Improving Teachers' Cognition of Academic Language Learning in Technology Education

A Design-based Research Project between Flanders and South Africa

Jan Ardies, Piet Ankiewicz, Nele De Witte and Eva Dierickx

Less than 11% of South African learners choose STEM subjects in higher education, although STEM is compulsory in junior high school. One reason is the difficulties many school learners have with English as the language of teaching as most of them have a different mother tongue. In Flanders the STaalvaardig project which consists of an online professional development programme, operates in a context where about 20% of the learners' mother tongue is different from the language of teaching. As a result, Flemish teachers have become more aware of their cognitive academic language proficiency (CALP) which is needed for successful STEM education. Despite the ratio between English second language (ESL) learners and home language learners in South Africa (80:20) being a mirror image of the ratio in Flanders (20:80), the best practices of the STaalvaardig project in Flanders may hold affordances for a similar project within the South African context. The purpose of this paper is to identify such best practices and affordances. Online professional development has proven to be sustainable and stimulating in Flanders. The aim of a similar two-year project in South Africa which started in January 2020, is to improve technology teachers' awareness and pedagogical knowledge about cognitive academic language in technology education. This will be done by adapting the existing STaalvaardig online environment to scaffold junior high school technology teachers' CALP. The South African online programme will be piloted in five junior high schools where mainly ESL learners are being taught technology in English. The methodology will be design-based research. The findings indicate that the best practices associated with the STaalvaardig project may hold valuable affordances for a similar research-based project in South Africa in future, provided that the context is sufficiently taken into account. The successful implementation of such a project will be of crucial importance to support the teaching and learning of technology education in English in South Africa and to improve ESL as Language of learning and teaching (LOLT) in technology education.

Keywords: Technology education, Professional teacher development, Cognitive academic language proficiency (CALP), English second language (ESL), Language of learning and teaching (LOLT), Design-based research (DBR)

Introduction to the South African context

Multilingualism in South Africa

South Africa is not only a multicultural country but also a multilingual one. There are 11 official languages in South Africa. The majority of school learners have an African language as home language. In the junior primary school (i.e. Grade R – 3) learners' home language is the language of learning and teaching (LOLT). Schools usually cater for the dominant African language spoken in the specific area as languages vary from area to area. In the vicinity of the Soweto Campus of the University of Johannesburg (UJ), for example, the dominant African languages are isiZulu and Sesotho.

Taylor and Coetzee (2013) have pointed out that South African learners perform poorly in international assessments of educational achievement. The Progress in International Reading Literacy Study (PIRLS) surveys of 2006 and 2011, as well as the TIMSS surveys of 1995, 1999, 2003 and 2011 consistently demonstrated that South Africa's performance is amongst the lowest of all participating countries.

Some of the factors affecting performance include the non-utilization of mother tongue language (GDE, 2009). “Language is not everything in education, but without language everything is nothing in education” (Wolff, 2006:50). Evidence suggests that the switch from home language to English as LOLT at the beginning of Grade 4 has a significant effect on learners’ performance and poses great challenges to both the learners and their teachers. In the case of a primary school for example, the pass rate of 90% at the end of term 4 in Grade 3 dropped significantly to 57% at the end of term 1 in grade 4. Based on the work of Cummins (1981) it seems that although learners may have basic interpersonal skills (BICS), they lack cognitive academic language proficiency (CALP) and as a result struggle with academic English. Language proficiency refers to the level of competence at which an individual is able to use a language for both basic communication tasks and academic purposes (DBE, 2010).

Close to 80% of learners in Grades 7 – 9 in junior high school in the South African school system learnt via medium of English and 82% in Grades 10 – 12 in senior high school in 2007. The dominance of English as LOLT in the South African school system reflects a combination of factors, namely parental preference, tradition and capacity. English is usually favoured as LOLT because of the following perceptions:

- English is associated with economic growth
- It is seen as a global language
- It is useful for future studies, as tertiary education tends to be offered in English
- It is a common language in the working environment in South Africa (DBE, 2010).

English as the predominant LOLT is an obstacle to learning for most learners as it is not their home language. Many teachers lack proficiency in English and their lack of proficiency in both BICS and CALP negatively affects learner performance (NSTF, 2017). The DBE report (DBE, 2010) recommended, inter alia, that teacher training and development programmes should include issues related to LOLT.

