Limitations of Regular Terminology Development Practices: the Case of isiZulu Computing Terminology

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Abstract. Terminology development for a scientific discipline is an essential prerequisite for education in the chosen language. The young disciplines of Computer Science and Information Technology are lagging behind in this respect for many non-English languages. Between the few resources for isiZulu that exist, isiZulu computer literacy terms often differ. This suggests that any resultant terminology in an evolving scientific discipline will differ depending on who is consulted and how, affecting its quality and stability. We evaluated this with three experiments: an experts-only workshop, two online surveys, and voting on computer literacy terms. We obtained the, at present, longest list consisting of 233 terms for 146 entities. There are notable differences in preferred terms between experts and computer literate users, and while the passive voting yielded more results quicker than the surveys, some entities still have many different isiZulu terms. The results indicate that a broadly participative and inclusive collection and proposal stage yielding multiple contenders for an entity should be a compulsory and explicit stage before, and possibly also during, multidisciplinary terminology development workshops.

Keywords: isiZulu, terminology development, computer science, computer literacy, methodology, terminology quality

1. Introduction

The principal obstacle to teach and tutor Computer Science (CS) and Information Technology (IT) in isiZulu is the absence of isiZulu CS & IT terminology and fragmented knowledge of existing isiZulu terms, even among isiZulu speakers. Even more challenging, is the localisation of productivity and software engineering software in African languages, which has been shown to be perceived useful at least for compilers (Neves and EyonoObono 2013). In several other language areas, CS & IT terminology has been developed gradually or pushed by national organisations. For instance, the Académie Française and the Real Academia Española instituted new terms in 2013, including *mot-dièse* for the Twitter 'hashtag' and *whatsappear* for using WhatsApp, and the public has been translating and inventing new terms for CS & IT concepts and devices once they became ubiquitous, such *Datenbank* (Ger.) and *databasis* (Afrikaans) for database. This has occurred only to a very limited extent in isiZulu CS & IT; e.g., *izilungiselelo* ('settings'), *igundane* ('mouse'), and *uhlelokusebenza* ('software'). A major difference between Indo-European languages and isiZulu is that the latter is one of the underresourced languages and faces an uphill struggle to redress injustices of the past, which is even more profound for scientific terminologies. In addition, computer science is a relatively new discipline, and words are being invented in *all* languages. Our initial exploration of different sources for CS & IT isiZulu terms, including the Department of Arts and Culture ICT list (henceforth, DAC2005), showed that (1) there are different words for the same entity in the few extant different term resources, (2) these are exclusively at the computer literacy level instead of the scientific level, and (3) there are both

zulufications of foreign terms and new terms. In addition, informal queries to students indicated duplication and lack of coordination of the creative efforts of word formation and usage. At the time of writing, there is no standardised or widely agreed-upon CS & IT isiZulu terminology. It will take many resources to develop terminology the typical way with multidisciplinary workshops, and moreover, it would not be sufficiently inclusive. Typical participants in such workshops are merely a few subject domain experts and more linguists and terminologists. For CS & IT, however, there is a clear distinction between laypeople at the computer literacy level, and experts. The former group includes learners, administrative officers and most non-CS/IT scientists, whereas the latter includes CS graduates and academics, systems administrators, and programmers. Concerning inclusiveness, this is meant not just as a value judgement, but especially from a terminology quality point of view, because asking only a few people in a few workshops will result in a lower quality terminology, which hampers its uptake. This claim entails the following, more modest, hypothesis that is yet to be evaluated experimentally: *A resultant terminology in an evolving scientific discipline will differ depending on whom you ask, and how*. If true, then the approach of terminology development via resource-consuming workshops is inadequate, due to the extremely small sample size in general, and the dearth of experts in particular. Further, laypersons, linguists, and terminologists dictating the terminology to experts does not foster its uptake[1], and it is not conducive for CS scientific terminology development that covers many terms that a computer user need not to know, such as the 'computational complexity of an algorithm', 'pass-by-reference', or 'argument' in the programming sense, but which are important concepts for a computing degree.

To evaluate the hypothesis, we collected data using the 'workshop approach' but *with experts only*, asked computer literacy students for their opinion on terms, conducted a survey to compare presenting entities as terms or as pictures, and gathered data from the dictionaries and any extant term lists, and compared the results. The workshop participants agreed on 37 terms, which is the first list of computing terms in isiZulu. There was agreement on some terms among the literacy students, but others received equal votes, and for several entities, the experts preferred another term than the computer literate participants, which was also observed between experts and extant resources. Overall, we now have 233 isiZulu terms for 146 entities. Due to limited participation in the survey, results are inconclusive whether text or pictures would be better; open, *de novo* creation or recall is the hardest, as exhibited by the short lists elsewhere, the 37 terms from the workshop, and the lack of response to the online survey, whereas the voting typically took no more than 5 minutes for the 19 terms.

Given the nature of the setting and outcome, it is expected that these limitations hold also for other underresourced languages that face not only collection of terms in the target language (when the entities are known already), but also a substantial amount of invention of terms. These results provide evidence-motivated suggestions as to how one can devise potentially more efficient and effective methods for terminology development that either avoids the above issues or can somehow quantify it. We will introduce one such option: crowdsourcing.

After addressing related works, we describe the materials and methods for the experiments, the results, discuss them, and conclude.

2. Related works

Among the two paths in terminology development—systemic aspects with status planning and corpus development—we focus on methods for the latter, both at the scientific level and the layperson level, and on "harvesting" terms in the target language in particular.

Terminology development efforts typically take a top-down and selective participation approach (e.g., Kalenderian *et al.* 2011; Engelbrecht *et al.* 2010), relying on workshops in a

[1] For instance, no one at the computer science department at the UKZN Westville campus—academics, students, administrators—was aware of the DAC2005 list, and, as we shall see in the results, there was not much agreement with it once presented to experts.

multidisciplinary setting, which is also advocated by TermNet[2]. An exception to this are the so-called 'structured controlled vocabularies' in the sciences that are expert-driven and with relatively broad participation, such as the health care terminology SNOMED CT[3], the UN Food and Agriculture Organisation's AOS[4], and the Gene Ontology (Gene Ontology Consortium 2000). They may have workshops involving terminologists and ontologists, but this is optional: the experts are the main, or even sole, contributors for scientific terminologies. This begs the question: why it is accepted that experts create a terminology in English when it concerns the scientific discipline, but that any localization supposedly should be controlled by linguists and terminologists?

