Bilingual 3rd Level Mathematics Education – Rich Insights from an Irish Context

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Abstract

It is often perceived that bilingual students experience a disadvantage in learning mathematics due to the complexity of utilising two languages. While research shows that bilingualism does have an effect on performance in mathematics, it offers less in the way of explanation. Clarkson (2007) has suggested that proficient bilingualism enhances students' meta-cognitive skills in mathematics. This paper reports on bilingual (Irish and English) third level students' language competencies and performance in mathematics, and how they utilise their languages when engaged in mathematical problem solving. The positive impact of bilingualism, provided appropriate language thresholds have been reached in each of the languages, is evident for particular students in this sample. In particular, students opting for the bilingual approach in first year undergraduate education are reaping the rewards of additive bilingualism and enhanced meta-cognitive skills.

Keywords: Bilingualism; additive bilingualism; language use; mathematical problem solving; third level mathematics education

1. Introduction

Decisions about which language(s) are used in education are predominantly political in nature (Edwards, 1994). The history of the Irish language in Ireland and its history as a medium of instruction in schools have been marred by issues of access, power and dominance. With the establishment of An Saor Stáit (Free State) in 1921 Irish-medium education was central to policy plans for the revitalisation of the language and compulsion was the norm throughout the country but detrimental to student learning (Kelly, 2002). Removal of this element of compulsion in the 1960's was a catalyst for change as it signalled an element of eliminating 'choice' of attending Irish-medium education for parents outside of Gaeltacht[1] regions and thus Irish-medium immersion education was established in the early 1970's. Socio-political developments have further contributed to the explosion and popularity of Irish-medium schools witnessed in Ireland today and expansion is set to continue (Gaelsoileanna Teo., 2013). It is only in recent years that research into Irish-medium education and the potential impact of bilingualism (Irish and English) is starting to emerge.

It is often perceived that bilingual students experience a disadvantage in learning mathematics due to the complexity of utilising two languages. While research shows that bilingualism does have an effect on performance in mathematics, it offers less in the way of explanation. Clarkson (2007) has suggested that proficient bilingualism enhances students' meta-cognitive skills in mathematics, that is, it allows students to think more effectively about their mathematical thinking. This idea is supported by experimental research in psycholinguistics (for a review see Moschkovich, 2007) that suggests, for example, that the advantage of multilingualism includes an enhanced capacity to analyse problems and select useful features, while ignoring other less useful features (e.g. Bialystok, 1992). At (author's affiliation), students are afforded the opportunity to take Mathematics through a bilingual approach during their first year of third level education. The research undertaken by the authors purports to examine if this type of bilingual offering facilitates a transition from Irish-medium to English-medium mathematics education, while examining bilingual students' use of their languages when engaged in mathematical problem solving and the cognitive benefits associated with high-ability bilingualism.

[1] Irish-speaking region in Ireland.

2. The Irish Context

Examination of linguistic influences on mathematics education within the Irish context is a relatively new phenomenon. Within the realm of Irish-medium education, two types exist: Maintenance Heritage Language (Gaeltacht primary and post-primary schools) and Immersion education (Gaelscoileanna[2] and Gaelchloláistí[3]). Immersion education has experienced substantial growth in the past decades with the numbers participating in this form of education increasing by more than forty percent, and the number of schools has more than doubled in the past twenty years (Gaelscoileanna Teo., 2013). For Gaeilgeoirí attending immersion Irish-medium education, the community in which this school is located is predominantly English speaking, and the language of the home may be English, Irish or both. Therefore, it is anticipated that various levels of language proficiency in English and Irish will be evident amongst Gaeilgeoirí entering third level education. The majority of Gaeilgeoirí face an imminent transition to English-medium tertiary education and this is what is of concern to the authors. Transitioning to a new language of learning for mathematics can be a source of difficulty for Gaeilgeoirí, as Gaeilgeoirí submerged in the transition will be required not only to learn mathematics, but also to learn mathematics through the medium of English (Barwell, 2003). This is not just a localised problem; such issues are prevalent in international literature.

