



Technical report No. 2



FINAL REPORT



Project factsheet information

Project title	Development of a Shona Early Learner Reading Application on Low-Cost Tablet (Shona Text-to-Speech Voice)
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Partner organizations	<ol style="list-style-type: none">1. F.I.R.E. (Funding for Internet Research Education) – funding for school tablets and research2. Collaboration between Depts. of Electrical Engineering, Linguistics and Education on research3. Ministry of Education Sports and Culture, Mr Sithole at ETC (Education Training Center) and UNESCO – Providing Shona linguistics training skills, and measurement and evaluation guidance4. Computers for Zimbabwe Schools providing link to rural schools, and technical support.5. Local Government Primary School (Name not provided)



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Total budget approved \$10,000.00

Project summary

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Project Summary

NatiV is an Android application under development for e-learning infrastructure that will teach children how to read Shona. In other words, NatiV is aimed at improving a child's syllable-to-sound (letter-to-sound) association. It implements simple, core Android application development concepts, with a UI and gestures that are child-friendly. A new TTS voice is being created for NatiV, in the Shona language, spoken in Zimbabwe. NatiV is also being made with special consideration of dyslectic children. This report outlines some of the work that has been done in the creation of NatiV, clearly outlining the successes and challenges faced in the endeavor.

Background and Justification

Thousands of children in Zimbabwe have little or no access to enough early-learning material. UNESCO points out the advantages of mother tongue based education in the early years; when children are offered opportunities to learn in their mother tongue, they are more likely to engage and succeed in school. Digital tablets offer an intuitive, rich platform for children to learn, in comparison to the ordinary pen-paper methods. Research has shown that children who have had a more interesting way of learning a certain concept will commit it to memory and apply it better.

There is no Android Text-to-Speech (TTS) voice for Shona (Zimbabwe) and many other African languages, and hence very few vernacular early learner ICT-based teaching tools are available.

Project objectives

1. To create a Shona TTS voice (limited domain)
 - a. Demo voice using Ian's voice
 - b. Final voice for application that caters for all the course content that will be on the app
2. To create an Android Application that uses the voice
3. To test this app based on some performance indicators
4. To conclude whether the app is useful or not to its intended audience

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The table below shows the current projects outputs and dissemination

Milestone	Result	Observation(s)/Conclusion
Define Shona Phonetset	Success, Faultless	The phonetset is a crucial and integral part of any Shona TTS system or voice because it defines part of the language's "fingerprint". <ol style="list-style-type: none"> 1. IPA for phones was difficult to generate. However, the resulting phone-set satisfactorily describes the language 2. Phonetset can now be used in any general-usage voice
Limited domain (Time) voice creation	Success, Little Fault	Audio recording and cleaning was a cumbersome and lengthy task. However after dedicating lots of time and patience in improving audio fidelity and labelling, the voice created is convincingly natural-sounding. <ol style="list-style-type: none"> 1. The voice is male 2. The flaws come from labelling issues – it will take a significant amount of time (months) to hand-label the audio files more accurately
General-use voice creation	Success, Significantly Faulty	Although generating a voice for the general-use voice was successful, the voice is not stable – synthesis of sentences or just even words produces undesirable audio hiccups. The reasons for this follow: <ol style="list-style-type: none"> 1. we are still in the process of defining the full Shona ¹lexical entries for a general-usage TTS voice for Festival 2. it will take an enormous amount of time to hand-label the 800 WAV files – most of the error is due to the labelling of phone-phone boundaries (hence determining accurate duration of phone) – if these are not well defined or labelled, there will be significant overlap, and a resulting synthesis inaccuracy.
Creation of demonstrative Android application	Success, Faultless	The application is being improved with time.
Creation of a useable app (for children)	Success, Faultless	The app is available for use, with a fully-functional level and extra mini-games created by other interested developers.

¹ Lexicon - a system of rules which allow for the combination of those words into meaningful sentences.

Summary of Current Results

We were successful at partnering with a local government primary school in Harare on an unofficial arrangement, mainly because of uncertainties as to how to get approval from the ministry of education or government for such a project. The purpose of the partnership is mainly for appreciation, as well as to create a curriculum for learning to read that is based on what and how the teachers are teaching the children. This will then be converted into digital format for the app we have created, which was received with great enthusiasm not only by the students but by staff as well. Several productive meetings were held with the headmaster and deputy head. We agreed on setting up a small team of two teachers from each grade, from grade one through three. This team will oversee the development of the curriculum, which is based on already-existing material but will nonetheless be original in that it will include some significant changes influenced by the teachers' experiences in teaching the subject (Shona). We were able to do some random tests, and observe experiences from both students and teachers. There was little time to train the teachers on how the app works, but intuitively they grasped the concepts and were already discussing the endless possibilities. We observed the terrible state in which the school's computer lab was in, and highlighted the advantages and benefits of having a lab that, instead of the students going **to it**, it comes to them. That is, they were made aware of the benefits of tablets compared to desktop computers - cost, power consumption, convenience, learning curve and many more. The general consensus was that the tablet might be the best ICT learning instrument especially for developing countries, as it also brings more possibilities of reaching rural communities in a practical and more financially viable way than the desktop computer. In short, NatiV is a growing success.

Users and uses

We are now targeting children in grades 1 through 3. This also includes a special group of children – those that are dyslectic. There are over 2000 primary schools in Zimbabwe. This makes the total target reach be over 700,000 children in both rural and urban areas, every year, for an app that will cost less than \$5.00 per year (just under 50c per month). An urban child can sacrifice buying candy to learn in a fun way. One urban child can help one rural child by donating 50c every month. And it is also easier to justify funding for under-privileged children from donors and well-wishers.

On Reading Disabilities

This is a special note on dyslexia. This is a language-based learning disability. It refers to a cluster of symptoms, which result in people having difficulties with specific language skills, particularly reading. (WETA, 2006). Dyslexia makes it very difficult for students to succeed academically. The treatment of this learning disability requires that schools implement academic modifications to help the students succeed. Extra time can be given to students for them to complete certain tasks. Traditionally, students are given “taped” lessons (video or audio) that they view. Dyslectic children

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are legally entitled to special services to help them overcome and accommodate their learning problems (IDA (International Dyslexia Association), 2000)

NatiV is being made in a way that also greatly helps dyslectic children learn faster and better. Here is a list of special NatiV objectives and targets focusing on this learning disability. These are taken from (WETA, 2006). Our standpoint is that we are in agreement of the research outcome: brain dysfunction in dyslexia can be improved (Kopko, 2006)

Teacher Strategies for Dyslexics (WETA, 2006) shares more information on other accommodations involving students’ performances, most of which are useable in the standard classroom as well. This information has been used to evaluate NatiV’s capabilities as follows.

	Theory	NatiV Practical
1	The big picture and how the details fit into it	The child is learning to read, to become successful in academics
2	From parts to whole	The child learns the language at the phonics level up to the level where they can construct whole words
3	From simple to complex	The stages presented to the child become harder. They are first presented with two-letter phones, then three and four as the phonics levels get harder. The word construction levels start off ‘easy’ (combination of two phones) to ‘difficult’ as the child progresses.
4	From concrete to abstract	Given that the child can now correctly identify phones, and make words - they will be able to make whole comprehensible sentences using word/phone stubs available for dragging and dropping into the correct sequence.

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<p>5 From visual to auditory</p>	<p>NatiV utilizes all the characteristics and benefits that come with android tablets (visual, audio, haptic). For example in the initial stages, it presents a child with a sound, and they pick the correct syllable - all in a beautiful and engaging view with bits of animation and haptic (vibrations) feedback.</p>
<p>6 With review</p>	<p>NatiV collects data and stores it in a secure database that will be accessible either remotely or locally for analysis by an expert, or it generates easy-to-understand reports for a teacher.</p>
<p>7 With practice</p>	<p>Practice makes perfect. NatiV will never run out of paper or ink or voice - all it needs is a decent electricity supply via battery or USB charger, so the child can practice as often as they like.</p>
<p>8 Always showing how new information fits in with what they have learned</p>	<p>In NatiV, a child can show Interest or be curious about how a word is used. They just press and hold a phone and up pops out a box showing how the phone is used in an actual word!</p>

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Baseline

The updated project baseline is detailed in the chart below.

Task	Notes	2013												2014				
		May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May				
Set up development environment (Linux)	Prepare Computer	Done																
Understanding linguistics (UZ Course)	Secondary articulation and vowels	Done																
Collect Shona corpus data	Using a collection of Shona poems, part of a collection prepared by the Zimbabwe Poems for Human Rights	Done																
Shona Speaker/Voice Talent	Wendy Tagarira - Media For Development Trust Studios, Milton Park, Harare	Done																
Bedroom setup for experimentation and audio recording	Using compact sound recording setup - condenser mic, headphones, desktop PC. Had problems eliminating noise	Done																
Limited Domain voice prompts recording	Used free recording software. Eliminated noise from hardware level first then software level.	Done																
	Used Ian's voice.	Done																
	Used free VST (virtual sound technology) software level noise removal tools	Done																
First Limited Domain Synthesizer	Successful. This is a talking clock in Shona. Development time close to two weeks - due to learning curve	Done																
Labeling	Optimization of Shona voice by manually defining, using software, where a phone starts/ends accurately	Done																
	Improves synthesis, very cumbersome and time-consuming	Done																
Shona phones and diphones generation	Identified (using the help of friends) 50 shona phones	Done																
	Created a program (NatiV Tools) in Java to generate all possible combinations of these phones to come up with diphone list	Done																
Start FIRE Award - First Payment \$4998	Came up with a possible 512 = 2601 diphones	Done																
	Funds to cover: Development tablets and screen, Projector, approx 50% of student tablets and 1st school evaluation	Done																
	Eliminate impossible combinations (manually) - cumbersome and time consuming. Generate diphone list	Done	Done															
	Alter NatiV Tools to import Shona corpus and identify use of diphones. Statistical results needed	Done	Done	Done														
Studio hours - recording of Shona corpus data	Ensure that in corpus data there is at least 70% use of diphones. If not, add more corpus	Done	Done	Done														
	Recording of selected corpus text. Recording of prompts to import to Festival			Done	Done													
Build and perfect Shona synthetic voice	Generate Voice			Done	Done													
	Test				Done													
Port Shona voice to Android device	Convert voice to Ffile (Festival Lite - for mobile devices)																	
	Create a linux voice/audio server for mobile devices?																	
Test voice on device	Create Android app for test purposes. Must read out typed Shona words																	
Study learning approaches and development of children skills	Work with UZ Education Department																	
Create interactive, colorful Android application	Concept			Done														
	Art			Done	Done													
	Programming			Done	Done													
First Interim Report to FIRE	Pilot testing with Prototype unit																	
	Report covering development work, prototyping and testing of Android applications with initial pilot results									Done								
Content Acquisition	Release second payment for purchase of remaining student tablets																	
Create final voice	Collaborate with faculty of education for application content																	
Embed voice in app	Use given content to generate final limited domain voice																	
Program content inside app	Embed the final voice into NatiV																	
Test app with discussion group, improvements	Programming																	
Students on holiday	Discussion on how the app can be improved etc, and suggested improvements																	
	Install Pilot	Install at pilot school. Train teachers																
Testing and Evaluation	First class assessment																	
	Second class assessment																	
	Data collection and analysis (MOS Test, Student Test)																	
Final Report to FIRE	Thesis Preparation and Defence																	
	Final report preparation and submission to FIRE																	
	Release of final payment																	
	Journal Papers and Conference																	