Language and STEM education in South Africa

Language has been found to be a critical issue in the teaching and learning of mathematics and science. Poor language development has severe negative consequences for learners at all levels and in all grades. Teachers have indicated that terminologies in especially mathematics and science have to be retaught in grade 4 with learners then having to master not only the subject content but also a new language. These factors impact dramatically on understanding and results. LOLT being generally different from home language poses a challenge, especially in mathematics, science and technology (MST), as terms often cannot be translated. This impacts greatly on knowledge content, interpretation and application. The Ministerial Task Team (DBE, 2013) has proposed that the DBE should consider the provision of mechanisms, resources and guidelines for all grades to support the teaching and learning of MST in English.

From the different reports (DBE 2013, 2016, 2019) it is clear why the serious issue of a low number of learners choosing STEM subjects at the end of Grade 9, as well as their unsatisfactory performance in Grade 12, has not improved significantly. The DBE focuses mainly on supplying learning and teacher support materials (LTSM) from Grades R to 9 in the form of workbooks, lesson plans and teacher guides. In junior high school (Grades 7 – 9) only workbooks for Mathematics as part of the MST subjects have been developed and distributed (DBE, 2016). Despite language having been found to be a critical issue in the teaching and learning of mathematics and science, and the proposal by the Ministerial task team (DBE, 2013) that the DBE should consider the provision of mechanisms, resources and guidelines for all grades to support the teaching and learning of MST in English, very little if anything has been done to improve English second language as LOLT.

The next section focuses briefly on the Flemish context and the STaalvaardig project. It also introduces the problem statement, purpose of the research and the research question.

The language in STEM project 'STaalvaardig' in Flanders

Flemish context, problem statement, purpose of the research and research question

In Flanders the STaalvaardig project, which started in September 2018, entails an online professional development programme and operates in a context where about 20% of the learners' mother tongue is different from the language of teaching. The aim of the project is to:

- create a profound attitude towards teaching in a language-developing way
- create an awareness of the importance and impact of cognitive academic language in STEM education
- improve teachers' awareness and pedagogical knowledge of cognitive academic language in STEM education.

The Staalvaardig project focuses on the teachers without ignoring previous research on learners' problems when they are not taught in their mother tongue (cf. Baylon, 2015). Teachers of subjects other than the languages might be ignorant of the importance of teaching in a language that learners understand, both on a linguistic and a cognitive level. Therefore, the project focuses on the improvement of teachers' academic language competency by means of a continuing professional teacher development (CPTD) programme in order to have a much wider impact than focusing on the learners only. Furthermore, Van Dijk and Hajer (2018) stated that technology and engineering teachers need knowledge about language that can be considered part of pedagogical content knowledge (PCK). Thus, research on teachers' development and application of such language-related PCK should be conducted in both in initial teacher education programmes and CPTD programmes.

Although the ratio between English second language (ESL) learners and home language learners in South Africa (80:20) is a mirror image of the ratio in Flanders (20:80), the best practices of the STaalvaardig project in Flanders may hold affordances for a similar project within the South African context. The purpose of the paper is to determine the best practices of the STaalvaardig project in Flanders that may hold affordances for a similar project in South Africa. The underlying research question for the paper is: What are the best practices of the STaalvaardig project in Flanders that may hold affordances for a similar project within the South African context? In the next section the research methodology of the Flemish STaalvaardig project is described.

Research methodology

The STaalvaardig project in Flanders employs qualitative design-based research (DBR). DBR is a systematic study aimed at the design, development and evaluation of an educational intervention, intended at improving educational practice and which leads to contextually-sensitive design principles and theories (Plomp, 2010). According to Anderson and Shattuck (2012) DBR is situated in a real educational context which provides a sense of validity to the research and ensures that the results may be effectively used to assess, inform and improve practice in at least the context concerned. DBR comprises various stages, namely needs assessment, design, development, implementation, redesign and product release (Chang, 2011), and the STaalvaardig project adheres to DBR-aligned stages.

