IV RESULTS AND DISCUSSION

This chapter shows the results of the four tests illustrated with tables so for each test, the table shows results for monolingual and bilingual learners separately, as well as for boys and girls. In the last column on the right, the averages of the scores obtained by monolingual and bilingual students can be observed. The averages of the scores obtained by boys and girls can be found in the last line of the table. After the results of each test, an explanation is given to clarify the outcomes, taking into account the findings from other studies. The results of the four tests listed for each participant separately is possible to verify in the appendix 5. The last subsection of this chapter contains the answers to each research question asked at the beginning.

4.1 Results of test 1: Spatial speed test

The first test investigated the speed of identifying geometric figures. Tables 11a and 11b show the results of the four groups.

This test gives various results: the first column of tables 11a and 11b indicates the time the child spent on the task, the second column shows the amount of points obtained for correct answers and the last column gives a percentage taking into account the time and the correct answers. The column of percentages is the one that indicates the end result because both variables, time and correct answers, both observed for test 1, are taken into account in the percentage.

	Boys			Girls		
	sec.	**Pts.**	**%**	**sec.**	**Pts.**	**%**
Monolinguals	17.05	430	90.5%	16.73	453	83%
Bilinguals	16.84	510	92.5%	17.29	540	93.8%
average	**16.95**	**470**	**91.5%**	**17.01**	**496.5**	**88.4%**

Table 11a: results of test 1

	Average		
	sec.	**Pts.**	**%**
Monolinguals	**16.89**	**441.5**	**86.75%**
Bilinguals	**17.07**	**525**	**93.15%**

Table 11b: results of test 1

Interesting results can be observed within the time parameter: The monolingual group did answer faster than bilingual group but they did more mistakes than the bilinguals students so this results in a larger amount of points for bilingual speakers. Their answers were better according to the time they used. In other words, monolingual learners answered faster but with more mistakes whereas bilingual learners answered a little slower but with a higher percentage of correct answers. The third column shows the percentage accumulated taking into consideration time and correct answers and we can see that the bilingual group had in the end a higher percentage than the monolingual group (93.15% vs. 86.75%). The group that achieved the highest percentage (this means that the participants were the fastest and had the most correct answers) was the group of the bilingual girls (93.8%). The group that had in the end the lowest percentage was the group of monolingual girls.

The time spent on answering the task was very similar for each group (there were differences but they are not major) which means that they all were almost as fast but the percentage of correct answers differed. Monolingual learners in general tended to be faster (a possible reason could be that they were more concerned about the time than about giving the correct answer) whereas the bilingual group in general was slightly slower than monolinguals (0.18 seconds slower). Possibly they were thinking more about the answer they gave. Although the monolingual speakers were faster this did not result in a higher amount of points. The test needed to be answered as fast as possible but correctly as well, which is a task that the bilingual girls performed the best. All participants received the same instructions: they needed to be fast *and* correct.

4.1.1 Significance of the results of test 1

A statistical analysis of the results of the monolingual and bilingual groups (the t-test) shown in table 12, demonstrates that the results are significant for test 1 with the population used for this study. Using $\rho < .05$ as the level of confidence, the results indicate that 95% of the results with the population tested are based on truly happening facts. This means that 95% of the results obtained are not accidental; this is no coincidence that the bilingual students scored higher than the monolingual students. The t-score has been calculated with the formula shown under subsection 3.4.1 on page 49 using the standard deviations, the means and the number of participants (see table 12.).

	Monolinguals	**Bilinguals**
Mean	86.75	93.15
Standard deviation	7.18	4.11
Variance	51.57	16.87
t - score	**3.4598**	
$\rho < .05$ (confidence level)	*df* = 39 (population)	1.697 (critical value)
Interpretation	Results are **significant** (t-score is greater than the critical value)	

Table 12: Significance of the results of test 1

The standard deviation is the indicator of dispersion of the average of all scores from the mean. The more spread apart the data is, the higher the standard deviation. In the case of test 1, the standard deviation is 7.18 for the monolingual learners and 4.11 for the bilingual learners which means that the bilingual participants obtained scores closer to each other. This also indicates that the monolingual speakers had scores that are more spread out than the bilingual speakers (some of the monolingual students scored high while others scored low).

