The Use of Local African Languages as Languages of Science

Philip Pare

The Standardisation of African Languages

Language political realities

CentRePoL and IFAS

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contents

chapter six

The use of local African languages as languages of science[1]

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[1] This paper is based on a combination of submissions to: a) the SAARMSTE 2006 conference held at the University of Pretoria; b) a Language in Maths and Science seminar held at the University of the Witwatersrand in April 2006; c) a language planning workshop held at the University of Pretoria in April 2006 and d) a language and society conference held in Botswana in June 2008

Introduction

In this paper, I focus on a number of multilingual initiatives that have been taken at the University of Pretoria to determine whether or not it is feasible to use African languages as media of instruction at secondary schools and in the Foundation Year Physics course which is intended for incoming University students. The initiatives include the translation of the 'Force Concept Inventory' into six languages and the administration thereof to Foundation Year students, the translation of South African Senior Certificate Physical Science papers and their memoranda into Northern Sotho; as well as various attitudinal surveys administered to asses students' opinions on being taught through languages other than English.

Historically, there have been relatively few black students studying Physics and related science disciplines at the University of Pretoria. One of the factors that has been of concern is the academic language ability of the black students (Fricke, 2006). Most of them do not come from homes where English is a/the primary language and so learning through English has put them at a disadvantage compared to those students who have been able to study through their home language, whether it be English or Afrikaans[2].

Black students do not usually regard their own languages as being sufficiently developed to be used for advanced level academic studies. Furthermore, for a variety of reasons, English is generally considered to be a language of high status (Webb, 2005). Black students would therefore tend to consider those people who have a good command of English to have a higher social status.

The South African Department of Education has, since 1997, encouraged a policy of additive bilingualism, where all students may use their primary languages up to the highest levels while gradually acquiring skills in other languages. This contrasts with the more common subtractive bilingualism where the primary African language gives way to a high status language as medium of instruction at some stage in the learner's educational career. For the additive bilingualism approach to be successful it would be necessary to develop the previously low status languages to the point where they can be used as languages of science. This paper will highlight some of the problems in developing these languages as languages of science.

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2 In most cases the term "primary language" has been used to refer to the local or predominant home language of the learners The term "vernacular" had been used previously, but this was met with opposition in some linguistic quarters

Theoretical background

I am approaching the language question within the context of Piaget's constructivism (Piaget, 1932), and Vygotsky's "process of mediation" (Vygotsky, 1978) and Lemke's "situated cognition" (Lemke, 1997).

Issues around the link between Piaget's work and constructivism have been described as follows by Ernst von Glasserfeld (http://www.oikos.org/Piagethom htm)[4]:

> *As development has to do with growth and childhood, when Piaget was first discovered in the United States - about 1940 - he was classified as a child psychologist. Twenty years later, he was discovered once more as the author of a theory that postulated four stages in the development of intelligence. Finally, in the 1980s, he was rediscovered for the third time, as the progenitor of constructivism. Since then, constructivism has become fashionable, especially in the educational domain. Many writers call themselves constructivists, but few have fully understood the revolutionary aspect of Piaget's theory.*

Anton Yasnitsky et al describe some of Vygotsky's contributions to cognitive theory in a 2007 Wikipedia article as follows[5]:

> *These thoughts on learning, which we now call cognitive constructivism, paved the way for the emergence of the educational theory called social constructivism (McMahon 1997)*
>
> *Lev Semenovich Vygotsky (1896 – 1934), a Belarusian psychologist who lived and worked in a Marxist environment, became famous for his view on mediation as an integral part of human psychology: "the central fact about our psychology is the fact of mediation" (Vygotsky 1978:166).*
>
> *Although his work only became known in the United States during the 1960s, his critique on his contemporary Piaget's cognitive constructivism, led to the understanding of the importance of culture, language and context in the process of constructing knowledge. Whilst Piaget in his Moral judgment of the Child (Piaget, 1932) and*

4 http://www oikos org/Piagethom htm

5 http://en wikipedia org/w/index php?title=Social_constructivism_%28learning_theory%29&direction=prev&oldid=193815804 With some corrections to the grammar and taking note of the continual changes to Wikipedia articles

Sociological Studies (1977;1995) argued for the importance of co-operation and mutual respect in social interaction as a necessary condition for cognitive development, Vygotsky emphasized the importance of discourse with others, language and culture, in order to, through the process of mediation, get to a higher order of truth that has also been socially tested (Derry 1999).

Vygotsky's "zone of proximal development" is probably his best-known concept. It argues that students can, with help from adults or peers who are more advanced, master concepts and ideas that they cannot understand on their own. Again the emphasis falls on learners actively constructing knowledge and meaning through participating in activities and challenges, with the added emphasis on the interaction between learners and facilitators in order to arrive at a higher level of truth (Sternberg and Williams 1998)

In another Wikipedia article, Anton Yasnitsky et al (2006)[6] expand on Vygotsky's work as follows:

According to Vygotsky, the intellectual development of children is a function of human communities, rather than of individuals. His contributions are widely respected and influential within the fields of developmental psychology, education, and child development.

In the Soviet Union, the ideas of Vygotsky were developed largely under the banner of activity theory that was introduced and systematically developed by such Vygotsky students and colleagues as Alexei Leont'ev, P. Zinchenko, Zaporozhets, D. El'konin, as well as Gal'perin, Davydov, Smirnov, Talyzina, etc.

In the West, most attention was aimed at the continuing work of Vygotsky's Western contemporary, Jean Piaget. Early - albeit indirectly - influence on the growing cognitive science community in the United States was already apparent in the late 1950s and early 1960s through the work of Vygotsky's student and collaborator Alexander Luria which was read by early pioneers of cognitive science J. S. Bruner and George Miller. However, Vygotsky's work appeared to be virtually unknown until its "rediscovery" in the 1960s, when the interpretative translation of Thought and Language (1934) was published in English in 1962[7]. In the end of the 1970s, a truly ground-breaking

6 http://en wikipedia org/w/index php?title=Lev_Vygotsky&oldid=42919842

7 A revised edition, translated by A Kozulin appeared in 1986 and, as Thinking and Speech, translated by N Minick, in 1987,

publication was the major compilation of Vygotsky's works that saw the light in 1978 under the header of "Mind in Society: The development of higher psychological processes".

