



# Playing the Long Game: Voice Computing to Support Education

Dr Laurette Marais & Ms Ilana Wilken

2 November 2022 15:50-16:10 Ruby Auditorium



science & innovation

Department:  
Science and Innovation  
REPUBLIC OF SOUTH AFRICA



# Why the long game?



- South Africa is not human resource-scarce
  - But we are **skilled** *human resource-scarce*
  - This begins with education
- Intervention is necessary at all levels
  - Foundation phase is critical for establishing **literacy**
- UNESCO definition of literacy
  - "... ability to **identify, understand, interpret, create, communicate** and **compute**, using printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to **achieve their goals**, to develop their **knowledge** and **potential**, and to **participate fully** in their **community and wider society**"

# The challenge in South Africa



- South Africa is a proudly multilingual society, offering home language education at foundation phase
  - "Research shows that education in the mother tongue is a key factor for **inclusion** and **quality learning**, and it also improves learning outcomes and **academic performance**. This is crucial, especially in primary school to avoid knowledge gaps and increase the **speed of learning and comprehension**." (UNESCO 2022)
- How are we doing?
  - "**78%** of South African Grade 4 children were not able to reach the lowest benchmark compared to 4% internationally." (PIRLS 2016)
  - "... the fact that most children do not learn to read fluently and with comprehension by the end of Grade 3 (in any language) is arguably **the binding constraint** to **improved educational outcomes for the poor**" (RESEP 2016)
- Major contributing factor
  - "... a paucity of research on reading in the **African languages**" (RESEP 2016)

# The challenge in South Africa



- **Bilingual** education system
  - "Because we have a bilingual education system in South Africa, the majority of children need to become not only bilingual but also **biliterate**" (RESEP 2016)
  - **Home language** (HL)
  - **First additional language** (FAL)
  - **Language of learning and teaching** (LOLT)

# How could the right technology help?



- Requirements for technology support
  - **Reliable**
    - Highly accurate processing (**respect** for the learner)
    - Developed with a focus on **African languages** (**respect** for the languages)
  - **Scalable**
    - 1M+ Grade 1 learners every year
    - 11 official written languages in South Africa

# Is language and voice computing the right technology?



- Learning to read involves expanding language ability
  - **Oral** modality to **written** modality
  - **Speech** processing and **text** processing
- Complement traditional ways of teaching
  - Some aspects can be **automated** (but which?)
- Enable and empower learners
- **Scalability** is baked in
  - 1 well-designed application can be run on millions of devices



# Past, present and future



- **Past**
  - Digital phrase books
  - Hand-crafted "canned" digital content (text and audio)
- **Present**
  - First attempts at applying **voice computing (VC) technology** in the education domain (**iSinkwe**<sup>1</sup> and **Qfrenxy**<sup>2</sup>)
- **Future**
  - High-accuracy natural language processing
  - Customised, expressive synthetic voices
  - Automatic speech scoring



# Ngiyaqonda!<sup>1</sup> An example



- Project to develop a **mobile application** that will harness voice computing technology, including multilingual **computational grammars**, text-to-speech (**TTS**) and automatic speech recognition (**ASR**), to assist in
  - Improving the ability of Grade 3 learners to read for comprehension in their **HL**
  - Assisting in the acquisition of the **LOLT** for Grade 4 and beyond
- Create a speech-enabled digital learning environment that allows children to practice reading and writing by creating grammatically **correct** sentences, first in their **HL** and later in the **FAL/LOLT**



# Reliable and scalable natural language generation

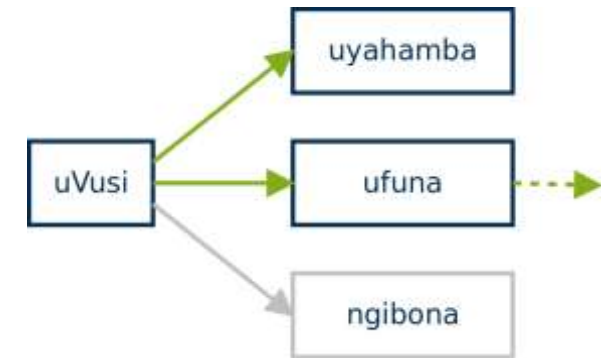


- **Reliability**

- Computational grammars explicitly model the **rules** of a language
- Language model as software
  - Mistakes are **bugs** that can be **fixed**

- **Scalability**

- A sentence is a composition of function applications
  - Automatically generate thousands of examples
  - Sentences are computational artefacts that can be reliably manipulated
- Explicit rules can directly leverage **linguistic similarity**
  - Bootstrap between **African languages**



# Reliable and scalable text-to-speech



- **Reliability**

- VC's **Qfrenzy** is the only commercial TTS product catering for all the South African official languages
- Improve naturalness of voices by improving models of expressiveness
  - Create corpora and develop models that capture expressive speech

- **Scalability**

- Voice adaptation
  - Adapt a baseline model with small amounts of custom data to expand voice catalogue
  - Wide variety of children's voices becomes **feasible**

# Reliable and scalable automatic speech scoring



- **Reliability**
  - Use automatic speech recognition techniques
  - Adapt to child speech
- **Scalability**
  - Leverage **linguistic similarities** between languages