4.1.2 Interpretation of the results of test 1

Bilingual learners need to be fast in their thinking because they have the necessity to decode in one language and to encode in another language. These strategies of decoding and encoding involve mental speed, which may explain why bilinguals are faster and able to find correct answers.

The results of test 1 seem to point to the conclusion that bilingual speakers are able to think fast and find the appropriate answer. The cognitive process of

thinking fast and correct is due to the mental gymnastic that bilingual or multilingual speakers are able to do with their two or more spoken language that enables them to switch from a language to another, explains Holmes (2001). This phenomenon is known as code switching or code mixing[5]. They start to speak in English for example and because of a change in the situation, such as the arrival of a new person, they switch and speak in French when it is the code of the new interlocutor. Code switching occurs automatically when a situation obliges the speakers to do it and code switching and code mixing help bilingual speakers to think faster and be more efficient in their communication. They need to change the language and the grammar structures within one conversation even sometimes within one sentence. Most of the time, bilingual speakers switch the language without having problems to keep speaking because they are able to think in both languages. They do not have to translate what they want to say, they just say it. The difference between monolingual speakers when they want to say something in a foreign language is that they need to translate, bilinguals on the other hand cannot translate, they transfer their thoughts in the other language: it is not a translation. This ability allows them to switch languages and as a consequence they are used to thinking fast because every bilingual speaker is able to code switch, says Holmes. Bilingual speakers have the training to listen, react and give output very promptly. This gives them an advantage in thinking fast in general, as shown with the test of spatial speed, which had no relation to language, only

[5] Code switching and code mixing are mostly associated with the sociolinguistic function of bilingual communication. It is a rule governed process that does not occur randomly. The speaker is changing the language in the part of the sentence where that makes sense. The difference between code switching and code mixing is evident: Code mixing can occur in the middle of a sentence while code switching happens only after the sentence is finished (Holmes, 2001).

mathematics. The conclusion is that bilingual learners can transfer their ability of thinking fast to tasks other than code switching / mixing.

Bilingual speakers have to deal with linguistic contexts at the time of retrieval that is sometimes different from the linguistic context at the time of encoding. As a result, they need to adjust their encoding strategies and encode information consistent with the language of retrieval (Marian & Fausey, 2006). These processes require a quicker velocity in thinking and sorting out information. The training bilingual speakers have to sort out information in more than one language gives them a general ability to think faster than a monolingual speaker which may explain the differences in the results of this test.

4.2 Results of test 2: visual memory test (pattern recognition)

The visual memory test had 12 points, one for each correct answer. Table 13 indicates the results of the four groups and the averages. The percentages refer to the average of correct answers given (12 correct answers = 100%). The percentages help the reader to compare the results in a scale of 100.

	Boys		**Girls**		**average**	
	Pts	**%**	**Pts**	**%**	**Pts**	**%**
Monolinguals	10.1	84.2%	9.5	79.2%	**9.8**	**81.7%**
Bilinguals	11.6	96.7%	11.1	92.5%	**11.35**	**94.6%**
average	**10.85**	**90.4%**	**10.3**	**85.85%**		

Table 13: results of test 2

The best group resulted to be the bilingual boys with an average of 11.6 points out of 12. The weakest group was the monolingual girls with only 9.5 points out of 12. Bilingual students in general outperformed monolingual students on that test (94.6% vs. 81.7%). The difference, 12.9%, indicates that the bilingual learners in this study have better skills for memory than monolingual learners. Boys in general scored higher than girls in both language groups (90.4% vs. 85.85%). The difference of percentages between the girls' and boys' results on the other hand is much smaller (difference of 4.55%). Bilingual students had better results than boys in general (94.6% vs. 90.4%). This seems to indicate that language variable is stronger than the gender variable.