The Flemish participants in the first year of the research consisted of four teachers from two different primary schools, one teacher from a secondary school, two primary school student teachers and two secondary school student teachers. All the participants were purposively sampled (Babbie, 2008) based on their prior knowledge and pedagogical capabilities regarding science and technology lessons. In Flemish primary schools, as in South Africa, science and technology is a combined subject. Subsequently, the online tool was a joint one for the single subject, science and technology. It focused on language in the combined subject and not on the individual subjects of science or technology and contained examples for both subjects. All selected schools were located in a neighbourhood with a significant number of non-native speakers. These participants co-created the learning environment during the design research.

Surveys, interviews and observation were used as data-collection methods. The data were analysed using the constant comparative method. Units of data were compared by searching for patterns, which were then grouped into categories and finally into research themes (Babbie, 2008; Merriam, 2009). Trustworthiness was ensured by means of source and methodological triangulation (Cohen et al., 2007; Van der Donk & Van Lanen, 2016) and member-checking (Merriam, 2009). Data were collected from various sources (literature review on language in STEM education, teachers, student teachers) and by means of various methods (surveys, interviews, observations). The DBR involved several researchers in close relation with the participants, thus increasing the trustworthiness by including multiple perspectives. In the next section the findings for the various DBR-aligned stages of the Flemish STaalvaardig project are reported.

Findings

Needs analysis stage

At the start of the research all the participants completed a pre-survey on their self-efficacy regarding language education in science and technology lessons. The survey was based on the Ohio State Teacher Efficacy Scale (OSTES) developed by Tschannen-Moran and Woolfolk Hoy (2001) as well as its underlying theoretical framework. It included questions like *"To what extent can you prepare good language-developing questions for your learners in science and technology lessons?"*

All the participants were also interviewed about their needs concerning language integration in science and technology lessons. Following the analysis of the data, the various categories of the design principles for a support tool for the teachers were grouped into categories and themes. These emerging categories and themes were thoroughly checked and refined at a meeting with the teachers and student teachers, which led to a broad consensus of the various design principles (refer to Table 1) that should underpin the support tool.

Table 1. Themes and categories of the design principles for a support tool.

Themes	Categories
• The tool should comply with specific aspects of pedagogical guidance.	• Contain relevant examples from practice • 'Ready-to-use' method • Manual or roadmap • Visual material to use in classrooms • Flexibility for personal input • Expert guidance. "*Preferably I would like to have good examples from practice in a visual way or on a plastic sheet. Tips that you simply hear are hard to remember." – Primary school teacher*
• The tool should meet certain practical requirements.	• Affordable price • Not time consuming • Web or paper based and easy to use • Gamification of the tool. *"Sometimes you want to change something, but you just don't have the time to do it." – Primary school teacher*

• The tool should promote teachers' competence.	• Improve self-efficacy
	• Develop of pedagogical knowledge
	  o What is language differentiation?
	  o How to integrate language in science and technology
	• Awareness of the difficulties
	• Alignment with school mission.
	
	"*In technology lessons work is so hectic ... Maybe I have to discover this a bit myself." – Primary school teacher*

• The tool should relate to the learners' context.	• All learners should understand the task • Link with home-language • Measure learners' progress • Assess learners' language competence. *"I would like to know how you can give specific instructions. And how to integrate relevant professional language into your projects (topics)." – Secondary school student teacher*

During the meeting with the participants the following six (6) categories of design principles were determined as the most essential for a support tool:

1. Web or paper based and easy to use
2. Assess learners' language competence
3. Not time consuming
4. Contain relevant examples from practice
5. Develop pedagogical knowledge
6. Improve self-efficacy.

It also became clear that teachers found the overall assessment of learners' language competence difficult. One teacher explicitly mentioned "*But how do we give grades to our learners in S&T?*" This response indicated that the question regarding support during the assessment of learners' language competence was not solely related to language teaching. As the focus of the research initially was on teachers and not on learners, the assessment of learners' language competence was not taken into account in the development of the tool.

Development stage

With the five remaining categories as design principles a web-based or online tool was developed founded on the work of Hajer and Meestringa (2015) as this would be economical, time-saving and cost-efficient for teachers. No extra training would be needed and teachers could follow the learning paths of their choice at their own pace. Theory on CPTD served also as input in the design principles (e.g. Mercie et al., 2018; Vansteelandt et al., 2020).