Concerning the state of computing terminologies: there is *no official computer science terminology* even in English, although many CS & IT terminologies are available online. With the invention of English terms for new entities in computing over the years, no linguist or terminologist was involved, sometimes to the dismay of language purists (Santini 2002). The Department of Arts and Culture of South Africa has developed a first version of an ICT terminology for the 11 official languages of South Africa (DAC2005) by availing of the top-down and multidisciplinary approach: for isiZulu, there were 17 collaborators, 29 participants from diverse disciplinary and professional backgrounds, and 4 members of the technical committee of the natural language board (DAC2005). DAC2005 has 135 terms that are, at most, at the level of computer literacy. Excluding non-computing terms, such as 'postcard' and 'pay TV', only about half of the terms are relevant. Dictionaries contain only computer literacy terms, if at all; we shall discuss these later in the paper, availing mainly of the *Shuter & Shooter isiZulu Scholars Dictionary* and *Collins Pocket Dictionary* for isiZulu. Other African language terminology development efforts exist, notably at Stellenbosch University for isiXhosa[5], but this does not yet include an isiXhosa CS & IT terminology, and their trilingual dictionaries are available in print for payment only, and at Rhodes University, where Sam developed and investigated adoption of computer literacy terminology in isiXhosa (Sam, 2010). Google's localization for their website is in flux and contains new terms that do and do not fit with isiZulu—e.g., *izilungiselelo* and *idrayivu*, respectively—and its new translation service has ample room for improvement. Microsoft has an isiZulu, isiXhosa, and Afrikaans localization for several applications for Windows 8. Large companies apparently do see the benefits of investing in localization and term development.

There are delicate issues surrounding opinions about African languages development. This ranges from, e.g., false dichotomies propagated in scientific literature about “developed” and “developing languages” (Huyssteen 1999:179)[6] to that “[t]he promotion of African languages in [high-function formal contexts] does not have the support of their speakers, who still seem to believe that their languages are unable to be used in such domains, that is: their minds are still colonised” (Webb 2013:180), which hamper isiZulu terminology development. In addition, one faces the trend in cultural imperialism and globalization, to the benefit of English as “indispensable for attaining personal advancement and for being seen as ‘modern and successful’.” (Webb, 2013:180), which is even more so in CS & IT. Notwithstanding, countries in at least continental Europe and Latin America still use mainly their own language and terminology *is* being developed in various languages without detriment for socio-economic and political status. Furthermore, it is possible to invent new computing terms also in isiZulu, just like in other languages, and this has been done. For instance, *ukwakhuhlelo* for 'programming' (n.) that is a contraction of *ukwakha* ('to build') and *uhlelo* ('arrangement' or 'grammar'),

[2] http://www.termnet.org/; Last accessed: 13-1-2014.
[3] http://www.ihtsdo.org/snomed-ct/
[4] http://aims.fao.org/
[5] http://www0.sun.ac.za/languagecentre/?page_id=47; Last accessed: 29-8-2013.
[6] no language is static and 'developed'—except for dead languages, they all change. There are languages that have been less extensively researched and for which less material is available, i.e., being a proper language that is *underresourced*.

uhlelokusebenza (software) from *uhlelo* + *uku* (for the verb) + *-sebenza* ('work'), *inhlokosiqoqelalwazi yohleloxhumano (*'server'), and *inhlansi* ('bit'). Some systematic work has been done on the analysis of creating new isiZulu terms by means of "conceptual blending", which is common practice in several other languages, such as German, and occurs in isiZulu as well (Buthelezi 2008). From experience, we know that term creation does happen among CS & IT students, perhaps as prolific as Mbuyazi's efforts (Steenkamp, 2011). Further, just as isiZulu has contributed to South African English, it can do also in the sciences, including computer science: the world-wide open source software community already knows of the Ubuntu Linux distribution.

It is important to contrast the current situation with that of Afrikaans, which is one of the few languages that evolved in the 20th century from one with no government recognition and existing mainly in spoken form, to one that plays a fundamental role in government, the economy and higher education (Madiba 2001). The development of Afrikaans stems from a linguistically-based ethnicity (de Kadt 2006) and it was developed via a politically motivated top-down approach. This was driven by South African language institutions such as the *Government Language Board* and the *Suid-Afrikaanse Akademie vir Wetenskap en Kuns* (Webb 1995), together with the Afrikaner universities that simply lectured in Afrikaans while borrowing from Dutch and German, thereby forcing the development of terminology (de Kadt 2006). No such top-down imperative exists for the South African indigenous languages today, despite the constitutional right and demand for the promotion and development of these languages, with non-prioritization of this task by the modern government (de Kadt, 2006). Consequently, these languages play a very limited role in higher education development. For the situation to change, a democratic bottom-up approach may be needed. The question then is how to do this with maximal efficiency and within a minimum period (Madiba 2001). Magagane (2011:133-143) has a long list of recommendations on how to improve the situation of language development in South Africa, but falls short of presenting a methodology for how best to do this. Likewise, Onyango (2005:222) only states that the "engineering of terms calls for input from language experts", but not how to do this. *Guidelines* for terminology development exist, such as from the DIN and ISO, the PEGITOSCA criterion[7] for proper term creation, general instructive notes when developing new terminology (Neundorf 1982:271-273), and guiding principles for a specific terminology (e.g., Donnell 2006:281), but none of them has a method that is shown to be tailored to respecting such guidelines. Also Engelbrecht *et al.* (2010:259-263) describes in the method section only how they did it for their case, using the selective participation with only three experts. An IT savvy approach was taken to invent a new Dutch word for the Twitter 'hashtag': 1) Let the public propose terms; 2) The Dutch Language Union (Nederlandse Taalunie) selects a subset of all the terms submitted; 3) Online voting on the subset[8]. To the best of our knowledge, there is no clear-cut, proven, agreed-upon *method* for scientific terminology development when the scope is localization of the terminology, such that is will be by the people and for the people. We will suggest that crowdsourcing may be key.

3. Materials and methods

We describe the materials and methods of the three experiments, namely the workshop, the computer literacy term survey, and the computer literacy term voting.

3.1 Workshop Experiment

The purpose of this experiment is to use the *typical workshop setting* and observe its effectiveness in terminology development when *only experts* participate, which should give an

[7] Precision, Economy, Generativity, Internationality, Transparency, anti-Obscenity, Systemicity, Consistency, and language-relative Acceptability (attributed to Kiingi).

[8] Explained in the sound file at http://www.vrt.be/taal/joos-zoekt-nederlands-woord-voor-hashtag; Last accessed: 17-1-2014.

idea of what terminology the experts use (regardless of whether that is linguistically the best term).

Set up. The set up of the experiment is as follows.

- Participants: 10 senior CS & IT students with isiZulu as first (home) language.
- Venue: Computer science seminar room, where the tables and chairs are ordered in a circle.
- Duration: 2 hours.
- Incentives: the honour of being at the forefront of this endeavour, and pizza and softdrinks afterward.
- Instructions: 1) Go through the prepared list of entities, 2) for each one, note whether there is consensus about that isiZulu term, 3) note whether there are synonyms, 4) you must do this together, not in smaller groups.