4.2.1 Significance of the results of test 2

Table 14 shows that the results of test 2 are significant using the population mentioned in this study. Using $\rho < .05$ as the confidence level, the results indicate that in 95% of the results obtained for test 2 with the population tested are not accidental. The t-score has been calculated with the formula shown under subsection 3.4.1 on page 49.

The standard deviation for test 2 is 1.40 for the monolingual participants and 0.93 for the bilingual participants (see table 14). These numbers indicate that the bilingual students scored closer to the mean than the monolingual students: There are no large difference between the best and the lowest scores for the bilingual participants; they are all relatively close to the mean when compared to monolingual participants.

	Monolinguals	**Bilinguals**
Mean	9.80	11.35
Standard deviation	1.40	0.93
Variance	1.96	0.87
t-score	**4.1213**	
$\rho < .05$ (confidence level)	*df* = 39 (population)	1.697 (critical value)
Interpretation	Results are **significant** (t-score is greater than the critical value)	

Table 14: Significance of the results of test 2

4.2.2 Interpretation of the results of test 2

These results are very positive and meet the expectations expressed in the research questions. In the pilot, the monolingual participants outperformed the bilingual participants, which was a surprise. Although the difference between the groups was very small in the pilot, the outcome was not the one expected. The test has been kept as it was for the pilot study (no adaptation was made). In the present study, bilingual speakers outperform monolingual speakers (94.6% vs. 81.7%). The fact that the results between the pilot study and the actual study did not coincide may be caused by a smaller population in the pilot study. The actual study was conducted with twice the number of the participants, which could explain a possible difference in the results.

In this study bilingual learners showed a better aptitude of memorizing mathematical figures than monolingual learners. According to Souviney (1983, cited in Clarkson, 1992), bilingual speakers have a greater ability to memorize than

monolingual speakers and the results of test 2 correspond with Souviney' statement.

French & Jacquet (2004) studied bilingual speakers and memory and they showed that, independently of whether the bilingual has one big storage or two storages, he is able to activate the channels in the brain that look for the correct item. This process requires a well developed memory, since bilinguals need to find the correct word out of two storages, or out of one big storage, in both cases twice the amount of words that a monolingual speaker has. Simply the fact that bilingual learners need to remember more words in two languages helps them to develop their memory skills. And they do not only improve it through vocabulary, they also memorize structural patterns and grammar rules in two languages. Researchers (Thorell, Lindqvist, Bergman Nutley, Bohlin & Klingberg, 2009) have shown that memory increases by its use. They have found that training in working memory can have significant effects in other cognitive skills. Bilingual speakers develop their memory skills more than monolingual speakers do, which lead to better results in memory tasks, such as in test 2.

The group that received the best results is that of the bilingual boys. In this test, gender is not stronger as the language variable since the two best groups are both bilinguals. By comparing gender with language variable, it is possible to deduce that boys are not automatically better at memory skills than girls. However, it can be concluded that bilingual students in this study have better memory skills than monolingual students due to their need of memorizing vocabulary and linguistic structures in two languages and also to the constant training they have

using two linguistic codes. According to the results of test 2, bilingual education seems to have a positive effect on memory.

4.3 Results of test 3: logical thinking test

The logical thinking test was a written test which had 10 points if the child answered every question correctly. Table 15 shows the results of the four groups and the averages. The participants had to answer five questions and find for each one the correct explanation. The test had multiple choice options for answers and explanations and in case they found the correct answer and the correct explanation, the participants received 2 points. If children chose a wrong answer but a correct explanation, they would get only one point. The table below shows that the best group was the bilingual boys (85% of correct answers) followed by the bilingual girls (82%). Both bilingual groups outperformed the monolingual groups (83.5% vs. 75.5%). The weakest group is the monolingual girls with 73% of correct answers.

