

The study of bilingual learning of mathematics at International High School in South Korea¹⁾

Gong, Mina²⁾ · Kim, Yunghwan³⁾

This study investigated results of bilingual learning of mathematics in teaching quadratic functions at an international high school in South Korea. Unlike a Korean traditional public school, this international school has provided bilingual learning. 10th grade students enrolled two math classes, Algebra II that was taught in English through CCSS and High School Mathematics I that was taught in Korean through the Korean National Math Curriculum. In order to collect information on students' behaviors and math achievement, we analyzed students' academic back grounds, mathematical abilities, results of interviews, observations, questionnaires and assessments.

The results of this study include specific benefits. Bilingual learning of mathematics is effective as a method to improve Korean students' mathematical abilities and attitudes as well as positive influence on Korean mathematics education.

Key Words : Bilingual Learning, International School, National Curriculum,
Common Core State Standards, Quadratic Functions

I . Introduction

In Korea, teaching mathematics should follow criteria from the National Curriculum, as set forth by the government. As a result, most of the math classes in public schools teach similar content with the same sequence. However, this specific requirement does not apply to all math classes in Korea. There are many alternative schools, including an international school, that are permitted to teach different content and make their own curriculum. Therefore, it is possible for an international school student to learn mathematics in English and prepare for an ACT or SAT Test like an American student does. However, most of the students that attend an international school are still studying mathematics through the Korean National Math Curriculum.

* 2010 Mathematics Subject Classification : 97D40

1) This is a restructuring paper of first author's master degree thesis.

2) Kongju National University graduate school (mathminagong@gmail.com)

3) Kongju National University (yhkim@kongju.ac.kr), Corresponding Author

Even after students have attended or transferred from a public school to an international school, they need to study Korean National Curriculum Mathematics as the only way for international students to get their public high school diploma is by passing a special exam. Therefore, some international schools provide Korean National Curriculum Math classes for test prep while students are still taught math in English through the United States curriculum. Evidently, bilingual education also occurs within the South Korean education system, especially in mathematics.

In this paper, bilingual learning of mathematics is defined by enrolling in two math classes: Algebra II in English and High School Mathematics I in Korean. Several studies evaluate the effect of bilingual education in the United States. Although it is difficult to isolate bilingualism as a determining factor in one's mathematical ability, several studies suggest some evidence of a relationship between bilingualism and mathematical performance (Elezi & Kennedy, 2015).

The aim of this study is to investigate the effects of bilingual learning of English as a second language on mathematics achievement and disposition of students. We observed 11 sophomore students at an international high school in Kyongin, South Korea.

Therefore, we observed the presence of bilingual learning within math classes in terms of students' mathematical attitude and ability. To examine the results of each class, we analyzed responses from students as well as results of observations from quadratic function lesson in Mathematics I and Algebra II classes at an international school in South Korea.

II. Literature Review

1. Studies of Bilingual Education in the United States

A considerable amount of literature has been published on bilingual education in the United States. This is due to the fact that the number of individuals in the United States whose first language is not English has risen dramatically in recent decades (Yoon Kyong Kim, Lindsey A. Hutchison & Adam Winsler, Educational Review, 2013). In the 2014-2015 school year, there were approximately 4.8 million English Language Learners(ELL) in the United States, comprising 9.6 percent of all students in grades K-12. Approximately 50 languages, including Spanish, Chinese or Arabic, appear in one or more states' top list. (National Clearinghouse for English Acquisition and Language Instruction Education Program, 2017). As a result, children of immigrants often experience difficulties in class because of their bilingualism. Most of them have multi-cultural backgrounds and use English in school, but speak their native language at home.

Lack of English proficiency is a salient issue among schools serving these children, but not all ELL students are foreign born. In actuality, only 35% of all ELL students are foreign born and 80% of them have been in the United States for more than 5 years. Latino and Asian children are rapidly growing racial and ethnic groups in the United States, and this trend is projected to continue. In addition, this children often do not speak English at home (Han, 2012). These demographic properties are a main basis for the high volume of studies regarding bilingualism and academic achievement.

One of the types of bilingual education in the United States is a two-way immersion program(TWI). It is a dual-language education program that provides academic content in English along with partner language. These programs have existed for 40 years, and they are usually offered in public schools as Spanish and English programs (Howard & Christian 2002). Researchers have investigated the effectiveness of bilingual education by examining whether a bilingual two-way immersion program could improve academic performance in elementary school students.