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Changes and Justification

1. **Dates** – Although the dates remain unchanged, we lost a significant amount of time during the school holidays (April) – something which was overlooked and unplanned for. However, we made a lot of progress development-wise (programming, art and graphics etc) to make the app more user-friendly and enjoyable. We also did not manage to measure a lot of data, but were able to confirm via tests that the app collects data effectively.
2. **Voice Creation** – This is an iterative and time-consuming process. I was successful in creating a somewhat audible voice but not fit for public consumption, and it was also limited domain (telling time). I am working on making it sound more natural. For this reason, I have made the app use audio clips instead. An interface to include TTS will be easy to implement once done and will be available as an upgrade to the version of NatiV available at the time. I will use the rest of the year to finish this. This has undeniably been the most challenging task of the whole project.

Indicators

The table below describes the old project indicators.

INPUT Resources: Content, Children, Android Tablets, Funding, App Training, Administrators (Teachers),				PROCESS NatiV Android Application	OUTPUT App Efficiency (Results)	
Data Item	Variable	Min	Max	Description	Indicator	Rating
Mistakes made	MISTAKES - Measure of accuracy	0	Defined by number of syllables displayed or defined by level	This value increases by one when a child matches a sound to the wrong syllable, or the reverse depending on how the level is designed	ACCURACY - The less mistakes the child makes, the better they are at identifying syllables and their respective sounds	0-10
Hints taken	HINTS - Measure of confidence	0	Defined by number of syllables displayed or defined by level	This value increases by one when a child queries one of the sounds of the syllables on the screen available	CONFIDENCE - The less hints a child takes, the more confident they are about a particular syllable's sound	0-10
Usages queried	USAGES - Measure of interest	0	Defined by number of syllables displayed or defined by level	This value increases by one when a child queries how a syllable is used in an actual word. NatiV takes usages from words defined by the content	INTEREST - The more usages a child takes, the more interested they may be, or curious	0-10
Time spent	TIME - Measure of amount of time spent on app	0	Dependant on child (can get tired) and teacher (defines how long they will be using the app) We stipulate one hour	Will be used as independent variable for analysis of results over time	TIME - independent variable	N/A

Additional Indicators (Complete list including main indicators)

#	Indicator Type	Indicator	Definition & Unit of Measurement	Responsibility	Frequency	Data Sources	Baseline	Target ²
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² Refers to targets for the life of the project.

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#	Indicator Type	Indicator	Definition & Unit of Measurement	Responsibility	Frequency	Data Sources	Baseline	Target ²
1	Outcome (required)	% of primary school students (grades/levels one to three) that demonstrate they can read and understand grade level text	Grade-level text as defined by the National Education System.	Ian/Gary	Baseline and End line	EGRA or similar reading assessment	50%	90%
2	Output (required)	% of project stakeholders using ICT to improve reading.	ICT is defined as use of technology to improve reading.	Ian/Gary	Baseline and End line	Observation	50%	90%
3	Accuracy	% of primary school students that demonstrate they can identify syllables given the sound	The list of syllables to learn as defined by National Education System but presented as a challenge to students by the application	Ian	Baseline and End line	Electronic Database	50%	100%
4	Confidence	% of primary school students that demonstrate they need not take hints to recognize a syllable	The list of syllables to learn as defined by National Education System	Ian	Baseline and End line	Electronic Database	50%	100%
5	Interest	% of primary school students that have understood the curiosity function of the application and use it to find how a syllable is used in an actual word	The list of syllables to learn as defined by National Education System	Ian	Baseline and End line	Electronic Database	50%	100%
6	Response Time	% of primary school students, especially dyslectic, that take the 'normal' amount of time to respond to a challenge ³	The average amount of time in seconds that it takes for non-dyslectic children to respond to a challenge	Ian	Baseline and End line	Database	50%	70%
7	Reception	% of people worldwide who know about the project and agree that has been helpful	Poll on website and to users' parents	Grantee	Baseline and End line	Website (and personal) questionnaires	50%	100%

³ Example: student is presented with a phone and has to identify the correct syllable

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NatiV collects accuracy, confidence and interest data as the app is in use. We call these ACI values. The **primary indicator** is accuracy (A), while others (C and I) are secondary and may be of observational interest.

Progress

NatiV is now able to score Accuracy data and store it in a remote database for analysis. It has three interesting mini-games inside (see screen-shots at the end of this report).

Another application is in the pipeline – for automatic generation of reports as below.

Report	Key dependancies (Indicators) - ACI	Description
Accuracy Report	ACCURACY, TIME (A/T)	Observation of accuracy rating over given time
Confidence Report	CONFIDENCE, TIME (C/T)	Observation of child's confidence over time
Interest Report	INTEREST, TIME (I/T)	Observation of child's interest over time.
Top Students	Classifications based on top ACI values	
Low-performing Students	Based on low ACI values	Low-performing students will need more human-attention and extra help

We may also be able to do the following:

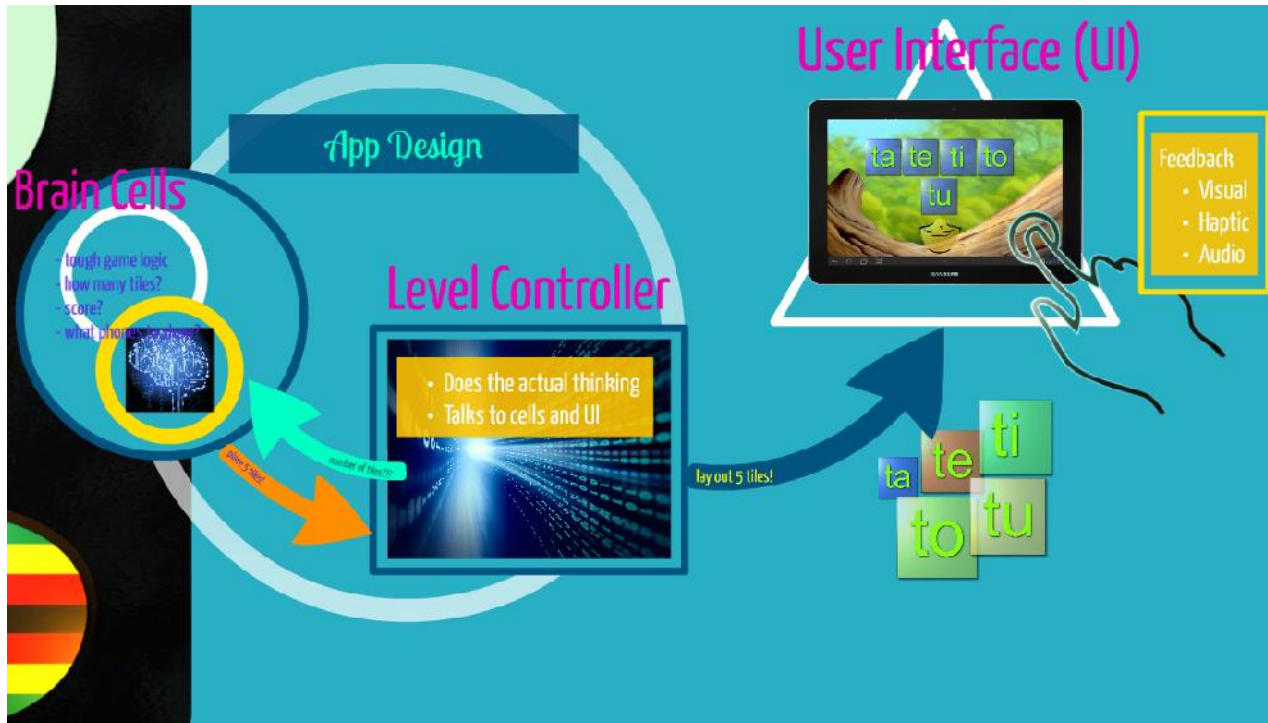
- Comparing the trend of confidence with the trend of accuracy, over time
- Comparing the trend of interest with the trend of accuracy, over time
- Observe how total time spent on the app affects changes in ACI values
- Observe how other performance indicators change over time

However the data can be readily pasted into Excel for analysis.

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Assessment

Care has been taken to ensure that the demo application meets the required programming standards. The model of the application is shown below and explained



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The application consists of three tiers

1. “Brain cells” – these contain level definitions, which are level characteristics and behavior. As well as some constants (like the number of tiles etc)
2. Level Controller – this does the actual thinking and handles communication between the cells and the user interface (UI). It makes decisions based on the level definitions versus use input and collects all kinds of data (indicators mentioned above)
3. User interface – this is the visible tier and is in charge of communicating application output to the user as well as feedback from the user.