	Boys		**Girls**		**average**	
	Pts	**%**	**Pts**	**%**	**Pts**	**%**
Monolinguals	7.8	78%	7.3	73%	**7.55**	**75.5%**
Bilinguals	8.5	85%	8.2	82%	**8.35**	**83.5%**
average	**8.15**	**81.5%**	**7.75**	**77.5%**		

Table 15: results of test 3

4.3.1 Significance of the results of test 3

For test 3, the results are significant, as illustrated in table 16 using the population mentioned in this study. The confidence level $\rho < .05$ indicates that for test 3 with the population tested 95% of the results are based on truly facts and no coincidence. The t-score has been calculated with the formula shown under subsection 3.4.1 on page 49.

	Monolinguals	**Bilinguals**
Mean	7.55	8.35
Standard deviation	1.43	1.14
Variance	2.05	1.29
t-score	**1.9570**	
$\rho < .05$ (confidence level)	*df* = 39 (population)	1.697 (critical value)
Interpretation	Results are **significant** (t-score is greater than the critical value)	

Table 16: Significance of the results of test 3

For test 3, the standard deviations obtained were 1.43 for the monolingual students and 1.14 for the bilingual students. Again, the bilingual participants scored closer to the mean than the monolingual participants which means they are a more homogenous group.

4.3.2 Interpretation of the results of test 3

Bilingual students performed better than monolingual students in this test where logical thinking ability was tested. According to a study conducted by Clarkson

(1992), the fact that bilingual speakers scored higher may be due to their greater ability to solve mathematical problem compared to monolingual speakers. By participating in bilingual education, students may have increased their logical thinking (Hutson, 2008).

Another variable that should be taken into consideration is that this test involved language and not only mathematical symbols. It is the only test in this study that examines how the participants deal with mathematical tasks described with language and not with only symbols. The participants had to read the questions first, to understand them linguistically and mathematically. The questions were asked according to the educational language (in Spanish for the monolinguals and in German for the bilinguals) but the fact that they had to first deal with the linguistic structures and then with mathematical reasoning might have given the bilingual speakers an advantage. Bialystok (2001) explains how bilingual children in general outperform monolingual children in tasks involving the cognitive control of linguistic processes. This is one possible explanation why bilingual participants had better results in this test.

In this test, the highest percentages of correct answers were not achieved by the two groups of boys since the bilingual girls outperformed the monolingual boys (82% vs. 78%). The results seem to indicate that logical thinking is a cognitive skill that bilingual speakers dominate better than monolingual speakers, independently of their gender.

The results lead to a general conclusion that bilingual education may increase the logical thinking skills of the learners because bilingual speakers performed the test with better outcomes than children who received an education in one language only.

4.4 Results of test 4: abstract reasoning test

This test was a written test investigating the abstract reasoning ability and they could only get four points as the maximum. Table 17 indicates two results per group: first the amount of points achieved in the test, then the percentage of correct answers. Bilingual speakers in general scored higher than monolingual speakers (92.5%. vs. 82.5%). The group that scored the highest was the bilingual boys with an average of 3.8 points out of 4 which means a 95% of correct answers were given. The group that scored the lowest was the monolingual girls with an average of 3.2 points achieved out of four.

	Boys		**Girls**		**average**	
	Pts	**%**	**Pts**	**%**	**Pts**	**%**
Monolinguals	3.4	85%	3.2	80%	**3.3**	**82.5%**
Bilinguals	3.8	95%	3.6	90%	**3.7**	**92.5%**
average	**3.6**	**90%**	**3.4**	**85%**		

Table 17: results of test 4

4.4.1 Significance of the results of test 4

Table 18 indicates that the results of test 4 are significant using the population mentioned in this study. Using $\rho < .05$ as the confidence level, 95% of the results

are no coincidence: it was meant to be that the bilingual students will score higher than the monolingual students in test 4. The t-score has been calculated with the formula shown under subsection 3.4.1 on page 49.

