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An integrated e-dictionary application
– the case of an open educational trainer for Zulu

Abstract: This article describes an English Zulu learners' dictionary that is part of a larger set of information tools, namely an online Zulu course, an e-dictionary of possessives (which was implemented earlier) accompanied by training software offering translation tasks on several levels, and an ontology of morphemic items categorizing and describing all parts of speech of Zulu. The underlying lexicographic database contains the usual type of lexicographic data, such as translation equivalents and their respective morphosyntactic data, but its entries have been extended with data related to the lessons of the online course in order to enable the learner to link both tools autonomously. The 'outer matter' is integrated into the website in the form of several texts on additional web pages (how-to-use, typical outputs, grammar tables, information on morphosyntactic rules, etc.). The dictionary comprises a modular system, where each module fulfils one of the necessary functions.

1. Introduction and aims

1.1. *Background*

Lexicographers nowadays see e-dictionaries as language tools that attempt to meet many kinds of information needs of language learners as well as of on-the-fly-users. Such tools need to provide extra-lexicographic content, such as modules processing morphophonetic rules or corpus data demonstrating the usage of words of a given language. As Gouws (2013: 136) stated, 'working towards such an environment where dictionaries are not seen as isolated

products but as part of a more comprehensive reference system implies that a stronger integration approach is also needed within the lexicographic environment.'

Particularly in the case of the African languages, Prinsloo (2010) showed that most dictionary websites have poor coverage and are rather static, one struggles to get a translation, and usually there is no paraphrase available describing the sense of an entered word. The *isiZulu.net* site is one of the few exceptions. This online dictionary provides users with morphosyntactic information on Zulu and more (ibid: 188). Oxford University Press (see *IsiZulu Oxford Living Dictionaries*) is in the process of preparing a free online dictionary of Zulu, but so far, their coverage is rather limited.

Our project is concerned with an online course for beginners[1] who are learning Zulu. The course is offered by the University of South Africa (Unisa), a dedicated open distance learning (ODL) institution, and is currently placed in the learning environment myUnisa[2] (with software provided by SAKAI[3]). The dictionary targets English speaking students of Zulu, it is bi-directional concerning words and mono-directional concerning phrases (Zulu to English only). While English is the language of tuition, the majority of data items concerns the Zulu language (e.g. information about usage of phrases). The online learning platform myUnisa, launched in 2006, facilitates online tuition and delivers study material of several types. The modes of online tuition range from the most elementary method (Group A), the so-called 'paper under glass' approach with no printed documents delivered to students, to the method using a wide variety of available electronic tools (Group D). These include online learning activities and tasks as well as new online learning experiences (cf. Kosch and Bosch 2014). The newly designed course belongs to category D and will be linked to the electronic dictionary described in this article.

Since the course is mostly focused on acquiring communication skills, the content is divided into several everyday topics that are presented in the form of a dialogue or paragraph in order to encourage students to engage in conversation with mother-tongue speakers. For instance, students are taught to exchange greetings, to make somebody's acquaintance, to talk about the weather and their health, and to communicate in the business sector as well as at the work place. Throughout the module, students are guided by hyperlinked sound recordings which form part of the tutorial package. The current tutorial package (of Group A) consists of a static study guide and a CD-ROM.

1.2. *Design aims*

When considering how to teach a language, we need to distinguish *behaviourist* versus *self-directed* (or *autonomous*) learning. The traditional behaviouristic way to learn a language is to follow the teacher's guidance in every step, while self-directed learning means that the student decides what to learn,

Figure 1: Welcome page of the myUnisa course (test environment).

how and when. This coincides with the Unisa ODL Policy (2008: 2) that states: 'Open learning is an approach to learning that gives students flexibility and choice over what, when, where, at what pace and how they learn.' To achieve this, learners must be equipped with a sufficient overview of the material provided so that they can work through the course independently.

While the language course on myUnisa guides our students through the lessons one by one[4] (see Figure 1 showing the welcoming page), the dictionary provided with the course can be seen as part of the newly implemented self-directed learning. Here, language learners decide themselves what to look up and how much information they require of the offered outputs (see Figure 2). In a country like South Africa, where most adults have experienced mainly behaviourist teaching, providing an easy-to-use dictionary website for users with limited experience in directing their learning themselves can be considered a challenge. We hence aim at a simple design where information overflow is avoided and where all parts of the page can be clearly distinguished from each other. In addition, a number of help texts, in case the user has no (e-)dictionary experience, are provided as well as links to the study guide material. We also seek to use the same terminology in the dictionary as in the connected online course.

