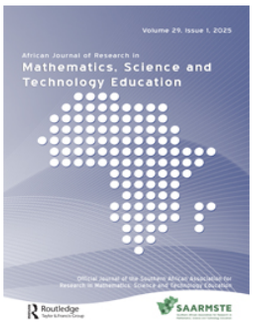

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Investigating the Transparency of Language for Place Value Understanding: Comparing Indigenous Southern African Languages and European-based Languages

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In this article we investigate the transparency of language in learning place value in either a Southern African indigenous language (isiXhosa, Setswana, Oshiwambo or Emakhuwa) or a European-based language (Afrikaans, English, German or Portuguese). Since language is a key mediator in developing place value understanding, it is important to investigate the ways in which the transparency of various languages may impact place value learning. A review of pertinent literature and an analysis of literal translations of number words (to thousands) of our eight languages lead us to the conclusion that Southern African indigenous languages are more accessible in their meaning, in relation to place value, than the four European-based languages spoken in Southern Africa, which we analysed. We identified two key advantages in the indigenous languages: (i) there was transparency of the 'places' in how numbers are named; and (ii) there was logical alignment between the spoken and symbolic representation of numbers. Despite this, many Southern African learners learn mathematics in English, Afrikaans or Portuguese even though this is not their home language (L1). This means that many learners are denied access to the transparency of the place value concepts that exist in their L1 and must manage learning place value, not only in a yet to be learned 'foreign' language, but also in one where they must learn to decode the idiosyncratic 'irregularities' of the way those languages name numbers. We conclude this article by discussing the implications of these findings for the teaching of place value in Southern African classrooms, in which indigenous learners are often learning in a European-based language that is not their L1.

Keywords: *Place value; language of instruction; second language learning; language transparency; mathematics education*

Introduction

A core underpinning of this article is the recognition that language is a key mediator in children's learning of mathematical concepts (Vygotsky, 2012). Cummins (1979) argues that teaching concepts in a child's home language (L1) has the additional benefit of the child being more likely to understand the

concepts presented (in the case of this article, place value concepts) and being more likely to participate in classroom discussions as they can identify culturally with the language of learning and teaching (LoLT). In the multilingual, postcolonial contexts of many Southern African countries, there have been efforts made to promote the learning of mathematics in early grades in indigenous languages. However, as Mostert (2019) notes, teaching mathematics in indigenous African languages is challenging as there is little research regarding how to leverage the linguistic features of these languages for learning and teaching. In addition, in the four countries of focus in this article (South Africa, Namibia, Botswana, and Mozambique), instruction in the indigenous African L1 is not universally available and the dominance of the European-based languages persists as the LoLT shifts to an official European-based language after the early grades. While language in education (LiE) policies often promote mother-tongue instruction for the first few years of schooling (see discussion on LiE policies of the four countries) tailoring the language of instruction to learners' home language is complicated by differences in the way local communities speak a main language (e.g. isiXhosa). Teachers will often use translanguaging—blending and integrating linguistic elements to support conveying meaning (Garcia & Lin, 2017) to support understanding of new concepts and will draw on local contextual reference. For example, teachers may use certain words familiar in the local dialect of the home language or English, for number names, money and telling time to support relatability if home language use incorporates these (Booi et al., 2024; Essien 2010).

In this article we explore the number name systems of four indigenous Southern African languages (isiXhosa, Setswana, Oshiwambo and Emakhuwa) and compare them with four European-based languages (Afrikaans,[1] English, German and Portuguese) brought to Southern Africa because of colonisation. Our purpose in comparing these languages is to establish the relative transparency of the languages in relation to the place value structure of numbers and to investigate the pedagogical implications of this transparency for place value learning. In this article we focus on the early years of schooling; for research regarding place value and early number naming by children prior to formal schooling see Magargee and Beauford (2016).

From a mathematical point of view, there are two core sub-concepts of place value: the sub-concept of the value of the place and the sub-concept of positional notation (Ladel et al., 2023). In this article we are only concerned with the value of the place, which is the understanding that there are designated places in the notation of numbers (e.g. Th, H, T, O),[2] and that it is only the place of a number that gives information about its value. Nuerk et al. (2015) suggest three different levels of positional understanding: place identification (i.e. to correctly identify the position of a single digit within the digit string), place value activation (i.e. each digit is associated with a specific position) and place value computation (e.g. adding and subtracting using positional knowledge).

It is necessary to state that the ability to say a number does not necessarily indicate an understanding of place value (see also Bahnmueller et al., 2018). However, the inability to say a number is similarly not necessarily an indication of a lack of understanding about place value and could instead be an issue of language proficiency. This is an important distinction, as understanding the concept of place value is not tied to only the language in which it is learned. Cummins' (2005) notion of common underlying language proficiency points to the interdependence of languages where concepts learned in one language do not have to be relearned in another language as some transferability across languages is possible. However, as language is an important artefact used to communicate and think (Hewitt & Alajmi, 2023), and because it plays a key role in teaching mathematics concepts and in the development of a learner's[3] mathematical thinking (Sun & Bartolini Bussi, 2018), we need to understand the influence of linguistic features on place value learning.

The features of a language can either help or hinder the learning of numerical concepts (Dowker & Nuerk, 2016). In terms of place value, the particular instance of saying a number is highly language dependent (Cummins, 2005) and we see that it is not unusual for irregularities (idiosyncratic changes to an established pattern or word, for example, number inversion where the ones are written prior to the tens) to exist in number naming. In addition, these irregularities are different in different languages, with some languages containing a greater range of irregularities than others (Arzarrello et al., 2018).

