Language issues for adults learning mathematics through a second language.

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Language plays an important role in the teaching and learning of mathematics. This investigation is focused on learners (Gaeilgeoirí) in the transition from learning mathematics through Gaeilge (Irish) to learning mathematics through English. The relationship between mathematics and language is complex and intricate. Although the overall research project is concerned with the influence of bilingualism on mathematics learning for Gaeilgeoirí, a maths life histories approach was utilized in order to gain narrative accounts of adult mathematics learners' experiences of the transition from Gaeilge-medium to English-medium mathematics education. This paper reports on the findings of these narrative accounts. The purpose of this exploratory research is to inform future research to be carried out by the author in this research domain.

Introduction

Language and communication are fundamental to the learning and teaching of mathematics (Gorgorió & Planas, 2001). Without language, relational understanding cannot be attained (Skemp, 1978). Thus the language we initially learn mathematics through will provide the mathematical foundations to be built upon and developed within that language. A characteristic feature of the Irish primary and post-primary school system is that the curriculum can be mediated in either Gaeilge (Irish) or in English. Learning and teaching through the medium of Gaeilge is the natural environment for students growing up in the Gaeltacht (Gaeilge-speaking districts) of Ireland. The rise in popularity of Gaeilge-medium education outside of Gaeltacht areas is also significant. The number of students attending these schools has increased by more than sixty percent in the last decade, with the number of schools increasing by more than fifty percent (Sunday Independent, 12th March, 2006). However, the majority of students learning through the medium of Gaeilge (Gaeilgeoirí) face an imminent transition to English medium-education, be it at second or third level education. Students have the option of transferring to learning through English at second level, whereas English-medium education is the norm at third level. At the end of the school year in 2006, there were 3414 Gaeilgeoirí in their final year of primary education (6.8% of entire final year population) and 904 Gaeilgeoirí in their final year of second level

education (1.5% of entire final year population). Thus a significant minority of students are confronted with the transition to English-medium education. The authors anticipate difficulties arising in the Science, Engineering and Technology (SET) subjects – mathematics in particular. Students submerged in these transitions will be required not only to learn mathematics, but also to learn mathematics through English (Barwell, 2003).

Mathematics and Language

The identification of language as an important factor in mathematics learning and teaching has significant implications for this research project. The 'language of mathematics' is referred to as the 'register' of mathematics (Pimm, 1987). This register does not just consist of technical vocabulary, but also includes words, phrases and methods of arguing within a given situation, conveyed through the use of natural language (Pimm, 1987). Therefore it is similar to learning a language and is an additional dimension to learning mathematics. If students cannot understand either the language of the teacher or the meanings of certain phrases/words involved in the mathematical context, then there is the danger that they will not be able to participate in the mathematical discourse (Gorgorió & Planas, 2001). If we adopt the viewpoint of mathematics as a language then the ability to communicate mathematically becomes an important consideration in the teaching and learning of mathematics. Furthermore, if the language of instruction is not the mother-tongue then mathematics learners are likely to be severely disadvantaged (Jones, 1982). In order to minimise this disadvantage it is necessary to develop adequate proficiency in both the student's mother-tongue and the new language (see Cummins, 1976 and 1979).

By delving into the area of psycholinguistics the complex nature of language and its relationship with thinking and understanding is revealed. Although conflicting views exist, the general consensus (cognitive science) is to presume that thinking is occurring in some language (Sierpinska, 1994). Language is necessary for comprehending and combining experiences, and is required for organising concepts. Concepts and thoughts are the foundations of our understanding. Language and thought are interrelated (Bruner, 1975; Vygotsky, 1962) and thought is necessary for our understanding, therefore language is involved in developing our mathematical understanding. Also one cannot overlook the importance of culture and its influence on mathematical teaching, learning and understanding. This is heightened for this project in the sense that it is concerned with mathematical learners moving between cultural environments. These include social, educational and pedagogical cultures. Although there is a broad range of issues emerging, the one encompassing theme is the need to cater for the language and cultural needs of Gaeilgeoirí in the transition so as to enhance their mathematical understanding.