Analysis. Count of the entities for which isiZulu terms are proposed, count of multiple entries, count of synonyms, count of consensus. Compare the results with those of the other experiments.

3.2 Computer literacy terms: Survey

We conducted two exploratory polls to obtain insight into how to ask for terms, whether there is a difference in term usage, and to gain some indication about current computer literacy terms and their use. The first survey considers the question of how entities should be presented—text or picture. It is aimed at examining two aspects in particular:

- What is the current body of knowledge on basic IT isiZulu computer literacy terms, given a fixed set of entities? What is the proportion of entities that have multiple words for one entity in everyday usage?
- Test the hypothesis that the entity set with pictures results in a significantly greater amount of term proposals compared to the entity set presented with only English terms.

The hypothesis in the second item is motivated by cognitive science and multilingualism. Consider Ogden and Richard's semiotic triangle depicted in Figure 1, which was influenced by Peirce, Saussure, and Frege. The sign or symbol invokes a concept an individual is thinking of, which identifies the object; e.g. the term 'keyboard' or its picture invokes a thought about what a keyboard is, which is such that, when given a set of things, one can pick the object that is the keyboard.

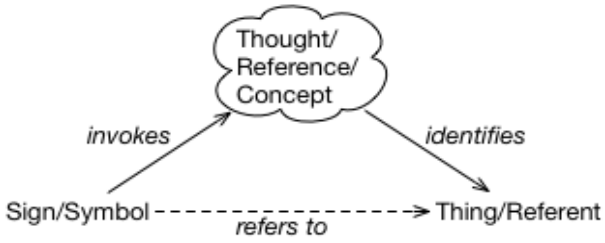

Figure 1: Ogden and Richard's semiotic triangle (after Guarino et al. 2009:15).

Regarding multilingualism, while there may still be a debate about whether a person thinks in a certain natural language or that the Thought/Reference/Concept is more abstract, in particular among monolingual people, this is not the case for multilingual people, as—besides the support of the semiotic triangle—such an approach becomes increasingly cognitively unmanageable the more languages one masters. *In casu*, most isiZulu speakers speak at least two languages. It may be that observing the Sign/Symbol as a term in one language may *impede* matching the Thought/Reference/Concept it invokes back to a Sign/Symbol in another language. If this is the

case, it will negatively affect the outcome when entities are presented to participants as English terms compared to a natural language-independent symbol, i.e., a picture or a diagram, that may be closer to the concept one thinks and therewith make it easier propose an isiZulu term. Moreover, it may induce a semantic translation rather than Zulufication of the English term, such as *uhlelokusebenza* for 'software' is andopting for *iposisiqoqelalwazi* instead of *i-imeyili* ('e-mail').

Set up. The set up of the experiment is as follows.

- Participants: 2nd and 3rd year isiZulu-speaking students in CS or CS & IT, who are contacted by email to participate, with the email written in isiZulu. Half will receive the link to the term-survey, half will receive a link to the picture-survey. The email list is divided by means of the www.random.org randomiser.
- Entity set: 50 entities, at the level of computer literacy (see results for the list).
- Mode: Through the open source LimeSurvey software [www.limesurvey.org], localised in isiZulu.
- Time the survey will be open: 2 weeks.
- Incentive: none.
- Instructions: 1) invite the students by email, where the email is written in isiZulu to filter out basic language proficiency, 2) ask them to fill in the isiZulu term(s) if known with multiple terms separated by a semicolon, or left empty if not known.

Analysis. For both sets, separately: Amount and percentage of entities that have at least one isiZulu term, list and number and percentage of entities that have no isiZulu term, list and number and percentage of entities that have more than one isiZulu term (be this proposed by a single participant or aggregated for all participants). Comparison of the two sets using basic statistical analysis.

3.3 Computer literacy terms: Voting

The second poll is aimed at examining three aspects:

- What is the current body of knowledge on isiZulu computer literacy terms among computer literacy students, given a fixed set of entities? What is the proportion of entities that have multiple words for one entity in English in everyday usage?
- Voting will reveal both synonyms and preferred terms.
- Voting is quicker and will result in more answers than asking *de novo* in the survey.

Set up. The set up of the experiment is as follows.

- Participants: 1st year students in the computer literacy module “computing for natural scientists” (COMP106 WVL 2013) who speak isiZulu.
- Entity set: those entities at a computer literacy level for which different sources list different terms. Sources used: the DAC2005 list, results of the workshop, *Shuter and Shooter isiZulu Scholar's Dictionary*, *Collins Pocket Dictionary for isiZulu*, and two terms from ii translation (http://iitranslation.com/resources/English-isiZulu.html).
- Time: during the last week of lectures, in the lecture break and afterward.
- Incentive: none.
- Instructions: select the preferred/best option for each entity, or *angazi* (“don't know”) if you do not know, and return the sheet to the lecturer.

Analysis. For each entity, calculate the percentage of overall votes for each answer option. Cross-check and compare them with the outcome of the workshop. Note clear preferences and potential synonyms, and whether the terms from one source typically receives more votes.

4. Results

The results of the three experiments are described and then compared to each other and to other sources.

4.1 Workshop Experiment

The set up was as depicted in Figure 2, where the research assistants had a desk on the side to place their laptop on.

Characterisation of the participants. Fifteen students participated in the workshop session instead of the envisaged 10, thanks to students' interest. Nine students were CS or information systems honours students, and 6 were in their final year BSc CS or CS & IT. The gender distribution was slightly higher than the institutional average, being 5 females and 10 males. All participants have isiZulu as home language, as self-registered in the student database upon enrollment at UKZN. The four moderators were CS honours students (two with isiZulu as home language, and the other two fluent in isiZulu), one of whom fulfilled the role of chair/moderator, and the other three managed the note-taking, proposed entities to discuss, and looked up definitions. The participants were not aware of the DAC2005 nor its contents, nor of the private collection of terms of one of the authors, and this was not used during the session.