Researchers have discussed problems in transcoding (Dowker & Nuerk, 2016; Hewitt & Alajmi, 2023) and their claims support our position regarding the importance of understanding the impact of language transparency in place value understanding. Kamii (1986) related the conceptual development of number to both the culturally derived conventional representations of language (verbal system) and notation (graphic system) and to learners' personal constructions on notational recording. The personal constructions are important as they are the externalisation of individually arrived at ideas and reflect the learner's interactions with conventional verbal and graphic systems. More recent work (see Cheung & Asari, 2021) has supported the notion that 'cracking the place value code' is often a difficult task for young children.

Following Bahnmuller et al. (2018) and Hewitt and Alajmi (2023), who argue that language considerably influences numerical cognition, and who encourage researchers to understand the influence of language on mathematics learning, our focus here is investigating the influence of language in learners' understanding of place value, with the caveat that we are not suggesting that understanding place value is *only* an issue of language. Bahnmuller et al. (2018) also identify differences between linguistic influences *and* place value processing. Finally, as Howe (2018) cautions, we should not treat place value as merely the naming of the places, ones, tens, hundreds as this can result in a procedural rather than a conceptual understanding of the concept (see also Bass, 2018; Longwe, et al., 2022).

In this article, when we speak of a language understanding of name number systems, we are referring to learners being competent in writing and reading numbers in their L1. From this perspective, language is seen as a mediator, as a tool to communicate, and difficulties for learners in learning place value in a second language, as indicated in the introduction, may well be semantic rather than mathematical (Ladel et al., 2023). Although it is largely accepted that a language changes according to how it is spoken in everyday life, Sun et al. (2018) suggest that it appears to be more difficult to change number names because of cultural considerations (tradition, history or national identity), even though doing so would likely help learners better understand numbers. The Zwanzig-eins[4] (21) movement in Germany where the pedagogical suggestion is that the tens should be pronounced before the ones is an example of this phenomenon. Such movements point to increasing awareness that transparency in language, and alignment between the order of written digits and the naming of numbers impacts the accessibility for learners in developing place value understanding.

In this article, when we refer to the transparency of a place value language, following Mostert (2019), we mean 'the extent to which spoken numbers explicitly state the units that are implied in the written place-value system' (p. 68).

Framing Assumptions and Defining the Research Question

In framing this article, we draw on a broadly socio-cultural Vygotskian (Vygotsky, 2012) perspective of learning whereby learners actively construct their knowledge in social situations, often with more knowledgeable others, and that language is a key mediator of learning. We work from the assumption that different languages express ideas in different ways and this gives rise to nuanced differences in the access that learners have to concepts when engaging with them in different languages. In terms of naming numbers, different languages have greater or lesser transparency. So, for example, determining that the number 35, when pronounced in English, indicates three tens and five ones requires some decoding, that is, that *thir* means three and *-ty* indicates 'tens'. On the other hand, many languages simply name 35 with the literal translation of 'three tens and five', which does not require the same level of decoding.

A name number system (Nguyen & Gregoire, 2013) is initially rooted in oral language, and it naturally follows the grammar of local language and thus directly reflects cultural identity (Hewitt & Alajmi, 2023). Sun et al. (2018) suggest that the spoken number names are developed as sounds connected to the numbers of objects in the sets; however, written numbers are primarily learned at school as a second language. This has important pedagogical consequences, which we develop later in the article.

Our assumption that language mediates learning, and that some languages are more accessible and transparent in their meaning of place value than others, led to the formation of the following primary research question: *What differences exist in the naming of numbers in these four Southern African indigenous languages (isiXhosa, Setswana, Oshiwambo and Emakhuwa) and these four European-based languages (Afrikaans, English, German and Portuguese)?*

Our contribution in this paper however goes beyond answering this question. In the context section below we compare the LiE policies and practices of the four Southern African countries—and following our analysis of the difference in the naming systems, we discuss the implications of the differences in relation to the LiE contexts (where indigenous learners are often learning in a European-based language that is not their L1) and the accessibility of place value concepts in each of these languages.

Context and Literature Review

We begin with a brief discussion regarding the LiE policies and the LoLT practices in primary mathematics classrooms in South Africa, Namibia, Botswana and Mozambique.

Language Challenges in Southern African Primary Mathematics Classrooms

Robertson and Graven (2020) argue that language has the power to 'either include or exclude certain groups of students from genuine opportunities for mathematical sense-making' (p. 77). There are 12 official languages in South Africa, of which one is sign language and nine are indigenous languages. Most learners can learn in their L1 up to the end of Grade 3 with approximately 75% of them doing so. Currently the LoLT for learners from Grade 4 in South Africa is mostly either English or Afrikaans. Despite English being the L1 of just 10% of learners, it is the language of learning and teaching for 80% of learners from Grade 4 (South Africa, Department of Basic Education, 2010). Although the Language in Education Policy (Department of Education, South Africa, 1997) advocates for additive bilingualism, there is in fact a 'progressively assimilationist and monolingual trend in the direction of English' (Robertson & Graven, 2020: 80) that undermines this priority. Some positive steps to support bilingualism are occurring, including a long-term pilot of Mother Tongue Based Bilingual Education in the Eastern Cape that involves extending the use of isiXhosa and Sesotho as the LoLT beyond Grade 3 with promising results (Motshekga, 2022).