Like Nerbonne (2003: 680), we consider hypertext links essential, allowing the student to acquire details on issues described in the dictionary entries. We add links not only to our own descriptions and tools developed previously (e.g. an e-dictionary of possessives, as described in Bosch and Faaß 2014), but also to external sources such as *isiZulu*.net, a well-known and reliable English to/ from Zulu dictionary, and to linguistic glossaries. Still, we do not know our users and their expectations (in the framework of our project, there are no statistics available on the type of student taking this course), hence we also cater for the experienced (maybe on-the-fly) user who might only want to have a word or phrase translated (cf. Figure 2). Other functions offered by the

Figure 2: Home[5] page of the dictionary

dictionary's welcome page are, among others, to provide the user with all lexicographic details stored about a Zulu word, noun formation from stems, and the analysis of inflected and/or complex verbs. For inexperienced users, the 'dictionary' page offers the same options, but with more background information and direct access to the help texts, as shown in Figure 3. Each of the dictionary functions will be explained in more detail in Section 3.

1.3. Evaluation aims

In our general methodological approach for the evaluation of both the online course and the dictionary, we follow Colpaert (2006: 481-482) describing a 'cyclical process of development, implementation, and evaluation', as stated in Heift (2010: 445). We are still in the initial phase of conceptualizing and developing the first electronic versions and implementing them. A first phase of evaluation (by lecturers) will follow. As Swanepoel (2015: 364) suggests, our (hopefully) useful 'tool [. . .] still has to be tested empirically for effectiveness'. Hence, once the suggestions and corrections of the lecturers have been implemented, we plan to have a second phase of evaluation, this time by students, who will get access to the original and the modified courses, and will be asked

Figure 3: The 'DICTIONARY' page

to give feedback and suggestions for further changes. Additional usage studies (monitoring log files, etc.) will also be included in order to enhance the system continuously.

1.4. Implementation aims

Villiger (2004: 192-193) describes *communicative CALL* as an approach to teaching language structures and meaning by making the student practise alongside language material which is as authentic as possible. The Zulu beginners' course on myUnisa is structured in lessons describing specific communicative situations with a number of new words and phrases that are to be learnt and practised right away. As will be described in Section 2, it is nevertheless very important for Zulu learners to also understand the morphophonological rules when building words from morphemes. Therefore, we add additional information on such rules and provide several tables for a better overview similar to a grammar section of other learners' dictionaries such as the *Oxford Bilingual School Dictionary: Zulu and English* (2010: S2-S27). These are made available by static links present on every page of the dictionary (see the top horizontal frame in Figure 2 which remains stable). In a way we thus offer a poly-functional dictionary while avoiding the problem of information overload. As users can select their information needs on the home page directly, only the data requested will be shown.

The SAKAI learning environment does not foresee a dictionary, hence we implement our learners' dictionary on a separate server and link it with the course, thereby making the dictionary available to other users, too. As communicative situations are in the foreground for the learners, the dictionary contains – in addition to the words appearing in the study guide – a number of appropriate phrases as well as additional information about the context in which they are used. Sound files are linked with a number of words and phrases, so the user can listen to typical conversations as well.

In summary, our electronic dictionary is one part of several tools assisting the language learner with a number of modules that are described in detail in Section 3. As it targets English speaking students, the surfaces and all explanations are in English. It can translate words from English to Zulu and vice versa, but focuses on the Zulu language concerning details about words and phrases and their usage.

The dictionary will be evaluated by lecturers of the department alongside the newly designed online course, and as a second step of the evaluation process students will be able to access the system. Only after completion of these two rounds of evaluation and internal approval will the system go online and replace the current, rather static material.

2. Zulu background

As stated above, modern language learning – at least on the basic levels – usually avoids any kind of grammar instruction as students should be enabled to learn a language by practising communicative situations only. In this section, we will describe some morphophonological phenomena of the Zulu language, showing that grammar lessons as part of a beginners' course are essential for Zulu (and Bantu languages in general).

Zulu is a member of the Bantu language family, which has more than 400 languages spoken on the African continent in an area stretching from the Cape of Good Hope to just north of the Equator. Zulu, as one of the eleven official languages of South Africa, belongs to the Nguni group of languages (S30 according to Guthrie's classification (Nurse & Philippson, 2003: 649)) and falls under the South Eastern zone of the Bantu language family.