	Monolinguals	**Bilinguals**
Mean	3.30	3.70
Standard deviation	0.66	0.47
Variance	0.43	0.22
t-score	**2.2143**	
$\rho < .05$ (confidence level)	*df* = 39 (population)	1.697 (critical value)
Interpretation	Results are **significant** (t-score is greater than the critical value)	

Table 18: Significance of the results of test 4

The standard deviations (0.66 for monolingual participants and 0.47 for bilingual participants) indicate that the bilingual students, as well as in the three other tests, scored closer to the mean than the monolingual students. These results also give the information that the bilingual speakers tend to have a similar aptitude to use the four cognitive skills tested than the monolingual speakers (bilingual participants obtained in the four tests a smaller standard deviation). In the monolingual group, there are children with high abilities and at the same time with low abilities of using cognitive skills (see SD). But the averages of the four tests show significantly that the bilinguals are better at using cognitive skills.

4.4.2 Interpretation of the results of test 4

In these results bilingual participants in general performed better on the test than monolingual participants (92.5% vs. 82.5%). These results confirm that bilingual speakers in this study have a greater ability of abstract reasoning. However, the results show that both groups, monolingual and bilingual, scored high. The difference between the groups is exactly 10% which means that bilingual participants over scored monolingual participants by 0.4 points. According to Hamers & Blanc (1993), bilingual speakers show in general more positive cognitive aptitudes than monolingual speakers. The authors mention dealing with abstraction as one of the positive cognitive aptitudes more developed by bilingual individuals. The results of test 4 and Hamers & Blanc's statement are coherent. Another factor that I feel played a role in these results is the amount of attention the bilingual participants paid to the task. Bilingual students have a better ability to focus on a task than monolingual students (Bialystok, Craik, Klein & Viswanathan, 2004). This ability, called *selective attention* by Bialystok (2001), explains how the bilingual learner is able to focus on one important aspect while blocking out the less important information. Because bilingual speakers have this ability to select and sort the information required, they are able to pay attention to only what is needed. These findings might be one possible explanation for the differences in the results between monolingual and bilingual participants.

Having well developed abstract reasoning ability means that the individual can see the mental picture of what is asked. The abstract reasoning test uses this skill by asking the correct pattern that follows a series. If the participants answer

correctly, it means that they are able to develop a mental picture of what is coming next. According to Tomioka (2002), this ability is more developed in bilingual speakers than monolingual speakers because of their capacity of having different items stored separately in each linguistic system and when they want to use one item, they need to locate it in the correct linguistic system. This comes from the tripartite system hypothesis described by Tomioka who states that the fact that they have to find the right item needed increases their abstract reasoning ability. For example, the item needed is stored in only one linguistic code (or language), and the speaker needs it in the other code. This abstract reasoning ability leads to an appropriate translation of the item, if this item has not been stored in the other language yet. The results are congruent to what Bialystok & Hakuta (1994) had found: The mind of a speaker who has learned two sets of linguistic aspects for a single conceptual representation has possibilities that the monolingual speaker does not, in this case, this abstract reasoning ability.

The ability of the child to reason deductively lies in mathematical understanding, and according to Dawe (1983) this is highly related to the development of abstract thought. In order to answer correctly the questions of test 4, the participants need to have a mathematical understanding of the tasks asked which also means that their abstract thinking ability is well developed. The results obtained from the two groups lead to the conclusion that the ability of abstract thinking is better developed by bilingual speakers than by monolingual speakers because of the higher percentages of correct answers that were achieved by the bilingual participants.

Another interesting fact observed in the results of test 4 is that boys have higher percentages compared to girls (90% vs. 85%). Gender seems to play a role in test 4 as well and these gender differences are discussed under the next subsection, in the answer of research question 4.

4.5 Answers to the research questions

This subsection is a summary of the results explained previously formulated in concrete answers to the five original research questions.