Namibian education policy stipulates that learners are to be taught in their L1 until Grade 3, and thereafter in English (National Institute for Educational Development. Ministry of Education, Arts and Culture, 2015). Grade 4 is viewed as a 'transitional year' (p. 31) during which the LoLT shifts towards English, and from Grades 5 onwards, English is established as the LoLT and the indigenous L1 may 'be used in a supportive role' (p. 31). There are 14 languages in which learners can be taught up to Grade 3, including 10 indigenous languages, English, Afrikaans, German and Namibian Sign Language. However, because of some ambiguity in the language policy, many schools have opted to provide English as the only LoLT from Grade 1, and parents are showing a preference for sending their children to these schools (Chavez, 2016).

Despite having 28 indigenous language groups, the only languages used in education in Botswana are Setswana and English (Chebanne, 2022). It is argued (Chebanne, 2022; Mokibelo, 2016) that this might account for the poor academic performance of primary school children in Botswana, as there are areas where neither Setswana nor English is spoken, and therefore there is no option for learners in these areas to commence formal schooling using their L1. Only 18% of the population have Setswana as their L1, and even for those learning in Setswana as their L1, the Language in Education policy in Botswana requires a shift after the early grades into learning in English (Mokibelo, 2014). As Nyati-Ramahobo (2004) noted, 'more resources continue to be directed towards the use of English in all social domains including education' (p. 45).

In Mozambique, Portuguese remains the only official language, despite it being the L1 of just 3% of the population (Lopes, 2004). In contrast, Emakhuwa is the L1 of 25% of the population, and is one of more than 20 indigenous language groups in the country, that account for the L1 of over 95% of the population (Lopes, 2004). Despite the multilingual and multicultural nature of Mozambican society,

there was a single language policy in education from independence in 1975 to the more recent adoption of a bilingual model in 2003 (Chimbutane & Reinikka, 2023). This dual policy of Portuguese and one of 16 'national languages' is, however, not practised nationally. As Henriksen (2010) explains, urban and rural contexts effectively have separate language education practices, whereby in urban primary schools, Portuguese is the language of instruction, while in rural areas, some schools make use of bilingual education.

Regardless of location, most of the country's primary schools have Portuguese as the language of instruction (UNICEF, 2017). Terra (2021) outlines the current bilingual system as consisting of 'mother-tongue education for the first two years … where 60–80% of the allocated time is given to the Mozambican language, while Portuguese is taught as a subject' (p. 20). Children then learn to read and write in Portuguese in the third grade, and by the fourth-grade instruction is in Portuguese, with the L1 used as a resource to support learning and teaching (Terra, 2021). Terra (2021) reports that despite official education policies, when their practices were examined, bilingual teachers showed a preference for Portuguese as the language of instruction, and there was a lack of bilingual resources available to teachers complicating the successful implementation of instruction in the L1.

Much is common across the four countries discussed above, including the transition from learning in the L1 in the early grades (where this occurs) to learning through the medium of a European-based language in mid-primary grades. However, in all contexts, because of inconsistencies between policy and practice, and the 'progressively assimilationist and monolingual trend' (Robertson & Graven, 2020: 80), the dominance of the European-based languages persists (Chavez, 2016; Nyati-Ramahodo, 2004; Robertson & Graven, 2020; Terra, 2021). An implication for our place value research project is that, where there are affordances in the use of indigenous African languages in place value instruction, these are unlikely to be realised in these contexts.

Methodology

In examining the name number systems of our target languages, we follow a similar methodology to that used by Cortina (2013) in his work exploring the numeration systems of 14 Mesoamerican indigenous languages. Cortina (2013) conducted a six-step morphological analysis of the numeration systems. In brief, the six steps involved:

(1) identifying and writing the linguistic expressions conforming to the system, for numbers up to 100;
(2) identifying the numeric lexemes used in each of the expressions conforming to the system by translating, as literally as possible, each of the numeral expressions of the system;
(3) identifying the arithmetic operations present in the numeral expressions involving two or more lexemes;
(4) identifying the additive and multiplicative bases in the system;
(5) identifying irregularities in the system; and
(6) identifying other distinguishing characteristics of a numeration system.

Following Cortina (2013) we first mapped out, for each of the eight languages of interest, the number names up to 99, the hundreds from 100 to 900, and the thousands from 1000 to 9000. In addition, we investigated the rules for how two-digit and three-digit numbers are written in words and numerals. To do this, we drew on the language proficiencies of the authors (for English, Afrikaans and German), consulted with colleagues who were L1 speakers of indigenous languages (for isiXhosa, Setswana and Oshiwambo), and used the website languagesandnumbers.com for the Emakhuwa and Portuguese number names.

After tabulating this information, we looked for patterns in how the number words are constructed and compared the linguistic rules for constructing these numbers across the eight languages. To help us explore how the number names were constructed in languages other than English, we also generated a literal translation from the target language into English. We further identified the additive and multiplicative bases within each number name system.