Marian, Shock and Schroeder (2013) analyzed math standardized test scores from third, fourth, and fifth grade students enrolled in various educational programs within a single school district. They compared the test performance of minority—language students enrolled in a two—way immersion program to that of minority—language students enrolled in a transitional program of instruction. The results of their study suggest that bilingual two—way immersion in math is beneficial for both minority and majority—language elementary students. In the minority—language students, standardized math scores in the two—way immersion(TWI-S) group increased across grades, with students in higher grades performing better than students in lower grades. Conversely, in the transitional program of instruction (TPI), standardized math scores did not increase across grades, as students in the higher grades did not perform significantly better than students in the lower grades. Moreover, among the oldest students, the TWI—S group outperformed the TPI group in math. In the majority—language students, the two—way immersion (TWI—E) group outperformed the mainstream classroom students in math in third, fourth, and fifth grades.

Elezi and Kennedy (2015) examined the relationship between bilingual skills and strong mathematical abilities. In detail, this case study sought to discover whether being fluent in a second language makes a student better at mathematics as compared to a student who is monolingual. They collected data from the National Longitudinal Study of Adolescent Health, which was conducted in the United States during the 1994—1995 school year. The data was analyzed along with several variables: the language that students speak at home, country of origin, the year they came to the US, their most recent grade in mathematics and in English, and their gender.

The results showed that students who speak other languages at home performed equally well in English, and balanced bilinguals had high average math grades, regardless of their country of birth. This result indicates that balanced bilingualism could offer an advantage, and one language did not predict stronger results than another.

Presently, many students in South Korea also have multi-cultural backgrounds for various reasons. Bilingual learning has been very beneficial for students and by providing advantages in mathematics in other countries. These studies imply the present need to evaluate bilingual education in South Korea.

2. Comparison between the Korean National Curriculum and CCSS

The governments of both South Korea and the United States have developed national curriculums for mathematics and implemented them in the public schools. Although the two countries have different political backgrounds, the main purpose of the national curriculum is to create a coherent education and to improve students' mathematics achievement.

In South Korea, the Ministry of Education oversees the national curriculum, as designated by Article 23 of the Primary and Secondary School Education Law. This organization ensures that equal educational opportunities are provided for all students and works to maintain the quality of education. The national curriculum and regional guidelines offer flexibility to individual schools in accordance with the specific characteristics and objectives of the school. The national curriculum is revised on a periodic basis to reflect the rising demands for education, the emerging needs of a changing society, and new frontiers of academic disciplines. Curriculum standards serve as the basis for educational contents at each school and for textbook development. The government has undergone seven curriculum revisions to meet national and social needs as well as to stay current with the changes that are created through research development (National Curriculum Information Center, 2009).

The Common Core State Standards (CCSS) are a set of high-quality academic standards in mathematics and English language arts (ELA). These learning goals outline what a student should know and be able to do at the end of each grade. The standards were created to ensure that all students graduate from high school with the skills and knowledge necessary to succeed in college, career, and life, regardless of where they live. Forty-two states, the District of Columbia, four territories, and the Department of Defense Education Activity (DoDEA) have voluntarily adopted the Common Core and are moving forward with the future vision.

Recognizing the value of consistent learning goals across states, the state school chiefs and governors that comprise CCSSO and the NGA Center coordinated a state-led effort in 2009 to develop the Common Core State Standards. Designed through collaboration among teachers, school chiefs, administrators, and other experts, the standards provide a clear and consistent framework for educators (Common Core State Standards Initiative, 2017).

The high school standards are listed in the following conceptual categories: Number and Quantity, Algebra, Functions, Modeling, Geometry, Statistics and Probability. Conceptual categories portray a coherent view of high school mathematics; a student's understanding of functions, for example, crosses a number of traditional course boundaries, potentially up through and including calculus.

The Standards for Mathematical Practice describe a variety of expertise that mathematics educators at all levels should seek to develop in their students. These practices rest on important "processes and proficiencies" that have longstanding importance in mathematics education.