Overall Study

This research project is primarily concerned with the influence of bilingualism on mathematics learning and teaching in Ireland. The project incorporates a two-phased approach. Phase 1 will be reported on in this paper and is concerned with the findings from exploratory research carried out by the author. Findings from an undergraduate dissertation undertaken by the author revealed that Gaeilgeoirí under-perform and

experience a variety of difficulties due to the medium of instruction (English). It also highlighted a lack of resources, teaching strategies and support available to those in the transition from Gaeilge-medium to English-medium education. Recommendations included further investigation in relation to the particular aspects of the mathematics register and the English language that hinder Gaeilgeoirí's learning of mathematics and cause difficulties for students learning in a second language (Ní Ríordáin, 2005). Subsequently exploratory research was carried out during the academic year 2005/2006 in order to gain a deeper understanding of this complex area of research.

Exploratory Research

The aim of the exploratory research was to establish and clarify the key issues facing Gaeilgeoirí in the transition from learning mathematics through Gaeilge to learning mathematics through English. This is to ensure that subsequent research to be carried out by the author will address the relevant issues and contribute to development in this research domain.

Methodology

In choosing an exploratory methodology the primary rationale is that it is the most appropriate for the context and will fulfil the aims of the research (Goodson & Sikes, 2001). A qualitative approach was employed in this exploratory phase, with the purpose of eliciting information to help describe and understand the participants' transition from learning mathematics through Gaeilge to learning mathematics through English (Leedy & Ormrod, 2001). More specifically, a Maths Life Histories approach was utilized in which the use of semi-structured interviews provides for the gathering of narrative accounts of the subjects' experiences (Coben & Thumpston, 1994). Interviews were conducted with adults, which included first year mathematics students at third level, and professionals who had experienced the transition during their education/training. In total six subjects were interviewed (3 students & 3 professionals) and all subjects were required to have transferred from learning mathematics through Gaeilge at second level to learning mathematics through English at third level. It should be noted that when a life histories approach is employed, sample sizes tend to be small, non-random and purposive (Goodson & Sikes, 2001).

Data Collection

Semi-structured interviewing is the principal method of data collection when using a Maths Life Histories approach. Hollway and Jefferson (2000) contend that the questions used should encourage the interviewee to talk about specific times/experiences, rather than relying on the use of general questions concerned with a long period of time in the interviewee's life. The author devised a list of questions, which were used as a guide when conducting the interviews. These questions were adapted if necessary for each interview, based on the information obtained from previous interviews. The questions employed were constructed using the 'TAP' acronym, as formulated by Foddy (1993) i.e. the topic should be clearly defined, applicable to the respondent and with a specified perspective. The interviews were recorded using an IC Recorder and the one-one conversations lasted approximately half an hour. After the interview the recording was transferred to Voice Editor 3 (voice editing PC software). The interviews were then transcribed and saved as a Word

document. This facilitated the importation into NVivo - software designed for the analysis of qualitative data.

Data Analysis

From initial analysis of the data using NVivo, eight themes emerged. These were - Mathematics Experience, Perception of Mathematics, Primary School Experience, Secondary School Experience, Transfer to Learning through English, Difficulties Experienced, Learning and Teaching Strategies, Support. These were consistent with the topics discussed during the interviews. These eight themes were then used as node titles under which the data was reanalysed. From this reanalysis four prominent themes emerged, namely Language, Understanding, Personal Conceptions and Culture. The data was analysed again using these themes as node titles.

Findings

From the reanalysis a number of relationships were established between the nodes (Figure 1). These relationships are shown diagrammatically and are discussed in pairs in the following paragraphs.