Findings

Southern African Indigenous Language Name Number Systems

By way of language classification, isiXhosa (an official language in South Africa) is a Nguni language; Setswana (an official language in Botswana and South Africa) is classified in the Sotho–Tswana group of languages; Oshiwambo (a widely spoken language in Namibia) is a southwest Bantu language of the Wambo group of languages; and Emakhuwa is a Bantu language spoken in northern

Table 1. Number names in four Southern African indigenous languages

	isiXhosa (South Africa)	Setswana (Botswana & South Africa)	Oshiwambo (Namibia & Angola)	Emakhuwa (Mozambique)
1	Nye	nngwe	imwe	mosa
2	mbini	pedi	mbali	pili
3	ntathu	tharo	nhatu	tharu
4	ne	nne	nhee	sheshe
5	ntlanu	tlhano	nano	thanu
6	nthandathu	thataro	hamano	thanu na mosa
7	sixhenxe	supa	heyali	thanu na pili
8	sibhozo	robedi	hetatu	thanu na tharu
9	lithoba	robongwe	omuwoyi	thanu na sheshe
10	**lishumi**	**lesome**	**omulongo**	**mulokó**
11	lishumi elinaye	lesomenngwe	omulongo naimwe	mulokó na mosa
12	lishumi elinesibini	lesomepedi	omulongo nambali	mulokó na pili
13	lishumi elinesithathu	lesometharo	omulongo nanhatu	mulokó na tharu
…				
19	lishumi elinethoba	lesomerobongwe	omulongo nomuwoyi	mulokó na thanu na sheshe
20	amashumi amabini	masomepedi	omilongo mbali	milokó mili
21	amashumi amabini ananye	masomepedi nngwe	omilongo mbali naimwe	milokó mili na mosa
22	amashumi amabini anesibini	masomepedi pedi	omilongo mbali nambali	milokó mili na pili
…				
30	amashumi amathathu	masometharo	omilongo nhatu	milokó miraru
40	amashumi amane	masomenne	omilongo nhee	milokó misheshe
…				
90	amashumi alithoba	masomerobongwe	omilongo omuwoyi	milokó mithanu na misheshe
100	**likhulu**	**lekgolo**	**efele**	**milokó mulokó**
200	amakhulu amabini	makgolopedi	omafele avali	milokó mulokó mili
300	amakhulu amathathu	makgolotharo	omafele atatu	milokó mulokó miraru
…				
900	amakhulu alithoba	makgolorobongwe	omafele omuwoyi	milokó mulokó mithanu na misheshe
1000	**iwaka**	**sekete**	**eyovi**	**álufu (or miloko muloko miloko)**
2000	amawaka amabini	diketepedi	omayovi avali	álufu pili
3000	amawaka amathathu	diketetharo	omayovi atatu	álufu tharu
…				
9000	amawaka alithoba	diketerobongwe	omayovi omuwoyi	álufu thanu na sheshe

Mozambique (Maho, 2009). Table 1 summarises the number naming conventions in these four Southern African indigenous languages.

For isiXhosa, Setswana and Oshiwambo, there are distinct number names for the numbers one to nine, as well as distinct number names for each new place value position (e.g. ten, hundred and thousand). In Emakhuwa, there are remnants of a base five system evident in the names for numbers 6–9: *thanu na mosa* (five and one) for 6, *thanu na pili* (five and two) for 7, *thanu na tharu* (five and three) for 8 and *thanu na sheshe* (five and four) for 9. The remainder of the number names for all four indigenous languages are composite names, which indicate the referent place value (e.g. ten, hundred, thousand) as the multiplicative base and the quantity of that value. For example, in isiXhosa, 200 is expressed as *amakhulu amabini* (from the root word *khulu* referring to hundred, and the root word *mbini* referring to two), which translates as 'hundreds, of which there are two', and this structure is also evident in Setswana, Oshiwambo and Emakhuwa. The decades from 20 to 90 have a logical structure and the wording clearly signifies how many tens are present. By way of example, the number '35' in Oshiwambo is *omilongo* (tens) *nhatu* (three) *nanano* (five), which translates as 'tens of which there are three and five' and denotes mathematically three tens and five.

For each of the languages, the form of the word for ten changes from an additive base (for numbers 11–19) to a multiplicative base for numbers greater than 19. For example, twelve is *lishumi elinesibini* (isiXhosa), *lesomepedi* (Setswana), *omulongo nambali* (Oshiwambo) and *mulokó na pilo* (Emakhuwa) to indicate 10 + 2; whereas twenty is *amashumi amabini* (isiXhosa), *masomepedi* (Setswana), *omilongo mbali* (Oshiwambo), and *milokó mili* (Emakhuwa) to indicate 10 × 2. Thus, there is some grammatical complexity to the transformation from the additive to the multiplicative form, but the structure is transparent once the grammar is understood as in each case the 'ten' and the 'two' is spoken, with the relationship between the numbers explicit. In contrast, in English, both the words for 12 and 20 are new words that obscure the additive (12) or multiplicative (20) relationship between the ten and the two. While the place value structuring of the numbers is transparent in the indigenous languages, as agglutinative languages, it is important to recognise that there is greater complexity in terms of the length of the words. By way of example, in Emakhuwa the name for 90 is five words in length: *milokó mulokó mithanu na misheshe*. This language also does not have a single word for hundred, rather it is expressed as 'ten tens', *milokó mulokó*.

European-based Languages Name Number Systems

The four European-based languages that we analysed are all languages brought to Southern Africa through colonisation. Table 2 summarises the number naming conventions in these four European-based languages. The words in *italics* in the table indicate that these words represent idiosyncratic irregularities within the number naming conventions of the language concerned (e.g. *eleven* is a word that does not contain the -teen suffix to indicate the number of ones added to a ten in English; *siebzehn* in German does not connect the full word *sieben* to the *-zehn* as with the other '-teen' numbers in German).

As is the case with Cortina's (2013) research, all the name number systems are structured on a multiplicative base (i.e. ten and powers of ten). One minor exception is the Portuguese word for twenty, *vinte*, which is a unique word in the number naming system, disconnected from both the words for two (*dois*) and ten (*dez*). The additive bases for all are similarly the multiples of a power of ten (e.g. sixty-three is 6 × 10 + 3).

