on Filipino students' mathematics achievement. Analyses of data from the TIMSS-R for the Philippine sample showed interesting results about this relationship.

First, students who took the English version of the test performed significantly better than those who took the Filipino version of the test. These results somewhat contradicted research findings (Conde, 1998; Ebert, 1985; Ferro, 1983; Moscovitch, 1996; Myers & Milne, 1988; Valladoloid; 1991), which showed that the use of the first language positively increase bilingual students' mathematics achievement. However, in the case of the Philippine sample, it was important to note that Filipino students, generally, learned mathematics in English, their second language. Thus, instruction and assessment were conducted in the English language. So, the sudden use of the Filipino language in the test posed conflict with how the students were normally taught and evaluated. Test taking in the Filipino language was not a common practice in the Philippines. Thus, the consistency of having taught in the second language and being assessed in the first language contradicted a good teaching practice. In this case, students were not given equal opportunity to learn mathematics (Travers, 1988). Travers, in his SIMS analysis, suggested that students should be provided equal instructional opportunity to learn mathematics. In addition, the Filipino students who took the Filipino version of the test were not given the free choice to decide whether they would take the Filipino or the English translation. It was their principal who made the decision for them. Wang and Goldschmidt (1999) refereed to this as one of the directing policy of a school, which they found to hinder students' opportunity to learn. Thus, from the onset, the decision was not a fair decision. Besides, language proficiency as a contributor to mathematics achievement (Cummins, 1981) was not assured. This concern was critical in a country like the Philippines, which has a complex language system. The country has at least 200 languages (dialects) and students have their native language aside from the national language, Filipino. Thus, the proficiency in Filipino was not assured for those who took the Filipino test.

Second, students who took the English version of the test performed significantly better in all mathematics content areas. They significantly outperformed those who took the Filipino version of the test on questions about fractions/number, measurement, data representation, geometry, and algebra. As a corollary to the discussion on the first result, this significant difference was again not guaranteed. The practice of teaching and assessing in different languages violated the idea of fairness and equity. Thus, the practice of language use posed a validity issue on this result. In other words, it was not fair that students were taught in one language and be assessed in another language. Again, studies (Bacon, 1983; Travers, 1988; Wang & Goldschmidt, 1999) proved that such was not a recommendable practice.

Third, correlation analysis found that there was a significant but weak relationship between students' self-concept on language and mathematics proficiency and their mathematics achievement. It was important to note that the language and mathematics proficiency used here were based on students' self-perception. TIMSS-R data lacked information on specific and nationally acceptable measures of students' language and mathematics proficiency. This was, however, beyond the scope of the data collection of the TIMSS due to the nature of its study. Thus, acceptable language and mathematics proficiency measures were needed to have a more comparable analysis of the relationship between language and mathematics achievement. Studies such as that of Dawe (1983) and Clarkson and Galbraith (1992) showed this interesting relationship.

This study as a whole had certain limitations. Specifically, the TIMSS-R data lacked language related variables (e.g., language proficiency score in both English and Filipino, use of the Filipino language in mathematics teaching, teacher's language and mathematics competency in teaching mathematics, and schools language policy program). Research studies (Conde, 1998; Ebert, 1985; Ferro, 1983; Moscovitch, 1996; Myers & Milne, 1988; Valladoloid; 1991) had identified these variables as affecting bilingual students' mathematics achievement. The inadequacy of information, however, was due to the nature of the TIMSS-R data, which focused on the mathematics and science achievement of students. Thus, the analyses lacked comparison between the extrinsic factors (Cocking & Chipman, 1988) affecting mathematics learning and students' mathematics achievement scores. Also, the language proficiency used in the study was self-reported or students' self-concept of his or her proficiency in language and mathematics. Thus, the results could not be generalized. Furthermore, students were not given a free hand to choose what language version of the test they preferred to take. Instead, the school principals made the decision for them. Thus, the significant difference in achievement scores between those who took the English and the Filipino version of the test might be attributed to biased sampling.

Implications

In spite of the limitations discussed above, the results of this study support research findings (Clarkson & Galbraith, 1992; Dawe, 1983; Han, 1998; Jones, 1982; Moscovitch, 1996) linking language and mathematics achievement. In particular, there is a need to (1) strengthen both the first and second language skills of the Filipino students, and (2) improve curriculum and instruction.