Those content standards that set an expectation of understanding a concept are potential "points of intersection" between the Standards for Mathematical Content and the Standards for Mathematical Practice. These points of intersection are intended to be weighted toward central and generative concepts in the mathematics curriculum that merit the time, resources, innovative energy, and focus necessary to qualitatively improve the curriculum, instruction, assessment, professional development,

and student achievement in mathematics (Common Core States Standards for Mathematics, 2017).

3. Learning Quadratic Functions

According to the Korean National Math Curriculum, learning quadratic functions must start in the middle school level at grade 9. The curriculum of the middle school level was separated into the following categories: Numbers and Operations, Algebraic expressions, Equations, Functions, Geometry, Probability and Statistics. Students learn quadratic functions in the last chapter of the category of Functions. Since equations and functions are divided into separate chapters, quadratic functions are explained in detail after completing the chapter of quadratic equations. Through this chapter, students are able to understand all general concepts as well as how to model quadratic functions. The core concept of learning quadratic functions is finding the maximum or minimum value of quantities that are modeled by a quadratic function.

In grade 10 at the high school level, quadratic functions are revisited so that students can discover a relationship between the quadratic function and a linear function using the discriminant. Thus, it is more than a quadratic function itself. The maximum and minimum value of a quadratic function are evaluated especially on the constraint of x interval in various situations. The concepts of the quadratic equation and those of the quadratic function are combined in this concept, and they lead to a deeper understanding of the quadratic function with graphics and a polynomial perspective(고호경(2003), 조정수(2006).

In CCSS, there is no direct requirement for a particular teaching sequence, but quadratic equations are mentioned in the section of High School Math - Functions. Under the section Linear, Quadratic, and Exponential Models (F-LE), the standard states: “Construct and compare linear, quadratic, and exponential models and solve problems”, and “Interpret expressions for functions in terms of the situation they model.” Therefore, this concept should be taught through modeling and solving problems in real-life situations.

According to the Pearson textbooks for Algebra I and Algebra II, the chapter consists of quadratic functions and equations together, but the concepts of the quadratic function are introduced first. Therefore, solving quadratic equations is addressed first, while completing the square and discriminant are learned later. The Algebra II course follows similar sequences of those in Algebra I. However, Algebra II requires a deeper understanding of concepts and present more complex problems than Algebra I.

Since the examples and problems model situations real-world situations, students are allowed to utilize a graphing calculator and must also be familiar with decimal expressions. Lastly, students are required to model a quadratic function using a quadratic regression. They analyze data from a given situation and find a reasonable quadratic model to represent or predict what they want to know.

Although there are not restrictions on which grade levels can teach quadratic functions, a typical curriculum that follows CCSS will introduce quadratic functions in grade 10 - 12, since most of the Algebra I and Algebra II content covers high school levels.

<Table II-1> Learning Sequence of Quadratic Functions from Two Curriculum

Curriculum	Course Title	Contents
Korean National Curriculum	Middle School Mathematics III (Grade 9)	Chapter 5. Quadratic Functions 1-1. Meaning of Quadratic Functions 1-2. The Graph of $y = ax^2$ 1-3. The Graph of $y = a(x-p)^2 + q$ 1-4. The Graph of $y = ax^2 + bx + c$ 2-1. The Maximum or Minimum Value of $y = ax^2$ 2-2. The Maximum or Minimum Value of $y = ax^2 + bx + c$
	High School Mathematics I (Grade 10)	Chapter 2. Quadratic Equations and Functions 1. Quadratic Equations and Functions 2. Relationship between the Graph of a Quadratic and a Linear Function 3. Finding the Maximum or Minimum Value
Common Core States Standard (CCSS)	Algebra I (Grade 9-10)	Chapter 4. Quadratic Functions and Equations 1. Quadratic Graphs and Their Properties 2. Quadratic Functions 3. Solving Quadratic Equations 4. Writing Quadratic Equations 5. Completing the Square 6. The Quadratic Formula and Discriminant 7. Linear, Quadratic, and Exponential Models 8. Systems of Linear and Quadratic Equations
	Algebra II (Grade 10-11)	Chapter 9. Quadratic Functions and Equations 1. Quadratic Functions and Transformations 2. Standard Form of a Quadratic Function 3. Modeling with Quadratic Functions 4. Factoring Quadratic Expressions 5. Quadratic Equations 6. Completing the Square 7. The Quadratic Formula 8. Complex Numbers 9. Quadratic Systems