Assessment of the application is a process whereby we continuously verify that at each level design, we follow the structure in the diagram above. This is a modification of the MVC (Model-View-Controller) concept (Zhang, 2012).

Multiple attempts should be made to get feedback from practitioners about findings to make instrument revisions efficient and meaningful (Jurkiewicz, 2013). NatiV was exposed to a number of local software developers, who are currently looking at it to see how it can be improved.

Quality Dimensions are there to ensure the completeness of NatiV by addressing the constraints/freedoms mentioned in the table below (Wieggers, 2012)

Item	Description	Type
Features/Scope	Completeness of course content (Scope) Completeness of application capabilities (Features)	Constraint
Quality	NatiV must meet the technical standards for mobile applications	Driver
Cost	Currently, NatiV is being done on a fixed-value budget	Constraint
Staff	There is one person doing the software development, graphics and sound. Any other people willing to contribute must come at no cost (volunteer)	Freedom
Schedule	Defined by Gantt chart	Constraint

Data Collection

When operating on a larger scale, it would be ideal to set up a data center where the

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NatiV resources reside and are available for secure access by authenticated clients residing at their respective schools via small servers resident at the schools. This brings about ubiquity, ease of data collection and better project management. All the schools need is a decent internet connection, which is the case for a large percentage of urban schools.

In the current case, we deployed a prototype at a local school for testing and evaluation. The data was collected live, and we unfortunately could not leave the setup. With favourable results, we will then take further steps to get the application endorsed by other enabling bodies (government, critics etc) via the results, and then strategically deploy nation-wide.

In the case of a rural setting with no electricity nor internet connectivity we are willing to work with local ISPs to negotiate subsidized installation costs. In the case that the costs are too high, or installation is not practical, we can always set up a small local area network and travel monthly or every fortnight to collect data.

In addition to the two main indicators that are given in the Monitoring and Evaluation templates, we have added three more performance indicators that are measured by NatiV. NatiV automatically measures these as the student uses it, and sends results to a remote database, securely. Yet another special indicator is 'response time' which may be a variable of interest for dyslectic children or children with related disabilities.

The structures for the NatiV Class which was used, and Data Center which would be an ideal addition to the project, follow.

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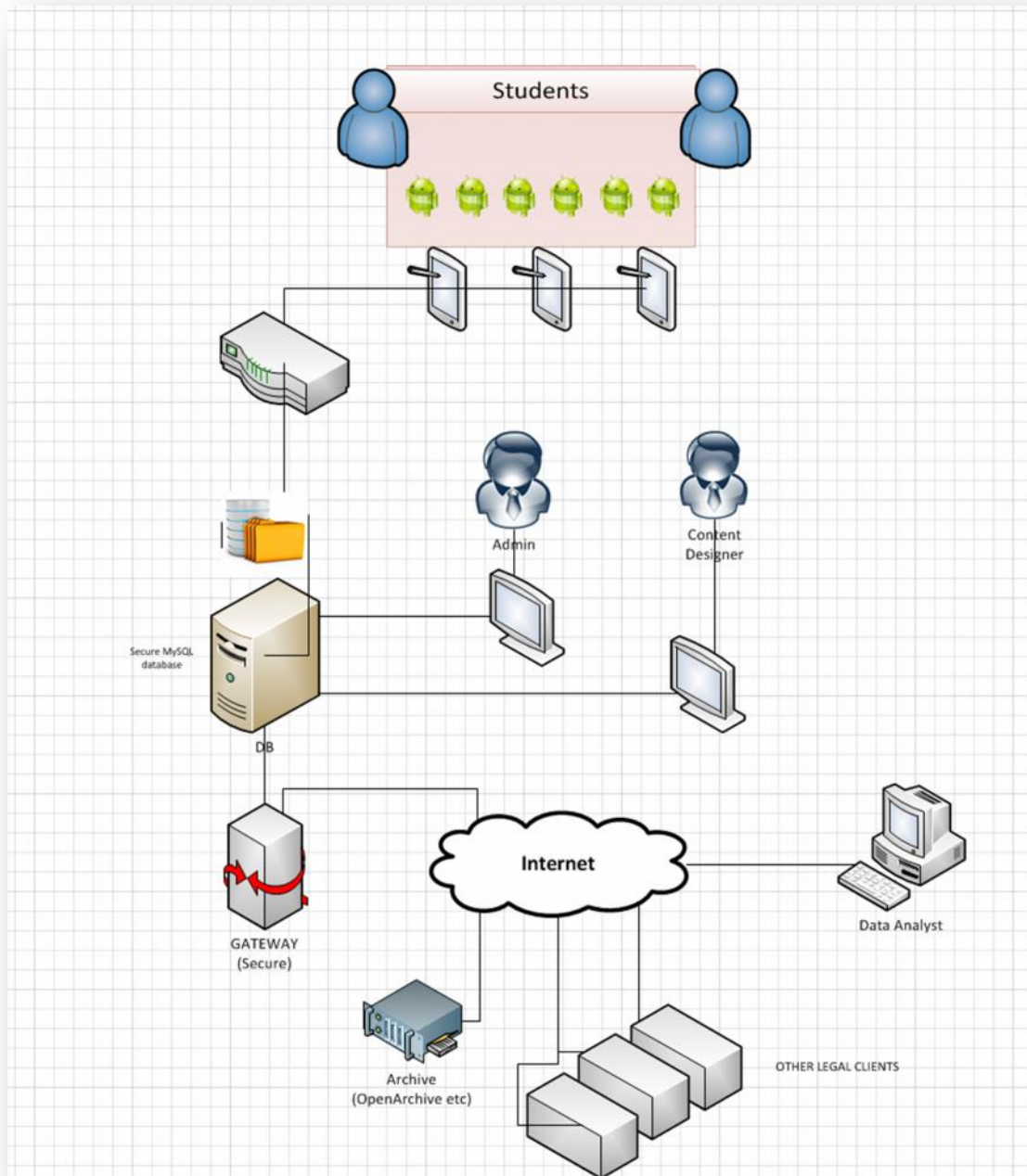
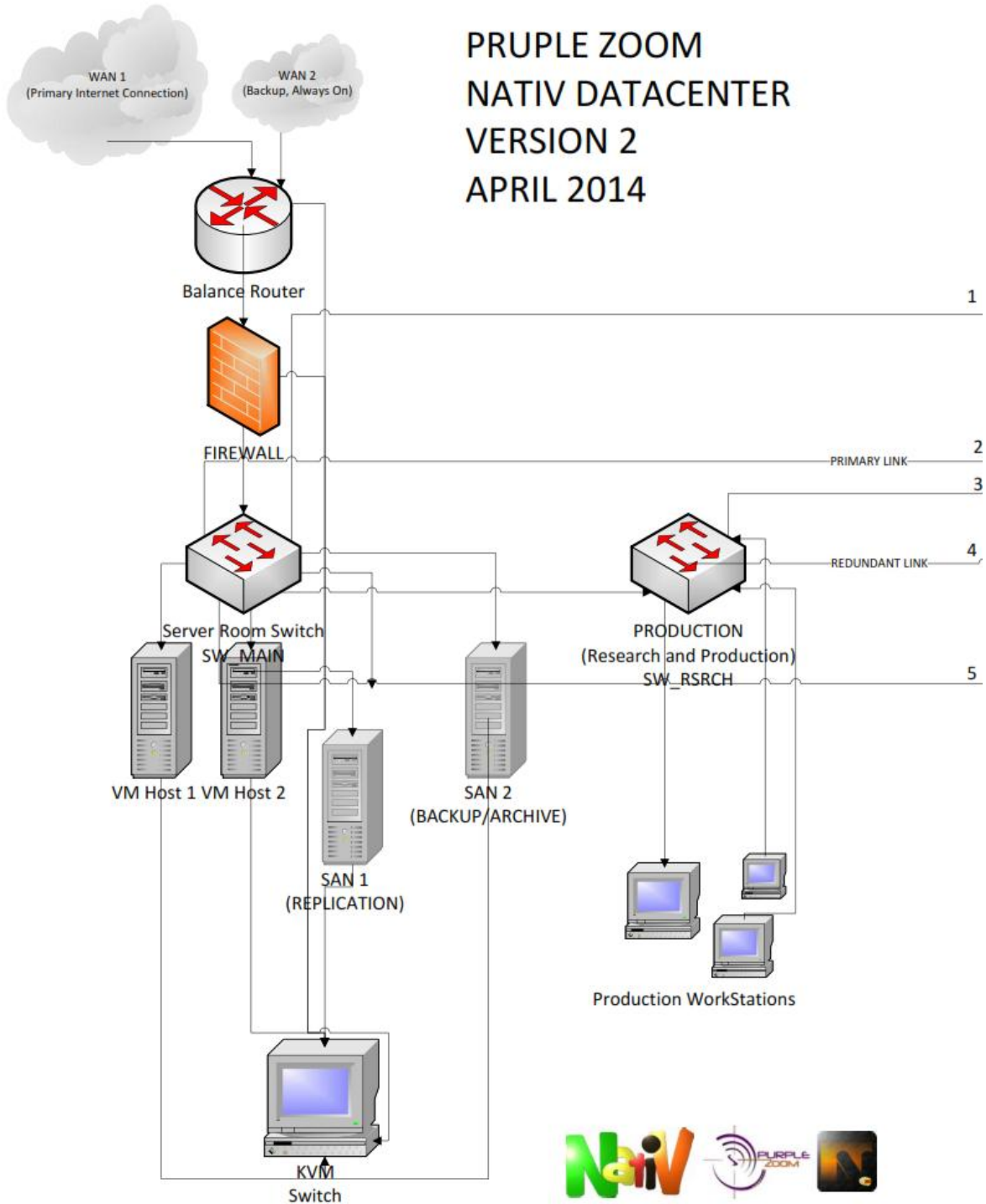