However, the significance of this work lies in assessing how a bilingual (Irish and English) first year undergraduate mathematics programme may help facilitate this key transition in education. (The Author's affiliation) has a special role in the protection and promotion of the Irish language. Accordingly, it offers the subject Mathematics at first year undergraduate level to both Arts and Science students as an English-medium option or a bilingual (Irish/English) option. The subject is year-long and is taught as four lectures per week together with a compulsory weekly workshop. Additionally, weekly tutorials are provided. The bilingual option provides lectures through the medium of Irish while these students then integrate with their English counterparts in the weekly workshops and tutorials. For a variety of reasons, uptake of the bilingual option is small (typically in the range 3 – 10 students). This bilingual option is only available to ***first*** year undergraduate students.

3. Language and Mathematics

There are conflicting views about the learning of mathematics in a second language at all levels of education. Some studies (immersion programmes) have found positive correlations with learning mathematics in a second language and academic achievement (e.g. Barwell, 2003; Clarkson, 1992; Swain, 1996; Williams, 2002), while other studies (submersion programmes) have put forward concerns that such pupils underachieve in mathematics (e.g. Adler & Setati, 2000; Gorgorió & Planas, 2001; Secada, 1992;). More specifically, empirical studies investigating the relationship between language proficiency and mathematics performance have been instrumental in furthering this area of research. Prior to the early seventies, it was assumed that bilingualism had a negative impact on cognitive development and mathematical learning (Clarkson, 2007). Research investigating the cognitive effect of bilingualism on mathematical learning began in the early eighties and has progressed from there. Both Dawe (1983) and Clarkson (1992) concluded that bilingual mathematics students competent in both their languages performed significantly better in mathematics than bilingual students dominant in only one language, and better than their monolingual peers. They also found that mathematics students who were weak in both their languages performed poorly mathematically also. This research substantiates the theoretical idea of threshold levels of language competence and this is further supported by research carried out by Secada (1992) with bilingual mathematics students in America.

More recent research carried out at second and third level education in New Zealand (Barton, Chan, King, Neville-Barton, & Sneddon, 2005) with students for whom English is a second language concluded that these students experience a disadvantage of between ten and fifteen percent in mathematics as a result of language difficulties, which again reinforces the notion of the necessity of language competency in both languages. The author's work and other recent studies conducted in Ireland into Irish-medium education have demonstrated positive cognitive advantages in relation to mathematical and English reading attainment in comparison to students who attend all-English medium education (Shiel, Gilleece, Clerkin & Millar, 2011).

[2] Irish-medium primary schools outside of Gaeltacht regions.

[3] Irish-medium post-primary schools outside of Gaeltacht regions.

These investigations accentuate the positive benefits that can be reaped from being bilingual and are consistent with international findings in relation to the benefits of bilingual and immersion education (e.g. Bourton-Trites & Reeder, 2001).

Literature on language use by bilingual/multilingual students when learning mathematics emphasises the important role of language switching in relation to explaining the positive benefits associated with high ability bilinguals (Clarkson, 2007). Research undertaken by Kern (1994) provides a number of explanations for a learner to revert to their first language such as it allows for processing of text; maintaining concentration; adapting and integrating concepts with prior knowledge; clarifying meaning; and enhancing confidence. In relation to Spanish immersion mathematics classrooms in the United States, Cohen (1994) found that most children preferred using English for mathematical processing, even though the questions were presented in Spanish. The children primarily utilised English for comprehension and clarification purposes, when they encountered a difficulty and for affective reasons. Also of importance to this research project is the implication of bilingualism for metacognition and problem solving, in particular bilingual students' ability to focus on and manipulate language (metalinguistic abilities) in the process of solving a problem (Schoenfeld, 1992). For example, Bialystok (1992) found that bilinguals were able to distinguish essential information from non-essential information and displayed a superior ability to solve problems. Given that this type of metalinguistic skill is connected to metacognition, it suggests that it may be important in terms of mathematics performance (Clarkson, 2007) and is supported by studies undertaken in psycholingusitics (Moschkovich, 2007).