By the 1980s, Vygotsky's work became well known in the United States in part due to the opening of the Soviet Union that followed glasnost. Vygotsky's work became extremely influential because it offered a way of reconciling the competing notions of maturation by which a child is seen as an unfolding flower best left to develop on his or her own, and environmentalism, in which a child is seen as a blank slate onto which must be poured knowledge. His views are influential on activity theory, distributed cognition, and Cognitive Apprenticeships.

Works of Vygotsky are also studied today by linguists regarding language and its influence on the formation of the perception of reality. His work has also been influential on second language acquisition theory.

Whereas constructivism stressed the importance of linking any new knowledge to existing concepts and ideas, Vygotsky suggests that intellectual development may be largely influenced by a child's interactions with others. Rollnick (2000) summarises some of Vygotsky's work by saying that "mediation and shared discourse through language lie at the basis of Vygotsky's work"

In a further article (Dahms 2007)[8] it is written that
Vygotsky maintained that language plays a central role in cognitive development. He argued that language was the tool for determining the ways a child learns "how" to think. That is because complex concepts are conveyed to the child through words. "Learning, according to Vygotsky, always involves some type of external experience being transformed into internal processes through the use of language."[9] It follows that speech and language are the primary tools used to communicate with others, promoting learning.

Following Vygotsky, my premises are that if some of the linguistic units and rules used in Physics are not familiar to the student, then that student would not be able to engage in effective linguistic interaction. The student would then have difficulty linking any new material to his/her pre-knowledge. If the student could find other linguistic units and rules in his primary language with similar functions as those used in English, then

8 http://www newfoundations com/GALLERY/Vygotsky html

the Piageten constructivist process of accommodating the new knowledge would be made easier. Furthermore linguistic interaction with the students' tutor and his/her peers will be promoted.

Classroom interaction is far more than just a question of a knowledge of words. Interlocutors need a command of complex morphological and syntactic structures, text types, functional capacities and sociolinguistic competence. Also they need an understanding of the relevance of situational, psychological, socio-cultural contexts, as well as the required background knowledge. Furthermore, with a more competent control over the language, communication with the learner's peers is facilitated. This process allows meaning to be developed by "shared discourse" (Rollnick, 2000) between both teachers and learners as discussed in the literature (e.g. Lemke, 1997)

However intellectually satisfying Vygotskyian and Piageten perspectives may be, the students' social and economic need for English encourages them to disregard the cognitive advantages of learning through the primary language and to express their desire to be taught in English only (informal interviews with UP students).

The University of Pretoria Foundation Year Program in Mathematics and the Basic Sciences (UPFY)

In 2001, UP started a Foundation Year Programme (UPFY) directed at preparing disadvantaged students to enter the mainstream courses offered at the University. The medium of instruction was English and the students followed a year-long programme where they studied Physics, Mathematics, Chemistry, Biology and English and Study Skills (ESS).

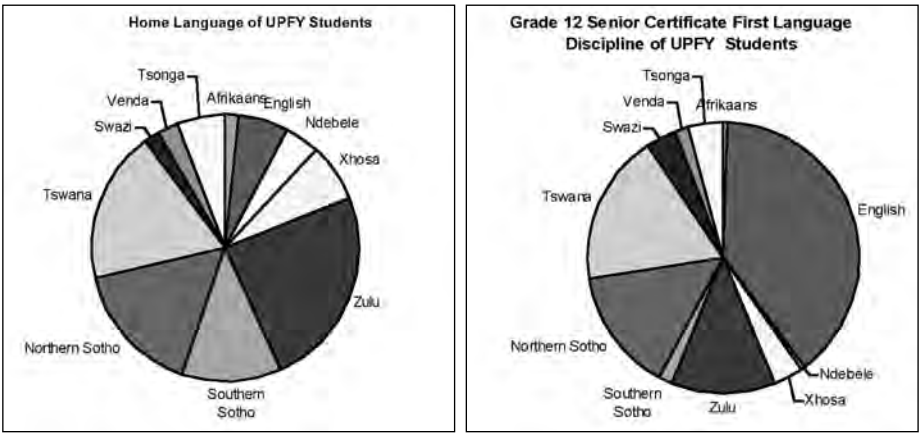
In my Physics classes I observed, however, that the UPFY students did not limit themselves to the use of English only and would converse amongst themselves in their different primary languages in class. Many of these UPFY students also welcomed some clarification of the concepts by the lecturer in their primary language (from informal interviews with them).

The background of the UPFY learners was very mixed. Some came from poor dysfunctional rural government schools, while a few others had attended expensive urban private schools. They were selected on the basis of their performance in the Senior Certificate examination (the attainment of at least an F symbol on the standard grade for Mathematics and a standard grade F for either Biology or Physical Science) and in a special UPFY placement test set by University of Pretoria lecturers. This placement test included tests in Maths,

Physics, Chemistry, Biology and English. In January 2005, 192 students were selected from about 2000 students who wrote the entrance examination.

I mention the make-up of the UPFY group in detail to show that it is a selected group and hence their opinions could be substantially different from learners still studying for the Senior Certificate.