Figure 1: NatiV classroom structure - network diagram

PRUPLE ZOOM NATIV DATACENTER VERSION 2 APRIL 2014



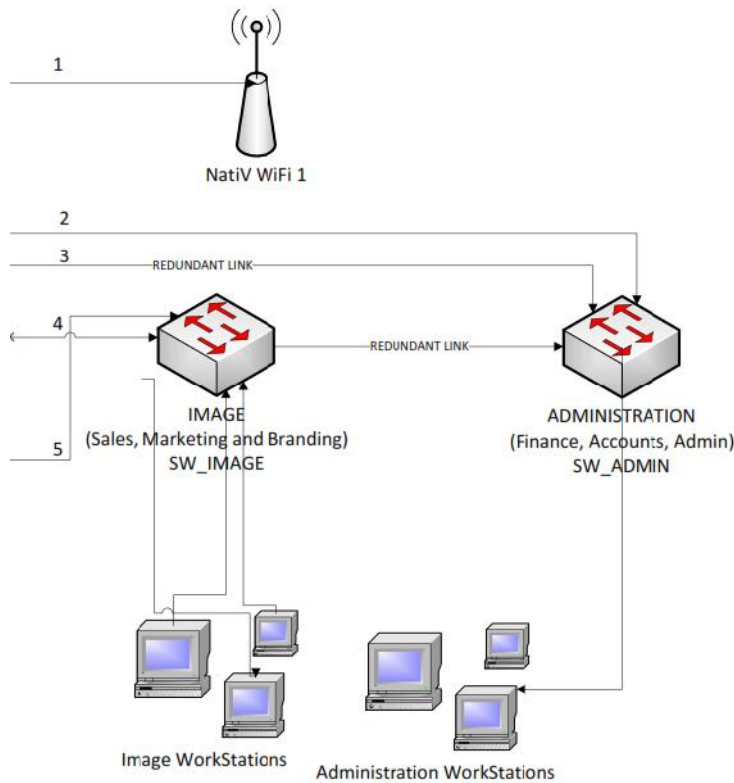


Figure 2: NatiV Data Center Proposal

The data center is on our wish-list. Besides the advantageous fact that it centralizes operations, it has huge capacity – meaning it can handle several other innovation projects managed by the same team.

Risk Analysis

Early parts of the system development cycle such as requirements and design specifications are especially prone to error, but that is notorious in projects involving

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multiple stakeholders with different points of view. In this case, NatiV's design specifications are focused on one goal: teaching letter-sound associations, and then moving to single word construction to full sentence construction. How: by implementing software that uses the auditorial, visual and kinesthetic-tactile features that come with mobile tablets, as these aid in learning. If the objective is clearly outlined, and the scope is defined, then the risk factors are clear and there will be no unexpected events that cannot be countered (SQATester, 2000). The following are risk dimensions identified:

1. Project Structure – This is a software project, which follows a design structure that is tested and defined (by standards), hence there is less risk. It is important to understand these structures and adhering to them as much as possible.
2. Project Size – this is directly proportional to risk. We are keeping the pilot project local to one school ('size' scope) until we have supporting research results that show that the application *does* help to learn reading.
3. Experience with Technology – I personally have over 6 years in software development, and with the people that help me we have a combined total of more than 15 years of experience, which brings down the risk significantly.

The following are areas of risk that we have also identified with the help of (SQATester, 2000)

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Table 1: Risk Assessment Chart

Question	Risk	Mitigation
Which functionality is most important to the project's intended purpose?	Letter-Sound Association	All levels must implement this
Which functionality is most visible to the user?	Ability to pick a syllable and/or sound	All levels must implement this
Which functionality has the largest safety impact?	Ease-of-use	All levels must implement this
Which functionality has the largest financial impact on users?	Number of levels present	Look for great developers who would like to contribute
Which aspects of the application are most important to the customer?	Syllable identification and Data Capturing	All levels must implement this
Which aspects of the application can be tested early in the development cycle?	Data Capturing and general Workflow (Navigation from Screen to Screen)	Ensure smooth motion
Which parts of the code are most complex, and thus most subject to errors?	Game logic, taking into account response time for dyslexic children	Consult where necessary
Which parts of the application were developed in rush or panic mode?	User interface for the first prototype	Graphics can always be edited later after satisfactory functionality has been achieved
Which aspects of similar/related previous projects caused problems?	None	
Which aspects of similar/related previous projects had large maintenance expenses?	None	
Which parts of the requirements and design is unclear or poorly thought out?	None. Although I can say that the concept of the game is the same, the only challenge is to bring this in different, interesting and engaging ways to users	Engage different developers with different creative flavours
What do the developers think are the highest-risk aspects of the application?	Look and Feel and other factors contributing to the appeal of the app to users	Engage good graphics designers
What kinds of problems would cause the worst publicity?	Overstating the application's abilities, hence disappointing users	Be honest, highlight the positive facts about it
What kinds of problems would cause the most customer service complaints?	Connectivity. To counter this we are making a 'lite' version that does not need data connectivity	Create 'lite' version, and make sure networking on the corporate version is 100%
What kinds of tests could easily cover multiple functionalities?	N/A	

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Which tests will have the best high-risk-coverage to time-required ratio?

Connectivity tests

Test often and in different environments

Priorities

Some priorities have been negotiated in advance to help define the rules and bounds of the project. Currently we have no control over the cost – and the tablets needed for pilot testing are already in the budget. Attending development seminars and/or courses to improve programming skills may be a worthwhile investment because it will improve the quality (and features) of NatiV, but that cannot be done as the budget does not allow. The internet is the source of any learning material at the moment. We are compromising the schedule in favor of quality and features, as this is a very sensitive project in the sense that we are working with children and their education – which is a life-long investment for them. It takes time to contact the right people in the field of expertise we need who can assist in the different parts of the project.

We successfully engaged three more programmers who have contributed immensely on development of the app.

Course of action

We met with the authorities at a local primary school to discuss installing a pilot of the project for grade ones. They showed great interest and were very forthcoming in terms of rendering assistance wherever they could. We gave them a live demonstration of NatiV, and already comments and recommendations were made on the way the content was structured within the application and how important it was to meet with education disseminators or teachers to create a customized curriculum for the children. We have set up a team comprising two teachers from each grade (one through three), who have shown interest in the project. This is an on-going process, until we reach a point of satisfaction where the technology blends well with the information to be delivered to the children and how it is doing that (that is, the complete solution). Objectives from here on forward are as follows.

Objective	Persons Involved	Estimated Time
Create reading curriculum (content)	Team of experienced teachers	One month (two meetings per week)
Develop dynamic mini-games that use the content	Development Team	1 week (mini-games already there, content programming needed)

Project implementation

Partnerships

So far our partnerships extend to the University’s linguistics and education departments, as well as

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FIRE – which has provided most of the funding for the project. From the Linguistics Department we have been working with Dr Victor Mugari on the Shona phoneset. We are also currently developing the Shona lexicon structure. His input has been extremely instrumental in as far as the development of the voice is concerned, which makes the heart of the application.

We have partnered with a local (government) school in an aim to create a curriculum that can be converted into digital format for inclusion in NatiV.

We also took heed of advice given from the previous report assessment of working with more developers. The following advert was placed on Facebook and shared. Out of this, three talented programmers showed interest and are currently proactively working on new levels or ‘mini-games’ for NatiV, ranging from simple apps for grade ones, to more complicated ones for grade 3s and even a word processor for e-books to be made for a special NatiV platform for older students. Although it is currently being made to contest for the All Children Reading grant competition due in October, it will be in continual development for actual consumption here in Zimbabwe. All this is to promote local solutions to local challenges.



NatiV Write (Nyora) - Icon

A PRIVATE organization IS DOING research ON TECHNOLOGY that ASSISTS CHILDREN TO LEARN TO READ **their** Native Language



we are LOOKING for LEVEL DEVELOPERS for the ANDROID games
(Programmers)

 <http://www.facebook.com/nativevoicezim>



Figure 3: Facebook Advert for Programmers

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The table below summarizes the project implementation...

Input	Project activities	Outputs	Outcomes	Timeline	Status	Assessment
<ul style="list-style-type: none"> • Funding, • Programmer • Graphics Designer • Sound Engineer • Tablets • Content • Language research 	Please refer to Gantt chart under Baseline section	<ol style="list-style-type: none"> 1. Correct Shona Phoneset 2. Demo voice (male) 3. Demo app (3 levels) 	<ol style="list-style-type: none"> 1. Great interest was shown on the Research and Intellectual Expo 2013 (UZ) 2. I did a most welcomed presentation at the eLearning Africa conference, where I was able to learn a lot about the current states of the art of tech-based learning 3. Managed to partner with a local school for more content development via teamwork 4. Managed to partner with three more programmers/developers who got interested in the project and are passionate about making it come to life 5. Created a team of multidisciplinary people (finance, engineering, law, IT, public relations, marketing) to prepare for and help with mass deployment in the future 6. Recognized the possibility, potential and need of creating a technology hub focused on solving societal 	Please refer to Gantt chart	Please refer to the Gantt chart	Please refer to Assessment section above

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			challenges using technology			
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Project outputs, communication and dissemination activities

The main output is the android application, which is an amalgamation of the linguistic studies, the TTS voice and the app itself. The app currently lacks the feature of the TTS voice that is currently in the iterative process of perfection for a more natural and comprehensible voice.