On Language Skills

The significant mean difference between those who took the English and the Filipino version of the test suggests a closer study on the curricular and instructional policy in teaching mathematics in the second language. Cummins (1981) hypothesized that language competence is an important factor in students' mathematics learning. Similarly, Dawe (1983), Han (1998), Moscovitch (1996), and Clarkson and Galbraith (1992) emphasized that bilingual students' competence in both languages should also be aimed at in improving students' mathematical understanding. In particular, they suggested that the socio-linguistic differences of these two languages should also be taken into account as another important factor affecting students' mathematics learning. Generally, research findings substantiated the idea that students with higher mathematical competence have languages that are more flexible and adaptable in dealing with the diversity of mathematics test questions. They supported the need to strengthen bilingual students' first and second language skills. Furthermore, the possibility of implementing bilingual instruction for the Filipino students should be taken into consideration to address the multilingual capabilities of the students. Besides, studies (Conde, 1998; Ebert, 1985; Ferro, 1983; Moscovitch, 1996; Myers & Milne, 1988; Valladoloid; 1991) have shown how bilingual instruction affects students' mathematics achievement. Even with non-bilingual students, most difficulties in mathematics were rooted in language (Orr, 1987). Thus, it is significant to consider the consistency and compatibility between the teaching styles of teachers and the learning styles of the students.

On Curriculum and Instruction

Achievement differences between the English and the Filipino group suggest curricular and instructional differences between the two groups. Thus, a closer study on these differences is needed to make sure that opportunity to learn is equally provided (Bacon, 1983; Travers, 1988; Wang & Goldschmidt, 1999). This finding implies the need to improve curriculum and instruction that will provide fair and equal opportunity for students to learn mathematics in their second language. Wang and Goldschmidt (1999) showed that students' opportunity to learn is related to their language proficiency. Their study of U.S. immigrant students suggests that immigrant students and those with limited English proficiency are self-directed by their schools into less demanding courses. This results in a reduction of their opportunity to master core subjects in the curriculum. Thus, their achievement in mathematics is affected. They suggested that schools and teachers should monitor the type of courses students choose and encourage them to take subjects that are more challenging. It cannot be denied that school policies and teacher beliefs influence students' course taking decisions.

Furthermore, Travers (1988) supported the need for equal opportunity for quality instruction for bilingual students. He attributed the low performance of bilingual students to the differences in the quality of mathematics instruction given to them. Travers agreed with Linde (1984) who suggested that a closer study on the variations in instructional materials, text, content, and qualifications of teachers for classes having different forms of bilingual instruction. Bacon (1983) and Ebert (1985), on the other hand, encouraged the employment of trained bilingual teachers to teach in bilingual classrooms. Their studies have proven how trained bilingual teachers positively affect the facilitation of the mathematics teaching for bilingual students. With these concerns, the curriculum and instructional practices of Filipino teachers should be reviewed and modified. Furthermore, it is important to check the consistency of using the same language in teaching mathematics and assessing students' achievement.

Suggestion for Further Research

Studies (Bacon, 1983; Travers, 1988; Wang & Goldschmidt, 1999) have stressed the need to improve curriculum and instruction in the teaching and learning of mathematics in the second language by providing fair and equal opportunity for bilingual students to learn mathematics. To respond to this growing need, I suggest the need to further investigate instructional and assessment practices or strategies in a bilingual or multilingual classroom. This investigation should identify effective and non-effective teaching practices in a multicultural classroom. In particular, a case study should be conducted to document the possible practice of code-switching (Setati & Adler, 2000) and language approach (Spanos, Rhodes, Dale, & Crandal, 1988) during classroom interaction.

References

Bacon, H. (1983). A comparative study of achievement test scores between bilingually instructed and not bilingually instructed Cherokee Indian students (Doctoral dissertation, The University of Oklahoma).

Basurto, I. (1999). Conditions of reading comprehension which facilitate word problems for second language learners. *Reading Improvement, 36*, 143-148.

Clarkson, P. C. (1983). Types of errors made by Papua New Guinean students. *Educational Studies in Mathematics*, *14*, 355-367.

Clarkson, P., & Galbraith, P. (1992). Bilingualism and mathematics learning: Another perspective. *Journal for Research in Mathematics Education, 23*, 34-44.

Cocking, R. R., & Chipman, S. (1988). Conceptual issues related to mathematics achievement of language minority children. In R. D. Cocking & J. P. Maestre (Eds.), *Linguistic and cultural influences on learning mathematics*. Hillsdale, NJ: Lawrence Erlbaum.

Conde, M. (1998). The effect of dual language and instruction on academic achievement as measured by the SAT: An evaluation of the "international studies program" of Miami-Dade county public schools (Doctoral dissertation, Florida International University).

Cummins, J. (1981). Linguistic interdependence and the educational development of bilingual children. *Review of Educational Research*, 49, 222-251.

