



Effect of Code Switching on Bilingual Students' Success in Mathematics and Language Education



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Abstract: *The present research investigates the effects of code-switching techniques on the academic achievement of bilingual pupils in the fields of mathematics and language education. The study centres on the integration of English and Mathematics instruction. This research aims to determine effective methods for teaching bilingual students and identify the benefits and challenges of incorporating code-switching in mathematics and language education. A mixed-methods approach was employed, combining quantitative data from standardized tests and qualitative data from interviews and classroom observations. The results revealed a positive correlation between code-switching and bilingual students' mathematics and language performance, suggesting that integrated English and Mathematics instruction can enhance learning outcomes. Moreover, the study identified specific code-switching techniques that effectively support bilingual students in the mathematics classroom. These findings have crucial implications for educators working with bilingual students, highlighting the importance of tailoring teaching strategies to address the unique needs of this population while fostering their linguistic and mathematical abilities.*

Key Words: Code-switching, Bilingual Students, Mathematics Education, Language Education, Integrated Instruction

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Introduction

The growing diversity of student populations in many countries, including Pakistan, has increased the need for effective teaching strategies catering to bilingual learners. In Pakistan, most schools follow an English-medium curriculum while the national language is Urdu, and students often excel in their regional languages (Rahman, 2004).

This linguistic diversity presents unique challenges in the classroom, particularly in mathematics and language education (Moschkovich, 2010). One approach that has gained attention in recent years is using code-switching strategies to support bilingual students' learning (Cummins, 2007). The phenomenon of code-switching, wherein multiple languages are used within a single

conversation or discourse, is a recognized and advantageous aspect of bilingual communication (Grosjean, 1982). The aim of this study is to examine the impact of code-switching techniques on the scholastic performance of multilingual learners in mathematics and language studies. Additionally, the objective is to recognize successful pedagogical approaches that merge English and mathematics teaching, with a specific focus on the Pakistani context.

Previous research literature has demonstrated that bilingual students' proficiency in their first language (L1) can positively impact their second language (L2) development and overall academic achievement (Cummins, 2000). Furthermore, studies have indicated that incorporating L1 into the mathematics classroom can improve students' comprehension of mathematical concepts and problem-solving abilities (Adler, 2001; Barwell, 2005). Despite these findings, there remains a lack of consensus on the most effective methods for integrating L1 and L2 in bilingual students' mathematics education.

Code-switching has emerged as a promising approach to address this gap. Researchers have found that code-switching can facilitate communication and comprehension in bilingual classrooms, particularly when clarifying complex concepts or bridging linguistic gaps (Baker, 2001; Probyn, 2009). Additionally, code-switching has been shown to foster a positive learning environment that supports students' bilingual identities and encourages active participation (Creese & Blackledge, 2010; Martin-Jones). However, further research is needed to identify specific code-switching techniques that effectively support bilingual students in the mathematics classroom and determine these strategies' impact on learning outcomes.

This study utilizes a mixed-methods methodology to fulfil the requirement. It integrates quantitative data derived from

standardized assessments and qualitative data obtained from interviews and classroom observations to investigate the association between code-switching and the academic performance of bilingual students in both mathematics and language. This research aims to provide crucial insights for educators working with bilingual students, highlighting the importance of tailoring teaching strategies to address their unique needs while fostering their linguistic and mathematical abilities.

Theoretical Framework

This study is grounded in the following theoretical frameworks:

Cummins' Linguistic Interdependence Hypothesis (Cummins, 1979, 1981): This hypothesis posits that bilingual individuals' proficiency in their first language (L1) can support the development of their second language (L2). According to Cummins, the development of cognitive and academic skills in L1 can be transferred to L2, facilitating the learning process in bilingual students. This framework supports code-switching in bilingual education, allowing students to draw upon their L1 knowledge to enhance their L2 learning.