Figure 1.
language diversity of the UPFY group:



The Force Concept Inventory

I have used translated versions of the Force Concept Inventory (FCI) to test the effect of the language of the test on student performance. I have chosen the FCI as it is a very well used instrument in Physics Education circles. The FCI is a test that evolved from the Mechanics Diagnostic Test to assess students' understanding and knowledge of the basic concepts in Newtonian mechanics. The FCI was developed by Hestenes, Wells, & Swackhamer, in 1992, and revised in 1995 by Halloun, Hake, Mosca & Hestenes. The introduction to the 1995 revised FCI explains :

> *"The two standardized tests, and especially FCI, have been administered to tens of thousands of students around the world. The physics education community used them for a multitude of purposes, but most importantly for assessing student conceptual understanding of the basic concepts and principles of Newtonian mechanics, and subsequently for evaluating instruction*[9]*."*

Because of the widespread use of the FCI, I thought that it would be a very good instrument to investigate the effect of language on students' understanding of the basic concepts in Newtonian mechanics. I had the English FCI translated through commercial translators, (that is, they did not have detailed knowledge in the field of Physics) into Afrikaans, Southern Sotho (Sesotho), Northern Sotho (Sesotho sa Leboa), Tswana (Setswana), Venda (TshiVenda) and Zulu (isiZulu). These languages were selected since they were the main primary languages of the UPFY and Mamelodi students - the Mamelodi campus, formerly part of VISTA University, had recently been incorporated into the University of Pretoria.

Figure 2 is an example from one of the distractors of one of the questions from the FCI and its translation into a number of languages. The highlighted words show some of the problems that arose with the translation and that I changed after discussing them with mother-tongue speakers of the language, who were also knowledgeable about Physics. Further terminological issues are illustrated in Appendix 1 and are described further in Elsabé Taljard's chapter in this publication.

9 Newtonian mechanics is that branch of Physics that deals with the basic laws of motion It was initially developed by Isaac Newton and is centred around his three principal laws together with his law of gravitation

Figure 2
A common misconception
English

The truck exerts a greater amount of **force** on the car than the car exerts on the truck

Northern Sotho: (initial commercial translation)

Lori e ntšha **maatla** a mantši kudu mmotorong go feta ao a ntšhwago ke mmotoro go lori.

Northern Sotho: – modified translation

Lori e dira **kgapeletšo** e kgolo kudu koloing go feta eo e dirilwego ke koloi loring.

Tswana: (initial commercial translation)

Llori e gatelela ka **maatla** a magolo thata mo koloing go na le a koloi e a gatelelang mo lloring.

Tswana: – modified translation

Lori e gatelela ka **kgapeletso** ye kgolo thata mo koloing go na le e koloi e a gatelelang mo loring.

Southern Sotho: (initial commercial translation)

Lori e fehla **matla** a maholo ho hatella koloi ho feta kamoo koloi e fehlang matla ka teng ho hatella.

Southern Sotho: – modified translation

Lori e etsa **qobello** e ngata koloing ho feta qobello ya koloi loring.

Zulu: (initial commercial translation)

iLoli liba **nomfutho** omkhulu emotweni kunomfutho imoti enawo elolini.

Zulu: – modified translation

iLoli liba **nendluzula** enkulu emotweni kunendluzulu yemoto encane.

In my experimental design I chose three groups of students of equal academic strength to represent firstly those who wrote the FCI from an English only question paper, secondly those who wrote from a bilingual question paper, and thirdly those who wrote from a question paper in their primary language only. In order to create three groups of equal average academic strength, I used the students' performance in the first semester of the Physics course. This was done by using a spread sheet to sort the students by language and by their first semester performance.

I assigned the students into the different language groups based on data that they supplied concerning their primary, or home, language. The intended use of those languages however turned out to be problematic in a number of cases as some students were not able to read these languages since they had attended primary and secondary schools where no use was made of these languages.

The students were divided into three groups: A, B and C. Group A were given the English-only version of the FCI, Group B the version in their primary language, and Group C the bilingual (English plus home language) version.

The FCI pre-test was conducted on the 22nd July 2005, after a semester of Physics but before the students had studied any mechanics at the university. The first semester Physics had concentrated on Heat, Measurements and Light. The FCI post-test was conducted on 25th October 2005 after the students had studied some Kinematics, Statics and Dynamics. They had not studied any circular motion and this may explain the poor performance on some of the FCI questions. The tests were also conducted at the Mamelodi Campus where the students were following a similar Physics curriculum to that offered at the main Hatfield Campus of the University of Pretoria. The results from these two pre- and post-FCI tests are summarised in Table 1 below.

In 2004, pre- and post-FCI tests were conducted in English only amongst the 2004 UPFY students. The average percentages obtained were as follows: Pre-Test - 27.1 % ; Post-Test 39.2%. The difference was 12.1 percentage points.

In the 2005 experimental test, there does not appear to be any significant difference related to language. Hence it would seem that the language of the test is not a significant factor in the overall poor performance of the students in this test.

A comparison between the 2004 and 2005 results show little difference, again suggesting that the language of test was not a statistically significant factor.

To get an international perspective on the UPFY student performance, I have compared the results in Table 1 below to the results presented in Hake's interactive engagement paper (Hake, 1998). This is done in figue 1 where the Gain is plotted against the pre-test result. In UPFY, we attempted to use what in Physics educational circles are called *"interactive engagement methods*" (IE")[10] and yet the gains that our students made are significantly below the gains that similar courses in the USA achieved. Not only are they below interactive engagement courses, but they are also below the gains that students would normally be expected to show in traditional lecture-, laboratory- and tutorial-based courses. This poor performance is of great concern to us and we note that providing the test in the students' primary languages does not significantly improve the situation.

The concept of a standardised gain was developed by Richard Hake (1998) and this is just the actual difference between the pre and post test result divided by the maximum possible gain. So if a student achieved a gain of 25 percentage points from 30 percent in the prestest to 55 percent in the post test, (s)he would have a standardised gain of

$$\frac{55 - 30}{100 - 30} = \frac{25}{70} = 0.35 = 35\%$$

Hake classified standardised gains of between 70% and 100% as high gains, and those between 30% and 70% as medium gains and those less than 30% as low gains.

The standardised gain is also represented by the gradient of the %<gain> vs %<Pretest [P.T.5] > [16] graph and so a steep graph represents a high gain while a graph with a gentle sloap would represent a low gain.