4. Outline of the Paper

This paper will present evidence-based insights into, and the influences of, bilingualism and bilingual education for undergraduate mathematics learners in the Irish context. All participants in this study had learnt mathematics entirely through the medium of Irish at primary (age 5 to 12) and post-primary (age 12 to 18) level education. All participants were studying mathematics in their first year of third level education. This research project was devised into two data collection phases, with each phase using a different cohort of Gaeilgeoirí. Study 1 quantitatively assessed whether the level of language proficiency in Irish and in English is related to mathematical performance and whether the bilingual year assists in developing additive bilingualism for these students. It was designed to provide the authors with significant insights into the potential benefits of bilingual mathematics instruction at 1st year undergraduate mathematics education. Study 2 replicated Study 1 with a new cohort of Gaeilgeoirí in order to assess the accuracy of the findings emerging from Study 1. In addition to the quantitative element, in-depth interviews were undertaken with the participants identified in order to examine their specific language uses in mathematics, in conjunction with their ability to undertake mathematical problem solving. Accordingly, Findings Section 1 of the paper summarises the relationship between language proficiency/bilingualism and mathematics performance for the students in both studies undertaken. Findings Section 2 delves into how bilinguals (in particular high ability bilinguals) utilise their languages (English and Irish) when engaged in mathematical problem solving. The specific methodology and data collection tools will be discussed in each of the findings sections.

There are a number of limitations in these studies which the authors would like to address for the readers of this paper, and which are of importance when interpreting the findings emerging from the work. The number of participants in both studies is low. This is due to the difficulty in sourcing students who have studied entirely through the medium of Irish up to third level education and them then choosing a course containing a mathematical element at the university. For the students participating in the bilingual programme, they receive their mathematics lectures through the medium of Irish and are then integrated with all first year mathematics students for their weekly workshops through the medium of English. Clearly, there are a low number of students in the lecture situation and thus they receive significant attention and instruction from the lecturer in comparison to those who opt to take the subject through the medium of English. However, in the workshop context, no distinction between the groups is observed.

5. Findings Section 1: Bilingualism and Mathematics Performance

Both studies quantitatively assessed whether the level of language proficiency in Irish and in English is related to mathematical performance and whether the bilingual year assists in developing additive bilingualism.

The research also evaluates if differences in mathematical performance exist between Gaeilgeoirí who opt to take bilingual instruction (lectures through the medium of Irish; workshops through the medium of English) and those Gaeilgeoirí who opt for all English instruction at third level education. The authors have identified a gap in the literature specific to addressing how to support bilingual students in the transition between language mediums of learning. These studies were the first of their type to be undertaken in an Irish context and provide significant insights into advantages for the learning of mathematics in a bilingual context.

5.1 Methodology

Participants' performance on a variety of linguistic and mathematical tests will be discussed, and the relationship(s) between these tests. The following were completed by the participants: *Short Algebra Test* (Mestre, 1986); *Mathematics Word Problem Test* (Newman's Research Method, 1977; Hater & Kane, 1975; OECD, 2006); *English Proficiency Test* (Cambridge Examinations Publishing, 2002); *Irish Proficiency Test* (Aonad na Gaeilge, University of Limerick); *Language Use Survey* (Clarkson, 2007).

5.2 Description of the Language Proficiency Groups

In Study 1, seven Gaeilgeoirí participated in the study and ten Gaeilgeoirí participated in the Study 2. Of the seventeen participants, seven were completing first year undergraduate mathematics education through the medium of Irish **and** English (bilingual option), and ten were taking mathematics through the medium of English only. A modification of the technique employed by Clarkson (2007) was used to segregate the participants into language proficiency groups. The median scores for the proficiency tests in Irish and in English were used in order to divide Gaeilgeoirí into comparatively high or low proficiency groups in Irish and in English. Gaeilgeoirí were then categorised as having relatively high proficiency in both languages, dominance in one language (combination of high/low) or relatively low proficiency in both languages (combination of low/low). Each student was assigned to only one of these language proficiency groups (see Table 1). All data was coded and imported into SPSS (Version 16) for analysis. The findings described in subsequent sections are intended to demonstrate the relationship between bilingualism and performance in mathematics for 1st year undergraduate mathematics students.