1. How do monolingual students between 10 and 12 years old score on cognitive and mathematic tests?

Table 19 indicates the results of monolingual participants only in percentages of correct answers in each test.

Test	Scores obtained by monolinguals
1. Spatial speed	86.75%
2. Visual memory	81.7 %
3. Logical thinking	75.5%
4. Abstract reasoning	82.5%

Table 19: Summary of the results of monolinguals

The test in which the monolingual participants performed best is that of the spatial speed test. The one that they scored the lowest is the logical thinking test and the results showed that monolingual speakers do have a well developed capacity of using cognitive skills. They had an average of 81.61% of correct

answers for the questions in the 4 tests. The results lead to a conclusion that the monolingual speakers in this study have skills for spatial speed, visual memory, logical thinking and abstract reasoning.

2. How do bilingual students between 10 and 12 years old score on cognitive and mathematic tests?

Table 20 shows the results of the bilingual participants on the four tests. The percentages indicate the amount of correct answers.

Test	Scores obtained by bilinguals
1. Spatial speed	93.8%
2. Visual memory	94.6%
3. Logical thinking	83.5%
4. Abstract reasoning	92.5%

Table 20: Summary of the results of bilinguals

Bilingual participants achieved high percentages in all of the four tests, especially in visual memory, spatial speed and abstract reasoning. The average of correct answers in general is 91.1% and logical thinking had been the test in which bilingual speakers achieved the lowest percentage. These results are extremely positive, since over 90% of the tasks were completed correctly. Bilingual learners in this study, according to the results, have a well developed capacity for using cognitive skills in spatial speed, visual memory, logical thinking and abstract reasoning. Their strength seems to be visual memory, closely followed by spatial speed, and abstract reasoning. The difference of correct answers given between

the three skills is very small (2.1%) showing that they all are almost equally well developed. The reason why logical thinking had weaker results might be caused by the fact that this test not only involved mathematical knowledge, but as well, linguistic knowledge. In order to perform this test, the participants had to understand mathematical tasks through language, which makes the questions more complex. The results of this test, 83.5%, are still very high and show that bilingual speakers have the capacity to connect mathematical knowledge and language skills to complete successfully the task. Mathematics understanding is influenced by language, say Ríordáin & O' Donoghue (2008) who investigated the relationship between language and mathematics.

3. What similarities and differences can be found between the monolingual and bilingual students' results of the four cognitive tests? Are these results significant?

Monolinguals' and bilinguals' results have been analyzed separately. In table 21 (on page 76), the results are shown again, in order to compare the two groups. The numbers in bold indicate which group had the highest score.

The biggest difference in the results between monolinguals and bilinguals can be observed in the second test: visual memory (81.7% vs. 94.6%). The bilingual participants had a higher percentage of appropriate answers compared to the monolingual participants. Due to the difference between the two groups one can infer that bilingual education has a positive impact on visual memory.

Test	Monolinguals	Bilinguals	Significance
1. Spatial speed	86.75%	**93.8%**	Difference is significant
2. Visual memory	81.7 %	**94.6%**	Difference is significant
3. Logical thinking	75.5%	**83.5%**	Difference is significant
4. Abstract reasoning	82.5%	**92.5%**	Difference is significant

Table 21: Comparison of the monolinguals' and bilinguals' results

Bilingual participants not only scored higher on the visual memory test; they achieved a higher percentage of correct answers in all four tests. The difference between the results was significant in all the four tests. These results were expected and to have the evidence that bilinguals in this study scored significantly higher on cognitive tests makes the argument stronger for bilingual education. In other words, bilingual education seems to have a positive impact on cognitive skills such as spatial speed, visual memory, logical thinking and abstract reasoning.