In many languages, words belonging together in a sentence show the same grammatical features, they "agree". To achieve such an agreement, a number of morphemes are available, such as *s* (or its allomorph *es*) suffixed in English to a verb of the present tense when its subject is third person singular. The morphological structure of Zulu, as is the case in all Bantu languages, is characterised by concordial agreement, that is so-called *concords* utilized to signal grammatical agreement. The Bantu languages are moreover characterized by a nominal classification system where all nouns of the third person are sorted into noun classes. For ease of reference, numbers have been assigned to them

by scholars working in the field of Bantu linguistics. Each of the noun classes has its own concord that is prefixed to the noun stem as a noun class prefix. In example (1)(a), for example, the noun class is 01 and the noun class prefix is *umu*. Other types of concords are defined for different parts of speech, see the examples in (3) below. Only together with the prefix, does a noun have a sense that can be translated into another language.

(1)(a)	*umngane*	
	umu	*ngane*
	PrefClass_01[5]	ROOT_NC
	'friend'	
(1)(b)	*abangane*	
	aba	*ngane*
	PrefClass_02	ROOT_NC
	'friends'	
(1)(c)	*ubungane*	
	ubu	*ngane*
	PrefClass_14	ROOT_NC
	'friendship, comradeship, friendliness'	
(2)(a)	*isihlalo*	
	isi	*hlalo*
	PrefClass_07	ROOT_NC
	'chair'	
(2)(b)	*izihlalo*	
	izi	*hlalo*
	PrefClass_08	ROOT_NC
	'chairs'	

As shown in examples (1)(a)/(b) and (2)(a)/(b), noun prefixes usually indicate number, with the uneven class numbers indicating singular and the corresponding even class numbers indicating plural. There are, however, exceptions, such as class 9 singular pairing with class 6 as plural.

To enable agreement in phrases and sentences, a suitable subject concord is prefixed to the verb denoting the same noun class as is used by its subject. If the object is pronominalized, a respective object concord is prefixed as well: this object concord then functions as the pronoun. Adjectives, possessives, pronouns and all other parts of speech that agree with the noun they belong to must also have a noun class indicating concord, as illustrated in example (3), where all class indicating morphemes referring to the subject are underlined.

(3) *Abafundi laba bafuna izincwadi ezimbili*

aba	fundi	laba	ba	fun	a	izin	ncwadi	ezim	bili
PrefClass_ 02	ROOT_ NC	PRO_ DEM_02	CS_ 02	ROOT_ VMAIN	SuffV End	PrefClass_ 10	ROOT_ NC	CRel_ 02	ROOT_ QUAL_ ADJ

'These scholars want two books'

Zulu, like all the members of the Bantu language family, is predominantly agglutinating in nature, with the majority of words consisting of more than one morpheme, see example (4).

(4)(a) *sisazobatshela*

si	sa	zo	ba	tshel	a
CS_2p_pl	PrefAspProg	PrefTenseFut	CO_02	ROOT_VMAIN	SuffVEnd

'we will still tell them'

(4)(b) *ningahambi!*

ni	nga	hamb	i
CS_2p_pl	PrefNeg	ROOT_VMAIN	SuffVEnd

'Do not go!'

Each Zulu example represents a number of bound morphemes which cannot occur independently as separate words. Hence each of these orthographic words is of a polymorphemic nature consisting of affixes attached to the root or core of the word. Zulu has only a limited number of monomorphemic words, that is, words consisting of free morphemes, such as, for instance, ideophones (e.g. *nti* 'of stinging'), some conjunctions (e.g. *uma* 'when') and interjections (e.g. *cha* 'no').