5.3 Performance on the Algebra Test

The first concept explored in the analysis of the data gathered is to establish if a relationship exists between Gaeilgeoirí's performance on the algebra test and their overall language proficiency, as well their chosen medium of learning mathematics at third level education. From Figure 1 it is clear that Gaeilgeoirí with relatively high proficiency in both languages performed better mathematically on the algebra test than Gaeilgeoirí dominant in one language and the Gaeilgeoirí with low proficiency in both languages. Given that the high proficiency group dominates the course group learning through the medium of Irish, it is not surprising that the bilingual group learning through the medium of Irish and English at third level did better than the Gaeilgeoirí who opted to study mathematics entirely through the medium of English (Figure 2). No significant difference was found between the means of the various groups in Figure 1 and 2 (Mann-Whitney U, $p<0.05$). However, this may be attributed to the low number of participants in the study and it is anticipated a significant difference would exist between the groups if a larger cohort were involved in the study.

5.4 Performance on the Mathematics Word Problem Test

Given the previous observations reported on the algebra test, the authors were keen to see if these findings are replicated in the mathematics word problem test (in English). From Figure 3, it is evident that the high language proficiency group outperformed the dominant group and the student with low language proficiency. However, the differences in means was not found to be statistically significant (Mann-Whitney U, $p<0.05$), which again may be attributed to the low numbers participating in the study. When segregating the Gaeilgeoirí according to the medium of mathematics education at third level, visibly the bilingual instruction group outperform the Gaeilgeoirí learning through the medium of English only (Figure 4). The difference was found to be significant (Mann-Whitney U, $p<0.05$). This suggests that Gaeilgeoirí pursuing mathematics through the bilingual approach are reaping the cognitive benefits from being bilingual, evident for those with high proficiency in both languages (The Author).

5.5 Language Use Survey

Irish is still of importance for mathematical learning for the participants in this study. From analysis of the language use survey, it is evident that the Gaeilgeoirí drew on their first language of learning (Irish) primarily when answering the algebra questions, even though all of the questions were presented in English (Table 2). In particular, the High Proficiency language group employed Irish when answering both sets of questions, demonstrating its importance to them for undertaking problem solving and their ability to accomplish mathematical thinking in ***two*** languages. This may explain why the High Proficiency group (the majority of whom who are enrolled in the bilingual 1st year mathematics course) outperformed the other students mathematically in this study.

6. Findings Section 2 – Mathematics Problem Solving and Language Use

Findings from a previous quantitative element of the studies undertaken by the authors demonstrate that bilingualism and bilingual instruction is a positive outcome for undergraduate mathematics education. The Qualitative element of Study 2 investigated bilingual students' (English and Irish) use of their languages when undertaking mathematical problem solving in undergraduate mathematics education and how their language competencies impact on mathematical performance.

6.1 Methodology

Ten participants in total took part in Study 2. As discussed in Section 5.1 the participants completed a number of mathematical and linguistic tests that facilitated segregation into high and low ability bilingual students based on findings from the testing. Subsequently in-depth recorded interviews were undertaken with the participants in order to look at their specific language uses in mathematics learning, along with their ability to undertake mathematical problem solving. Each participant took part in a follow-up interview *after* completing the series of previous tests. The interviewer had the results of the completed tests and the language information sheet filled in by each student. As part of the interview process each participant was asked to solve three mathematics problems. Each problem was presented in English on a single sheet of paper with space for working out a solution. Each participant had to read the problem out loud and the interviewer checked that they understood its context. They then proceeded to solve the problem without interference until they signalled that they had finished it. Following this a discussion took place between the interviewer and the student in relation to their thinking, language use and problem solving strategies employed in the process of reaching a solution.

A comparison is made between those opting for all English instruction and those opting for bilingual instruction at third level education (Table 3). Three of the students had opted for the bilingual approach and seven had opted for the all-English approach. This is to facilitate comparison and to assess the effectiveness of participating in a bilingual (Irish and English) year in third level mathematics education.

6.2 Findings

The following section will present some of the key findings emerging from the qualitative element of Study 2 undertaken by the authors. Given the small sample size, the authors are not claiming that these results are generalizable but that they offer rich insights into the nature of bilingualism and its potential impact on mathematical learning and problem solving in undergraduate mathematics education.