The results in general are high in the four tests. Bilingual learners are not the only participants who were able to use their cognitive skills to perform the tasks because monolingual learners as well achieved good scores. Both monolingual and bilingual speakers have cognitive skills that they use to perform mathematical tasks. Paradis (2000) mentions that there is no function available to the bilingual speaker that is not already available to the unilingual. The difference is, as these results confirm that bilingual speakers either make better use of their skills or have

more developed skills than monolingual speakers. For Paradis, the only difference seems to rely in the degree of use of the mental skills since bilingual education seems to increase the ability to apply cognitive skills appropriately. The results obtained by the analysis of the tests in this study are evidence that children are totally capable of learning content in two languages and that the benefits of learning more than one language are not only linguistically but also cognitively significant, as Espinosa (2008) explains.

4. What similarities and differences can be found between the girls' and boys' results of the four cognitive tests?

The following table shows first percentages of correct answers obtained by boys and girls and then the results of monolingual and bilingual participants combined by gender (see total). The bold numbers indicate which gender in which group performed better on the test.

Test	Boys			Girls		
	monolinguals	bilinguals	total	monolinguals	bilinguals	total
1. Spatial speed	90.5%	92.5%	91.5%	83%	**93.8%**	88.4%
2. Visual memory	84.2%	**96.7%**	90.4%	79.2%	92.5%	85.85%
3. Logical thinking	78%	**85%**	81.5%	73%	82%	77.5%
4. Abstract reasoning	85%	**95%**	90%	80%	90%	85%

Table 22: Comparison of boys' and girls' results

In three of four tests, boys scored higher than girls. As mentioned previously in the individual results of each test, the gender variable was weaker than the language variable: boys were better than girls (see total), but not better than both sexes of bilingual participants. The fact that boys achieved in three of four tests better results than girls might be a coincidence, but the theoretical background found by linguists can explain these differences between the sexes. Neuroscientists have studied differences between boys and girls in language processing and have found that they use a different part of the brain to process some aspects of language such as grammar, for example, when they start to learn their first language (Melville, 2006; Burman, 2007). But, does this have an impact on how they apply cognitive skills? Globally, boys tend to outperform girls in math (Lipsett, 2008) but according to new research published in the journal *Science*, Lipsett explains that boys are not automatically better at mathematics than girls anymore. The fact that the masculine gender was better at mathematics is disappearing in societies that treat both sexes equally. Lipsett mentions that in countries such as Sweden, both sexes have equal results in mathematics. However, in countries such as Turkey, boys generally outperformed girls. A question I can now ask is, would this mean that the differences in results between girls and boys in this study do come from the fact that the society in Mexico does not treat boys and girls equally? Lipsett mentions that any difference in test scores is due to nurture rather than nature.

A study conducted by Huang (1993) investigated cognitive skills between gender of high school Chinese students. Their findings are interesting since they

do not totally match the findings of the current study. Girls were superior to boys on memory, and verbal composites, whereas boys were superior to girls on the spatial composites. They did not find any differences in logical thinking tests and other reasoning tests, whereas this study explicitly showed that boys outperformed girls. Using Lipsett's suggestions (2008) concerning the equality of treating both sexes, can we then imply that in Puebla, girls are not considered equal to boys? If not what is the cause of the difference between boys and girls in mathematics in this study?

Cook & Cook (2009) studied differences and similarities between girls and boys. They found out that in cognitive skills, the largest and most consistent difference appeared to be in language and certain spatial skills but that usually the differences favoring boys start at adolescence and increase during high school, especially in areas involving mathematical problem solving. The participants in the study had not reach adolescence yet, however the differences already exist. Cook & Cook give a plausible explanation for why boys tend to be better at mathematics than girls. They mentioned studies (Eccles, Wigfield & Schiefele, 1998; Maccoby, 1998; Perie, Moran & Lutkus, 2005) which found that girls hold less positive attitudes toward mathematics, show less interest in this subject, and receive less encouragement due to the fact that society believes that boys are better than girls in mathematics. This explanation seems to be a more appropriate one for the differences found in the current study because the participants are all between the age of 10 and 12 years old so the factor of adolescence is not taken into consideration as a reason for the difference. Cook & Cook also mentioned that

since the late 1970s boys have consistently scored about 10% higher than girls on the math portion of the SAT (a standardized test required by many colleges in the USA for admission). In the current study, the percentage of difference is not as high, finding only an average of 4.2% higher for the boys.