Dotted lines have been drawn on the graphs in figure 3 to represent gains of 30%, 70% and 100%

10 For survey classification and analysis purposes following Hake (1998 I define:
(a) "Interactive Engagement" (IE) methods as those designed at least in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors, all as judged by their literature descriptions;
(b) "Traditional" (T) courses as those reported by instructors to make little or no use of IE methods, relying primarily on passive-student lectures, recipe labs, and algorithmic problem exams;
(c) "Interactive Engagement" (IE) courses as those reported by instructors to make substantial use of IE methods

TABLE 1

AVERAGE MARKS OBTAINED IN THE FORCE CONCEPT INVENTORY AT THE HATFIELD AND MAMELODI CAMPUSES OF THE UNIVERSITY OF PRETORIA

Bilingual Group

Language of Test	Hatfield (UPFY)								Mamelodi (CGS)							
	N	Pre Test %	Standard deviation of Pre Test	Post Test %	Standard deviation of Post Test	%<Gain>	Standard deviation of %<Gain>	Normalised gain -g	N	Pre Test %	Standard deviation of Pre Test	Post Test %	Standard deviation of Post Test	%<Gain>	Standard deviation of %<Gain>	Normalised gain -g
Afrikaans-English	1	33.3		23.3		-10.0		-0.15	0							
S. Sotho-English	4	25.0	4.3	39.2	3.2	14.2	5.0	0.19	2	21.7	2.4	20.0	14.1	-1.7	11.8	-0.02
Northern Sotho - English	19	28.9	12.6	40.4	16.6	11.4	15.1	0.16	8	26.3	21.4	38.8	16.6	12.5	8.7	0.17
Tswana-English	18	28.7	12.4	39.4	13.6	10.7	15.1	0.15	1	20.0		33.3		13.3		0.17
Venda-English	2	25.0	2.4	55.0	11.8	30.0	14.1	0.40	3	31.1	8.4	23.3	8.8	-7.8	11.7	-0.11
Zulu-English	38	28.5	7.6	41.5	12.5	13.0	13.6	0.18	15	29.8	15.9	45.1	15.3	15.3	15.6	0.22
Summary	82	**28.5**	**9.8**	**40.7**	**13.5**	**12.3**	**14.2**	**0.17**	**29**	**28.0**	**13.1**	**39.0**	**16.5**	**10.9**	**14.7**	**0.20**

English only Groups

Language Group	Hatfield (UPFY)								Mamelodi (CGS)							
	N	Pre Test %	Standard deviation of Pre Test	Post Test %	Standard deviation of Post Test	%<Gain>	Standard deviation of %<Gain>	Normalised gain -g	N	Pre Test %	Standard deviation of Pre Test	Post Test %	Standard deviation of Post Test	%<Gain>	Standard deviation of %<Gain>	Normalised gain -g
English only 2005	**60**	**32.6**	**13.2**	**40.8**	**13.5**	**8.2**	**12.3**	**0.12**	**32**	**24.6**	**11**	**37.2**	**9.5**	**12.6**	**11.4**	**0.17**
English only 2004	**151**	**27.1**		**39.2**		**12.1**		**0.17**								

Primary Language Only Group

Language of Test	Hatfield (UPFY)								Mamelodi (CGS)							
	N	Pre Test %	Standard deviation of Pre Test	Post Test %	Standard deviation of Post Test	%<Gain>	Standard deviation of %<Gain>	Normalised gain -g	N	Pre Test %	Standard deviation of Pre Test	Post Test %	Standard deviation of Post Test	%<Gain>	Standard deviation of %<Gain>	Normalised gain -g
S. Sotho-English	5	30.7	5.5	32.7	16.9	2.0	16.4	0.03	2	21.7	2.4	11.7	16.5	-10.0	18.9	-0.13
Northern Sotho	7	26.2	7.6	41.0	13.2	14.8	12.1	0.20	10	20.0	12.0	32.3	10.2	12.3	12.6	0.15
Tswana	8	21.7	6.4	27.9	13.1	6.3	10.9	0.08	1	26.7		36.7		10.0		0.14
Venda	1	20.0		23.3		3.3		0.04	1	16.7		33.3		16.7		0.20
Zulu	14	27.6	11.5	40.7	13.3	13.1	11.3	0.18	3	15.6	10.2	34.4	5.1	18.9	10.7	0.22
Summary	**35**	**26.2**	**9.1**	**36.2**	**14.3**	**10.0**	**12.4**	**0.14**	**17**	**19.6**	**10.1**	**30.6**	**11.4**	**11.0**	**14.0**	**0.14**

Figure 3.
FCI Gain vs pretest graphs from FCI results at the University of Pretoria and at various institutions in the USA from Hake (1998)