To use the online tool in the most effective and efficient way, the teachers' competence of LOLT in terms of their actual strengths and needs were assessed by means of an instrument based on the assessment developed by Pulles et al. (2007). After this assessment all teachers followed two obligatory online learning paths that guided them through the background of CALP namely "Language and STEM" and "To work…". Thereafter, based on the outcomes of the assessment, one of three parallel paths, though partly interrelated, with different final goals and approaches was elected. Teachers could learn more about either providing a stronger context for their learners; classroom interactions; or giving additional language support to their learners (refer to Figure 1).

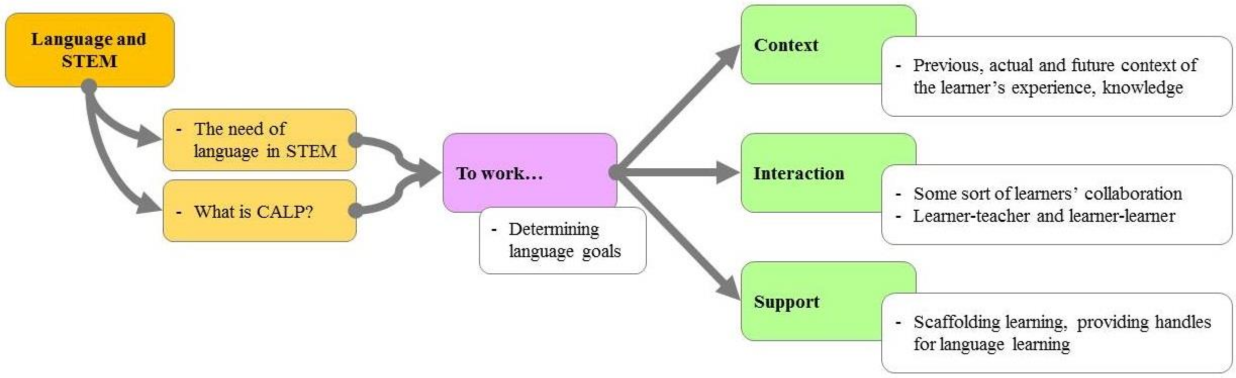

Figure 1. Schematic overview of the learning paths.

Implementation stage

During the implementation stage the participants followed the entire process and developed a series of lessons on a self-chosen topic and goals, using the online tool as guideline, over a period of two months. During this period the student researchers observed the teachers' lessons and interviewed them to establish the teachers' experiences of the tool.

Overall the teachers were positive about the tool and how it affected their lessons. The focused guidance in one of the three learning paths was put forward as a positive aspect as it was not time consuming. According to one teacher *"The handy thing about the tool was that you received a few sample guiding questions based on the core concepts that you selected."*

The participants also experienced that even with this focus on relevant information there was a lot of 'theory' to grasp. A teacher pointed out that *"You had to read a lot."* Teachers also discovered that when they had completed the online test which was included in the learning paths, they got a response that they had made an error without knowing for which question. A teacher remarked *"So I kept filling it all in again until I was right."*

The teachers were positive about the perceived effects on learners' learning. As teachers paid more attention to language during the lessons their learners' attention increased. A teacher remarked "*Due to more variety in the questions you will notice that learners keep their attention for longer."*

The participants also experienced some personal changes and development. One teacher explained that "*The tool helped me to think more about the vocabulary that learners use. It offers language opportunities*." This self-evaluation of teachers is in line with the findings of the survey on teachers' self-efficacy.

Teachers' self-efficacy

As mentioned before, all participants completed a pre-survey on their self-efficacy of language education in science and technology lessons. They also completed a similar post-survey after the use of the online tool. Some teachers were also interviewed about their experiences with using the tool. Surprisingly, the results of the pre- and post-surveys showed almost no change in the teachers' self-efficacy. It appeared from interviews with five teachers and four student teachers that their self-efficacy had decreased slightly. They felt less able to implement CALP in their lessons. They reported that it was difficult to provide alternative explanations and examples, ask language-developing questions and to use language-developing and assessment strategies to evaluate language in their science and technology lessons.