Project outputs	Status	Assessment	Dissemination efforts
1. Correct Shona Phonetset	Completed: APRIL 2013	Complete and comprehensive. Applicable Dimensions: Reliable – all Shona phones were listed and the corresponding SAMPA (computer-readable) format was created using international standards Conformance – the IPA (international phonetic alphabet) was used for theoretical writings. During voice creation, we are using SAMPA.	One publication: https://uz-ac.academia.edu/IanMutamiri More following.
2. Demo Voice	Partially Completed (Completed a limited domain voice which tells time in Shona) A more natural, general usage voice is in the pipeline as it takes a large amount of time to do some of the tasks.	First successfully completed voice cannot be used for public consumption.	Presentation an last year (2013)'s Research and Intellectual Expo (University of Zimbabwe) Presentation at the 2013 eLearning Africa conference in Namibia
3. NatiV App	Completed: OCTOBER 2013	Complete and Working. Applicable dimensions and comments: Quality (functional) – performs the main function: to teach how to read, very well and in different ways too. Quality (structural) – uses object oriented programming and is modular. Android makes user interface design separate from application business logic – hence maintainability is made easier, and robustness can be added to business logic without ruining UI. Coding standards were taken seriously. Performance – meets all documented objectives. Efficiency – data management and data access handled as according to standards. There is room for improvement when it comes to sending data to remote storage. Currently being done 'in-game' and not after. However this is because there is very little data being sent. There is also efficient use of memory and cpu (to conserve power).	Dissemination efforts for grades 1 – 3: <ul style="list-style-type: none">– Via school authorities Awareness at the University faculties of Linguistics, Engineering and education using posters Targeting parents and individuals via: <ul style="list-style-type: none">– Facebook page for interested fans https://www.facebook.com/nativev

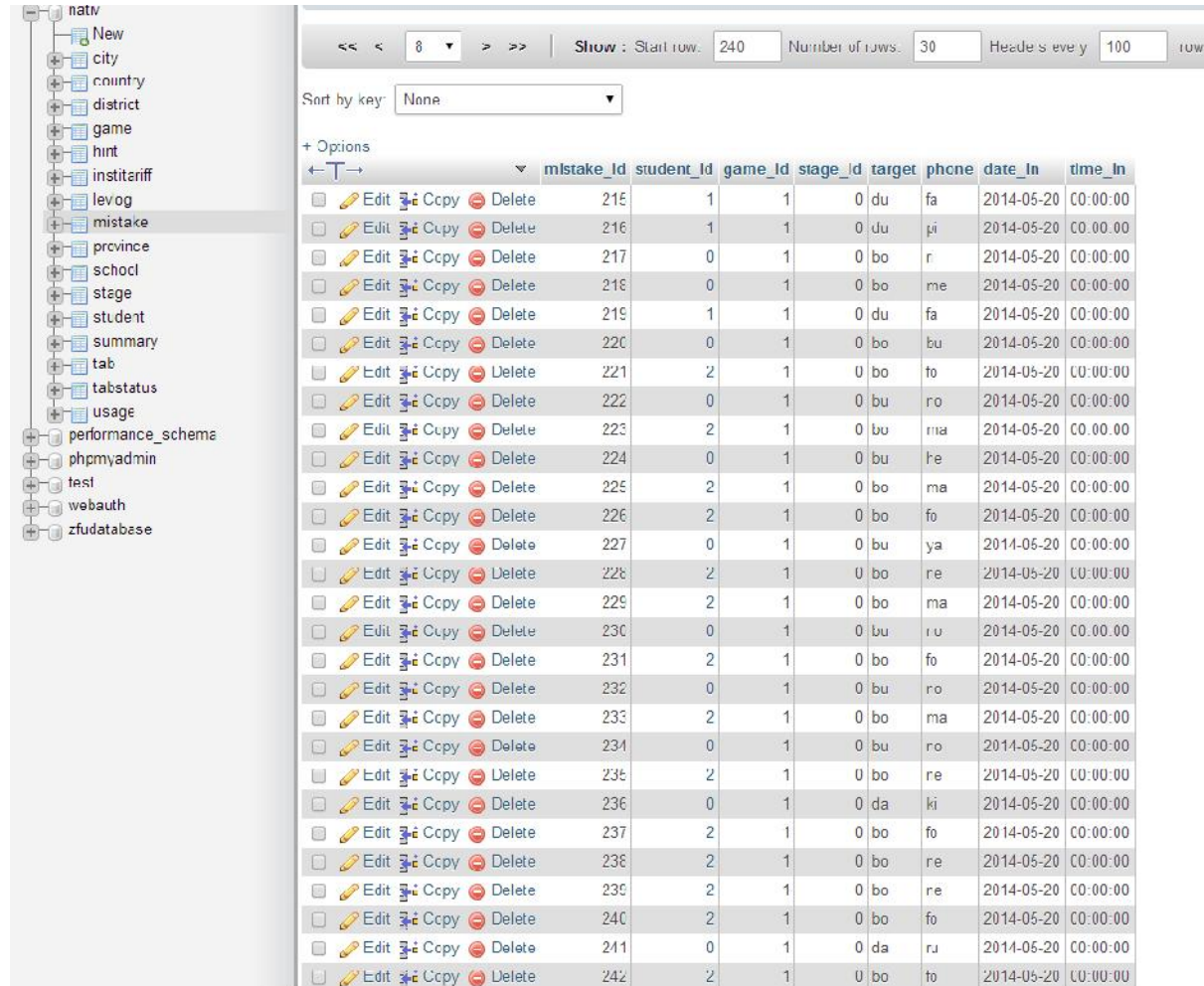
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		<p>Security – good exception handling, secure SQL server with authentication for app requests, system function access deemed private or public where appropriate in code.</p> <p>Maintainability – the code is readable, the UI is separate, understandable amount of dynamic coding (comments available), and documentation is provided by in-line comments in the code. Simple (not deep) inheritance trees.</p> <p>Features – fun, interactive (visuals, audio, vibrations), simple and intuitive to learn how to use, comes on a colour tablet with added benefits.</p> <p>Aesthetics – colourful graphics, friendly user interface that is easy to figure out.</p> <p>Reliability –uses MVC (model-view-controller) where possible, decent exception handling, component re-use, complies with OOP, and uses simple and CPU-friendly algorithms.</p> <p>Serviceability – software failures highly unlikely. Hardware failure as easy as replacement and reinstallation.</p> <p>Conformance to current standards – Android development takes design standards seriously and it is very difficult to diverge from these, as there would be little or no support in the case one needs assistance. We tried as much as possible to meet all standards from coding to UI design to meet users’ expectations.</p>	<p>oicezim</p> <ul style="list-style-type: none"> - Mailing list for people who look forward to urgent announcements and letters nativzim@gmail.com - YouTube videos (more coming soon from talented colleagues) https://www.youtube.com/watch?v=WDQthjgtQ4 - Twitter personal account using hashtag #NatiV or #NativZim (changed so as not to confuse with the band NatiV) and other conference/meeting/organization hashtags <p>Presentation at Africomm Tech Conference (2013) in Malawi</p> <p>Presentation at IAD (Innovation Africa Digital Summit) 2013, Gambia</p>
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Results

Please find some screen-shots of NatiV at the end of the report. The following image shows NatiV database results extract when three students were playing the same level:

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	mistake_id	student_id	game_id	stage_id	target	phone	date_in	time_in
<input type="checkbox"/> Edit Copy Delete	215	1	1	0	du	fa	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	216	1	1	0	du	ji	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	217	0	1	0	bo	r	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	218	0	1	0	bo	me	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	219	1	1	0	du	fa	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	220	0	1	0	bo	bu	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	221	2	1	0	bo	fo	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	222	0	1	0	bu	ro	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	223	2	1	0	bu	ma	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	224	0	1	0	bu	he	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	225	2	1	0	bo	ma	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	226	2	1	0	bo	fo	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	227	0	1	0	bu	ya	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	228	2	1	0	bo	re	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	229	2	1	0	bo	ma	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	230	0	1	0	bu	ru	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	231	2	1	0	bo	fo	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	232	0	1	0	bu	ro	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	233	2	1	0	bo	ma	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	234	0	1	0	bu	ro	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	235	2	1	0	bo	re	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	236	0	1	0	da	ki	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	237	2	1	0	bo	fo	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	238	2	1	0	bo	re	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	239	2	1	0	bo	re	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	240	2	1	0	bo	fo	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	241	0	1	0	da	ru	2014-05-20	00:00:00
<input type="checkbox"/> Edit Copy Delete	242	2	1	0	bo	fo	2014-05-20	00:00:00

During testing, we noticed that values in the “time_in” column of the database were incorrect. This is one of the few errors we identified during testing and that has since been fixed. We are constantly looking for bugs and improving the app with time.

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Project outcomes

1. Great interest was shown on the Research and Intellectual Expo 2013 (UZ) – I was able to present current work for NatiV at the research and intellectual expo of 2013 at the University of Zimbabwe. I showcased the time-telling Shona voice seperately with a demonstrative app of NatiV.



Figure 4: Interested guest at the RIE Stand 2013, UZ



Figure 5: Pausing with the demo app at the RIE 2013, UZ

2. Managed to partner with a local school for more content development via teamwork. I was not allowed to take pictures and we were not sure whether it would be fine to mention names. But the teachers are very forthcoming and eager to work with us to create the digital curriculum.
3. Managed to partner with three more programmers/developers who got interested in the project and are passionate about making it come to life. Jayden Shamhu, Tinashe Mutiwanyuka and Simbarashe Makura. After explaining the concept to them and sharing my source code so they catch up with my progress, Jayden and I wrote a NatiV mini-game for grade two/three. Tinashe is writing a fully animated one for grade threes. Simbarashe and I are working on a special word processor (NatiV Write or Nyora) for grades 3 onwards, for authors who would like to publish local content and avail it to young readers.

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4. Created a team of multidisciplinary people (finance, engineering, law, IT, public relations, marketing etc) to prepare for and help with mass deployment in the future. We will essentially be working for the NatiV hub. Here is a list of people who have pledged their time and skills for the NatiV cause.