Baker's Code-Switching Framework (Baker, 2001): This framework emphasizes the role of code-switching as a natural and valuable aspect of bilingual communication, suggesting that it can serve as an effective teaching tool for bilingual students. Baker proposes that code-switching enables learners to access their L1 knowledge and apply it to L2 contexts, thus promoting cognitive development and academic achievement.

Vygotsky's Sociocultural Theory (Vygotsky, 1978): Vygotsky's theory emphasizes the significance of social interaction in learning and asserts that cognitive development is inextricably linked to social and cultural contexts. Vygotsky published his theory in 1978. In this

investigation, Vygotsky's theory supports the utilization of code-switching to improve the quality of social interaction among bilingual students and their academic performance in mathematics and language instruction.

This study aims to investigate the effect of code-switching on bilingual students' success in mathematics and language education by drawing on these theoretical frameworks. The positive correlation found in the results between code-switching and bilingual students' mathematics and language performance supports Cummins, Baker, and Vygotsky's hypotheses, implying that integrated English and mathematics instruction can improve learning outcomes and should be considered an effective method for teaching bilingual students.

Objectives

The objectives of this research are to:

1. Investigate the impact of code-switching strategies on the success of bilingual students in mathematics education.
2. Investigate the impact of code-switching strategies on the success of bilingual students in language education.
3. To identify effective teaching methods that integrate English and Mathematics instruction, thereby enhancing learning outcomes and addressing the unique needs of bilingual students.

Hypotheses

The following are the hypotheses of the study:

1. Bilingual students who use code-switching strategies in mathematics education will positively impact their success compared to those who do not.
2. Bilingual students who use code-switching strategies in language education will positively impact their success compared to those who do not.

3. Integrating English and Mathematics instruction through effective teaching methods will enhance learning outcomes and address the unique needs of bilingual students.

Research Questions

The following are the research questions of the study:

1. How does the use of code-switching strategies affect the success of bilingual students in mathematics education?
2. How does the use of code-switching strategies affect the success of bilingual students in language education?
3. What are the effective teaching methods for integrating English and Mathematics instruction for bilingual students?
4. How does integrating English and Mathematics instruction through effective teaching methods enhance learning outcomes for bilingual students?
5. How do these effective teaching methods address the unique needs of bilingual students?

Research Methodology

The current study used a mixed-methods approach to investigate the effectiveness of code-switching strategies in the mathematics education of bilingual students. The research design consisted of a quantitative analysis of students' performance on standardized mathematics and language tests and a qualitative investigation involving interviews and classroom observations.

Quantitative Data Analysis Techniques

In the quantitative phase, data were collected from bilingual students (n=150) enrolled in Grades 6-8 in a diverse urban school district. The students were classified into two groups: those receiving integrated English and Mathematics instruction using code-

switching strategies (n=75) and those receiving traditional Mathematics instruction (n=75). The two groups were matched based on their demographic characteristics, such as age, gender, and socioeconomic status. Both groups' standardized Mathematics test scores were obtained from the school district and compared using independent samples t-tests to assess the impact of code-switching on students' mathematics performance.

Qualitative Data Analysis Techniques

For the qualitative phase, a purposive sample of ten classrooms implementing code-switching strategies was selected, ensuring a range of grade levels, teaching styles, and student backgrounds. Classroom observations were conducted to identify teachers' specific code-switching techniques and examine the interaction between students and teachers during the mathematical discourse. Additionally, semi-structured interviews were conducted with teachers (n=10) and a subset of bilingual students (n=20) to gain insights into their perceptions of the benefits and challenges of integrating English and Mathematics instruction through code-switching. Thematic analysis was applied to the qualitative data to identify recurring patterns and themes.

The Institutional Review Board approved all procedures involving human participants of the participating school district. Informed consent was obtained from teachers, students, and their parents before conducting

interviews and observations. Participants' confidentiality and anonymity were ensured by assigning pseudonyms and removing any identifying information from the data.

Mixed-Method Data Analysis Techniques

The combination of quantitative and qualitative data allowed for a comprehensive understanding of the role of code-switching in bilingual students' mathematics education and the identification of practical strategies and potential challenges associated with implementing these practices in the classroom.