There are significant differences between the learning process for quadratic equations in the Korean National Math Curriculum and CCSS. First, the grade level and learning sequences vary, as quadratic equations are taught over two courses in CCSS: Algebra I and Algebra II. Students usually take these course from 9th to 11th grade. However, Korean students learn about quadratic functions in grade 9 and explore much deeper concepts, such as relationships between linear and quadratic functions, in grade 10. These deeper concepts are not included in the CCSS guidelines, which means that the Korean national curriculum covers a broader range of topics related to quadratic functions. These differences can cause difficulties when a student transfers to a school that follows different curriculum. Those students often lack prerequisite knowledge, especially in High School Mathematics I. In addition, a quadratic equation is taught in CCSS after students learn about quadratic functions. On the other hand, a quadratic equation is introduced first in the learning sequence of the Korean National Math Curriculum.

Second, the core concepts of each course are different. The instruction from the Korean National Math Curriculum focuses on problem-solving abilities. Practicing problem solving using algebraic or graphical techniques should occur during the class. The core concepts also include finding the maximum and minimum value from a given function. However, Algebra II puts more emphasis on developing the ability to model and predict the maximum and minimum value from the given situation. For this reason, students are allowed to use a calculator to find estimates, whereas computation power and precision of solving problems are more critical in the Korean curriculum.

This study analyzed 10th grade students's mathematical abilities and behaviors within the chapter of quadratic functions in a Mathematics I and Algebra II class. Each course contained a mix of similar and different features since they followed learning sequences and standards from two different curricula.

Algebra tends to be more affected by language than in other areas. This shows that algebra, especially functions, is proper to a case study of bilingual learning. Another reason is that function is the basis of high school math and one of the intersections between the U.S. math and Korean math curriculum. This study observed how algebraic reasoning in two other languages helps build mathematical ability.

III. Research Methods

1. Participants

The aim of this study is to investigate the effects of bilingual learning of English as a second language on mathematics achievement. We observed 11 sophomore students at an international high school in Kyongin, South Korea. They all enrolled in Algebra II and High School Mathematics I during grade 10, according to the policy of the school.

<Table III-1> Students' Academic Backgrounds and Proficiency of English

Name	Age	Types of Academic Backgrounds	Fluency in English
Sophia	16	Korean Public School	Beginner
Seung-Jun	16	Korean Public School	Beginner
Byung-Hun	16	Korean Public School	Intermediate
Yedam	16	Korean Public School	Intermediate
Nancy	16	United States & International School	Intermediate
Calab	16	New Zealand & International School	Intermediate
Soo-Jin	16	Canada	Fluent
Diana	16	United States	Fluent
Chae-Yun	16	International School	Intermediate
Curie	16	Thailand	Fluent
Tom	17	International School	Intermediate

*These students' names are not real.

Among the students that participated in this study, there were three primary groups of academic backgrounds. The first group is from Korean public school; students in this group had been educated only at a public school in Korea. They were beginner or intermediate English speakers since they had few experiences communicating in other languages. All of them graduated from a Korean public middle school. The second group is from international schools in Korea. Students from these schools had learned from both Korean and U.S. curricula in the past 3 years, and they possessed enough English skills to participate in a bilingual program with no significant issues. The last group is from institutions in other countries that use English as a primary language. Most of the students in this group achieved an excellent or good evaluation in English, and some students had only experienced education through the U.S. curriculum.

In summary, 8 students had experienced public junior high math classes in Korea with an instructor that was a native Korean teacher. 7 students had learned math in a different institution, such as schools in other countries whose native language is English or international schools in Korea that provide bilingual learning. 2 students are beginner English speaker but are able to understand and interpret directions with extra help and assistance. The English proficiency of the remaining students does not significantly affect their ability to understand instructions and express their mathematical opinions.

2. Methods

We analyzed students' mathematical ability based on their previous math test grades and observations of their performance during class. This included assessments, class assignments and homework. The purpose of this process was to collect basic information on math achievement for all students. This information helped us better understand students' behaviors and the results of examinations.

<Table III-2> Students' Test Scores and Mathematical Ability

Name	Average Middle School Math Letter Grade	Mathematical Ability
Sophia	C-	Poor
Seung-Jun	A-	Good
Byung-Hun	A	Excellent
Yedam	A	Excellent
Nancy	B	Average
Calab	C-	Poor
Soo-Jin	B+	Average
Diana	A	Excellent
Chae-Yun	A	Good
Curie	A	Good
Tom	B	Average

6 out of 11 students showed excellent or good mastery of general concepts under the middle school curriculum. 2 students that received a "C" grade showed a poor level of mathematical ability.