In contrast to the indigenous languages discussed earlier, place value in European-based languages can be seen as an artificial construct for written purposes. Therefore, for learners using name number systems based on these languages, the language of place value becomes an artificially learned construct rather than one they have learned as part of conversational language (Sun & Bartolini Bussi, 2018). Although units of hundreds and thousands are always explicit, units of tens are often implicit in European-based languages. For example, units of tens are not visible in 'thirty-three. We now briefly discuss the four European-based number systems in our study—English, German, Afrikaans and Portuguese.

Table 2. Number names in four European-based languages

	English	Afrikaans	German	Portuguese
1	one	een	eins	um
2	two	twee	zwei	dois
3	three	drie	drei	três
4	four	vier	vier	quatro
5	five	vyf	fünf	cinco
6	six	ses	sechs	seis
7	seven	sewe	sieben	sete
8	eight	agt	acht	oito
9	nine	nege	neun	nove
10	**ten**	**tien**	**zehn**	**dez**
11	*eleven*	*elf*	*elf*	*onze*
12	*twelve*	*twaalf*	*zwölf*	*doze*
13	*thirteen*	*dertien*	dreizehn	*treze*
14	fourteen	viertien	vierzehn	*catorze*
15	*fifteen*	vyftien	fünfzehn	*quinze*
16	sixteen	sestien	*sechzehn*	dezesseis
17	seventeen	sewentien	*siebzehn*	dezessete
18	eighteen	agtien	achtzehn	dezoito
19	nineteen	negentien	neunzehn	dezenove
20	*twenty*	*twintig*	*zwanzig*	*vinte*
21	twenty-one	een-en-twintig	*einundzwanzig*	vinte e um
22	twenty-two	twee-en-twintig	zweiundzwanzig	vinte e dois
…				
30	*thirty*	*dertig*	*dreißig*	*trinta*
40	forty	veertig	vierzig	*quarenta*
50	*fifty*	vyftig	fünfzig	*cinquenta*
60	sixty	sestig	*sechzig*	sessenta
70	seventy	sewentig	*siebzig*	setenta
80	eighty	tagtig	achtzig	oitenta
90	ninety	negentig	neunzig	noventa
100	**(one) hundred**	**(een)honderd**	***einhundert***	**cem (pl. centos)**
200	two hundred	tweehonderd	zweihundert	*duzentos*
300	three hundred	driehonderd	dreihundert	trezentos
…				
900	nine hundred	negehonderd	neunhundert	novecentos
1000	**(one) thousand**	**(een)duisend**	***eintausend***	**mil**
2000	two thousand	tweeduisend	zweitausend	dois mil
3000	three thousand	drieduisend	dreitausend	três mil
…				
9000	nine thousand	negeduisend	neuntausend	nove mil

English

In terms of the English language for number learning, there are two core problems that need to be overcome—the 'teens' and the 'decade' (Fuson, 1990; Young-Loveridge & Bicknell, 2016). In the case of the 'teens', these numbers cannot be easily decoded in terms of the value of tens and ones, and this hinders understanding of the ten-structured regroup aspects of multi-digit calculations. The structure of the language also makes it more difficult to understand that '-teen' numbers are composed of a ten and some ones. In addition, the '-teen' numbers are also spoken as an inversion when compared with the written symbol by naming the ones first, for example, 16, is named as sixteen (6 + 10)—while this changes after 19 as, for example, 26 is named twenty-six (20 + 6).

In the case of 'decade', two complications are identified (Fuson, 1990; Young-Loveridge & Bicknell, 2016). Firstly, the change in pronunciation from two, three, and five to twen-, thir-, and fif- obscures the related pattern of six-ty, seven-ty, eight-ty, nine-ty and, consequently, many learners memorise a list of decade words (twenty, thirty, forty, fifty, etc.) to learn to count to one hundred. Second, the unitary conceptual structure elicited by the English words leads many learners to write 608 for sixty-eight: They know 60 is sixty, and sixty-eight is sixty followed by eight (i.e. 60 and then 8) making 608 seems a sensible way to write sixty-eight.

German and Afrikaans

As is also the case in the English language, examples in German and Afrikaans show irregularities in naming amounts (e.g. 11 or 12; *elf* or *zwölf*). Likewise, there are also names for amounts that relate to the existence of more ancient representation with non-ten groupings, for example, *ein Dutzend Eier*—one dozen eggs (12 eggs) or one *gros*, that is 12 × 12 (Sun & Bartolini Bussi, 2018). As well as the use of independent number names up to 12, and the use of teens (*-tien* in Afrikaans and *-zehn* in German), in Afrikaans and German the teens pattern of 'number inversion' (i.e. pronouncing the ones before the tens) continues in the number range 21–99 (e.g. seventy-six is *ses-en-sewentig* and *sechsundsiebzig* respectively in Afrikaans and German). This number inversion of ones and tens also occurs for larger numbers up to, and beyond, one million (e.g. the number one hundred and twenty-three thousand four hundred and fifty-six is *eenhonderd drie-en-twintig duisend vierhonderd ses-en-vyftig* and *einhundert-dreiundzwanzigtausendvierhundertsechsundfünfzig* respectively in Afrikaans and German). An additional difficulty exists in the German written naming convention, as there are no 'gaps' between words that can assist learners in recognising place value places.