Some Gaeilgeoirí did make errors when reading the problems, usually not reading carefully all of the key information and critical elements of the word problems. Naturally, this in turn impacted on the comprehension of the problem(s) and the solution of it. What was interesting with the students classified as high ability bilinguals was their ability to recognise that they had made an error and self –correct. The following interview excerpt demonstrates one of the high ability bilingual student's ability to self-correct a misunderstanding.

Interviewer:	So your first answer was that you think it makes a difference deducting the 30% discount first and then calculating the 5% extra for the printed name on the jersey but you changed your answer, why?
Student:	Well I first thought that 5% of a discounted price would be lower than 5% of the original price.
Interviewer:	….and then you changed your answer. What made you change your answer?
Student:	Well I just started to think about it more and realised that it's the same if you do it either way like adding the 5% first and then calculating the 30% discount or the other way around, won't change the final price.

From analysing the high ability bilingual students' self-correction incidents, it largely centred on utilising the language of the word problem, demonstrating these students enhanced metacognition abilities (Clarkson, 2007) and consistent with literature on bilingual students (Bialystok, 1992).

From Table 4 it is evident that the use of Irish or a combination of Irish and English was dominant for solving the algebra test. When questioned on this, the majority of students alluded to the fact that they had learnt 'this type of maths' through the medium of Irish at post-primary education and that this was what was normal to them. Half the Gaeilgeoirí employed English only when solving the word problems (Table 4). They referred to the fact that when a problem is presented in English they tend to revert to this language for solving the problem. Therefore *context* is playing a role in language selection. All of these students had opted for the all-English instruction at third level education and when undertaking problem solving during the interview all five claimed to only use English in this scenario also. For those who employed Irish only (1 student) or a combination of English and Irish (4 students) when engaged in mathematical problem solving, they tended to use Irish when they encountered a perceived difficulty and/or when reverting to familiar procedures acquired through the medium of Irish initially. This became very apparent in the interview setting where all five students employed Irish at some stage in the process of reaching a solution to each of the problems. They tended mainly to employ Irish for thinking out a strategy for solving the problem and for undertaking mathematical operations.

Interviewer:	Can you think about what parts you did use Irish for solving the problem…
Student:	Hmmm, well I definitely used Irish when I was working out the numbers
Interviewer:	So when you carry out mathematical operations like addition and subtraction?
Student:	Yeah exactly and sometimes I guess I just think in Irish…it is just very difficult to explain.
Interviewer:	Do you find it helps you to use Irish to solve the maths questions?
Student:	Yeah like it's [Irish] what I'm used to using and so I kinda just always go back to using it without really thinking about what language I use. But I like using Irish, I feel more comfortable doing maths through Irish.

Those Gaeilgeoirí who utilised a combination of Irish and English when completing the word problems in the interview situation performed better mathematically than those who employed English only, although this was not statistically significant. Overall the participants found it difficult to express when and how they use their languages for mathematical problem solving. It appears to be a subconscious process and there is a lack of *awareness* amongst the students that they utilise two languages when engaged in problem solving, but it facilitates better performance in solving mathematics word problems for these students. The data suggests that some Gaeilgeoirí found it easier to process mathematical concepts/ideas in Irish, their first language of learning. This may be for *cognitive reasons* and/or for *confidence* reasons (i.e. it is familiar and they have experienced success in solving problems through Irish prior to this). Many of the students referred to the 'difficulty of doing it (maths) in English', preferring to use Irish as it is 'easier'. A comparison of Irish and English language features and the potential impact on mathematical processing warrants further study.

The high ability bilingual students in this study displayed greater *meta-cognitive skills* when engaged in problem solving during the interview process in comparison to the other bilingual students (Bialystok, 1992). These enhanced meta-cognitive skills displayed by the high ability bilingual students in this study included comprehension of the problem; self-correction (realising they had made an error without prompt from the interviewer); selecting appropriate features in the problems and disregarding unimportant information in the problem; and knowledge of strategies. It is important to note that two of the three high ability students had opted for bilingual instruction at third level education and all three employed both languages when engaged in mathematical problem solving. This significant group of students have performed better mathematically than other students in this study and this can be attributed in part to their competency in both languages.