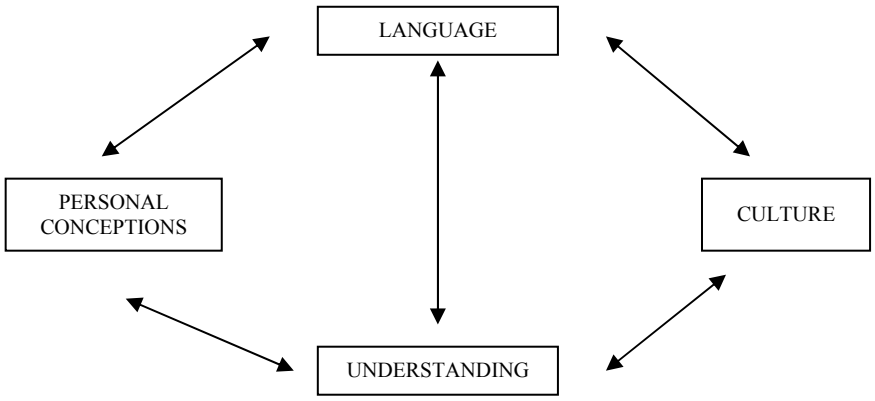

Figure 1. The relationship between nodes.

Language – Personal Conceptions:

Mathematics terminology was the primary source of difficulty when transferring from learning through Gaeilge to learning through English for all subjects interviewed. In particular, it was the "basic maths" or fundamentals that they had learnt through Gaeilge at primary/secondary level. These "basic maths" included simple operations such as addition (suimiú), subtraction (dealú); types of numbers e.g. integer (uimhir), complex (casta); and labels e.g. denominator (ainmneoir), hypotenuse (taobhagán).

"I couldn't understand a word of what the lecturer was saying because I had no idea of what orthogonal meant because I had never heard the word before. Things like that and not understanding what she was looking for because I didn't know the English words."

(Interviewee No.3, 11/04/2006).

Also highlighted by the subjects was the "self-explanatory" characteristic of mathematics words in Gaeilge in comparison to their English equivalent. This was of immense benefit for the subjects when studying mathematics through Gaeilge as it facilitated the development of their understanding of mathematics. The structuring of mathematical problems in English was also a cause of confusion as it varies from the structure of Gaeilge and thus the subjects found it difficult to "pick out the important information needed for the question" (Interviewee No. 4, 07/04/2006).

However, given the huge emphasis that *all* the subjects placed on mathematics terminology it was surprising that the majority of them did not perceive language as a component of mathematics. Perceptions of mathematics ranged from "just solving stuff", to "loads of formulas for solving problems" to "figures and computations and working out answers". However, the interviewees that had pursued mathematics beyond degree level had a more developed understanding of mathematics and could see its relationship with everyday life. But yet their personal conceptions of mathematics failed to develop an association between mathematics and language.

"..with mathematics you don't have a huge element of language, even when you're writing it you're working it out in numbers and symbols, you're not working it out in Gaeilge or in English. So the actual physical working out of a problem isn't done in a language."

(Interviewee No. 1, 27/03/2006).

Language – Culture:

One of the fundamental requirements of existence is the ability to participate in a culture and participate in situations arising from this culture. Appropriate linguistic choices are made so as to maximise understanding by the listener/reader (Meaney, 2005). English medium education is largely the norm in Irish third level institutions thus catering for the majority and isolating the minority. The transition from Gaeilge medium second level education to English medium third level education was described by the interviewees as "difficult", "hilarious!", "hell" and "being thrown in the deep end". One of the subjects expressed the difficulty and discomfort he experienced on entering third level education due to his language and cultural background.

"I suppose I'm from a very Irish place, Gaeilge is the main language spoken there and even the culture is different. I'm seen as the 'culchie' boy from Galway and even the way I speak is different."

(Interviewee No. 6, 03/04/2006).