Name	Role	Sex/Age	Qualifications/Skills	Links	Other Skills
Ian Nyasha Mutamiri	Technical Director	M/26	<ul style="list-style-type: none"> BSc. Electrical Engineering MPhil Telecommunications Engineering (Pending) Software Development (Java, Android) CCNA Networking Network Design and Engineering Global Anti-corruption Laws Trained (ENRC) ISO 9001:2008 Certified Quality Management Internal Auditor 	http://zw.linkedin.com/in/ahsayn/ ahsayn@gmail.com	<ul style="list-style-type: none"> Music Production Digital Art Gaming Innovation
Grace Pisirai	Partner	F/25	<ul style="list-style-type: none"> BSc. Electrical Engineering Dip. Project Management 	http://zw.linkedin.com/pub/grace-pisirai/50/877/135 pisirai@gmail.com	<ul style="list-style-type: none"> Interior Décor Fashion and Design
Saewyd Miller	Partner	F/28	<ul style="list-style-type: none"> Insurance Fraud Investigation - Conversation management Marketing Sales Skincare, EU legalities Legal Secretary (Illex qualified) Employee Training Customer Service Public Relations 	http://uk.linkedin.com/pub/saewyd-m/24/76a/157 officialsaysay@gmail.com mamasayscosmetics@gmail.com	<ul style="list-style-type: none"> Music Entrepreneurship Cosmetics
Ngqobile Zwimba	Sales and Marketing Director	M/27	<ul style="list-style-type: none"> BSc Information Systems (pending) Sales Marketing 	http://zw.linkedin.com/pub/nqoe-zwimba/53/306/55 nqobilezwimba@gmail.com	<ul style="list-style-type: none"> Networking Advertising Entrepreneurship

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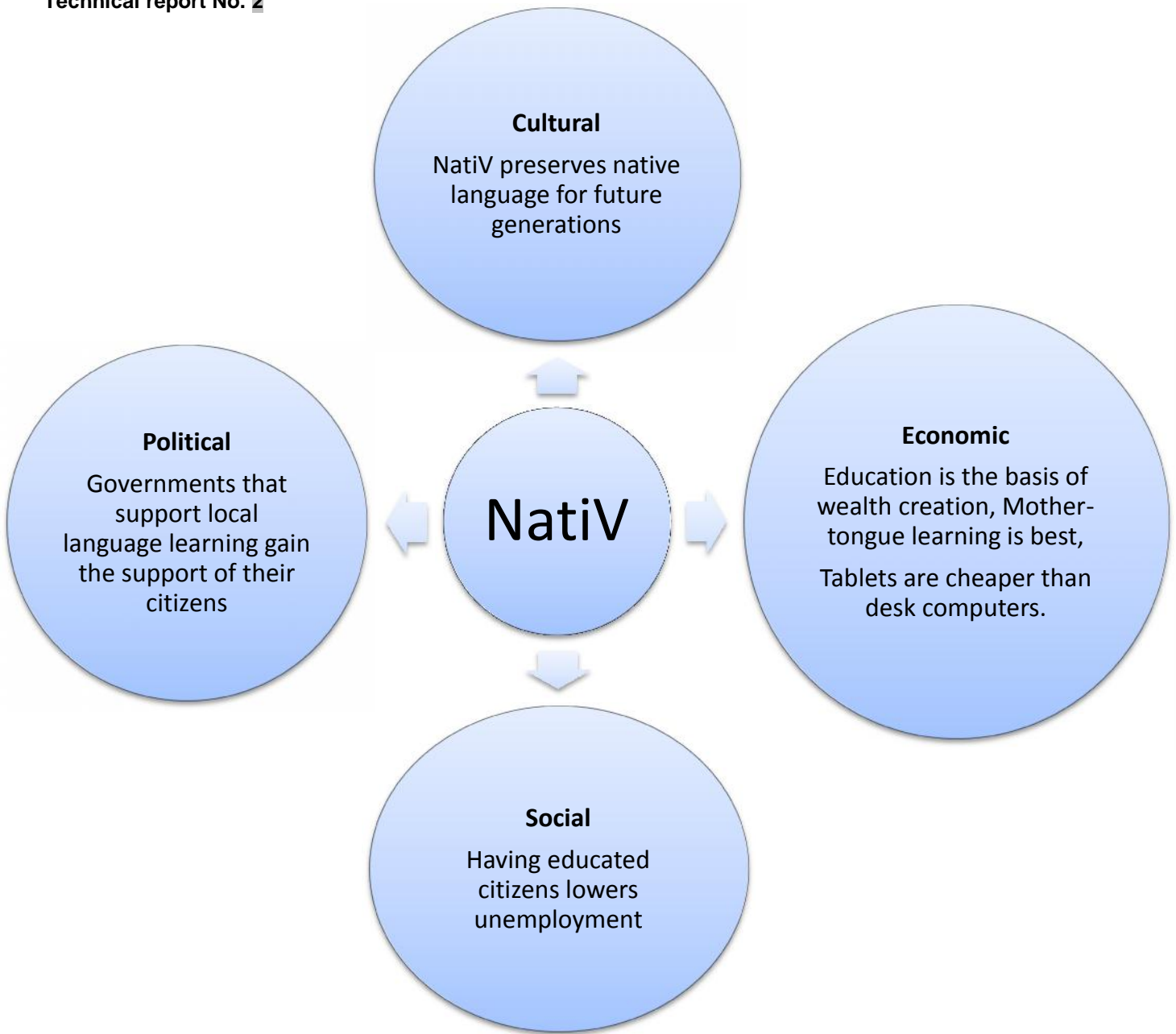
Tatenda Kusena	Finance Director	M/25	<ul style="list-style-type: none"> Bachelor of Accounting Science University of South Africa [UNISA] (2011), Pretoria, South Africa Post graduate diploma in Accounting Science University of South Africa [UNISA] (2012), Pretoria, South Africa First part Qualifying Examination (ITC) (2014) with the Institute of Chartered Accountants of Zimbabwe (ICAZ) Final part Qualifying Examination (APC) (2014) with the Institute of Chartered Accountants of Zimbabwe (ICAZ) (current studies) 	tlkusena@gmail.com	<ul style="list-style-type: none"> Problem solving Good interpersonal skills Undergoing public speaking training.
Grace Zwimba	Partner	F/31	<ul style="list-style-type: none"> Marketing and Admin Customer Service Project development Emergency Medical Dispatch 	http://zw.linkedin.com/pub/grace-mutamiri/53/253/a85 gracezwimba@gmail.com	<ul style="list-style-type: none"> Music First Aid
Gary Brooking (Dr.)	Technical Supervisor and Consultant	M/50	<ul style="list-style-type: none"> PhD Engineering ICT Expert 	http://zw.linkedin.com/pub/gary-brooking/47/b42/129 gary@brookingfamily.net	<ul style="list-style-type: none"> Educational Technology Research Teaching Entrepreneurship
Tinashe Mutiwanyuka	Partner	M/34	<ul style="list-style-type: none"> BSc Computer Science (Business Computing) Software Development Software Support Software Implementation Software Project Management 	http://uk.linkedin.com/pub/tinashe-mutiwanyuka/4/97a/2a0 tinashemutiwanyuka@gmail.com	<ul style="list-style-type: none"> Change Management Team Leadership Farming

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5. Recognized the possibility, potential and need of creating a technology hub focused on solving societal challenges using technology – I already have a small company called Purple Zoom, registered legally here in Zimbabwe. We have one project – a GPS/GPRS based vehicle tracking and fleet management solution for locals. With the right capital investment and training, we can take up NatiV on a larger scale than it currently is. Budgets and writeups for this are available and we are confident that someday this will all materialize.



The diagram following summarizes the Social, Economic, Political, Cultural benefits of the project.



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Project management and sustainability

The FIRE program, through funding and mentoring, has given me a chance to make a difference in:

1. Young peoples' lives – by using existing technology to create a new solution that is specific to the environment they are growing in;
2. My peers' lives – by giving them a chance to showcase their skills to the world, and gain experience and fulfilment through trying to solve the challenge at hand. It has also shown us the importance of teamwork, as well as leadership;
3. My own life. Every single day of working on this project has given me something new to learn, understand and apply. I plan to take this project to a higher level and make this solution available nationwide. I am also eager to help other countries develop similar solutions for their own languages through networking and sharing ideas.

As part of the plan for sustainability, it is crucial to have a central point of operations. I've mentioned the idea of a tech hub, a physical place here in the country where smart minds physically meet to discuss ideas, also giving opportunity to other smart minds in the country to contribute their ideas. Working apart through the internet has its advantages, but there is always something special and great about working together in one physical location and concentrating all skills to achieve one goal. It is practical to do so, provided a working financial model/structure is present. The team is working on a business plan for this. The general idea is that learning via tablet renders affordability, convenience and more engagement as opposed to traditional pen and paper ways. If such an app can be sold to each child (through their parent of course) at 80cents per year (20cents cheaper than the famous whatsapp, yet more beneficial) – we are looking at over \$600,000.00 for sustainability purposes, per year, give or take. Many of us are ready to leave formal employment to pursue this cause.

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Impact

The table below shows the practical to theoretical comparisons of the NatiV product. The first column lists down how a child needs to learn, the second column states how NatiV has achieved to make this work. The impact of this shall be discussed afterwards. The table focuses on dyslexic children, but also applies to children in general.