Three different methods were applied to examine students' attitudes and performance during the class. First, a survey and questionnaire was used to analyze student responses and feedback about their bilingual learning. Another method of data collection was to determine how much students had progressed in their learning over time. This entailed observing events and visible student behaviors at various moment. The last method was to evaluate results of assessments to measure students' academic achievement.

3. Measures

This study was conducted in an Algebra II class and High school Mathematics I, which were each taken twice a week for 4 weeks in the 2nd semester of the 2016-2017 school year. The textbooks utilized to teach quadratic functions followed the corresponding national curriculum from the United States and South Korea: Algebra II used a Common Core version from Pearson, and

High School Mathematics I used a Korean National Math Curriculum from Sinsago Publishing Company.

<Table III-3> Sequence of Teaching Quadratic Functions

Algebra II		High School Mathematics I	
4-1	Quadratic Function and Transformation	2-1	Quadratic Equations and Functions
4-2	Standard Form of a Quadratic Function	2-2	Relationship between graphs of Quadratic and Linear Functions
4-3	Modeling with Quadratic Functions	2-3	Maximum and Minimum value of Quadratic Functions

During the instruction, students sit facing a teacher to concentrate on the lesson. After the teacher's explanation and demonstration, student imitate the solving process and then practice more problems independently. Questions and answers were continuous to keep students engaged in their learning and help differentiate the lesson for various abilities. All materials were from the textbook and teacher resources. Also, students were allowed to use a calculator for a problem related to a real-world situation.

For the Algebra II class, we planned to introduce mathematical words and terms at the beginning of each class. A list of terms for each lesson was provided to students, and it helped them study by explaining the meaning of words in both English and Korean. This practice partially alleviated the burden of learning mathematics in a foreign language.

IV. Results

This study analyzed observations of the bilingual learning process for mathematics in 4 categories: Interest and attitude, Academic achievement, Benefits and Difficulties in learning, and Preference of language.

1. Interest and Attitude

We gathered students' responses on whether they had interest in bilingual learning of math from a survey.

<Table IV-1> Responses on Students' Interest

Responses	Interest(%)
Strongly Agree	9.1
Agree	45.4
Disagree	27.3
Strongly Disagree	18.2
Total	100.0

The academic attitude of every student was evaluated through classroom observation. The instructor recorded each student's behavior in the class and generated evaluations of their participation, confidence and academic expectations.

<Table IV-2> Evaluations of Student Attitudes

Evaluations	Participation(%)	Confidence(%)	Academic Expectation(%)
Excellent	45.4	27.3	27.3
Good	36.4	18.2	18.2
Average	18.2	45.4	54.5
Poor	0	9.1	0
Total	100.0	100.0	100.0

According to the results, over 50% of students answered that they had interest in bilingual learning. Participants in this study had a plan to study abroad in the future, which led them to engage in math classes taught in a foreign language. Some students considered this bilingual learning to be an academic challenge motivating them to strive for higher mathematical ability. However, the other half of students showed little or no interest. Compared to 81.8% of students that had high participation, a portion of students demonstrated less enjoyment while they put forth a great deal of effort. A strong academic atmosphere and classroom culture among students was observed, which means that most of the students were under pressure to achieve high grades. Moreover, lack of English proficiency caused some students to require additional time to understand the lesson, and this obstacle led to low interest. Another reason for low interest is that students should have possibly learned both contents areas related to quadratic function in the same semester.

45.5% of students exhibited excellent or good confidence in math, and only 9.1% had low confidence. This is consistent with the teacher's academic expectations for students. Some students answered that their math confidence was higher due to bilingual learning because it was easier for them to learn quadratic functions in English than in Korean. Two students, Soo-Jin and Nancy, understood general concepts of quadratic functions after completing the bilingual program. This

helped them to overcome difficulties in learning quadratic functions within the Korean math class. It shows that the bilingual learning process created both benefits and difficulties for learning.

2. Academic Achievement

We analyzed scores from the chapter exam of Algebra II and High School Mathematics I in order to examine students' math performances.