My personal explanation for the difference between boys and girls is caused by a different level of expectations: the fact that society (parents and maybe teachers) has higher expectations for boys than they have for girls about mathematics has the consequences that boys tend to be better. I agree with the findings of the studies mentioned by Cook & Cook (2009) because since boys know that good results are expected from them, they tend to work harder to meet these expectations. In a certain way, it is an inequality of treatments between gender, a theory that Lipsett (2008) supports.

5. Based on the results, what recommendations can be made regarding taking content classes in a language other than the one spoken at home?

The results of this study showed that bilingual education seems to lead to positive cognitive advantages. It presents a strong argument encouraging bilingual education. The results are explicit: In none of the 4 tests did the monolingual participants outperform the bilingual participants. These excellent results for the bilingual participants appear to be caused by their education which is bilingual.

Theoretical backgrounds and studies have shown many advantages for children taking content classes in a language other than the native language. The results of the study confirm the other results found in the literature and give parents

the evidence that bilingual education is also working well in Mexico, as long as the schools respect the rules of bilingual education. As mentioned previously, a school that offers some hours of English or any other second language during the week is not bilingual education. In order to increase the skills investigated in the study, the child needs to have content classes in his L2, not only language classes, in order to assure positive cognitive advantages.

Another important aspect is the difference between additive and subtractive bilingualism. Positive results on the brain are only guaranteed, according to literature and to the results of this study, if the speakers come from an additive bilinguality setting. Clarkson (1992) mentions that competences in two languages bring advantages for bilingual students but the level of language competence in each language is an important factor. Being bilingual with low competences in the two languages is neither an advantage for mathematics learning nor for the use of cognitive skills. This explains why a true bilingual institution should encourage learning in both languages. If the pupils want to gain advantages from their bilingualism, they need to come from an additive background which values the home and the educational languages and accepts their use in society. Competence of language is the crucial point for their benefit and if the proficiency level is not high enough, the learner will not be able to acquire the advantages a competent monolingual speaker could obtain.

4.6 Evaluation of the hypotheses

In chapter 1, four hypotheses were presented. With the results obtained in this study, summed up in table 21, it is now possible to accept or reject the hypotheses.

Null hypothesis: There is no difference between the monolinguals' and bilinguals' results.

This hypothesis is rejected. The results showed a significant difference between monolingual and bilingual group results which is why the hypothesis must be rejected. The fact that the null hypothesis has been rejected opens the possibility to accept the other three hypotheses.

1. Speaking two languages does not cause any interference nor overwhelm the students in content classes. Bilingual education is not negative.

The results have shown that bilingual speakers did not score lower than monolingual speakers. This seems to indicate that bilingual education is not negative so the results obtained in this study support this hypothesis.

2. There is a difference in the use of cognitive skills depending on if a child is bilingual or monolingual.

The results have shown significant differences. They imply that the use of cognitive skills depends on if a child is bilingual or not so this hypothesis is also accepted.

3. Bilingual students have advantages over monolingual students in content classes such as in mathematics. Bilingual education is positive.

Again, the results demonstrate that bilingual education is positive, since the bilingual speakers achieve significantly higher scores than monolingual speakers on all four tests.

The three hypotheses presented at the beginning are accepted. The outcomes for these hypotheses were expected and because they resulted to be correct they have become now strong claims arguing for bilingual education.

The last chapter of this thesis offers a general conclusion, pointing out the most important aspects found in the investigation. As well, it mentions various further research possibilities to add to the already found results. Finally, the chapter reveals what is going to happen with the information obtained in the study.