The session and resultant terminology. At the start of the session, the principal investigator (author [AN]) commenced with the dictionary entry *uhlelokusebenza* ('software'), and asked whether they agreed with that. This generated immediate response, and the conversation started (in isiZulu). Initially, the female participants dominated the conversation, but in about 5 minutes, everyone participated, and from about 20-30 minutes into the session, it was lively, oscillating from thinking, to discussion of the meaning of the entity and possible alternative terms, to

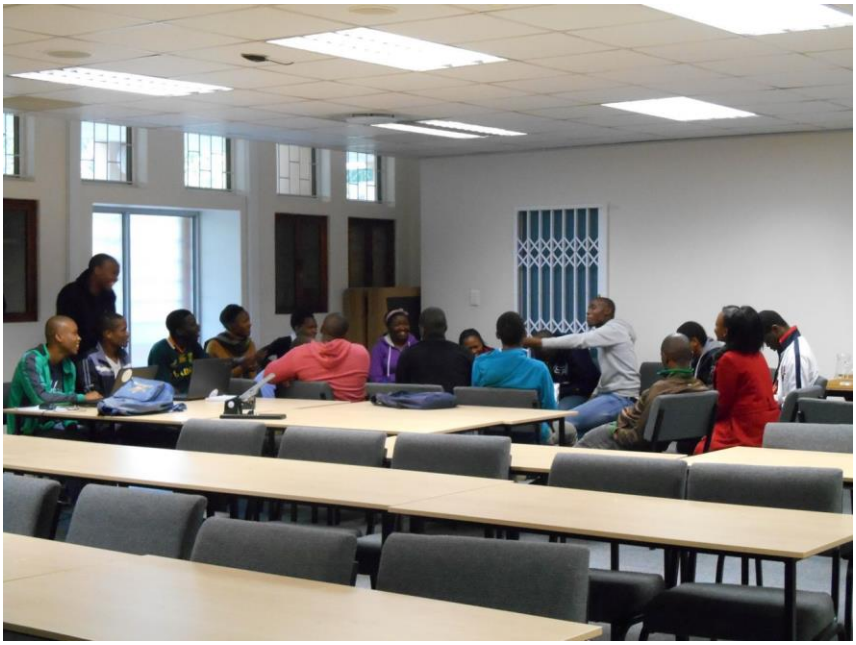

Figure 2: Photo taken during the session, with the participants in discussion and the moderators on the left.

laughter and applause. When the time was up, there was a general murmur that they were not finished yet.

Finding isiZulu words occurred in various ways. In some cases, when an entity's English term was mentioned by a moderator, many or all of the participants instantly mentioned the isiZulu term. In a majority of cases, the meaning of the term was discussed before reaching an

agreement on possible alternatives. This, at times, was augmented by a request to the moderator to read aloud a definition of the entity to reconsider the meaning, and at times which of the options was better or whether they were sufficiently similar to count as synonymous.

Table 1 presents the list for which there is at least one isiZulu term for the entities about programming and Table 2 presents those for networking, which is a total of 37 entities that clearly include entities also well beyond the level of computer literacy. Exception, garbage, and method have consensually agreed synonyms in isiZulu. *Indlela yokwenza* may be a homonym, because it is used for both algorithm and method. The following entities were discussed—still in the context of programming and networking—but no isiZulu term was provided: instance variable, object oriented design, class, subclass, ad-hoc, bandwidth, beacon interval, broadband, buffer, datagram, domain. In addition, one can observe that there is no zulufication of foreign terms in Tables 1 and 2, other than the *ithuluzi*-part (from 'tool') of *ithuluzi lokucinga*; thus, all proposed terms denote the meaning of the entity, not a string of text that is devoid of semantics in isiZulu. Even algorithm is unrecognizable from its origin: the etymology of 'algorithm' is not to be found in the English language, but the entity was named after the Persian mathematician Al Khwarizmi.

Informal feedback after the session during the pizza dinner revealed that participants found it a difficult task to carry out. A suggestion was made to distribute the entities beforehand, if the experiment were to be conducted again.

Table 1: Entities within the context of programming with their English term and isiZulu term(s).

Entity (programming)	
English	***isiZulu***
algorithm	indlela yokwenza
object	into
argument	ilungu lohlelo
method	uhlelo, indlela yokwenza
comment	isiphawulo
encapsulation	ukucatshisa
exception	isivimbelo, inkinga, isqaphelo, isixwayiso
field	ilunga
formal parameter list	amalungu ohlelo ahlelekile
garbage	doti, izibi
graphical user interface	inkundla
inheritance	ufuzo
initialize	ukuqaliso
member	ilunga
overloading	ukugqilaza
overriding	ukushintsha ufuzo
pass-by-reference	ukudlulisa ikheli
pass-by-value	ukunikeza uqobo lwento
polymorphism	ubululwane
runtime-error	iphutha elivela uma usubheka ukusebenza kohle
reference	umsuka
scope	indima
array	amagumbi

sub-array	amagumbi phakathi kwegumbi

Table 2: Entities within the context of networking with their English term and isiZulu term.

Entity (networking)	
English	***isiZulu***
access-point	indawo yokungena
adapter	isengezo sokuxhumana
amplifier	umlekeleli
backbone	umgogodla
bit	inhlansi
boot	ukuhloma
bridge	ibloho
browser	ithuluzi lokucinga
Internet	inkanji yolwazi
byte	izinhlansi ezili shagalo-mbili
client	incelebane
cryptography	ubhalo mfihlo
database	inqolobane

4.2 Computer Literacy Survey Results

Emails were taken from the student management system for the core 2nd year and core 3rd year modules (COMP201 and COMP314), amounting to 178 emails, which includes the deregistered students. The email addresses were randomised, and split into two groups based on order in the list, and the first group received an email invitation with the link to the text-based survey and the second one to the picture-based survey. By rough estimate, only about half have isiZulu as home language, so one could have about 80 responses in total for the two surveys as the maximum response rate. The invitation was sent at the end of the lectures in the semester, a reminder in the following week, and results were collected 1.5 months later.

There were two challenges that affected the realisation of the survey. The major obstacle to realise the survey was that no survey software has an isiZulu localisation, which meant that it had to be developed and compiled into LimeSurvey. Autotext needed for that particular survey has been translated, so that not only the questions, but also the standard features, and the introduction and closing messages of the surveys was in isiZulu only[9]. Now there are, e.g., buttons labelled *Hambisa* for 'Submit' and autotext *Khetha kulezi ezilandelayo* for 'Check any that apply', and error messages in isiZulu; some examples are shown in Figures 3 and 4. The surveys are available online at http://limesurvey.cs.ukzn.ac.za/index.php?sid=18396 (terms) and http://limesurvey.cs.ukzn.ac.za/ index.php?sid=75575 (pictures). Second, it was difficult to find or create an unambiguous picture for some of the entities without using any text, such as megabyte, spyware, softcopy, and internet protocol suite. For 20 of the 50 entities, also the term was added below the figure to clarify it, and anecdotal feedback suggests more pictures should have been annotated for disambiguation.

[9] Anyone can contribute to the localization at http://www.limesurvey.org/en/contribute/translations-status.