7. Discussion

These studies support the concept that language competencies and mathematics performance are related. Gaeilgeoirí pursuing mathematics through the medium of Irish and English demonstrate high proficiency in both languages, whereas the Gaeilgeoirí opting for instruction entirely through the medium of English demonstrate dominant proficiency in one of their languages or low proficiency in both. Gaeilgeoirí with high ability in both languages performed better on the algebra and word problem tests than those dominant in one language or weak in both of their languages (Cummins, 1976).

Therefore bilingualism should not be viewed as negative and emphasis should be placed upon developing competence in both languages. This research demonstrates that bilingualism and bilingual instruction is a positive outcome for mathematics at third level education. It suggests that bilingual instruction at the university may be facilitating the development of additive bilingualism, and accordingly the cognitive advantages associated with this type of bilingualism (Dawe, 1983).

All of the participants in this research were transitioning from Irish-medium second level education to English-medium third level education. Research on the transition between language mediums for mathematics learning has shown that it can be difficult and may affect mathematical learning for those experiencing subtractive bilingualism (Thomas & Collier, 2002). Some of the participants opted for bilingual instruction, while others opted for all English instruction. Given that the bilingual mathematics group in this study performed mathematically better than the Gaeilgeoirí who opted for all English instruction it implies that this bilingual year may assist the transition to a new language of learning mathematics (English) for Gaeilgeoirí, as well providing Gaeilgeoirí with the opportunity of developing additive bilingualism.

The findings from the interviews in relation to language use were quite revealing. Context plays a significant role in the selection of a language for engaging in a problem solving process. The findings support evidence from other research in that bilingual adults' preferred language for undertaking mathematical processes tends to be the language of instruction (Moschkovich, 2007). Those opting for all-English instruction at third level education tended to utilize only English, whereas as those opting for a bilingual approach at third level employed both languages for arithmetic computation and problem solving. Participants who employed a bilingual approach to problem solving on average performed better than those adopting a monolingual approach, although this was not found to be statistically significant. Reverting to the use of Irish tended to relate to previous experiences, perceived difficulty and for affective reasons (Clarkson, 2007). Clearly, Irish is still of importance in mathematical computation and problem solving when transitioning to English-medium third level education.
The high ability bilingual students displayed an enhanced meta-cognitive ability demonstrating flexibility in thinking and reasoning, self-correction, and an ability to select appropriate features for problem solving (Bialystok, 1992; Clarkson, 2007). This reinforces the point that bilingualism has the potential to enhance mathematical teaching and learning and a focus should be on the development of strategies and processes in order to reap the benefits of being bilingual. It is important to note here that two of the three high ability bilingual students had opted for the bilingual approach in first year undergraduate mathematics education. This suggests that a bilingual approach may contribute to the development of additive bilingualism and can lead to enhanced meta-cognitive skills.

For Gaeilgeoirí in this study, their use of their languages in mathematical problem solving appears to be unconscious – it does not appear to be a deliberate activity. Moreover, there is a lack of awareness on their behalf of the fact that they have two languages for learning and problem solving. It was difficult for the participants to explain their use of English and Irish. This demonstrates the intricacy of the processes undertaken by Gaeilgeoirí and is only partially elicited by the interview process. There is a need to promote awareness and an understanding of the advantages of bilingualism for (mathematical) learning amongst our student population.

8. Recommendations and Conclusion

Bilingual (Irish and English) undergraduate students' language competencies, their mathematics ability, and how they utilise their languages are key components explored in this research study. The positive impact of bilingualism, provided appropriate language thresholds have been reached in each of the languages, is evident for particular students in this sample. In particular, Gaeilgeoirí opting for the bilingual approach in first year undergraduate education appear to be reaping the rewards of additive bilingualism and enhanced meta-cognitive skills. Clearly the numbers in this study are very small and it needs to be replicated on a larger scale to ratify findings. However, this research project was conducted in order to give some insights into advantages or disadvantages that Gaeilgeoirí may experience from undertaking bilingual (Gaeilge & English) mathematics education during their first year of undergraduate education. The findings of this research offer substantial insights into the potential benefits of this type of course in developing additive bilingualism and in easing the transition to all-English medium mathematics education subsequent to completing their first year at the university. A number of recommendations can be suggested from the work undertaken. These include:

- There is an obvious need to conduct repeat and further research into this bilingual mathematics course with larger numbers in order to assess its effectiveness in developing additive bilingualism and for facilitating the transition to learning mathematics through the medium of English.
- The data suggests that Gaeilgeoirí with high proficiency in both languages experience a cognitive advantage in mathematics. Adopting a longitudinal perspective, the Gaeilgeoirí who participated in this study should be monitored and further testing undertaken throughout their mathematical studies.
- Other third level institutes should be made aware of these results and encouraged to adopt a similar opportunity in their mathematics programmes in order to cater for bilingual students in their institutions, and to foster additive bilingualism.

This research has generated some rich insights into the influence of languages on bilingual undergraduate students' mathematical problem solving processes. The knowledge and understanding that both languages play a role can provide insights into bilingual students' mathematical thinking (Clarkson, 2007). Internationally very little research has been carried out in relation to bilingualism and mathematics education at tertiary level (Barton *et al*., 2005). Therefore, this study goes some of the way in examining this issue, as well as providing a foundation for future work to be undertaken.

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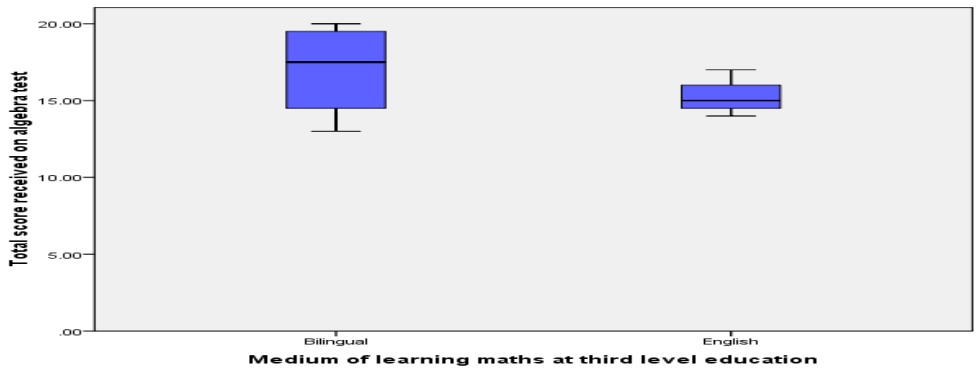

Figure 1: Comparison of Language Proficiency Groups with Performance on Algebra Test

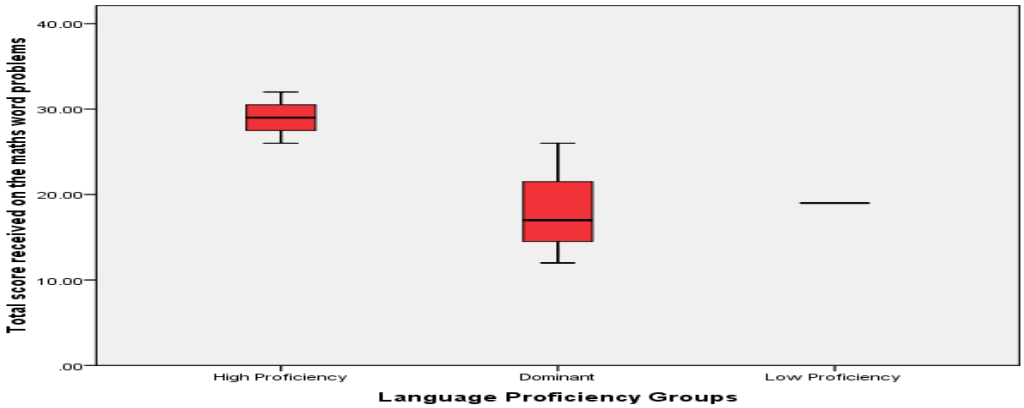

Figure 2: Comparison of Language Medium of Learning with Performance on Algebra Test