But it was not just language that caused a barrier. A number of other issues became prominent such as the culture of third level institutions, which are directed towards independent and self-directed learning. None of the subjects interviewed had approached their lecturers/tutors about difficulties they were experiencing due to the language barrier and few were aware of support services available to them. Only one of the interviewees had availed of support provided by their mathematics department. The general consensus was a fear of being perceived as "different (because of their language background)", "looking stupid because you don't know the maths" and a fear of lack of understanding of the issue on behalf of those providing support. All relied heavily on

the support of *close* friends whom they felt comfortable talking to about their mathematics problems.

Language – Understanding:

The concept of understanding has been the focus of much research undertaken in the past and up to recent times. On one side of the spectrum is Piaget's work and his theory of the growth of understanding in children – primarily that language is an instrument for articulating our thoughts (Snowman & Biehler, 2003). Others such as Vygotsky, Bruner and Skemp take a different perspective on understanding – that language shapes and is a requirement for thoughts (Yushau & Bokhari, 2005). One dominant embodiment of the latter theory is the Whorf-Sapir hypothesis – that different languages arrange reality differently for their users (Prins & Ulijn, 1998). It follows from interpretation of this theory that the language we speak facilitates our thinking and our perception, and that "concepts not encoded in their language will not be accessible to them, or will at least prove difficult" (Durkin & Shire, 1991, p.12). Although conflicting views exist, what is of importance is that language plays a role in developing our mathematical understanding.

Many types of mathematical understanding have been identified. These include Skemp's relational understanding (knowing both what to do and why) and instrumental understanding (rules without reasons) (1978, p.9). Likewise, Byers and Herscovics' (1977) model defined understanding as being intuitive (reaching solutions without prior analysis) and formal (ability to connect mathematical ideas and form chains of logical reasoning) (Herscovics, 1996). A more recent development is Hiebert and Carpenter's (1992) conceptual and procedural knowledge. Conceptual knowledge is necessary for understanding the mathematical processes while procedural knowledge is associated with knowing the sequence of actions.

Discussion of these types of understanding, as well as the relationship between language and understanding became an importance aspect of the mathematical life histories. It soon became apparent that the interviewees associated learning/"knowing" their mathematics through Gaeilge with understanding and comprehending their mathematics. Four of the subjects relied heavily on translation of terminology/mathematical questions in order to help them to complete tutorial sheets and exam questions during their first year at university. In particular one subject found that

"…translation helped ease the stress if I didn't know something. Like if I translated it back to Gaeilge I would be like ok I know what this is so I can do it."

(Interviewee No.5, 31/03/2006).

Likewise, having English as the medium of instruction influenced their learning strategies. All subjects acknowledged that they "learnt stuff off" for examinations and that they didn't understand some of the concepts behind the mathematics that they were learning. They described learning the English mathematics register as "relearning the words", not as developing mathematical understandings through English and transferring skills learnt through Gaeilge to English. A considerable effort was

dedicated towards rote learning and practice of mathematical questions. One subject described it as

"..learning the rules all over again. They are hard enough to remember as it is without the added confusion of changing the language."

(Interviewee No. 2, 28/03/2006).

Thus the subjects relied on procedural knowledge with little development of relational understanding.

Personal Conceptions – Understanding:

"It's (maths) ok. If I understand it I enjoy it" (Interviewee No. 3, 11/04/2006). The subjects' experiences in mathematics at all levels of education were intermingled with their perceptions of their "ability" and understanding of mathematics. Three of the subjects had positive experiences at primary and secondary level and thus opted to study degree courses with mathematics as a large component. They felt confident in completing mathematical tasks and felt that the transition to English medium education didn't hinder their progress in mathematics long term. The remaining three had negative experiences, particularly at second level, and were pursuing degree courses where mathematics was only required at service level. One subject in particular saw mathematics as "..an eight foot wall that I couldn't get over." (Interviewee No. 6, 03/04/2006). Moreover they felt that they lacked ability in mathematics and this in turn was a source of negative attitudes towards the topic.