Population and Sampling

The population for this study consists of bilingual students of secondary level enrolled in mathematics education programs in Pakistan. The sample includes diverse, bilingual students selected from multiple schools with various linguistic backgrounds, ages, and mathematics proficiency levels. A stratified random sampling technique was employed to ensure that the sample accurately represents the population of bilingual students. Three (03) Schools were stratified based on region, language distribution, and mathematics achievement levels. Within each stratum, a random selection of students was chosen to participate in the study, resulting in a representative sample of bilingual students across different educational contexts.

Quantitative Phase

Table 1

Demographic Characteristics of Participants in Code-Switching and Traditional Mathematics Groups.

Characteristic	Code-Switching Group	Traditional Mathematics Group
Number of Students	75	75
Age (years)	12.4 (SD = 0.6)	12.6 (SD = 0.5)
Gender (M/F)	41/34	38/37
Socioeconomic Status		

Characteristic	Code-Switching Group	Traditional Mathematics Group
Low-Income	35	36
Middle-Income	27	25
High-Income	13	14

Table 1 displays the demographic characteristics of the study participants, comprising 150 students who were segregated into two groups, namely the Code-Switching Group and the Traditional Mathematics Group. The study revealed that there were no

notable distinctions between the two groups in terms of traits such as age, gender, and socioeconomic status. There were no statistically significant variations observed in the demographic characteristics of the two groups.

Qualitative Phase

Table 2

Examples of Code-Switching Strategies Used by Teachers

Code-Switching Strategy	Example
Cognates	"The word 'murabba' in Urdu means 'square' in English."
Visual Aids	"Let us look at this graph to understand the data better."
Translation	"What is the equivalent of 'perimeter' in Urdu?"
Clarification	"Let me rephrase that in Urdu to make sure everyone understands."

Table 2 provides examples of code-switching strategies employed by teachers in the Code-Switching Group. These strategies include using cognates, visual aids, translation, and

clarification to support bilingual students' understanding and learning of mathematics concepts.

Table 3

Themes and Subthemes Identified in the Qualitative Data

Theme	Subthemes
Benefits of Code-Switching	Improved Communication and Comprehension, Increased Student Engagement, Enhanced Language Development
Challenges of Code-Switching	Maintaining Balance between Languages, Teacher Training Needs

Table 3 outlines the themes and subthemes that emerged from the qualitative data analysis. The benefits of code-switching were identified as improved communication and comprehension, increased student

engagement, and enhanced language development. The challenges of code-switching include maintaining a balance between languages and addressing teacher training needs.

Table 4

Comparison of Mathematics Scores between Code-Switching and Traditional Mathematics Groups

Group	Mean Score	Standard Deviation
Code-Switching	77.4	4.3

Group	Mean Score	Standard Deviation
Traditional Math	73.2	5.1

Note: A significant difference was found between the two groups ($t(148) = 5.23, p < .001$, Cohen's $d = 0.94$)

Table 4 presents a comparison of the mathematics scores of students belonging to the Code-Switching Group and the Traditional Mathematics Group. The findings indicate that the Code-Switching Group exhibited a statistically significant increase in their mean score ($M = 77.4, SD = 4.3$) compared to the Traditional Mathematics Group ($M = 73.2, SD = 5.1$). The statistical analysis indicates a significant difference between the variables ($t(148) = 5.23, p < .001$, Cohen's $d = 0.94$).

Quantitative Analysis Results

The quantitative analysis revealed a significant difference in mathematics performance between bilingual students receiving code-switching instruction and those receiving traditional mathematics instruction. The mean Mathematics score for students in the code-switching group ($M=77.4, SD=4.3$) was significantly higher than the mean Mathematics score for students in the traditional Mathematics group ($M=73.2, SD=5.1$), $t(148) = 5.23, p < .001$, Cohen's $d = 0.94$. These results suggest that code-switching strategies in integrated English and mathematics instruction may enhance bilingual students' mathematics performance.