A diagnostic test was taken to evaluate the level of prerequisite knowledge that student had regarding quadratic functions. Questions on the test asked about general concepts related to quadratic functions. This test covered the following 9th grade topic as well as the Korean middle school mathematics: graphing and modeling a quadratic function, and finding the maximum and minimum value from a given function.

The average score from the diagnostic test was 78.6%. Most of the students who transferred from a Korean public middle school showed good mastery of quadratic functions in the middle school level. However, 5 students got lower scores than the average.

All students achieved higher scores in Algebra II and the High School Mathematics I course than on the diagnostic test. The average score of both courses was high: the Algebra II test was 88.3% and the Mathematics I test was 87.3%. Although Sophia and Calab initially scored under 80%, they raised their grades significantly.

These results demonstrate that bilingual learning was beneficial for students to enhance their mathematical ability. We observed that most of the students were satisfied with their learning in these overall areas. This observation was also consistent with their positive learning attitude.

<Table IV-3> Students' Chapter Exam Scores in Two Courses

Name	Diagnostic Test	Algebra II	Mathematics I
Sophia	64	80	78
Seung-Jun	82	85	90
Byung-Hun	87	94	92
Yedam	87	92	95
Nancy	78	87	82
Calab	66	78	75
Soo-Jin	75	83	82
Diana	89	100	96
Chae-Yun	80	97	92
Curie	80	89	87
Tom	77	86	91
Average	78.6	88.3	87.3

3. Benefits and Difficulties in Learning

Surveys and interview that were conducted with students showed specific benefits and difficulties that were related to bilingual learning.

Students pointed out that one of the benefits of bilingual learning is that it is easy to study math in English. Many of them argued that Korean math courses are very difficult to understand. In contrast, in the Algebra II course, they could learn mathematical concepts with simple directions and a clear problem-solving process. This characteristic helped students acquire or catch up on missed knowledge from previous courses. According to the results of the diagnostic test, students below the average needed to spend more time studying quadratic functions. Thus, the Algebra II course was beneficial for them because they had opportunities to make up the missed content with easier methods.

Another benefit that students mentioned was that bilingual learning was interesting to use in math, but also helpful in improving their English proficiency. Most of students acknowledged the importance of learning English. Thus, bilingual learning could be a motivation to further their English skills. In addition, students recognized that bilingual learning was an alternative method of traditional education. Therefore, they tended to feel more engaged in mathematics with this learning method.

한국수학은 한자어로 되어있어서 어려웠지만 영어수학은 이해가 쉽게 되서 좋았고 계산 문제에 대해서도 풀기 쉬워서 좋았다

영어 수학을 배우면서 모르는 단어도 알게 되고 왜지 모르게

개있다

도움이 많이 되었습니다. 한국수학과 영어수학의 차이를 알게 되었고 두 수학 모두 푸는 방법을 알았다

[그림 IV-1] Students' Responses about Benefits of Bilingual Learning

We found two primary types of learning difficulties. First, language problems were evident. Studying in English as a foreign language forced some students to focus on more English than on math. Students needed to spend a lot of time studying English to be successful in Algebra II. They had to study math terms in English before the class started, and some of these terms were already familiar to them in Korean. Not only that, word problems required students to improve their reading and writing skills. For example, Yedam usually struggled to interpret the direction of math questions. Writing down answers in English was another challenge for him. Other students who were not fluent in English also mentioned that they experienced similar language problems in their bilingual math learning.

Secondly, bilingual learning caused a double burden for students. This was because that students perceived that bilingual learning required them to study the same math concepts twice. They noted that two math courses in English and Korean were totally different types of math even though many concepts overlapped in both courses.

한 번에 두 가지의 수학을 배우다보니 서로 다른 수학이기도 해서 수학을 두배로 한 것 같아서 어려웠다
문제는 쉬웠지만 영어 단어가 어려워 해석을 잘 못한 경우가 있었다
영미문제 이해하는 것, 계산기 사용법 익히는 것
독립을 잘 배우는데 좋은 방식이 많아서 좋았다는 점이 있어요.

[그림 IV-2] Students' Responses about Benefits of Bilingual Learning

For example, converting a quadratic function in standard form to vertex form requires completing the square in the Mathematic I class. However, it uses a formula of for the axis of symmetry in Algebra II, which confused students that were solving those problems. Different learning sequences for Mathematic I and Algebra II caused this problem because completing the square, one of the methods to solve quadratic equations, is placed at the end of the chapter.