Culture – Understanding:

The various types of understanding were discussed in a previous section and when these are considered from a cultural (and pedagogical) perspective, they are reflective of that particular culture's belief about the learning of mathematics (Davidenko, 2000). The majority of the participants spoke of the new environment they were suddenly immersed in –

"Going from secondary school to college is hard because you're in a lecture with 300 more students and the lecturers don't teach as such, they just read off slides."

(Interviewee No. 2, 28/03/2006).

Subjects spoke of the expectation of having a certain competency in mathematics before entering university, but that this was hindered by the level of mathematics taken at second level and also by the language barrier. Abandonment was a significant issue for three of the subjects in particular. Progressing from having been "spoon-fed" all through second level, as well as having the constant support of teachers, to suddenly being an insignificant number in a crowd was a difficult transition for them. This is consistent with universities' strategy of producing independent learners. However, where they fail is in providing direction in becoming an independent learner. People need support and guidance in the right direction. Thus, all of the interviewees relied on

procedural knowledge in order to succeed in examinations, and little time was given to the development of conceptual understanding.

This exploratory research highlights that mathematical understanding is influenced by language and that the students' cultural background and experiences exercise a large influence on the development of this understanding also.

Conclusions and Recommendations from Exploratory Research

This type of research is in its infancy in Ireland but further more in-depth research is needed as a matter of urgency considering the increasing numbers of students learning through the medium of Gaeilge. The majority of these students face an imminent transition to English medium education, be it at second or third level education. From the studies carried out by the author, and by researchers in other countries, it can be seen that language is a crucial component in the learning of mathematics, in particular for those learning through the medium of a second language. Language and mathematics is a complex area of investigation and many diverse research options exist. The author focused on the area of learning mathematics through the medium of English having previously studied it through Gaeilge. The studies were carried out on a small scale and thus are not generalizable but recommendations can be drawn up for future research in this area in Ireland.

- The studies demonstrate that the Gaeilgeoirí are experiencing difficulties in studying mathematics through English. There is an obvious requirement for this study to be continued on a larger scale so as to determine if it is a significant issue and one which merits follow-up research.

- There is a lack of resources and support available to those in the transition from studying through Gaeilge to English, which makes the transition difficult, isolated and confusing for those experiencing it. Schools and universities need to be made aware of the needs of Gaeilgeoirí in their institutions and provide the necessary help required.

- If important progress is to be made in improving mathematics education for those learning mathematics in a second language (English), further investigation is required in relation to the particular aspects of the mathematics register which hinder their learning of mathematics and cause difficulties for the students learning in a second language.

- Cummins (1976, 1979) conjectured that there may be a threshold level of language competence that bilingual children must achieve both in order to avoid cognitive deficits and to allow the potential benefits of being bilingual to come to the fore. This hypothesis should be investigated in relation to Gaeilgeoirí in order to assess whether the level of language competence in both languages (Gaeilge & English) has detrimental/beneficial influences on their learning.

- The various cultural influences on learning, understanding and mathematics to be examined and assessed in relation to its impact upon the key transition stages – primary to second level education and second to third level education.

- The potential role of the mathematics teacher of second language learners needs to be investigated so as to determine how they can influence and support the learning of all the learners in their class.

- The possibility of introducing Gaeilge as an optional medium of instruction at third level education should be investigated, so as to cater for those students wishing to continue their education through this medium.

References

Barwell, R. (2003) 'Patterns of attention in the interaction of a primary school mathematics student with English as an additional language', *Educational Studies in Mathematics*, **53**(1), pp.35-59.

Bruner, J.S. (1975) *Towards a Theory of Instruction,* Cambridge; London: The Belknap Press of Harvard University Press.

Coben, D. and Thumpston, G. (1994) 'Getting personal: Research into adults' maths Life Histories', in Coben, D., ed., *Proceedings of the 1st Inaugural Conference of Adults Learning Maths,* London: Goldsmiths University**,** pp.30-33.