The mismatch between the order of digits in symbolic notation and the order of tens and ones in number words is identified (Bahnmueller et al., 2018; Hewitt & Alajmi, 2023) as a cause of conceptual misunderstanding in languages where such number inversion occurs (e.g. German and Afrikaans). The impacts of conceptual problems related to number inversion can be long lasting, with Ganayim et al. (2020) finding that the error of swapping tens and ones in transcoding tasks remained present for many university students.

Portuguese

The Portuguese name number system can be considered as broadly similar to the English for numbers greater than 20. It does have some unique features when compared with the other three European-based languages. For example, in Portuguese, there are more 'new' words or word parts required to count from 1 to 100 than in English, Afrikaans, and German. Beauford (2003) provides data (counting suffixes such as -ty or -zig only once) indicating that for English there are 18 new words or word parts, for German and Afrikaans there are 17 and for Portuguese 28. On the less transparent side, there are also more 'irregular' words in the 11–15 range and in the decade numbers in Portuguese than in the other European-based languages. However, greater transparency can be seen for numbers from 16 onwards as there is no inversion of the number order (e.g. *dezesseis* [16] is 10 + 6, rather than sixteen, which suggests 6 + 10). Thus, according to our analysis, Portuguese can be considered more transparent than German and Afrikaans and slightly less transparent than English.

Comparison Across all Eight Name Number Systems

As a way of illustrating degrees of transparency of the name number systems in this research, in Table 3 we compare the way in which the number 235 is written across our eight analysed languages.

The number 235 has a similar structure in each of the indigenous Southern African languages, with the English translation for all being the following: hundreds (of which there are) two; tens (of which there are) three, and five. In isiXhosa and Oshiwambo, there are prefixes at the beginning of each new place (denoted by the italics in the list above) that imply an 'and', which assists in signifying the end of the utterance of one place and the beginning of the next. In Emakhuwa, there is the word 'na' (and) inserted between places. However, in Setswana, the number words for each place

Table 3. The number 235 in the eight analysed languages

235			
isiXhosa	**Setswana**	**Oshiwambo**	**Emakhuwa**
amakhulu amabini *an*amashumi amathathu *ane*sihlanu	makgolopedi masometharo tlhano	omafele avali *n*omilongo nhatu *n*anhano	milokó mulokó mili *na* mulokó miraru *na* thanu
literal translation (lt:) hundred two *and*ten three *and*five	lt: hundredtwo tenthree five	lt: hundred two *and*ten three *and*five	lt: ten tens (hundred) two *and* ten three *and* five
English	**German**	**Afrikaans**	**Portuguese**
two hundred and thirty-five	zweihundertfünf*und*dreißig	tweehonderd vyf-*en*-dertig	duzentos *e* trinta *e* cinco
	lt: twohundredfive*and*thirty	lt: twohundred five-*and*-thirty	lt: twohundred *and* thirty *and* five

are simply stated one after the other with no prefixes to signify the shift to a new place. Thus, the indigenous languages demonstrate transparent positional place value, with the potential downside of generating longer number names in the process.

In contrast, there is a significant difference in the transparency of how European-based languages write 235. In both English and Portuguese, learners must account for irregular words (in English *thirty* denoting three tens; and in Portuguese *duzentos* and *trinta*—where new prefixes for two and three must be learned); however, the Portuguese language is otherwise structurally transparent. In both Afrikaans and German, the learners must also account for irregular words (e.g. *dreißig* or *dertig*) but have the added difficulty of recognising that the ones are named before the tens. This becomes even more complicated, as noted earlier, in each set of three digits in larger numbers. The linguistic knowledge required to write or speak European-based name number systems is not necessarily apparent to L1 learners, nor to learners studying in this language as a LoLT.

Discussion

In this section we discuss our findings in relation to curriculum and place value language, transparency of name number systems and place value as a second language for all learners.

Curriculum Issues Around Language and Place Value

In the context of teaching place value, where the indigenous languages offer a higher transparency when compared with English, Portuguese, Afrikaans, and German, it would seem that much is lost if indigenous name number systems are not incorporated into place value teaching. This claim is supported by the research of Göbel et al. (2014), who concluded that 'the structure of the language of instruction is an important factor in children's numerical development not only in basic numerical tasks such as transcoding and magnitude comparison but also in more complex arithmetic' (p. 25). It is heartening that, in the South African context at least, there has been a recent government announcement that indigenous African languages will be used beyond Grade 3, although implementation details are yet to be provided (Ketchell, 2022). However, in the Namibian context, Ninkova (2022) is more pessimistic and writes 'despite the progressive policy framework and efforts invested in the inclusion of mother tongues as official languages of instruction, the current and future status of indigenous languages in the system remains precarious' (p. 242).

In our previous research (Vale & Westaway, 2023; Westaway et al., 2024) we noted that the importance of language in learning place value is made explicit in both the German and Australian mathematics curricula. In the German curriculum, teachers are asked to pay attention to 'which errors in speech or spelling are due to misconceptions about place value or linguistic difficulties (for

example, language of origin, mixing up tens and ones)' (MKJS BW, 2016). The Australian curriculum makes explicit mention of language in Year 1, where learners should recognise 'that numbers are used in all languages and cultures but may be represented differently in words and symbols' and in Year 3 where learners should 'compare the Hindu-Arabic numeral system to other numeral systems' (ACARA, 2022).