In the majority of Zulu dictionaries, the so-called stem tradition has been followed in the lemmatization of nouns and verbs. This means that in the case of verbs, the lemma consists of 'the verb root plus all verbal extensions and verb endings, but without any prefixal inflections such as verbal prefixes, concords or morphemes' (Gauton, 2013: 918). The verb in (4)(a) above would therefore be lemmatized as *tshela*. The noun appears in the dictionary as noun stem minus its class prefix, for example the nouns in (1)(a) and (1)(b) above would both be lemmatized as *ngane*. Gauton (2013: 919) highlights the challenges experienced by dictionary users, in particular language learners, who do not usually have the necessary 'formal grammatical, morphological and morphonological training and skills to be able to extract the stem from a particular Zulu noun'. Nouns belonging to class 9/10 that start on *in/im* in the singular and *izin/izim* in the plural are cumbersome to find in a dictionary, e.g.
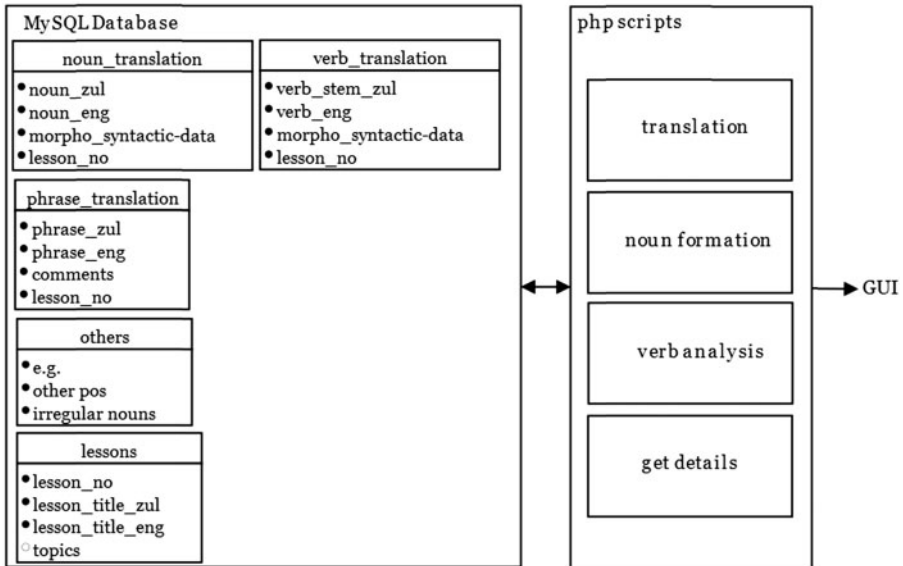
MySQL Database

noun_translation
• noun_zul
• noun_eng
• morpho_syntactic-data
• lesson_no

verb_translation
• verb_stem_zul
• verb_eng
• morpho_syntactic-data
• lesson_no

phrase_translation
• phrase_zul
• phrase_eng
• comments
• lesson_no

others
• e.g.
• other pos
• irregular nouns

lessons
• lesson_no
• lesson_title_zul
• lesson_title_eng
○ topics

php scripts

translation

noun formation

verb analysis

get details

→ GUI

Figure 4: System design (simplified).

inja (dog) is lemmatized as either *nja* or *ja*. We solve this problem by providing internal links from the stem version that is not described (but is expected to be entered) to the one described in the dictionary. A user entering *ja* will hence directly retrieve the data stored for *nja* (see Section 3.7.).

Certain sound changes also complicate the learner's task. For example, in the case of nouns in class 14 with the class prefix *ubu*, a noun such as *utshani* 'grass' is lemmatized under the stem *ani*, and *utshwala* '(traditional) beer' is lemma- tized under the stem *ala*. Such irregular cases are stored in the dictionary in a separate table.

As shown above, we need to provide the learner not only with a dictionary that allows entering stems and full forms of nouns; in the case of verbs (of which some forms would in other languages be described rather as *sentences*, because they contain their subjects and objects), we need to assist the learner in understanding each of the parts of the orthographic word entered. Additionally, it is necessary to provide tables offering an overview of all noun classes and the respective agreement morphemes to be used. Section 3 describes the database and the modules provided in more detail.

3. Database and modules

At present, with Zulu being an under-resourced language, a suitable corpus allowing self-directed learning of Zulu words and sentence structures in real world situations is not freely available; for a start, we can only provide the

learner with pre-defined phrases. We, however, aim at compiling such a corpus to be made available to learners in a later version of either the course or the dictionary. In the meantime, we link our dictionary with the Oxford isiZulu site (*IsiZulu Oxford Living Dictionaries*) because it provides example sentences.

3.l. Database contents, website generation, and connection to the online course

Internally, our dictionary database is a MySQL DB containing noun stems and the classes from which they form nouns (plus some additional information on whether the stem is of foreign origin). In addition, complete noun forms together with their English translation (and a link to the stem) are stored, enabling the user to request information about both noun stem and noun, as well as the lesson where the noun is described (if available). Verbs are stored solely as stems together with their English translation. Irregular tense forms are listed for both languages while regular tense forms can be analysed/generated with php scripts (see Figure 4).