The negative impact on their sense of competence made the teachers more aware of the importance and necessity of language-developing education. They developed a greater awareness of the importance of paying enough attention to language in science or technology education. Thus, despite the unexpected unfavourable effect on teachers' self-efficacy, an increased awareness of language development in science and technology education was achieved, which was evident in one teacher's remark that "*The tool helped because you become more aware of language use."*

The online tool that guides teachers through the three learning paths for context, interaction and language support thus creates an awareness of the importance of language development in science and technology. It seems that the tool does not develop teachers' language expertise, but does create an awareness of language goals and causes them to reflect on the fact that language-developing education requires proper preparation. The STaalvaardig project thus focuses on the development of subject-specific language among learners by using oral language skills. The teachers themselves play a major role, which is what the participating teachers realised after completing the first year of this design-based research.

Redesign and product release stages

In the near future the tool will be refined and regularly used in Flanders to ensure that the sense of competence of the teachers may be enhanced. Hence, there is certainly still room for further research that includes the evolution of the participating teachers.

The aim of a similar two-year project in South Africa, which started in January 2020 is to improve technology teachers' awareness and pedagogical knowledge about cognitive academic language in technology education. This will be done by adapting the existing STaalvaardig online environment to scaffold junior high school technology teachers' CALP. The South African online programme will be piloted in five junior high schools where mainly ESL learners are being taught technology in English. By importing this online tool to the different context of South African teachers and learners we hope to develop a functional and language-oriented instrument that turns each teacher into a language-wise teacher.

Discussion of the affordances of the STaalvaardig project in Flanders for South Africa

Based on the findings above the best practices associated with the STaalvaardig project may hold the following affordances for a similar project in South Africa:

South Africa can extensively borrow from the pioneering work regarding the STaalvaardig project in Flanders during its first year. The literature review of language in STEM education will be generic and of immense value as a theoretical framework which will give input to DBR in South Africa as well. The review will complement the existing theoretical framework for continuing professional development of technology teachers (Engelbrecht & Ankiewicz, 2016). Furthermore, similar difficulties and challenges to their Flemish peers may be experienced by the South African teachers and learners when teaching and learning in a second language.

DBR, although context specific, is suitable for researching this type of project and may be transferred to South Africa. It will however have to be contextualized for South Africa. The five design principles and their expansion and refinement may be taken as point as departure for the needs analysis in South Africa. They would then be adapted and refined, as they are contextually-sensitive (Plomp, 2010). It is anticipated that technology teachers in South Africa would also prefer language training that is not time consuming, easy to use and which provides direct support and advice for their lessons. The focus should be on the development of technology teachers' CALP, to enable them to develop subject-specific language among learners through oral language skills, without assessing the learners' language competence. In order to plan for learners' learning, technology teachers need to be able to recognise language as part of their learning objectives (Van Dijk and Hajer, 2018). The existing framework for the online tool with its five different learning paths may also be taken as point of departure for the adaptation and development of a similar tool in South Africa, based on the context-specific design principles derived from the needs analysis among South African technology teachers.

Regarding the implementation of the online tool, ways should be investigated of how to reduce the theory part to make it more manageable for teachers. The responses to teachers' answers in the online test should also be made more user friendly so that teachers will know exactly which answers were incorrect. In order to develop teacher self-efficacy one should consider expanding the online component to blended learning by means of face-to-face lectures, workshops and seminars. Teacher consultants or lead teachers could also assist and support the technology teachers physically in this regard. The support should focus on alternative explanations and examples, language-developing questions and language-developing assessment strategies to evaluate language in technology lessons. An instructional design consultant could provide ongoing support on and facilitation of the online tool and may assist teachers accessing it.

The Ohio State Teacher Efficacy Scale (OSTES), which measures teachers' self-efficacy on language education in science and technology lessons may also be applied in South Africa once it has been adapted to suit the specific context. Similarly, the instrument used to assess teachers' competence of LOLT (Pulles et al., 2007) will first have to be adapted to the South African context.

Conclusion

The above-mentioned findings and discussion indicate that the best practices associated with the STaalvaardig project may hold valuable affordances for a similar research-based project in South Africa in future, provided that the local context is sufficiently taken into account. The successful implementation of such a project will be of crucial importance to support the teaching and learning of technology education in English and to improve ESL as LOLT in technology education.

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