This is not the case in the Southern African curricula we examined (Larkin et al., 2024) where, despite learners transitioning from learning in one of the indigenous languages to a European-based LoLT, there is no mention of how the transparency of language impacts on the learning of place value. Given the mediating role of language in learning, particularly in situations where learners transition from one language of instruction to another during their schooling, or when learners are required to learn in a language that is not their L1 from their first year of schooling, it is surprising that this issue is not explicitly addressed in Southern African curricula documents. Given the wide range of indigenous and European-based languages used in Southern Africa, with languages exhibiting several differing name number conventions, we see that this is a missed opportunity for curriculum writers to clearly articulate the impact of language transparency in learning place value.

Leveraging the Relative Transparency of the Indigenous Languages

Across the world there is increasing attention to the integral connections between language and mathematical learning (see Bahnmueller et al., 2018; Planas & Pimm, 2023). Differences in the explicitness or transparency of the way mathematics is expressed in a language is increasingly noted to influence learners' access to sense making. Fuson's (1990) research reinforces this claim, as her research points to how named-value Asian words support the construction of multi-unit conceptual structures of tens and ones more than do English words. The named Asian ten makes it easier than in English to learn the name for the second marks position, because *shi* is used in every word above nine (i.e. it appears in 90 different number words below one hundred). This omnipresent *shi* is a constant reminder of the presence of tens within numbers between ten and one hundred. In contrast, the English word ten is used only once in the English words for those same 90 numbers. Furthermore, named-ten Asian words make it easier to link the written marks to any word because the pattern is the same for all words between nine and one hundred (Fuson, 1990).

In a similar vein, Nguyen and Gregoire (2013) conducted a study investigating Vietnamese and Belgian (French-speaking) children's performance on place value tasks. They indicate that Vietnamese has a more 'transparent name-number system' (p. 1926) and their findings show that the Vietnamese children performed better when the task was related to the number name. The research of Fuson (1990) and Nguyen and Gregoire (2013) supports our claims that indigenous Southern African languages may assist learners in their early number naming experiences.

Similarly, there is increasing attention to the language of place value in Southern Africa (e.g. Herzog et al., 2017; Longwe et al., 2022). We found that the indigenous Southern African languages we reviewed (isiXhosa, Setswana, Oshiwambo and Emakhuwa) have greater transparency than the European-based languages (English, Portuguese, Afrikaans and German) in that the tens are explicitly named in the indigenous languages, rather than being indicated by a modified suffix in the European-based languages. In addition, the indigenous languages also avoid the problem of number inversion where the lack of alignment between the order of the digits and the language used to write them (in the teens in the case of English and from 11 to 15 in Portuguese, and the ones and the tens (in every set of three), in Afrikaans and German) is problematic for learners. Despite the advantages of indigenous languages for place value learning, many teachers are not leveraging the advantages of L1 in terms of their transparency and instead are, by using a European-based LoLT, adding additional linguistic-based complexities to learners' understanding of place value.

While we acknowledge that long number names can strain the working memory of learners (Bezuidenhout, 2022), they also have the advantage, in the context of teaching place value, of making the base ten structure of the numbers clear, and on balance this trade-off is positive (Mostert, 2019). Thus, we recommend the use of indigenous name number systems to support place value learning.

As Bezuidenhout (2022) explains, 'mathematics-specific vocabulary scaffolds a child's number concept development through an interplay between the development of language and conceptual representations' (p. 3). Overall, in the context of teaching place value, where indigenous languages offer a higher transparency when compared with European-based ones, it would seem much is lost if they are not incorporated into place value teaching.

For teachers to effectively work with both English and L1 number names in a classroom they need to understand the similarities and differences in number systems and then be explicit about these when working across languages. Further, teachers need to draw on their knowledge of language use in the local context of learners to tailor their teaching to whether learners are familiar and fluent in the use of number names in their L1 or whether instead they use English number names in their local community —as can be the case in some urban contexts where learners are exposed to English number names in their daily life (Booi et al., 2024). If the learners are familiar (although not fully fluent) with the number names in their L1 (as they mostly use, for example, English number names at home) then there is likely to still be value in teachers drawing on this knowledge to support understanding of place value. However, if learners are not familiar with these names, the advantage of drawing on these number names could be questioned and research would be required to investigate any possible advantage in such cases.

The Dual Challenge of Simultaneously Learning Place Value and a New Language

Given what we have found and argued above in relation to place value name number conventions in European-based languages being different to the patterns of language used by many learners prior to formal schooling, and based on research (see below), learning place value at school can be double challenging for those learning it in a language that they are not yet fluent in. The way place value operates in Sino-based number systems is instructive in terms of conceiving the challenges of learning of place value as similar to the challenges of learning a new language.

According to Sun and Bartolini Bussi (2018), spoken Chinese whole numbers are pronounced the same as written numbers, implying that the written numeral directly reflects its pronunciation and thus has not diverged from the spoken language. Therefore, in an important sense, place value in such contexts is an inherited concept, like an L1, where native speakers are often unaware of the complexities of their language. These authors go on to suggest that this may also explain why many curricula or textbooks based on Sino name-number conventions do not include the topic of place value as a separate sub-strand or chapter, as is the case in many curricula (e.g. Germany, Australia and South Africa). Instead, place value appears across all strands and chapters, along with reading and writing number activities, as an overarching principle (Sun & Bartolini Bussi, 2018).