Entries describing other parts of speech are available as well, together with their English translation and additional information. For each of the words, the lesson in which it is first mentioned is stored. We focus on the vocabulary included in the study guide, however, additional data (see 3.8.) is added to allow wider use at a later stage. The study guide describes mainly communicative situations, hence phrases play an important role. Each of the phrases comes with its topic, explanatory data and, again, the number of the lesson in which it was mentioned for the first time. All the scripts generating the dynamic website are written in php (and html), thus allowing flexible design and rule-based morphosyntactic processing to facilitate the generation of full forms from stems and finding stems in full forms. Unlike finite state tools, php allows for a modular design of rules to be added step by step, enhancing the functionality of the tool. At the same time, one has to accept the down side of having to implement the generation and analyses modules separately. We do not foresee fully-fledged morphosyntactic processing as it would necessitate a separate project. Although this would be desirable for a Zulu dictionary, we currently only implement the main structures to be learnt in the beginners' course[7]. Similar to the 'outer matter' provided by printed dictionaries, we aim at describing all of the uses of the dictionary in the form of help texts containing screenshots. Inexperienced users can access those by clicking on question mark icons to be found on the parts of the page where we expect them to experience problems.

In the online course and on the dictionary home page, a link to our ontology of morphemic items (Faaß et al., 2012; and Taljard et al., 2015) is available, as this database provides the user with information on all the closed class morphemes and descriptions of the Zulu parts of speech.

As stated above, the database is implemented modularly, with each of the modules fulfilling one function of the dictionary. The following paragraphs summarize these functions and describe them in more detail. Note that this article is not concerned with the modules implemented in the myUnisa environment, hence the lessons as such, the games, quizzes and other tools for self-assessment are not described.

3.2. Basic translation module

The basic translation module translates words and phrases from English into Zulu and vice versa. It is not necessary to select the language first, as the module will look for the queried character string in both languages and – one by one – in the nouns, verbs, and other parts of speech. The resulting page will then show all translations found in a list ordered according to parts of speech (nouns, verbs, etc. and then phrases). If the results are Zulu words, the user may click on any of them (i.e. translations found) to retrieve more information, such as the lesson number and other microstructural data like sound files, pictures, etc. If the user enters a Zulu word directly under the option 'get details' (see Figure 2), all of this data is shown right away.

3.3. Noun formation

As described in Section 2, Zulu noun formation is a rather complicated matter. Not only are there numerous noun classes, but stems generally occur in two or more classes, and their meaning changes dependent on the class they appear in. We therefore enable our users to enter a stem and retrieve all the Zulu nouns in the dictionary that are formed from it together with the noun class they appear in. For example, by entering the noun stem *ngane* shown in (1)(a), four different results can be expected: *umngane* (noun class 1, 'friend'), *abangane* (noun class 2, 'friends'), *ingane* (noun class 9, 'child/offspring/young') and *izingane* (noun class 10, 'children/offspring/young'). Again, the results are shown as hyperlinks and clicking on one of them leads to showing its details.

3.4. Verb analysis

Orthographic verb forms of Zulu may contain their subjects and their objects together with a number of morphemes triggering negation or setting tense and mood, etc. (see examples (4)(a) and (4)(b) in Section 2 which represent relatively simple forms). In the time given for our project, we cannot develop a fully-fledged verb morphology, i.e. a rule-based lemmatizer covering all possible forms a verb can take, but we do implement as many verb structures introduced in the study guide as possible in this timeframe, that is, among others, the present tense verb stems merged with all possible subject concords

(abbreviated 'CS' in the examples above) as well as object concords. We also plan to implement all so-called long present tense and perfect forms, and some simple past and future tense forms. When a learner enters such a verb form, it will be lemmatized and looked up in the database, and the learner will be presented with the morphemes that make up the queried form. If the resulting stem is contained in the dictionary, its translation into English will be shown as well.

3.5. Lists of entries

We want to enable learners to also browse through the available data, hence the dictionary produces lists of all nouns and verbs on request (see the right-hand frame in Figure 2) for both languages. After selecting an entry, users can choose whether they only require its translation or all the related data contained in the dictionary (in other words, the 'translate' and 'get details' buttons are both available).