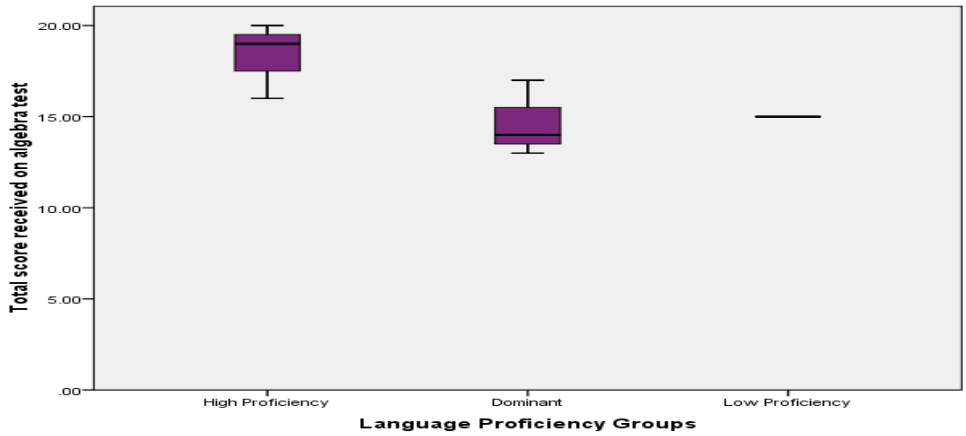

Figure 3: Comparison of Language Proficiency Groups with Performance on Mathematics Word Problem Test

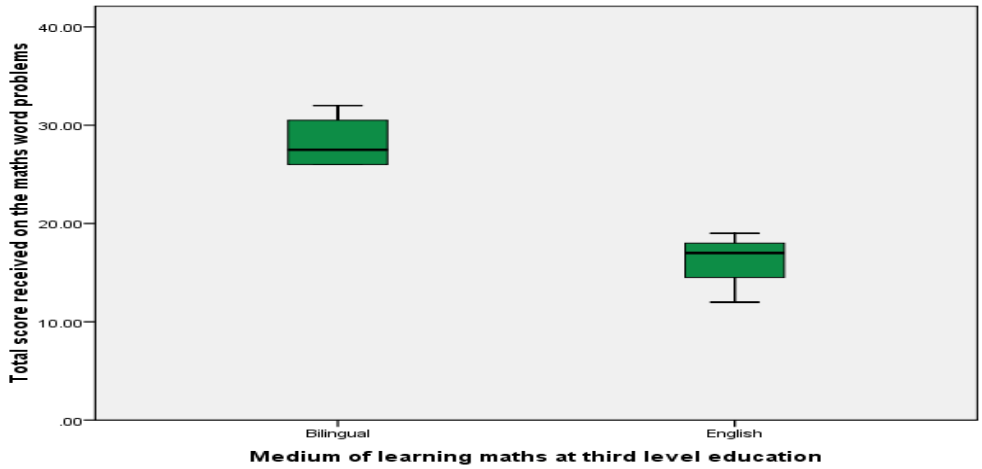

Figure 4: Comparison of Medium of Learning with Performance on Mathematics Word Problem Test

Table 1: Description of the Language Proficiency Groups

	Categorisation	**No. of Students**	**Medium of Learning at 3rd Level**
High Proficiency	High Irish & High English	6	5 Bilingual 1 all-English
Dominant Proficiency	High Irish and low English Low Irish and High English	6 3	2 Bilingual 7 all-English
Low Proficiency	Low Irish and Low English	2	2 all-English

Table 2: Findings of the Language Use Survey

	Algebra Test	**Word Problem Test**
English Only	8	12
English and Irish	5	4
Irish Only	4	1

Table 3: Language Proficiency Groups

	Categorisation	**No. of Students**	**Medium of Learning at 3rd Level**
High Proficiency	High Irish & High English	3	2 Bilingual 1 all-English
Dominant Proficiency	High Irish and low English Low Irish and High English	4 2	1 Bilingual 5 all-English
Low Proficiency	Low Irish and Low English	1	1 all-English

Table 4: Language Information Survey

	Algebra Test	**Word Problem Test**
English Only	3	5 (5 all-English medium of learning)
English and Irish	5	4 (3 Bilingual and 1 all-English medium of learning)
Irish Only	2	1(1 all-English medium of learning)