1	What dyslexic children need	What NatiV Ensures
2	A quiet, calm, structured, orderly, consistent and fair environment	In an African setting such as Zimbabwe, NatiV must be resident at a school, and administered by the teaching staff.
3	One or two verbal instructions at a time	NatiV outlines the instruction at the beginning (match sound with correct syllable) and only speaks when asked (will give the student the sound after they touch something)
4	Short, simple instructions with a few words	As above
5	A simultaneous multi-sensory structured approach to language learning that uses all three pathways of learning (Visual, Auditory and Kinesthetic-Tactile)	NatiV offers Engaging artwork and animation (visual), sound and music (auditory), and input via touching, swiping and other gestures with haptic feedback responses (kinesthetic tactile)
6	Time to process what is heard	NatiV does not have countdown timers. Response time is another performance indicator that will be measured, and it is expected to improve (decrease) with more usage of the application.
7	Time to respond	Linked to the above
8	Time to complete assignments	Linked to the above

The heads at the school we are partnering with are not very much techno-savvy. When we were speaking over the phone about our intentions, I could tell that the best way was to show them. Upon giving them a demonstration, light bulbs lit up. They were amazed that it did not even take time to set up the equipment needed, as opposed to their previous experience with the computer lab – having to deal with issues such as power, space, and the somewhat steep learning curve of the rules of a computer for a new learner. It took under two minutes to turn the tab on, start the

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app and configure it for a user (student). The head is a fervent student of child education, and has a lot of experience supervising and marking university students' theses and essays. We started discussing the philosophy behind technology (specifically solutions) and the impact it has made on the African society. Technology is defined as the application of scientific knowledge for practical purposes. That means technology is **not** in any way a solution. It is merely scientific practical methods. I came up with a thought: technology is global, but solutions are specific (to the target audience experiencing a challenge). However, some solutions do overlap for two totally different societies. We concurred that many African values have been lost, or rather somewhat diluted due to as-is adoption of foreign solutions. These solutions do not have content that is linked to the African consumers, popularly termed 'local content'. We discussed the importance of identity in solutions, given via the localization of content. We discussed the possibilities of the retention and preservation of African ethics, beliefs, traditions and customs using technology – and not having to adhere to the “new world” or so-called universal way of doing things. Without telling the heads, they found how the research done for NatiV could be used on rare and disappearing African languages and/or dialects, which is important for a nation.

The NatiV project has given the team powerful platforms for innovation such as follows:

1. **Creativity** (Sound design, Art and Graphics design, Programming including algorithm design and more).
2. **Digitization** of local content - not many Text-To-Speech voices exist for African languages, but the technology has been available since the 80s!
3. **Teamwork** - collaboration and strategic relationships between linguists, programmers, network engineers, ISPs, governments, policy makers and communities from all over the world.
4. **Research** - a great innovative idea is backed by proper and sound research. We cannot play dice with the education of children; hence we need to approach solutions using the discipline, thoroughness and transparency provided by good research methods, both qualitative and quantitative.
5. **Purpose** – a saying goes "Purpose is better than opportunity, and when an opportunity that comes as a means to fulfilling one's purpose presents itself, then one is destined to succeed" – FIRE presented that opportunity for us.

Below is the list of disciplines that the project has attracted, there could however be more:

1. Linguistics
2. Education
3. Engineering (IT/Networking)
4. Software Engineering
5. Finance
6. Marketing

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7. Politics
8. Graphics and Design
9. Sound Engineering
10. Human Rights organizations (Especially for enforcing the special rights that dyslexic children are entitled to)
11. Donors
12. Investors
13. Government
14. Policy Makers

With a seemingly simple project such as this one, we as Africans have a chance to change the investor perception that Africa (especially Zimbabwe) is too “risky” to invest in.

Overall Assessment

I may have already given much information relating to the overall assessment of this project in sections above, especially through personal experiences and other relevant anecdotes. In this case I will answer the questions that follow

- To what extent the project meet its objectives?
 - NatiV now exists as a fully-functional app that collects performance statistics and records them in a database for analysis. The only shortfall is the voice that cannot yet be embedded in the app due to some flaws, which can be fixed with time.
- What were the most important findings and outputs of the project? What will be done with them?
 - Findings: IPA (phonetic alphabet) for Shona, app development skills, project management skills, team-leading skills, and many more. These will be used in more innovations to come. Africa is a pool of endless possibilities – this is a good start to taking on even more challenging endeavours.
- What contribution to development did the project make?
 - Currently, Zimbabweans are hungry for this kind of learning aids. It is almost impossible to send desktop computers to rural school. But content that is available on desktop can be ported to tablets, which in turn can be used in rural areas. It then becomes easier for rural and other under privileged people to gain access to eLearning.
- Were certain aspects of project design, management and implementation particularly important to the degree of success of the project?
 - The most important ingredient for success is teamwork. We started off small, and we felt the pressure. We realized that this innovation is not only about the products, but the systems and structures that push the product to make it a success. With the

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inclusion of key people working on different aspects of the project, we were able to do much more.

- To what extent the project help build up the research capacity of your institution or of the individuals involved?
 - The project has benefited from international research collaborations and partnerships through the FIRE program, which in turn has helped us get connected to other people around the world working on different kinds of innovations.
 - The project has forced me to be a better writer in preparation for the academic papers I need to publish in the future. One, although it is a short paper, is already out and was presented at the Africomm conference in Malawi, 2013. I have also coerced my colleagues into collaborating on more papers for publication in local and international journals.
 - Lack of funding is a most common complaint for many African researchers. The FIRE program has indeed enabled us to surpass that barrier.
 - Long term partnerships facilitate equitable research collaborations (Chu, 2014). I have known the people in my team for a long time, and I am confident in their skills. They are also keen on improving their research skills and this project provides them with that opportunity.
 - This project has created an interesting link connecting Linguistics and Engineering. This partnership will go a long way in finding better understandings of the Shona language through obtaining mathematical/scientific relationships that are particular to that language, as has been done for other languages around the world in efforts to create TTS and even voice-recognition systems.
 - Working as a team has enforced a culture of good communication and debate. The activities which we assign to ourselves serve as good experience and growth towards realizing our goals.

Future performance can be improved by embracing all the lessons learnt through this experience. It is important to learn from mistakes, and to make room for error and its efficient and swift correction.

Recommendations

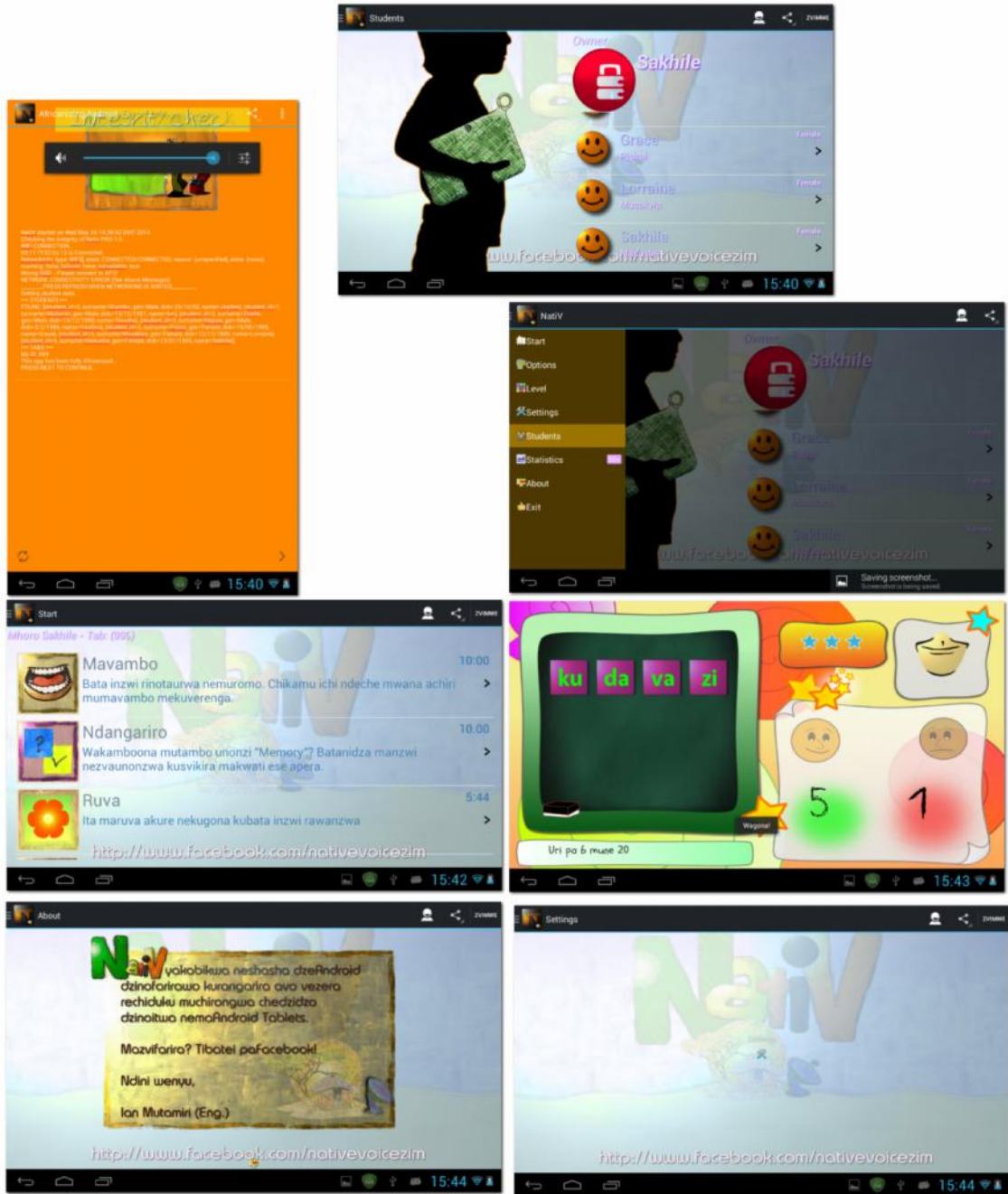
We seek to partner formally with an international university on especially on speech synthesis and support for new languages. Creating a TTS voice is a lengthy process that requires a lot of careful planning, research, and dedication. However, it is achievable. We need more content from Africa and more African language support on systems as popular as Google TTS. We are currently in talks with professionals and institutions that do research on speech.