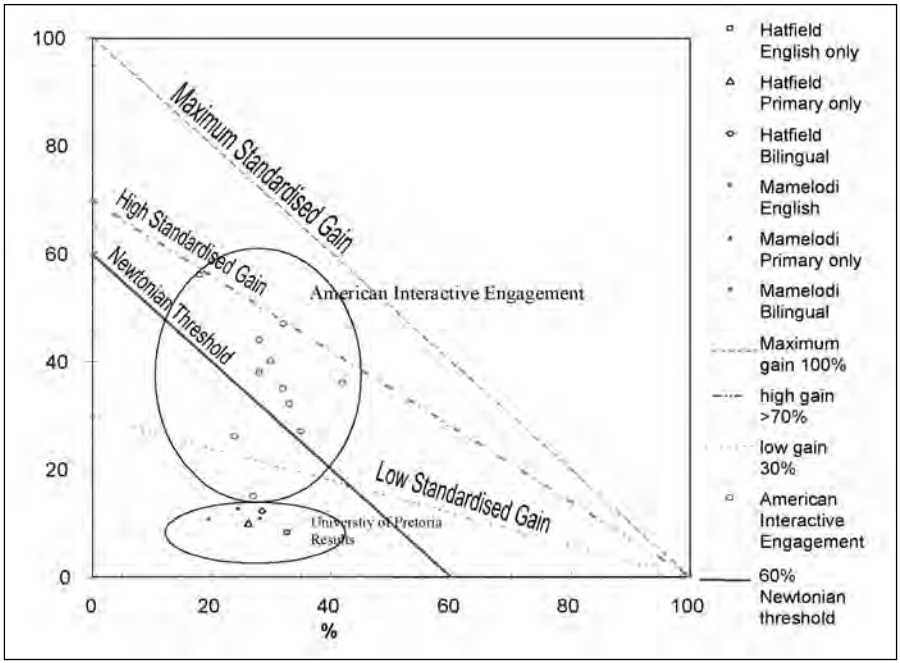
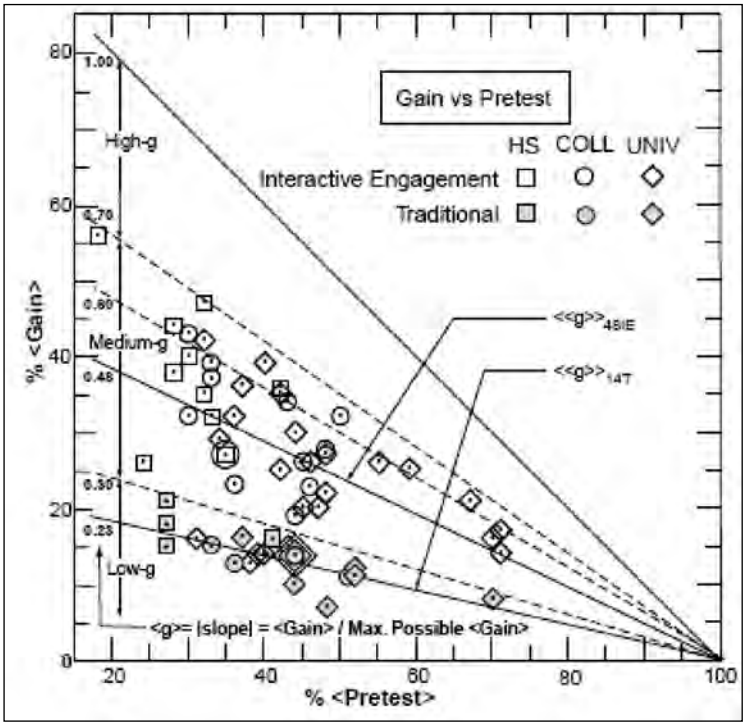


Figure 4.
(From Hake 1998)%<Gain> vs %<Pretest> score on the conceptual Mechanics Diagnostic (MD) or Force Concept Inventory (FCI) tests in the USA

This was done for 62 courses enrolling a total N = 6542 students: 14 traditional (T) courses (N = 2084) which made little or no use of interactive engagement (IE) methods, and 48 IE courses (N = 4458) which made considerable use of IE methods. Slope lines for the average of the 14 T courses <<g>>14T and 48 IE courses <<g>>48IE are shown, as explained in the text.



After writing the Force Concept Test, the UPFY students were asked to comment on the test. The request was expressed as follows:

"When you have finished the test please, comment on how understandable the language of the test was. Please give examples of any language that you found difficult to understand."

I have include two examples of the kind of comments that students wrote in Appendix 2.

Table 2.
Was the Primary Language easy to understand?

		Numbers			Percentages	
Test Type	Test_language	no	yes	no comment	no	yes
Bilingual	Afr-eng	1			100%	0%
	S. Sotho - English	3		2	60%	0%
	N. Sotho - English		13	6	0%	68%
	Tswana - English	1	10	10	5%	48%
	Venda - English	1	1		50%	50%
	Zulu - English	3	13	25	7%	32%
Total	Bilingual	9	37	43	10%	42%
Total	English only	7	37	22	11%	56%
Primary Language	S. Sotho	5			100%	0%
only	N. Sotho	7			100%	0%
	Tswana	6	1	1	75%	13%
	Venda			1	0%	0%
	Afrikaans		1		0%	100%
	Zulu	13		1	93%	0%
Total	Primary Language	31	2	3	86%	6%
Grand Total		47	76	68	25%	40%

Table 3.
Was the primary language useful?

		Numbers		Percentages	
Test type	Test_language	no	yes	no	yes
Bilingual	Afrikaans-Eng.				
	S. Sotho-Eng.	1	1	50%	50%
	N. Sotho -Eng.	7	8	47%	53%
	Tswana-Eng.	8	5	62%	38%
	Venda-Eng.	1	1	50%	50%
	Zulu-Eng.	21	3	88%	13%
Total	Bilingual	38	18	68%	32%
Primary	Afrikaans		1	0%	100%
Language	S. Sotho	5		100%	0%
Only	N. Sotho	7		100%	0%
	Tswana	6		100%	0%
	Venda				
	Zulu	13		100%	0%
Total	Primary Language	31	1	97%	3%
Grand Total		69	19	78%	22%

To analyse the responses, I considered two constructs:

(i) Was the language easy to understand;

(ii) Was the provision of an African language text useful.

In this way I was able to convert much qualitative data into quantitative data and so found that only twenty percent of the students who had a bilingual paper, thought that the primary language was useful.

This result compared with only three percent of students who thought the local language was useful when they had a question paper that was monolingual in the primary language. The main conclusion here was that it was a minority of students who found the primary language to be useful, but the provision of bilingual papers was much preferred compared to primary language monolingual papers. This is much what I expected as the students have studied most of their science to date in English and so were unfamiliar with many Physics terms in their primary language.