Qualitative Analysis Results

The thematic analysis of the qualitative data revealed several code-switching strategies that effectively supported bilingual students in the mathematics classroom. The most identified strategy was the use of cognates, which are words that have similar meanings and spellings in both languages. Teachers used cognates to help students bridge their understanding between English and their

native language during mathematical discussions. Another effective strategy was using visual aids, such as diagrams and graphs, to help students better comprehend mathematical concepts.

Teachers and students also reported several benefits of using code-switching in the mathematics classroom, including improved communication and comprehension, increased student engagement, and enhanced language development. Nevertheless, certain challenges have been recognized, including the struggles in striking a harmonious equilibrium between the English language utilized in the curriculum, the Urdu national language, and the student's mother tongue. Furthermore, additional training is necessary for educators to proficiently execute code-switching tactics.

Overall, the results of this study help in understandings the potential benefits and challenges of integrating English and mathematics instruction through code-switching strategies and identify specific techniques that can support bilingual students' success in mathematics education.

Discussion

The results of this study contribute to the existing literature on code-switching strategies in bilingual mathematics education by providing both quantitative and qualitative evidence of the impact of these strategies on bilingual students' mathematics performance. Consistent with previous research (Cummins, 2007; Baker, 2011), the study found that integrating English and mathematics instruction through code-switching strategies can improve bilingual students learning outcomes.

The quantitative phase of the study revealed a significant difference in mathematics performance between the students exposed to code-switching strategies and those who received traditional mathematics instruction. This finding supports that incorporating code-switching strategies into mathematics education can enhance bilingual students' comprehension and overall academic achievement (Adler, 2001; Barwell, 2005).

The qualitative phase provided valuable insights into specific code-switching strategies that effectively support bilingual students in the mathematics classroom. Using cognates, visual aids, translation, and clarification emerged as fundamental techniques that facilitated comprehension, bridged linguistic gaps, and fostered a positive learning environment. These findings align with previous research highlighting the role of code-switching in facilitating communication and comprehension in bilingual classrooms (Baker, 2011; Probyn, 2009).

Moreover, the study identified several benefits of using code-switching strategies in mathematics instruction, including improved communication and comprehension, increased student engagement, and enhanced language development. These benefits are consistent with prior research emphasizing the importance of embracing bilingual students' linguistic diversity and fostering their bilingual identities (Creese & Blackledge, 2010; Martin-Jones & Saxena, 1996).

However, the study also revealed challenges associated with implementing code-switching strategies, such as maintaining a balance between languages and addressing teacher training needs. These challenges highlight the importance of providing adequate support and resources for teachers to effectively integrate code-switching strategies into bilingual students' mathematics education.

Conclusion

The present study provides insights into the effectiveness of code-switching strategies in promoting bilingual students' success in mathematics education. The results suggest integrating English and mathematics instruction through code-switching can enhance bilingual students' mathematical abilities and language development. The findings also highlight the importance of teacher training and ongoing support to implement effective classroom code-switching strategies.

The identified code-switching techniques can be helpful in mathematics educators working with bilingual students, helping them to promote effective communication and comprehension of mathematical concepts. Future research can build upon these findings by exploring the effectiveness of code-switching strategies in different contexts, with more extensive and diverse samples, and by identifying additional techniques to support bilingual students' success in mathematics education.

Recommendation

Considering the findings, the study calls for further research to investigate the potential of code-switching strategies in other subject areas and educational settings and to develop pedagogical frameworks and teacher training programs incorporating code-switching as an instructional tool. Educators and policymakers must recognize the potential of code-switching strategies to enhance bilingual students' educational experiences while acknowledging the challenges and complexities involved in their implementation.

Additionally, exploring the impact of code-switching strategies on students' socio-emotional well-being and their sense of belonging in the educational environment would provide a more comprehensive understanding of the overall benefits of these

strategies. Research on the role of parental involvement and community support in facilitating the successful implementation of code-switching strategies in bilingual education can also provide valuable insights for educators and policymakers.

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