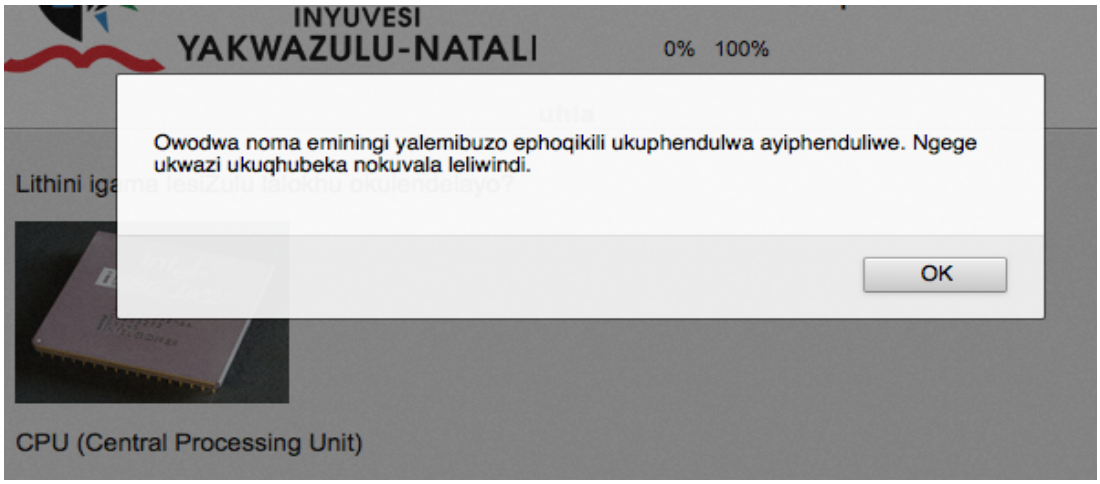

Figure 3: Message after submitting a survey where one or more questions that are mandatory have not been answered.

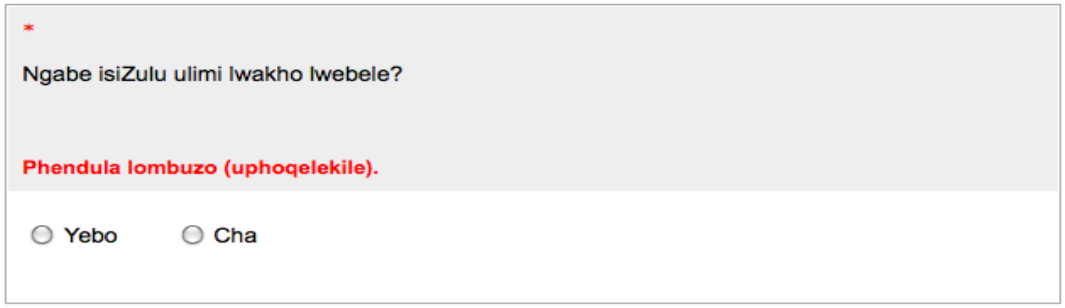

Figure 4: The question that was mandatory, now with explanatory text in addition to the red asterisk.

The response rate was very low for both surveys: 12 IDs were generated in the term-survey, of which one incomplete but with some responses and one successfully completed, and 16 IDs were generated for the picture-survey, of which one incomplete and only one term, and two completed. 44 terms have one or more isiZulu term proposed for it—21 times for the term-survey and 37 times for the picture-survey—of which 15 more than one; this set is included in Table 4 in the appendix. The entities for which no term was proposed are: network interface card, bit, cloud computing, terabyte, softcopy, and hacker. Given the low response rates, there is insufficient data to falsify or validate the experiment's hypothesis.

The responses do give some useful indications for the questions in the first item of the experiment design, notably that no terms were proposed for basic entities, such as network interface card and bit. There are only two terms exactly the same at least twice (*igundane* ('mouse') and *igciwane* ('virus')), and one could count as essentially the same 'logout' and 'shutdown': *phuma* and the infinitive *ukuphuma*, and *cisha* and the phrase *izindlela zokucisha ikhomp*, respectively. The (un-)clarity of the pictures most likely affected email and operating system, and certainly computer program whose picture indicated some code with both class and method but only a term for class was provided (*iklasi*), the picture for algorithm was alike a flowchart, which explains the proposed term for it (*umdwebomfanekiso*), and the pictures distinguishing bit and byte may have been ambiguous (*ibhay* for 'byte' that is probably meant for

bit, given that *amabhay'thi* was used by the same respondent for [mega]byte). There are only a few zulufications of foreign terms, such as *imemoly*, *iprintha*, and *idesithophu*: 9 out of 79 phrases, excluding the repetition of byte in the KB, MB, and GB (see also the discussion in Section 5).

4.3 Computer Literacy Voting Results

The 2-page list of 19 entities had the instruction on paper written in isiZulu and some context was provided to the students in English by the lecturer. 14 answer sheets were returned during the lecture and 4 afterwards. The demographics of the students were not recorded, nor whether their home language was isiZulu. Going by the class average, the respondents were predominantly first-year students, a large majority of whom are enrolled on a degree in geology, and some life science, applied chemistry, and marine biology. The terms, their source and the percentages the terms received are shown in Table 5 in the appendix.

Of the 19 entities, 6 did not have one isiZulu term option that received more than 50% of the votes, being bit, byte, database, email (n.), mouse, and directory, although when one aggregates the three *igundane* versions for mouse, it has a majority. Only four terms received a large majority (≥75%) of votes, being those for laptop, logic, data, and server. Byte, bandwidth, and open source software stand out by their comparative high percentage of *angazi* responses. The latter is noteworthy, given that the PCs in the labs have Fedora Linux installed, the office suite used was OpenOffice, and additional software was also open source. Other noteworthy results are the near-tie between *isiqoqelalwazi* and *ikhompuyutha* (computer), between *-xhuma* and *-faka* (installing [software]), between *isikhiphambhalo sesiqoqelalwazi* and *iphrinta* (printer), and the four options for email. A linguist may find it of interest to investigate why a zulufication such as *iphrinta* receives a near-tie, but that the zulufications for server (*iseva*) and satellite dish (*indishi yesathelathi*) received hardly any votes. Another discrepancy can be observed between data and database, which have specific and closely related meanings in computing, but apparently less so from a pure terminological viewpoint: data has a clearly preferred *ulwazi olungahluziwe* over the *imininingo*, but *imininingo egciniwe* received most votes for database over either of the two *ulwazi* variants.

There is no overall winner among the sources, but one could say that the terms from the workshop were less favoured overall by the computer literacy students compared to the DAC2005 and dictionaries: pitting workshop vs. DAC2005 results in a 1:4 score, workshop vs. S&S a 0:2 score, and DAC2005 vs. S&S a 1:1.

4.4 Comparisons

There is *no* overlap between the DAC2005 and the programming terms, and a partial overlap with the networking entities, which are included in Table 3. From this comparison, it can be observed that 1) there are 32 new terms recorded in our experiment, 2) the five common entities have an empty intersection between the terms from the experiment and the terms from the DAC2005, 3) there is a higher incidence of zulufying the English term (*intanethi, ibhithi*) in the DAC2005, and two of the terms proposed for database are definitely wrong from a computing viewpoint, because *ulwazi* means knowledge, not data, and a knowledge base is different from a database. Conversely, of the terms that were discussed but for which no isiZulu term was provided during the workshop, two were proposed elsewhere: Bandwidth has an entry in the DAC list, where *umkhawulokudonsa* has a slight preference over *umkhawulokwamukela* in the voting survey (see Table 5), although most computer literacy students did not know a term for it either, and 'class' in object-oriented programming has a proposed *iklasi* in the picture-based survey. Further, the term-based survey has *isisu* for 'hard drive' compared to Google's *idrayivu*.