Moreover, concepts and problems from Mathematics I are totally new and challenging for all students, especially those who had been receiving education through the U.S. curriculum. These students acknowledged that mastery of Algebra I and even Algebra II is required to understand the course concepts of Mathematics I. Many problems use the discriminant as a method in a more advanced process, which means that students will lack the ability to complete the problem, even though they learned it in Algebra I.

4. Preference of Language in Bilingual Learning

Students were asked to answer which subject they prefer to study further. As a result, preferences between learning math in English and Korean was affected by student's academic objective. All students who intended to go to college in other countries wanted to spend more time studying math in English through Algebra II. This is because it also helps to improve their English and it is easier to study than the Korean math class. However, two students selected math in Korean since they plan to go to college in Korea. They need to study math specifically in the Korean National Math Curriculum to prepare for future college course. We discovered that language preference in bilingual learning is entirely based on the students' academic goals and primary language in college.

Algebra II 너무 어렵지 않고 영문 실력으로
항상 되며 흥미도 생겼어서 더 하고 싶다
국내 수학, 대학로 가서 배우거나, 대학화가 이뤄져 배우야 하는 것이 아니라
좋아요.

[그림 IV-3] Students' Responses about Language Preference

Most of the participants in the study had interests in English learning, which led them to engage in math classes taught in another language since they would study abroad in the future. Moreover, some students had considered this bilingual learning to be an academic challenge motivating them to strive for higher mathematical ability. I expected them to have a great opportunity to experience mathematical thinking and reasoning in another way by studying math in a foreign language.

V. Conclusion

1. Conclusion

We questioned if bilingual learning of mathematics affects students' mathematical attitudes and abilities. We defined bilingual learning of mathematics as enrolling in two math classes, Algebra II in English and High School Mathematics I in Korean. This study was conducted at an international high school in South Korea for 4 weeks. All students were sophomores in the 2nd semester. We analyzed results of interviews, observations, questionnaires, and assessments after teaching about quadratic functions in both courses.

One primary result was that bilingual learning could give positively impact students' math progress. First, students demonstrated a positive attitude through regular participation, concentration in tasks and the teacher's academic expectations. Thus, bilingual learning can help students build an academic atmosphere and lead each student to be engaged in the class. Learning math in English has the advantages of teaching English Vocabulary at the same time. Moreover, easy and simple processes in English helped students alleviate difficulties they had in Korean math courses. Second, this bilingual learning can enhance students' math ability. Examining students' results from assessments showed that most of them received high scores in the chapter test. They also evaluated themselves and concluded that they were satisfied with their learning.

However, language problems were present as student attempted to learn math in a foreign language and were burdened with taking two types of math class during a semester. Although some students had lived in foreign countries for a few years, English was not their native

language and they still experienced challenges while studying math in a foreign language. Those students who were not fluent in English had to put more effort into learning since they needed to improve their English skills in order to participate in the class. Also, some students felt that learning math in different languages resulted in them studying two types of math in the same semester, which resulted in more time spent on studying.

Our findings support the statement that bilingual learning of mathematics affects students' mathematical attitude and ability. We observed that bilingual learning of mathematics positively influenced students' learning attitude and they achieved high rates of success in the middle of the class as well as at the end of the class. In addition, students tend to select courses that are in English or Korean according to their academic goals and desired college to enter in the future.

2. Discussion

This study examined the academic effects of bilingual learning of mathematics among 10th grade students at an international school in Korea. We recognize some limitations to the study and discuss promising avenues for future studies.

First, due to practical constraints, this result was drawn from only one class of an international school which makes it difficult to generalize results to all cases of bilingual learning in South Korea. For a more reliable generalization, further studies should collect data from diverse groups.

Second, a potential problem is that we only examined students' academic enhancements based on the results of learning quadratic functions. To show consistent improvements in mathematical ability, it is important to examine achievement across a broad range of mathematics topics.

A third limitation to consider is confounding variables that could affect the results, such as differences in curriculum and teaching methods. Algebra II was taught through the U.S. curriculum while the Korean math class utilizes a traditional Korean teaching style. In future works, researchers should also consider the constraints of these differences in teaching style.