Cummins, J. (1976) 'The influence of bilingualism on cognitive growth: A synthesis of research findings and exploratory hypotheses', *Working Papers on Bilingualism*, **No**.**9**, pp.1-43.

Cummins, J. (1979) 'Linguistic interdependence and the educational development of bilingual children', *Review of Educational Research*, **49**(2), pp.222-251.

Davidenko, S. (2000) 'Learning mathematics in English: ESL and non-ESL students' perspectives', *Dissertation Abstract International*, **61**(07): 2635 (UMI No. 9977964).

Durkin, K. and Shire, B. (1991) *Language in Mathematical Education: Research and Practice,* Milton Keyes: Open University Press.

Foddy, W. (1993) *Constructing Questions for Interviews and Questionnaires: Theory and Practice in Social Research,* Cambridge: Cambridge University Press.

Goodson, I. F. and Sikes, P. (2001) *Life History Research in Educational Settings,* Buckingham: Open University Press.

Gorgorió, N. and Planas, N. (2001) 'Teaching mathematics in multilingual classrooms', *Educational Studies in Mathematics*, **47**(1), pp.7-33.

Herscovics, N. (1996) 'The construction of conceptual schemes in mathematics', in Steffe, L., Nesher, P., Cobb, P., Goldin, G. and Greer, B., eds., *Theories of Mathematical Learning,* Mahwah, NJ: Lawrence Erlbaum Associates**,** pp.351-379.

Hiebert, J. and Carpenter, T. (1992) 'Learning and teaching with understanding', in Grouws, D. A., ed., *Handbook of Research on Mathematics Teaching and Learning,* New York: MacMillan**,** pp.65-97.

Hollway, W. and Jefferson, T. (2000) *Doing Qualitative Research Differently: Free Association, Narrative and the Interview Method,* London: SAGE.

Jones, P. L. (1982) 'Learning mathematics in a second language: A problem with more and less', *Educational Studies in Mathematics*, **13**(3), pp.269-287.

Leedy, P. and Ormrod, J. (2001) *Practical Research: Planning and Design,* 7th ed., Upper Saddle River, NJ: Merrill Prentice Hall.

Meaney, T. (2005) 'Mathematics as text', in Chonaki, A. and Christiansen, I. M., eds., *Challenging Perspectives on Mathematics Classroom Communication,* Westport, CT: Information Age Publishing, pp.109-141.
Ní Ríordáin, M. (2005) *Issues in Teaching and Learning Mathematics through Gaeilge,* unpublished thesis (Final Year Dissertation), University of Limerick
Nolan, L. (2006) 'Big hike in all-Irish schools as Gaeilge becomes trendy', *Sunday Independent,* 12th March, p.8.
Pimm, D. (1987) *Speaking Mathematically: Communication in Mathematics Classrooms,* London: Routledge & Kegan Paul Ltd.
Prins, E. and Ulijn, J. (1998) 'Linguistic and cultural factors in the readability of mathematics texts: The Whorfian Hypothesis revisited with evidence from the South African context', *Journal of Research in Reading*, **21**(2), pp.139-159.
Sierpinska, A. (1994) *Understanding in Mathematics. Studies in Mathematics Education Series: 2,* London; Washington, D.C.: The Falmer Press.
Skemp, R. R. (1978) 'Relational understanding and instrumental understanding', *Arithmetic Teacher*, **26**, pp.9-15.
Snowman, J. and Biehler, R. (2003) *Psychology Applied to Teaching,* 10th ed., Boston: Houghton Mifflin.
Vygotsky, L. S. (1962) *Thought and Language,* Cambridge: M.I.T. Press.
Yushau, B. and Bokhari, M. (2005) 'Language and mathematics: a mediational approach to bilingual Arabs', *International Journal for Mathematics Teaching and Learning, (April, 2005*).
Available online at http://www.cimit.plymouth.ac.uk/journal/yashau.pdf, (accessed on 2nd November, 2005).