Table 3: Comparison of isiZulu terms between our workshop results, the DAC2005 list, and the Shuter & Shooter Scholar's Dictionary.

Entity (networking)			
English term	***isiZulu term***		
	Workshop Experiment	*DAC 2005*	*S & S dictionary*
bit	inhlansi	isimumathalwazi esincu, ibhithi	N/A
browser	ithuluzi lokucinga	isiphequluli	N/A
byte	izinhlansi ezili shagalo-mbili	isimumathalwazi	isimumathikazi
database	inqolobane	ulwazi olugciniwe, ulwazi olulondoloziwe, imininingo egciniwe	inqolobane yolwazi/ isilondalwazi
internet	inkanji yolwazi	uhleloxhumano lomhlaba, intanethi	uhleloxhumano lomhlaba

There are some differences between the isiZulu terms used by the computer science students and the computer literacy students. In the workshop, there was agreement about database as *inqolobane*, yet this term received only 6% of the votes from the literacy students who slightly preferred *imininingo egciniwe* (47%) from the DAC2005, and likewise for the workshop's agreement about bit (*inhlansi*) versus *isimumathalwazi esincu* (44%) from the DAC2005, and the workshop agreement on byte (*izinhlansi ezili shagalo-mbili*) versus the literacy students divided voted across all four options and 33% for *angazi*. A clear difference can be observed regarding Internet, where the workshop's term, *inkanji yolwazi* received only 11% versus 56% for *uhleloxhumano lomhlaba* from the DAC2005 and S&S. On the other hand, the workshop's browser (*ithuluzi lokucinga*) received a clear majority with 66% over DAC2005's *isiphequluli*. However, if we put the results of the voting survey together with the workshop's preferences for terms and recalculate the votes with the experts included, then *inqolobane* would have come out highest with 50% and the difference between the two sets of respondents would have been missed, and likewise for *inkanji yolwazi* (Internet), *inhlansi* (bit), and *izinhlansi ezili shagalo-mbili* (byte).

5. Discussion

The results of the experiments are reflected upon, and a potential solution is proposed for the observed issues, namely crowdsourcing.

5.1 Reflection on the experiments

One might deem the workshop experiment set up limited, for, in theory at least, one could design the experiment with a second workshop running parallel using the same set of words, in order to examine whether those lists would differ. The limiting factor preventing this option, is the demographics of the students. Even for this workshop, information systems honours students (who completed a BSc in CS or in CS & IT) and 3rd year computer science students had to be invited to make up the numbers, and there was no isiZulu-speaking full-time postgraduate student.

Concerning the workshop's list of entities, it may be that providing one upfront may be beneficial, but from ontology development practices, it is known that discussions about the definition and meaning are helpful in teasing out the semantics of the entity, which aids capturing it better. That is, such an analysis phase is not a negative aspect, but an integral part of the process

and it occurs also in terminology development in other languages. In addition, also there is oftentimes not a literal translation; e.g., 'operating system' is *Betriebssystem* (Ger.), which means the 'managing' system, not 'operating' system. Moreover, some English IT terms are misnomers (Santini 2002) and are better not translated 1-to-1, such as 'wifi' and 'e-mail'. The case of email is interesting for isiZulu, as Santini's lamentations are not applicable. He notes that "*e-mail* refers to messages transferred through computer networks... not that it works by moving electrons around." (Santini 2002:114). While in several other languages it remains 'email' or 'e-mail' or as a literal translation; e.g., *correo electronico* (Sp.), and *e-pos* or *elektroniese pos* (Afrikaans), in isiZulu the e-somethings are a variant of *uhleloxhumano* ('network') with the relevant designator; e.g., instead of 'e-learning', we have *ukufunda ngohleloxhumano*, i.e., to learn with/by the network; other examples are included in Table 6 in the Appendix. Further, claims and lamentations about "zulufications of English" to construct a computing terminology is tricky to assess for the following two main reasons. First, about 75% of English lexicography originates from French or Latin (Elms, 2008); e.g. 'printer' has its origin from the French *preinte* and 'data' and 'compute' is based on Latin. Likewise, *programmare* (It.) and *programmieren* (Ger.) and *programmeren* (Ned.) may all seem Anglicisms for 'to program', but etymologically, its root comes from Latin. Second, there are also origins not based on language: e.g., while 'bit' is a contraction of 'binary digit', 'byte' is a language joke on 'bite' being larger than nibbling a bit of food, 'software' was a wordplay from 'hardware', 'worm' was inspired on the science fiction novel *The Shockwave Rider* by John Brunner, and we have mentioned 'algorithm' before. Perhaps the etymology of computing terms should be taken into account when devising isiZulu terms; either way, if there is some decipherable Indo-European in the coined isiZulu term, this is not necessarily a bad thing, as it may reflect a carrying over of the insider joke or respect for its inventor.

The survey experiment was not successful in terms of finding out which way—picture or text—is better to present the entities and obtain data, other than that one may speculate that asking people to provide terms from scratch is tougher than it may seem. Nevertheless, the experiment is useful in two aspects. First, with respect to how realistic presenting *all* entities with pictures and diagrams is: it is not. Even the picture-survey had some entities with text-only, such as megabyte, and roughly half had, or should have had, some explanatory text, demonstrating that a self-standing picture is not enough. This problem is exacerbated for the more abstract entities in the CS discipline. Second, considering the proposed terms, also here there is agreement on a few terms (browser, mouse), but more new terms have been proposed in addition to those in the other sources and the workshop, notably for Internet, email, computer, printer, and server. The new one for computer (*umshini*) is slang for computer, just like 'machine' is in English. Overall, though, these additional terms could, on the one hand, be potential synonyms to those proposed in the workshop, dictionaries, and DAC2005, but, on the other hand, be part of the normal "term proposal stage" in terminology development, alike with the Dutch term for the Twitter 'hashtag' mentioned in Section 2. Either way, also elsewhere, there is a stage where multiple terms are proposed, played with and mulled over, and eventually will settle on one or more preferred term.

The comparison of output from experts vs. laypersons voting and DAC2005 demonstrates that care has to be taken and documented on who proposes what. This also can involve some weighting of contributions by experts vs. laypersons, and to compute its effect on the draft terminology. If the amount of respondents in the voting poll would have been much larger than the amount of experts, then the experts' preferred term would have been outvoted and therewith lost in the process. While this may be of little interest to people outside an educational setting, when isiZulu is used as a medium of instruction, it is important to establish which terms the learners and students are introduced to, and which ones would be the preferred terms from a scientific discipline viewpoint. If there are irreconcilable differences, one could consider creating a "two-track" terminology for scientific and for layperson use, as already exists in several other languages.