3.6. List of phrases categorised by topics

In travel guides, the dictionary part is structured according to the communicative situation described. Similarly in our course, the titles of the lessons describing such situations are stored in the dictionary, where a drop-down list is available for students to select a topic (for example 'greeting' or 'introduction'), and to retrieve the Zulu phrases belonging to this lesson together with additional explanations and translations. Taking into account our aims and target users, we foresee only a mono-directional use of this feature.

3.7. Linking

As described in Section 2, we need to cater for variations of noun stems. Therefore, a linking table is included in the dictionary, where forms of stems that might be entered, but which are not described, are linked with those for which we have data. A user entering *ja*, for example, will be directed to the stem description of *nja*. On the screen, a comment will be shown saying this dictionary usually contains the stem forms beginning with 'n'. We also link alternative phrases (e.g. the greeting form *Sakubona*) to regular entries (in this case, *Sawubona*).

3.8. External tools and data

We recently developed a multilingual ontology of parts of speech for the nine national Bantu languages of South Africa, which *inter alia* includes all closed class morphemes of Zulu (Faaß et al. 2012, and Taljard et al. 2015). Since a

description is given for each part of speech, we have linked this ontology to the dictionary and to the online course. Students can, for example, select one category and not only read the description, but also ascertain which morphemes are available in this category. By linking our dictionary with the ontology, we can dispense with entries of function words in the dictionary and focus on content words.

In the preparatory phase of this project, we developed an e-dictionary of possessives, containing about 1,000 English nouns, which solely translates English possessive constructions into Zulu (Bosch and Faaß 2014). For each translation, users can retrieve not only the translation result, but a step-by-step explanation of the translation process. As one of the lessons in the beginners' course explicitly deals with the formation of Zulu possessives, we link this dictionary with ours (and with the course, too). We have also added all stems of the Zulu nouns to the learners' dictionary. Hence the noun formation module can be used as well and each of the nouns can be translated separately.

Sanasi (2015) has developed a trainer on the basis of the possessives e-dictionary, where students are able to perform translations of possessives step by step. For each of the steps, feedback is given to the user. The trainer is currently in its evaluation phase and will eventually be linked from the online course and the dictionary.

4. Conclusion and future work

The dictionary described in this article is part of a wider set of information tools that mainly consist of an online Zulu course developed in the SAKAI environment (myUnisa), an e-dictionary of possessives developed earlier, which comes with training software based on this dictionary, and an ontology of morphemic items categorizing and describing all Zulu parts of speech.

The design of the bilingual electronic learners' dictionary described here follows the principle of avoiding information overflow while still providing all information and data a first year student of Zulu is expected to retrieve with a mouse-click. The tool comes with four functions: (1) basic translation of full forms from English to Zulu and vice versa ('translate' in Figure 2), (2) Zulu noun formation from a given stem ('find nouns'), (3) verb form analysis to find the Zulu verb stem together with its English translation ('analyse'), and (4) providing all data contained for a Zulu word ('get details'). Additionally, lists of the entries can be produced for browsing. We have added a considerable amount of 'outer matter', such as help texts assisting learners in using the dictionary, a rules section describing the most important grammar rules (also linked with the myUnisa course), and a tables section offering an overview of the noun-class dependent morphemes to be selected when producing language, i.e. generating fully inflected words.

By February 2016, the system will have entered its first evaluation phase: Zulu lecturers of the Department of African Languages at Unisa will evaluate the tools and give feedback. After their comments and criticisms have been analyzed, a second version will be implemented to be offered to students for testing. From the third evaluation phase on, the monitoring of log files will be added. When the system is considered ready for use, it will replace the current basic Zulu course. The type and style of evaluation still has to be decided upon and will thus form part of our future work.

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Notes

1 This course is being developed by a team of Zulu lecturers and a computational linguist together with the Academy for Applied Technology in Teaching and eLearning (AATeL) at the University of South Africa (Unisa).

2 https://my.unisa.ac.za/portal

3 https://sakaiproject.org/

4 Though students can decide what to learn when (it is a distance learning course), we consider the course material behaviouristic, as it guides students through the issues to be learnt similar to a teacher, with regular self-assessments in between.

5 The template *education zone* was taken from www.templateworld.com. Accessed on 3 November 2015.

6 Abbreviations of morphemic units are accessible in Faaß et al. (2012), cf. http://www.njas.helsinki.fi/

7 For advanced learners, a finite-state machine ZulMorph, that analyses Zulu words (but without translations), is already available, see http://gama.unisa.ac.za/demo/demo/zulmorph.

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