References

- 고호경 (2003). 함수의 그래프에서 학생의 개념발달과정에 대한 특성. **한국학교수학회논문집**, 6(1), 163-175.
- 이준열 외 7명 (2013). **중학교 수학 3**. 천재교육.
- 조정수 (2006). 다항식 관점에 의한 이차함수의 성질 탐구와 지도방안 탐색. **한국학교수학회논문집**, 9(2), 121-139.
- 황선욱 외 12명 (2013). **고등학교 수학 1**. 좋은책 신사고.
- Elezi, E. & Kennedy, K. (2015). A Case Study Examining if Being Bilingual Can Improve One's Math Skills. *Global Education Journal*: 2015(3), 28.
- Han, W. (2012). Bilingualism and Academic Achievement. *Child Development*: 83(1), 300.
- Howard, E. & Christian, D. (2002). Two-Way Immersion 101: Designing and Implementing a Two-Way Immersion Education Program at the Elementary Level. *Center for Research on Education, Diversity & Excellence*. UC Berkely: Center for Research on Education, Diversity and Excellence. (<http://escholarship.org/uc/item/7cm4v2f5>)
- Hwang, S. (2010). High School Mathematics 1. Sinsago.
- Lee, J. (2013). Middle School Mathematics 3. Chunjae Education.
- Randall I. Charles (2012). Algebra 1: Common Core Edition. Pearson Education.
- Randall I. Charles (2012). Algebra 2: Common Core Edition. Pearson Education.
- Marian, V., Shook, Anthony. & Schroeder, S. (2013). Bilingual Two-Way Immersion Programs Benefit Academic Achievement. *Bilingual Research Journal*, 36, 167-186.
- National Clearinghouse for English Language Acquisition and Language Instruction Education Programs (2017). *Language spoken by English Learners(ELs)*. (http://www.ncele.us/files/fast_facts/FastFactsAllLanguages_February_2017.pdf)
- National Clearinghouse for English Language Acquisition and Language Instruction Education Programs (2017). *Profiles of English Learners(ELs)*. (http://www.ncele.us/files/fast_facts/05-19-2017/ProfilesOfELs_FastFacts.pdf)
- National Curriculum Information Center (2009). *Education System of Korea*. (<http://www.ncic.re.kr/english.inf.ivl.index.do>)
- Yoon Kyong Kim, Lindsey A. Hutchison & Adam Winsler, Educational Review (2013). Bilingual education in United States: a historical overview and examination of two-way-immersion. Educational Review, DOI: 10.1080/00131911.2013.865593

한국 국제학교에서의 이중 언어를 활용한 수학학습에 관한 연구

공미나⁴⁾ · 김응환⁵⁾

이 연구에서는 한국의 일반 고등학교와는 다르게 이중언어로 수학을 가르치고 있는 한국의 경인지역에 있는 A 국제학교에서 학생들이 이차함수와 그래프 단원을 중심으로 한국어와 영어로 학습하였을 때의 실태와 성향에 어떤 특징이 보이는지 조사하였다. 특별히 고등학교 1학년 학생들을 대상으로 국내 고1 교육과정을 따른 수학 I 수업을 한국어로 진행하였고 미국 Common Core State Standard을 따른 Algebra II 수업을 영어로 진행하였다.

본 연구의 결과로는 이중 언어를 활용한 수학 학습이 한국 학생들의 수학 학습능력 향상과 수학 학습 태도변화에 긍정적인 영향을 주고 있는 것으로 나타났다. 첫째는 학생들의 학습참여도와 동기부여가 잘 되었고 대학 진학을 위한 준비 단계로서도 유익한 과정이었다. 둘째로는 본 연구 결과로서 얻게 되는 시사점으로서 소수이기는 하지만 한국에서의 이중언어로서의 수학교육에서는 학생들의 필요와 다르게 되는 교재들의 국가 간의 차이에 의한 영향들을 고려하여 이중언어 수학수업에 보다 효율적인 지도방법의 연구가 지속되어야 할 것으로 기대된다.

주요용어 : 이중 언어학습, 국제학교, 국가교육과정, Common Core State Standard, 이차함수

Received April 9, 2019

Revised May 13, 2019

Accepted May 14, 2019

* MSC2010분류 : 97D40

4) 공주대학교 대학원생 (mathminagong@gmail.com)

5) 공주대학교 교수 (yhkim@kongju.ac.kr), 교신저자