Finally, these observations and considerations demonstrate that availing of the typical

selective workshop approach or dictionary-authority may actually not be such a good idea, because it only captures the prevailing term(s) of that small group, which may neither be the preferred term in everyday use nor from a specialist stance. Put differently: it demonstrates the need for broadening the pool of contributors and increasing its size, and having the facility to obtain and analyse data both aggregated and disaggregated by type of contributor. While terminology developers and society may wish to push ahead fast, when considering the data obtained in these experiments, one can infer that the stage at which the isiZulu CS terminology development is, is at the proposal and collection stage for most terms. This, then, should be facilitated.

5.2 Involving the masses

As a means of broadening the pool of contributors and at the same time collect more data about the terms for better analysis, we propose an alternative to the aforementioned techniques for terminology development, namely crowdsourcing. Crowdsourcing, in short, is the process of soliciting information from, or offloading tasks to, a large group of people typically via the Web and availing of games (Estellés-Arolas and González-Ladrón-de-Guevara 2012). It has been used to annotate pictures, solve scientific problems, and more. It should be feasible to use the same principle for collecting isiZulu computing terminology via such online games, although it has not been used for this purpose yet. Using crowdsourcing design principles described in (Doan *et al.* 2011:93-96), we are developing such a game, which is being implemented at present. In short, members of the community join and play the games by browsing to the website, and they begin scoring points by playing the games either against others, the computer, or on their own. The games are designed to solicit isiZulu terms and to solicit opinion about them. One can earn points for proposing terms and for voting for a term, where consensus has a higher payoff. The reward of earning points is expected to encourage participation for at least two reasons: the competitive aspect, which has been shown the best incentive in a Facebook-based South African cultural heritage game (Havenga *et al.* 2012), and that one one gets rewarded and valued for knowing what one knows without any punishment for not knowing.

To illustrate the idea, a walkthrough of the game is briefly described. A player is presented with a sequence of five entities sequentially in one game. For each entity, the player is presented with an English term, which is shown in Figure 5 with the English term 'CPU' (central processing unit). The player has the option to propose a corresponding isiZulu term, e.g., *umqondo womshini*, to skip it, or to vote for existing terms instead. Proposing a terms scores the most points, and even more when a co-player proposes the same term. When the player chooses to vote instead, the player can vote for terms proposed by others, or selects 'neither' to indicate dissatisfaction with all existing proposals; see Figure 6. Voting too earns points, but less than proposing a term.

The approach of crowdsourcing a terminology in such a manner engages the users of the terminology directly and as broadly as possible. Since the games can be played at any time and anywhere, the problem of finding time and members to sit in a workshop is alleviated. Participation is expected to be far broader than the workshop approach. By recording all actions, it is possible to track convergence and divergence of proposed terms. Upon registrations, players are (self) categorised into levels, layperson and expert, and so the method can track divergence based upon expertise and common usage. A terminology thus crowdsourced is expected to serve as a comprehensive input to further processes in the terminology standardization processes.

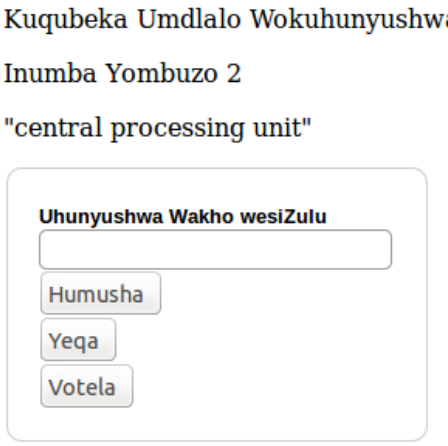

Figure 5: Crowdsourcing: Propose a translation for 'central processing unit', Skip, or Vote, respectively (screenshot of the beta version of the tool).

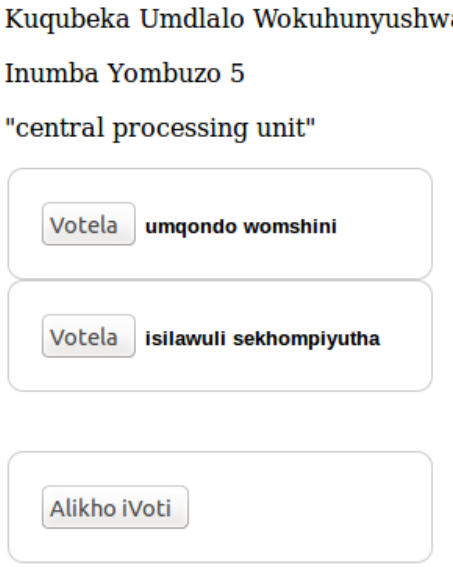

*Figure 6: Crowdsourcing: Voting (*Votela*) for an isiZulu term for 'central processing unit' or vote for neither of them (button with* Alikho iVoti*). (screenshot of the beta version of the tool)*

6. Conclusions

The experiments conducted demonstrate a marked divergence between the terms obtained by the Department of Arts & Culture ICT list and those sourced both from isiZulu-speaking computing experts and computer literacy students. In addition, the experiments indicate some difference in terms proposed by experts and those proposed by laypeople. Consequently, proposed terms must include a wide range of stakeholders and record the level of expertise of proposers, and this level must form part of the post analysis. Further, terminology sourced in this manner yields less zulufied English terms. Hence a clear need is demonstrated for the requirement to broaden the pool of terminology proposers, both in scope (domain experts, laypersons, etc.) and in number. The results also indicate that some form of voting for terms is a necessary component of the terminology development process to obtain preferred terms among synonyms. The results obtained with the computer literacy survey were insufficient to validate or falsify the hypothesis that pictures would result in more and better term proposals compared to English terms only.

Crowdsourcing was proposed as an alternative method for the proposal and collection

stage. It can be deployed democratically and bottom-up, is low-cost compared to resource-intensive workshops, and such a tool can capture new proposals, measure consensus, and store various statistics about the crowdsourced terminology, which can then constitute an informed input for any further stages in standardization. We are preparing for the first experiments of this approach.

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Appendix

Table 4: Results of the term versus picture survey. Note: this is uncurated data, and some proposed terms contain misspellings made by the participants.