Howe (2018) suggests that a way to help learners overcome the linguistic obstacle (of learning place value in a way that is different to the way they have learned their L1) is to treat the base-ten system for what it is in almost all countries – an imported piece of a foreign language – and to make the translation from traditional number names to 'structural names', or 'mathematics names', that explicitly describe the base-ten structure of each number, a topic of study (p. 132). This includes explicitly discussing the -teen numbers as being made from one 10 and some 1s and ensuring that learners are provided opportunities to translate between their traditional name number systems and the new place value structural descriptions. Furthermore, Howe (2018) suggests that the -ty numbers (20, 30, … , 90) should be explicitly identified as a certain number of tens and that the general two-digit numbers be understood as being the sum of multiples of 10s and some 1s.

A similar point of view is expressed by Hewitt and Alajmi (2023) who, somewhat provocatively, write that

> Overall, we feel that further research into the temporary use of regular language during the early teaching of number would be a fruitful avenue to pursue. We suggest that there is a general principle of regular first (to establish the underlying structure) and exceptions later. This guides not only the language used but also the order in which numbers might be worked on. We suggest that the mathematical order of numbers (smallest first and then gradually up to 10, then 20, then 100) might not be the best order to teach children about the structure of number names and the writing of numbers in symbolic form. (p. 170)

Arzarrello et al. (2018) argues that, from a pedagogical approach, teachers should first carefully consider the possible difficulties that children experience when learning numbers in a LoLT different from their L1, and then create opportunities to turn these difficulties into advantages. From a 'glass half full' perspective, the irregularities and differences also provide learners (under the guidance of the teacher) with opportunities to notice and reflect upon important characteristics of the decimal position system of writing numbers, such as the position value of digits. In the Southern African context, with reference to European-based languages, teachers might exploit the differences between the irregular forms of spoken numbers within the same language, and the irregularities between how numbers are spoken in one language and another (e.g. isiXhosa and either English or Afrikaans) to promote deep place value understanding. Activities such as this are important in all classrooms but are particularly pertinent in the Southern African context where the 'linguistic capital is not equitably distributed' (Arzarrello et al., 2018: 349).

Conclusion

In this article we have reviewed a range of literature concerning place value and provided examples of the way in which name number systems are constructed in eight languages. A clear finding is that the extent of transparency of the language, including the use of suffixes and the alignment between the order of writing the digits and the order of naming the numbers, contribute to opportunities or difficulties for learners.

It is worth noting here that we have not addressed the issue of translanguaging for place value except to acknowledge the complex nature of how teachers may support mathematical learning through drawing on learners' multilingual language repertoires. Historically, in many Southern African countries there has been a strong monolingual bias (see Sapire & Essien, 2021; Robertson & Graven, 2023) with many teachers feeling they are 'smuggling' (after Probyn, 2009) in other languages for understanding when code-switching to languages that are not the medium of instruction. Sapire and Essien refer to 'a system of multiple monolingualism rather than a truly multilingual system' (p. 75). However, more recently, there are shifts in research in Southern Africa and beyond that promote translanguaging as reflected, for example, in the Department of Basic Education, South Africa (2023) 'The status of LoLT in schools' document. We welcome this turn towards focusing on a more fluid conceptualisation of languaging (Swain, 2006) and foregrounding the communicative function of language, while still noting that the texts and the curriculum documents we have examined across the countries are monolingual documents.

What we have aimed to do is to discuss some of the important aspects of differences in the transparency of the different number naming systems and to raise possible avenues for future research in how to engage with differences and similarities in the naming conventions, when translanguaging across two languages that have similar or different naming conventions. Indeed, we have argued that the more transparent ways of naming numbers in the African languages could be effectively drawn on to support learners from those language backgrounds learning in English medium classrooms. Bringing explicit attention to the similarities and differences in the ways of naming numbers, in the languages present in multilingual classrooms, is important.

We have also presented an argument that suggests that a learner's experience of understanding how numbers are pronounced is highly language dependent and that the features of a language help or hinder learners in learning place value. Furthermore, such features are not uniformly distributed by the European-based languages often used as the LoLT in Southern Africa. This is of particular interest for us, given that the four European languages we investigated are in the group of languages with, to varying degrees, irregularities that impede place value understanding. In addition, the Southern African educational context presents additional challenges for learners who commence learning number concepts in their L1 before transitioning to a European-based LoLT early in their formal schooling.

An intention of this article is to contribute to the pedagogical knowledge of teachers and pre-service teachers regarding place value so that they can better themselves understand differences in name

number systems (probably present in the multiple languages that the teacher and learners in the class speak) and to use this knowledge to scaffold learners' name number development and understanding of place value. Given our findings, we would argue that it is particularly important that teachers and pre-service teachers (see Longwe et al., 2022), who are teaching in a different LoLT to the L1 of their learners, pay explicit attention to the irregularities in name numbering and find ways to capitalise on the affordances that L1 can offer. In this article we have primarily discussed the conceptual underpinnings of language and place value, as this was the focus in the early part of our four-year place value project. In future work we will investigate how this understanding can be translated into improved pedagogical practice for teachers and pre-service teachers, in Southern Africa, Germany and Australia.

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Notes

1. While Afrikaans is not a European-based language it is of European origin, stemming from Dutch and following the linguistic patterns of Dutch. In South Africa, Afrikaans and English are the only two languages that learners can use to complete their Grade 12 examinations. As a result of South Africa's occupation of Namibia, Afrikaans was also a language of instruction in many Namibian schools.
2. In this article we use the term 'ones' rather than the term 'units' (which is often used in the Southern African context), as this term can be confused with the naming of ten ones, ten tens, ten hundreds, etc., as a unit of ten, hundred and a thousand, etc.
3. In this article we use the Southern African term learners to refer to students or to children.
4. https://zwanzigeins.jetzt/

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