Figure 5.
A positive response to the question : "Was the language in the FCI test easy to understand?" (from Table 2)

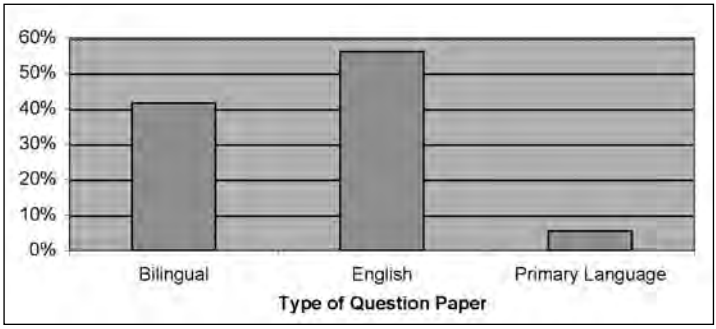
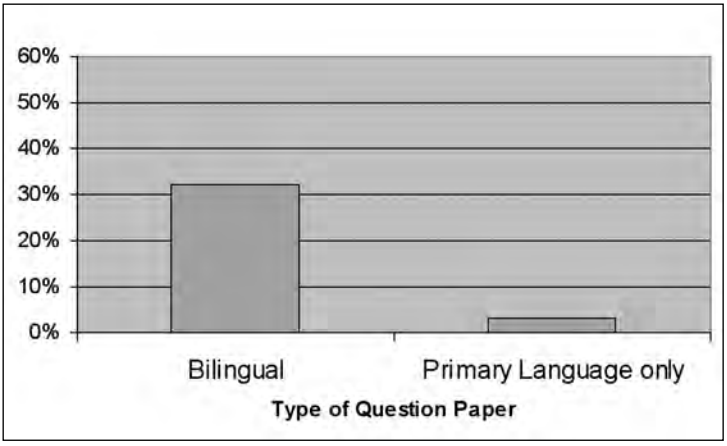


Figure 6.
A positive response to the question : "Was the language in the FCI test useful?" (from Table 3)



Concerning the first construct - was the language easy to understand - 86% of the students who wrote the FCI in the primary language, said that the language was **not easy** to understand but the figure decreased to only 10% for those who answered a bilingual question paper (English / primary language). This compared with 11% of the students who wrote the English-only paper and stated that the language was not easy to understand. So at least when the paper is presented bilingually, the disadvantages of being confronted with new terms is minimised by having the more familiar English term available. At the same time, some English words which are difficult to understand could be clarified by looking at the primary language section of the paper. In other words, the bilingual test gave the students the best of both worlds.

This then shows that there is considerable and widespread resistance to the use of African languages as sole media of testing. However, anecdotally, there is some support for concepts to be explained orally in the primary languages while the primary medium of instruction remains English.

The administration of the FCI to mainstream 101 Physics students.

In February 2006, I administered the FCI to a sample of Physics 101 students in the 1st year of the Mainstream Physics course. This included many mother tongue Afrikaans-speakers as well as mother tongue English-speakers. The sample was subdivided into two broad categories to allow one group to write a monolingual English FCI and another group to write a bilingual FCI. The results are shown opposite.

The bar graphs below in Figure 7 show that there was no significant difference in scores for those that wrote the bilingual test compared to those that wrote the English-only test.

I then obtained data on what language was used as medium of instruction in the secondary schools from which these students came. I plotted the bar graph in Figure 8 which shows their performance in the FCI compared to the medium of instruction at school.

The data tends to support the common sense opinion that students' concept formation is better when they have been taught through their home language at secondary school, which officially could only have occurred to Afrikaans-and English mother tongue speakers.

Figure 7.
Results of the FCI administered to students studying a standard first year physics course

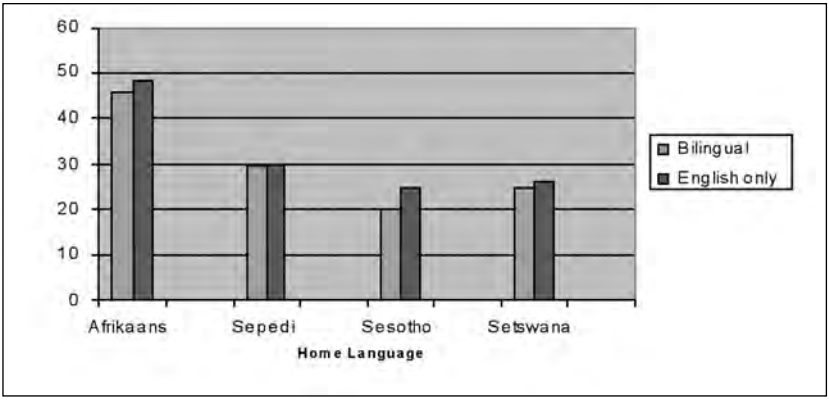
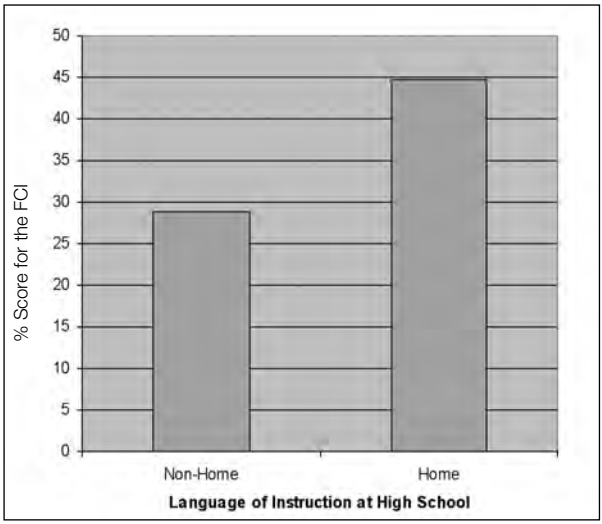


Table 4:
Results of the FCI administered to students studying a standard first year physics course