UP-NISMED. (2000). *TIMSS-R Philippine report*. Quezon City, Philippines: UP-NISMED, DOST-SEI, and UP-NISMED.

De Avila, E. A. (1998). Bilingualism, cognitive function, and language minority group membership. In R. D. Cocking & J. P. Maestre (Eds.), *Linguistic and cultural influences on learning mathematics*. Hillsdale, NJ: Lawrence Erlbaum.

Dawe, L. (1983). Bilingualism and mathematical reasoning in English as a second language. *Educational Studies in Mathematics, 14,* 325-353.

Ebert, C. (1985). The effects of an immersion bilingual mathematics institute on the achievement of seventh grade Mexican-American students (Doctoral dissertation, Oregon State University).

Ferro, S. (1983). Language influence on mathematics achievement of Capeverdean students (Doctoral dissertation, Boston University).

Gee, P. (1982). Reading and mathematics achievement of eighth-grade Chinese-American students enrolled in bilingual or monolingual programs (Doctoral dissertation, University of San Francisco).

Gonzalez, E. J., & Miles, J. A. (Eds.) (2001). *User guide for the TIMSS 1999 International database: IEA's repeat of the Third International Mathematics and Science Study at the eighth grade.* Chestnut Hill, MA: Boston College.

Han, Y. A. (1998). Chinese and English mathematics language: The relationship between linguistic clarity and mathematics performance (Doctoral dissertation, Columbia University Teachers College). *Dissertation Abstracts International, 59*, 2405.

Hatano, G. (1982). Learning to add and subtract: A Japanese perspective. In T. P. Carpenter, J. M. Moser & T. A. Romberg (Eds.), *Addition and subtraction: A cognitive perspective*. Hillsdale, NJ: Lawrence Erlbaum.

Jones, P. (1982). Learning mathematics in a second language: A problem with more or less. *Educational Studies in Mathematics, 13*, 269-287.

Linde, S. (1984). Different forms of bilingual education and corresponding levels of achievement among Finnish sixth-grade students in Sweden (Doctoral dissertation, University of Southern California).

Lester, F. K., Garofalo, J. & Kroll, D. L. (1989). Self-confidence, interest, belief, and metacognition: Key influences on Problem-solving behaviors. In D. B. McLeod & V. M. Adams (Eds.), *Affect and Mathematical Problem-Solving: A New Perspective*. New York: Springer-Verlag.

Moscovitch, J. (1996). Learning mathematics in two languages. In M. Carss (Ed.), *Proceedings of the 20th Conference of the International Group for the Psychology of Mathematics Education, Spain, 4,* 27-34.

Myers, D. E., & Milne, A. M. (1988). Effects of home language and primary language: A model and results for secondary analysis. In R. D. Cocking & J. P. Maestre (Eds.), *Linguistic and cultural influences on learning mathematics*. Hillsdale, NJ: Lawrence Erlbaum.

Orr, E. W. (1987). *Twice as less: Black English and the performance of black students in mathematics and science*. New York: Norton & Company, Inc.

Saxe, J. B. (1988). Linking language with mathematics achievement: Problems and prospects. In R. D. Cocking & J. P. Maestre (Eds.), *Linguistic and cultural influences on learning mathematics*. Hillsdale, NJ: Lawrence Erlbaum.

Taole, J. (1981). A study of the effect on pupils' achievement of studying a selected secondary school mathematics in the vernacular (Doctoral dissertation, Columbia University Teachers College).

Tsang, S. (1988). The mathematics achievement characteristics of Asian-American students. In R. D. Cocking & J. P. Maestre (Eds.), *Linguistic and cultural influences on learning mathematics*. Hillsdale, NJ: Lawrence Erlbaum.

Travers, K. J. (1988). Opportunity to learn mathematics in eighth-grade classrooms in the United States: Some findings from the Second International Mathematics Study. In R. D. Cocking & J. P. Maestre (Eds.), *Linguistic and cultural influences on learning mathematics*. Hillsdale, NJ: Lawrence Erlbaum.

Wang, J., & Goldschmidt, P. (1999). Opportunity to learn, language proficiency, and immigrant status effects on mathematics achievement. *The Journal of Educational Research, 93*, 101-111.

Watson, H. (1988). Language and mathematics education for aboriginal Australian children. *Language and Education: An International Journal, 2*, 255-273.

Valladoloid, L. (1991). The effect of bilingual education on students' academic achievement as they progress through a bilingual program (Doctoral dissertation, United States International University).

Author:

Leah Nillas , Illinois State University, Normal, Illinois, USA. nillas@lycos.com