Entity (English term)	CompLitTerm	CompLitPicture
CPU	Umqondo womshini, Inhlizoyo yekhompuyutha	isilawuli sekhompiyutha
RAM	--	umthamo wongeno
mouse	Igundane, igundane / igundwane	igundane lekhompyutha, inkomba, igundane
keyboard	Uqwembe lwezinkinobho	ikhibhodi, Isithebe sezinkinobho
microphone	umbhobho	umlekileli woculo, umbhobho wokukhuluma
monitor	Umtshengisi 'zithombe	imonitha
printer	Umgayi 'maphepha	Iphrinta
speaker	Umkhiphi 'msindo	izakha msindo
modem	--	imodemu
wireless	Akukho 'zintambo	umxhumana womoya
virus	Igciwane, igciwane	--
worm	Umnyundu, igciwane	--
spyware	impipi	ithola minininingwane, Ixoki
harddrive	isisu	--
USB	--	umgcina minininingwane
system software	--	uhlelo lesof
operating system	--	iwindi

server	Umsizi	--
computer	Umshini	ides
algorithm	--	umdwebomfanekiso
internet	Umxhumanisi womoya	--
HTML	--	i-html
browser	--	isiphequluli, inkanji/inkambu yolwazi
proxy	--	umngenisi weWephu
booting	Ukuvula	--
IP suite	--	uHlelo Lwe-Ithanethi
internet layer	--	ugqinsi Lwe-Ithanethi
memory	--	imemoli
PC	--	idesithophu
ROM	--	umthamo ofundwa kuphela
website	Indawo emoyeni	--
byte	--	ibhay
gigabyte	--	izingidi eziyizikhulugwane zamabhay'thi
megabyte	--	okubile okuzipende ngashumi amabili amabhay'thi
kilobyte	--	inkulungwane namashumi amabili nakune amabhay'thi
internet protocol	--	ikheli lekhompyutha
email	--	mthumela ncwadi
programming language	Ulimi lomshini	ulimi lokwakha isof[10]
login	Ngena	ikungena ngaphakathi
logout	Phuma	ukuphuma
shutdown	Cisha	izindlela zokucisha ikhomp
bus	--	isixhumanisi
computer program	--	iklasi
driver	--	abashayeli bekhompyutha

Table 5: Computer literacy entities with isiZulu term options, their source(s) and voting results. A term in italics received ≥50% of the votes. DAC: (DAC2005; WS: the workshop experiment; S&S: Shuter & Shooter isiZulu Scholar's Dictionary; Collins: Collins pocket isiZulu; ii translation: http://iitranslation.com/resources/English-isiZulu.html.

Entity	Source	Vote (%)

[10] Several proposed terms such as *isof* are used and can be traced etymologically from 'software' to *isoftware* to the shorthand *isof*, and similarly for *ides* [from *idesktop*, 'desktop computer'] and *ikhomp* [from *ikhompuyutha*, 'computer'].

English	***isiZulu***		
bit	inhlansi	Workshop	17
	isimumathalwazi esincu	DAC2005	44
	ibhithi	DAC2005	28
	angazi		11
browser	*ithuluzi lokucinga*	Workshop	61
	isiphequluli	DAC2005	33
	angazi		6
byte	izinhlansi ezili shagalo-mbili	Workshop	11
	isimumathalwazi	DAC2005	28
	isimumathikazi	S&S	28
	angazi		33
database	inqolobane	Workshop	6
	ulwazi olugciniwe	DAC2005	29
	ulwazi olulondoloziwe	DAC2005	12
	imininingo egciniwe	DAC2005	47
	inqolobane yolwazi/isilondalwazi	S&S	6
	angazi		0
internet	inkanji yolwazi	Workshop	11
	uhleloxhumano lomhlaba	DAC2005, S&S	56
	intanethi	DAC2005	28
	angazi		6
email (ibizo)	umbikombani	S&S, DAC2005	18
	isiqoqelalwazimbiko	S&S, DAC2005	24
	iposisiqoqelalwazi	S&S, DAC2005	18
	i-imeyili	S&S, DAC2005	29
	angazi		12
computer	*isiqoqelalwazi*	DAC2005, ii translation	53
	ikhompuyutha	DAC2005, collins, ii translation	47
	angazi		0
laptop	umathangeni	ii translation	11
	isiqoqelalwazi esipathekayo	DAC2005, ii translation	78
	angazi		11
bandwidth	umkhawulokwamukela	DAC2005	12
	umkhawulokudonsa	DAC2005	29

	angazi		59
mouse	igundane lesiqoqelalwazi	S&S	12
	Igundane lekhompyutha	S&S	35
	imawusi	S&S	18
	igundane	Charmaine M.	6
	isilawuli	DAC2005, ii translation	29
	angazi		0
logic	ilojiki	S&S	12
	ukwazi ukuqonda nokuhlazulula ngohlelo izindaba	S&S	6
	ukuhlela ngokulandelanisa	S&S	82
	angazi		0
data	*ulwazi olungahluziwe*	DAC2005	88
	imininingo	DAC2005	12
	angazi		0
directory	inkomba ekusiqoqelalwazi	DAC2005	35
	inkomba ekukhompuyutha	DAC2005	12
	inkombamininingwane	DAC2005	47
	angazi		6
install	-xhuma	DAC2005	41
	-faka	DAC2005	53
	angazi		6
open source software	uhlelokusebenza oluguqukayo [lwesiqoqelilwazi]	DAC2005	12
	uhlelo oluvulelekile [lwesiqoqelilwazi]	DAC2005	53
	angazi		35
printer	*isikhiphambhalo sesiqoqelalwazi*	DAC2005	59
	iphrinta	DAC2005	41
	angazi		0
satellite dish	*indishi yesiphakalwazimkhathi*	DAC2005	71
	indishi yesathelathi	DAC2005	18
	angazi		12
server	*inhlokosiqoqelalwazi yohleloxhumano*	DAC2005	76
	iseva	DAC2005	18
	angazi		6
wide area network	*uhleloxhumano olusabalele*	DAC2005	71

	uhleloxhumano olumgamubanzi	DAC2005	24
	angazi		6

Table 6: Entities of the "e-something" variety and their isiZulu counterpart.

English's e-term treatment in isiZulu		**Rough translation into English**
English term DAC2005	***isiZulu term(s) from DAC2005***	
e-commerce	uhwebo ngohleloxhumano	
e-government services	ukuthola usizo lukahulumeni ngohleloxhumano	
e-learning	ukufunda ngohleloxhumano	'to learn with/by the network'
e-literacy	ulwazi ngesiqoqelalwazi, ulwazi ngekhompuyutha	'knowledge with the computer'
electronic advertising	ukukhangisa ngohleloxhumano	
electronic media	ezokuxhumana ngobuchwepheshe bomoya	
electronic transaction	ukuthengiselana ngohleloxhumano	
email (n)	umbikombani, isiqoqelalwazimbiko, iposisiqoqelalwazi, i-imeyili	iposisiqoqelalwazi ≈ 'computer mail'
e-readiness	ukulungela ukusebenza ngesiqoqelalwazi, ukulungela ukusebenza ngekhompuyutha	'get ready for to learn with the computer'