		1st Language studied as a discipline at School																			
		Afrikaans		English		isiNdebele		Sepedi		Sesotho		Sestwana		Tshivenda		XiTsonga		isiZulu		Total	
FCI TEST LANGUAGE	Home Language	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Bilingual Paper	Afrikaans	46.2	14																	46.2	14
	Eng/Afr	40.0	1																	40.0	1
	Sepedi							31.1	9			30.0	1							31.0	10
	Sesotho							26.7	2	20.0	3									22.7	5
	Sestwana							23.3	1			22.2	6							22.4	7
	Tshivenda													23.3	2					23.3	2
	XiTsonga							26.7	1			33.3	1							30.0	2
Bilingual Total		**45.8**	15					**29.5**	13	**20.0**	3	**24.6**	8	**23.3**	2					**33.5**	41
English only paper	Afrikaans	45.4	13	43.3	2															45.1	15
	English			43.1	14															43.1	14
	German	86.7	1																	86.7	1
	isiNdebele			20.0	1	36.7	1													28.3	2
	isiXhosa											36.7	1							36.7	1
	isiZulu			25.0	2													36.7	2.0	30.8	4
	Sepedi			23.3	2			30.0	12	10.0	1									27.8	15
	Sesotho			35.6	3			23.3	2	40.0	1									32.2	6
	Sestwana			16.7	2							24.8	7							23.0	9
	Siswati			23.3	1															23.3	1
	XiTsonga							40.0	1							33.3	1			36.7	2
English only Total		**48.3**	14	**35.9**	27	**36.7**	1	**29.8**	15	**25.0**	2	**26.3**	8			**33.3**	1	**36.7**	2	**35.7**	70
Grand Total		47.0	29	35.9	27	36.7	1	29.6	28	22.0	5	25.4	16	23.3	2	33.3	1	36.7	2.0	34.9	111

The information in this bar graph refers only to Afrikaans- and English-speaking students, who are all taught through their home language or a language they know sufficiently well at secondary school. It concurs with dominant research on mother-tongue education that establishes that concept formation is better developed when learners have been taught in their primary language, as opposed to study in a language which learners do not know adequately[11].

Figure 8:
Force Concept Inventory performance of 1st year Physics students at the University of Pretoria



An interesting finding is that, in contrast to the medium of instruction, the language of the test makes little difference to the performance. There must be some threshold effect here which the data does not bring out, as it would stand to reason that students would not do well if the test was written in a language in which they had no competency at all for example Chinese!.

11 The term "foreign language" is used to refer to a language which is not the primary language of the students

The translation of Senior Certificate Physical Science papers and the memoranda into Northern Sotho

A study guide was produced in 2001, with funding from the Pan South African Language Board (PANSALB), which was similar to the widely used bilingual PhysiChem books. Whereas PhysiChem used English and Afrikaans, the "Questions and Answers" of this study guide used English and Northern Sotho (Sepedi) (Ntake and Pare, 2001).

To my knowledge, this was the first time that Physics and Chemistry material had been developed in an African language up to a senior secondary school level in SA. PanSALB was interested in the kind of reception that this book received from its target audience, which was grade 11 and grade 12 high school learners.

The papers were from 1996 to 1998 and covered both Chemistry and Physics, but from just one province, Limpopo. Just like the PhysiChem books, the PanSALB study guide also included both numerical and explanatory answers to each question. "Questions and Answers" included both higher grade and standard grade papers.

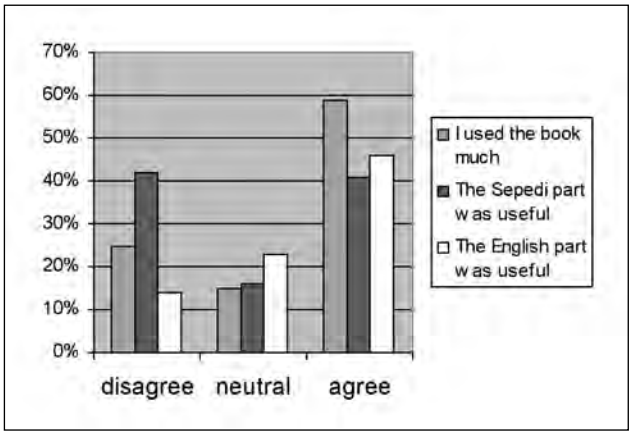
I designed a questionnaire which the learners filled in before receiving the study guide. The learners were also asked to fill in some questionnaires during the year and at the end of their Grade 12 year.

These questionnaires used a number of different types of questions. Some of the questions used a 5 point scale to measure the opinions of learners on the language issue. These questions were analysed quantitatively. Some questions required descriptive statements while others required a simple "yes" or "no."

Table 5.
Results from three questions on the questionnaire administered to learners in November 2005 after they had written their final Grade 12 Physics exam.

I used the book much	(N=184)		
	disagree	neutral	agree
	25%	15%	**59%**
The Sepedi part was useful	(N=184)		
	disagree	neutral	agree
	42%	16%	41%
The English part was useful	(N=184)		
	disagree	neutral	agree
	14%	23%	46%

Figure 9:
A graphical representation of Table 5



Ten interviews were conducted and tape-recorded after Grade 12 learners had used a copy of the bilingual Senior Certificate papers for at least nine months. These interviews were transcribed and typed. They are still being analysed using qualitative approaches.

The students and learners came from a variety of backgrounds: some of the Senior Certificate students attended rural government schools, some a rural Catholic school, and others urban government schools in the Mamelodi and Atteridgeville townships near Pretoria.

As the information in Table 4 shows, only 59% of the learners actually used the book quite often, 41% agreed that the Northern Sotho (Sepedi) part was useful, and 46% found the English part of the book useful. This shows that although the majority did not find science material in the primary language useful, there is a sizeable minority that does benefit from having science material translated into the primary language. What is also very interesting is that whereas only 14% found the English section not useful, 42% found the Northern Sotho section not useful. This could be because a sizeable number of students did not use Northern Sotho as their home languagewhich could have been Tswan, Zulu Venda or Tsonga given the multilingual nature of Pretoria.[19]. It is also interesting that 58% of the learners found it useful to have some of their Science explained in the primary language.

Physics terminology

Most of the African languages do not have different words for the concepts "force" and "power". In Northern Sotho the word *maatla* is normally used for both these concepts, *maatla* being also sometimes used for "mass".