# A reliable and scalable learning environment



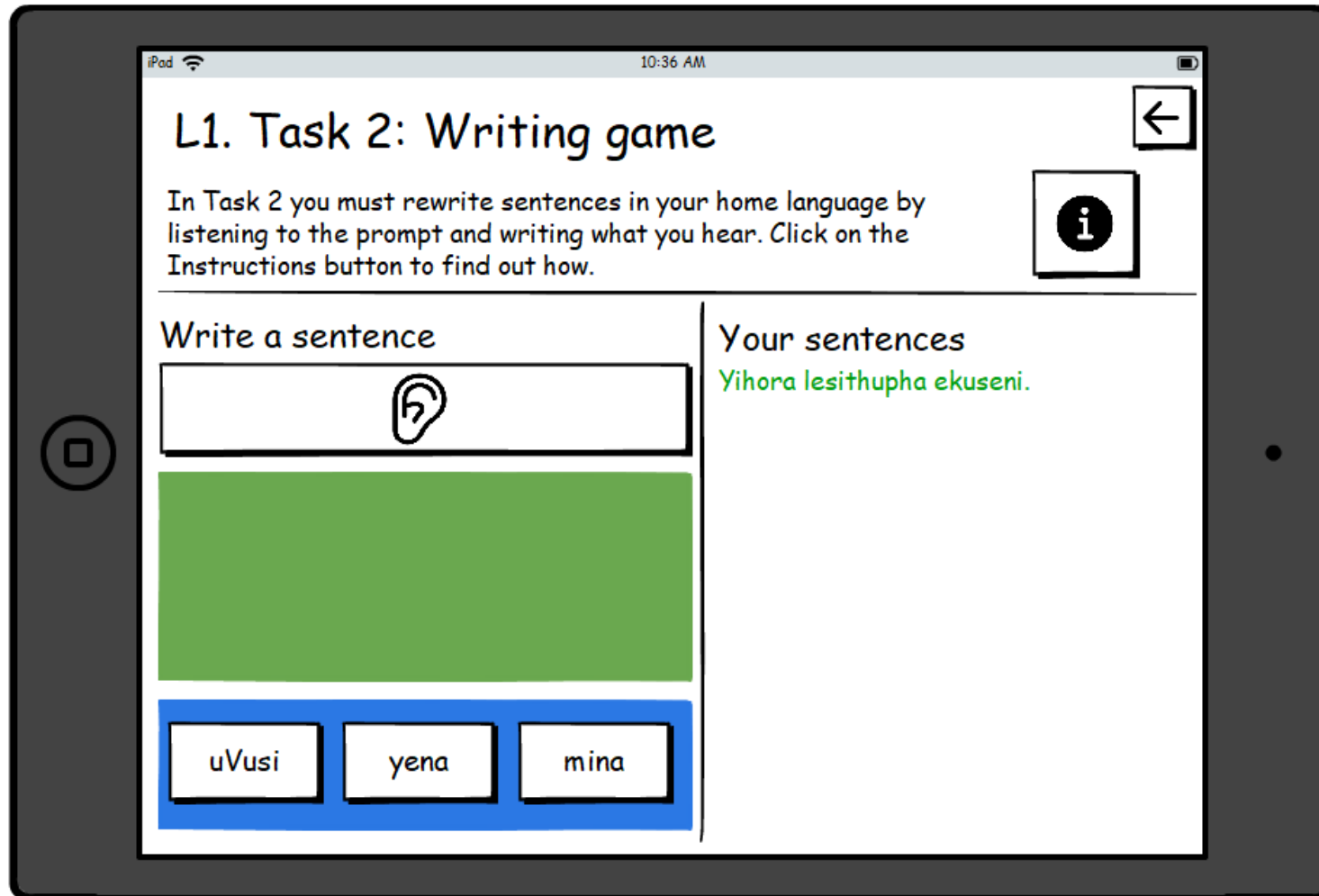
- VC technologies are integrated into a single **application**
- Human-computer interaction principles ensure **user needs** are taken into consideration
- **User stories** and **wireframes**

# A reliable learning environment: user stories



Functional Requirement	Title	User Story
FR01	Construct a sentence	As a learner, I want to listen to a sentence in my home language and rewrite it by dragging words from a list of correct words to an available space and clicking a button to add it to my story.
FR02	Undo a selection	As a learner, I want to remove the last word I added to my sentence so that I can select a different word.
FR03	Listen to a sentence	As a learner, I want to click on my constructed sentences so that I can listen as the app reads the sentences individually.

# A reliable learning environment: wireframes



A user can listen to all static text. The lesson number and task name are listed at the top of the screen. The user can go back to the profile/all lesson screen by clicking on the back arrow icon button. The task instructions are given just below the task name. More detailed instructions are given when a user clicks on the instructions icon button.

- Users must listen to a sentence prompt in their HL and make the correct selections to write the sentence in their HL.
- Once they have made all the right selections, the current sentence is automatically moved to the right hand panel.
- The authoring panel only accepts correct selections.
- Incorrect selections simply snap back.
- There are no "write" or "undo" buttons.
- Once the completed sentence is listed under Your sentences, the user can tap on each one to play them individually.



# Making a real difference



- Voice technology for education must be **placed in human hands**
- **Pilot study** to measure change in reading and writing skills of foundation phase learners
- Intervention group and control group, selected from Grade 3 classes
- Use **Ngiyaqonda!** application during their **reading lesson**
- Results to indicate if skills improved (**reliable**) → introduce to more schools (**scalable**)



# THANK YOU



science & innovation

Department:  
Science and Innovation  
REPUBLIC OF SOUTH AFRICA



**CSIR**  
Touching lives through innovation

# References



- *Why mother language-based education is essential* (2022) UNESCO.org. Available at: <https://www.unesco.org/en/articles/why-mother-language-based-education-essential> (Accessed: October 27, 2022).
- Howie, S.J., Combrinck, C., Tshele, M., Roux, K., McLeod Palane, N. and Mokoena, G., 2017. *PIRLS 2016: South African highlights report*. Centre for Evaluation and Assessment (CEA).
- Pretorius, E., Jackson, M., McKay, V., Murray, S., Spaull, N. *Teaching Reading (and Writing) in the Foundation Phase: A Concept Note*. Research on Socio-Economic Policy. 2017.