This is problematic. So a large heavy person would be, in Northern Sotho, powerful, forceful and massive.

In some of the questionnaires learners were asked to describe the difference between "maatla" (power?) and the specially coined "kgapeletšo" (physical force) They were asked to do this in both N. Sotho and in English. The answers suggest that *maatla* is also regarded as 'strength' and this would be in accordance with popular English usage where again, 'power', 'strength', 'force', and sometimes even 'mass', are used interchangeably. However, English has developed a particular register for Physics and once they recognize that the context of a text is a Physics context, English speakers would be able to accept the narrower definitions of 'power' and 'force' that are used.

The N. Sotho noun *kgapeletšo* was derived from the verb gapeletša which means "to coerce". Although this derivation would normally not be problematic for Sotho speakers in imaginative writing like poetry, many learners and teachers have expressed their dissatisfaction

with the term in a science context. This despite the fact that no other acceptable term was produced that could be used for 'force' to signal/express the difference between "force" and "power".

Maatla was generally accepted for "power" but this does not show that *maatla* is actually being associated with the rate at which work is performed. From the results of various questionnaires and informal interviews with students, it would appear that N. Sotho speakers actually resist the development of a carefully defined register within their own language.

"Weight" is not usually distinguished from "mass", and "acceleration" was translated by some professional translators as *koketšolebelo* which is literally "the increase in velocity". So the expression "force is equal to mass times acceleration" becomes *maatla ke boima atišitšwe ke koketšolebelo*. If this is translated back into English one could get the following "power is equal to weight times an increase in velocity".

It does indeed take some effort to give certain words a narrow definition for use in a Physics context; but it is will take considerably more effort to to get a linguistic community such as a group of Physicists to accept these narrower, and hence new definitions for existing terms. It stands to reason that the length of time that it will take to get a community's primary language generally used as a medium of precise communication of scientific thought is going to be dependent in some way on this community's scientists' acceptance of these new definitions.

Conclusion

The studies discussed above have confirmed the complexity of the language situation in South African classrooms. They have suggested that a monolingual primary language approach to the problem of limited English capability is not going to be widely accepted. Whereas students like to have difficult English phrases explained in their primary languages, from the answers to questionnaires and from informal interviews it would seem that they do not want their primary languages to replace English as the main medium of instruction (neither orally nor in written form).

A comparison between the Afrikaans-speaking students on the one hand and the Zulu- and Sotho-speaking students on the other hand, also supports the view that instruction through the primary language at school leads to better concept formation in Physics. It has shown that testing in the primary language does not provide any advantage to learners when compared to testing in a moderately well understood second language. However, there are many other socio-economic variables that could also play a significant role in the difference between the Afrikaans and the Zulu students.

The provision of bilingual educational texts could be part of the solution to language problems. This could break the loop that we are in at the moment where grade 0 primary school teachers do not want to teach in the primary language because the Grade 12 exam is written in English. Grade 12 learners do not want to write Grade 12 Science in the primary language because they were always taught through English.

From the constructivist and situated cognition perspective, the mediatory role of language in the acquisition of knowledge is so fundamental that the findings in my studies, which at surface level appear to reflect negatively on the use of the Bantu languages in learning and teaching, suggest that far more research on the issue is necessary.

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APPENDIX 1

Term formation in Northern Sotho

English	N.Sotho
21. A *rocket* drifts sideways in outer *space* from point "a" to point "b" as shown below. The *rocket* is subject to no outside *forces*. Starting at position "b", the *rocket's engine* is turned on and produces a constant *thrust (force on the rocket)* at *right angles* to the line "ab". The *constant* thrust is maintained until the *rocket* reaches a point "c" in *space*. Which of the *paths* below best represents the path of the *rocket* between points "b" and "c"?	21. *Rokhete* e *phaphamala* go ya ka mathoko *lefaufaung* go tloga go ntlha ya "a" go ya go ntlha ya "b" ka ge e bontšhitšwe ka fase. *Rokhete* ga e laolwe ke *kgapeletšo* ya ka ntle. Go thoma maemong a "b", *entšini* ya *rokhete* e a dumišwa ya ba ya tšweletša *kitlano* ya go se fetoge *(kgapeletšo rokheteng)* ka *dikhutlongtsepa* go ya go mothalo wa "ab". *Kitlano ya go se fetoge* e a diragatšwa go fihlela *rokhete* e fihla go ntlha ya "c" *lefaufaung.* Ke efe ya *ditsela* ka fase tšeo di tlogago di emela gabotse tsela ya *rokhete* magareng ga ntlha "b" le "c"?

	Term formation strategy	English Term	N. Sotho Term	Comments
1	**Transliteration**	rocket	rokhete,	
	Grammatical inflection of a transliterated word	on the rocket	rokheteng	the –ng is a "locative" suffix
2	**Grammatical Adaption of an existing word**	a force (noun)	*kgapeletšo*	from *gapeletša* which means "coerce"
3	**Compounding or Combination of existing words**	right angles	dikhutlongtsepa	*dikhutlong* - angles tsepa - perpendicular
4	**Ready translation equivalent**	thrust	kitlano	
		paths	ditsela	
		represent	emela	
5	**Use of a more general word**	to drift	phaphamala	generally it means to float
		space	lefaufaung	generally space or atmosphere
6	**Paraphrase using unrelated words**	constant	ya go se fetoge	that which is unchanging

APPENDIX 2

Some comments from students after having written the FCI

1. On the Zulu version

The language was difficult to follow, the quantities meaning speed, velocity, direction, force, momentum were difficult to understand , also some of the Zulu words were only known at tertiary level because of more language research and development. It is better to learn and write physical science in English because of the Zulu words we are unfamiliar with.

2. On the N.Sotho version

I think you have used deep Pedi, and nowdays we do not /no longer use that deep language. It was really difficult to understand clearly because we never used our own language to answer or to learn physics.