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Screen Shots

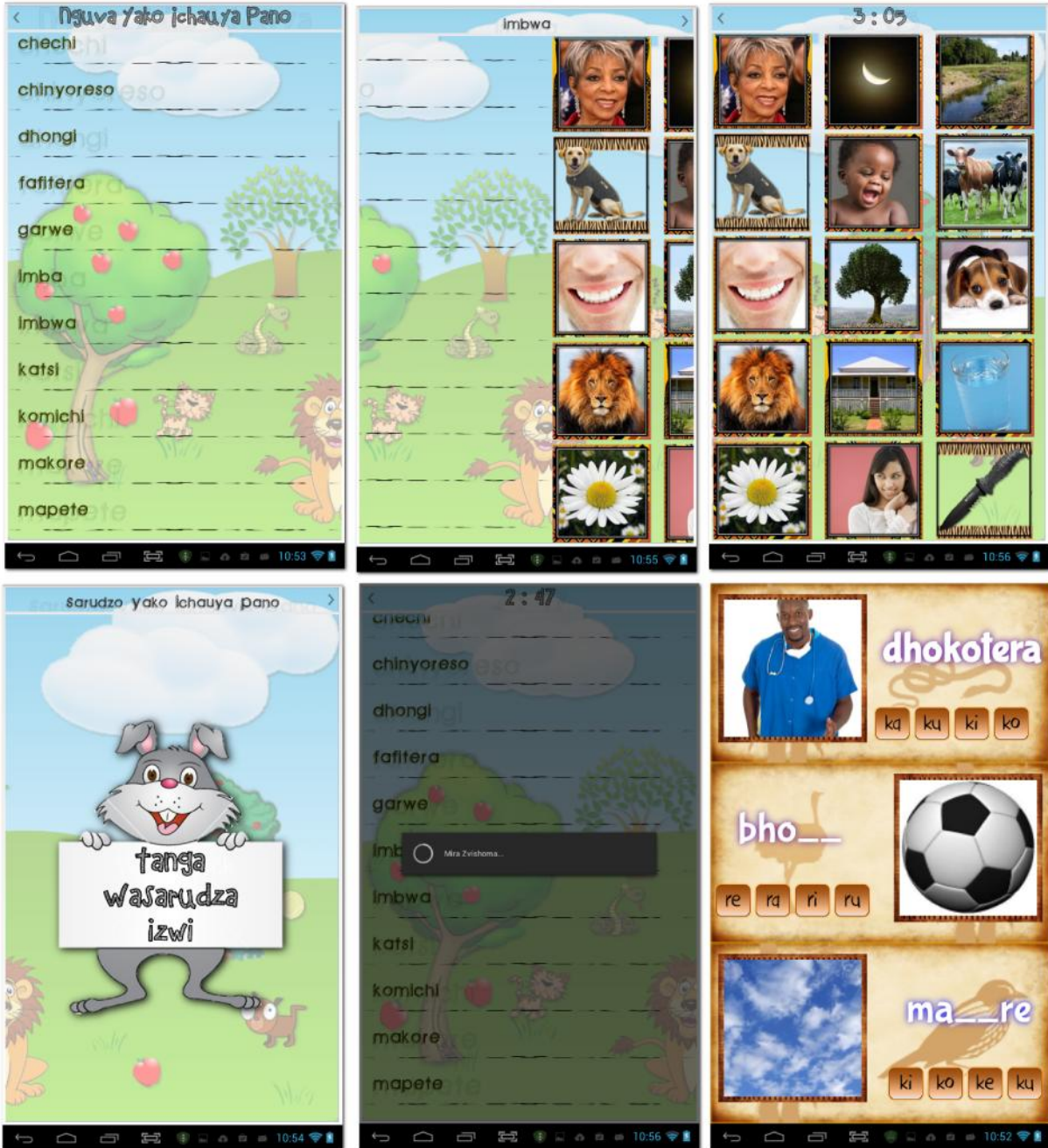
Game 1 – Ian

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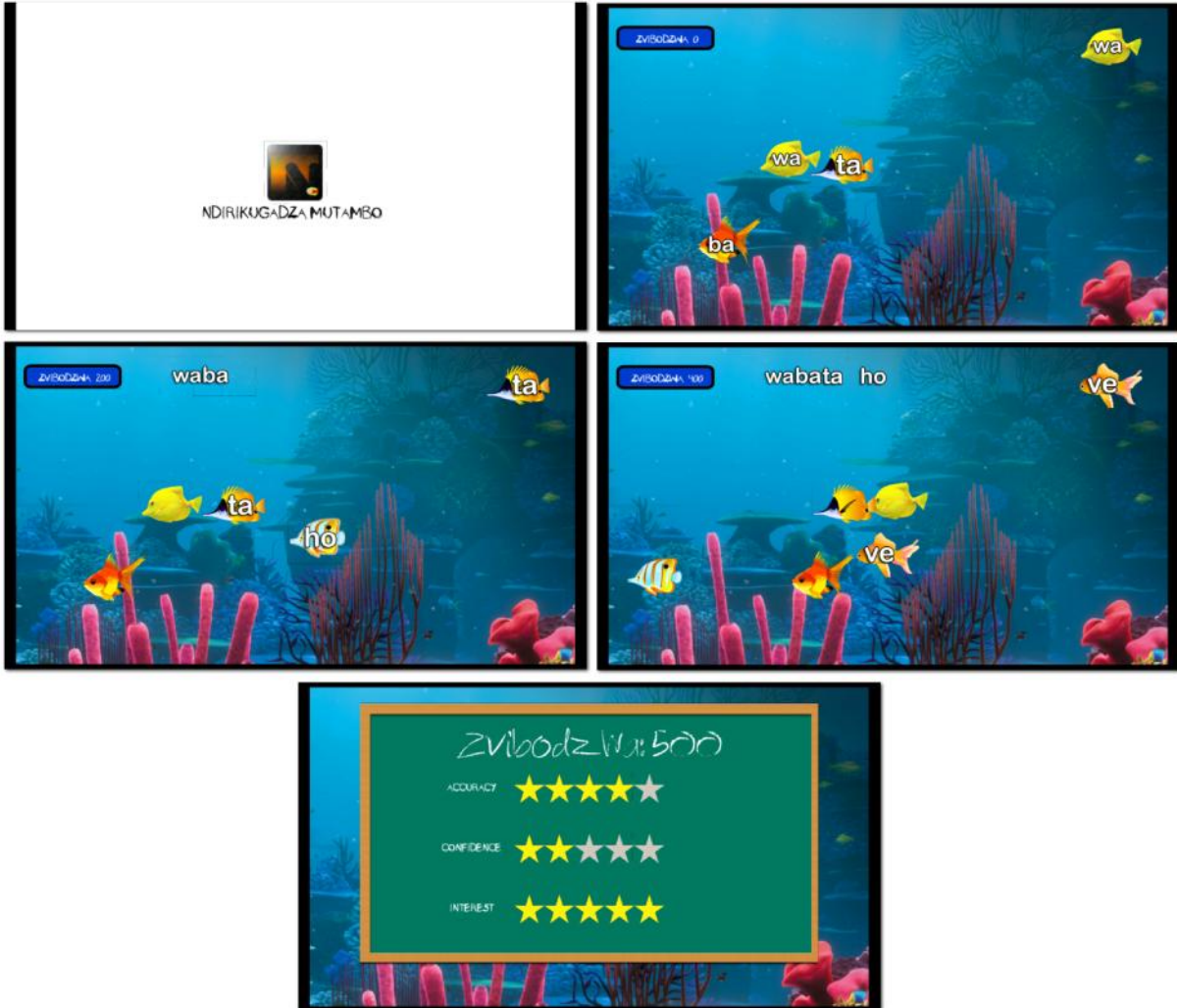
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Game 2 – Jayden



Game 3 – Tinashe

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Source code available.

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Bibliography

- Jurkiewicz, T. (2013, 01 01). *Harvard Family Research Project*. (H. F. Project, Editor, H. F. Project, Producer, & Harvard Family Research Project) Retrieved 10 21, 2013, from Designing Quality Assessment Tools in Early Childhood Education and Youth Development: <http://www.hfrp.org/evaluation/the-evaluation-exchange/issue-archive/evaluating-out-of-school-time-program-quality/designing-quality-assessment-tools-in-early-childhood-education-and-youth-development>
- Wiegiers, K. (2012, 09 18). *The Five Dimensions of a Software Project*. Retrieved 10 21, 2013, from Business Analyst Times: <http://www.batimes.com/articles/the-five-dimensions-of-a-software-project-part-1.html>
- Zhang, W. (2012). *Software Engineering and Knowledge Engineering: Theory and Practice*. In W. Zhang, *Software Engineering and Knowledge Engineering: Theory and Practice* (p. 352). Springer.
- Aghdasi, Farzin., "Digital Speech Processing." University Of Zimbabwe, Department of Electrical Engineering - MSc Telecommunications Module, 1995.
- Aghdasi, Farzin., "Digital Speech Processing – Advanced Concepts" University Of Zimbabwe, Department of Electrical Engineering - MSc Telecommunications Module, 1995.
- Android Developers [Online], *Developing Android Applications* (2012) 02/03/2012 Online: <HTTP://developer.android.com/developing/index.html>, 2012.
- Black, A., Burger, S., Langner, B., Parent, G., and Eskenazi, M. *Spoken Dialog Challenge 2010 Spoken Language Technologies 2010*, Berkeley, CA. (pdf) <HTTP://WWW.cs.cmu.edu/~awb/papers/slt2010/slt-sdc2010.pdf>
- Black, A., Bunnell, T., Dou, Y., Muthukumar, P., Metze, F., Perry, D., Polzehl, T., Prahallad, K., Steidl, S., and Vaughn, C. *Articulatory Features for Expressive Speech Synthesis, ICASSP 2012 Kyoto, Japan*. (pdf) HTTP://WWW.cs.cmu.edu/~awb/papers/icassp2012_npess.pdf
- Boersma, Paul & Weenik, David – *Praat: doing phonetics by Computer* (2012) 02/04/2012 Online: <HTTP://WWW.fon.hum.uva.nl/praat/>
- Carnegie Mellon University - *speech technology research, development, and deployment*. Online: <HTTP://WWW.speech.cs.cmu.edu/>
- Flemmert Jensen, Anne. "What do children need to learn to become powerful leaders in the world of tomorrow?" LEGO Learning Institute, 2006.
- Meier, Reto. "Professional Android Application Development." Wrox, 978-0-470-34471-2 , 2007.
- Katz, L. G., & Chard, S. C., "ENGAGING CHILDREN'S MINDS. THE PROJECT APPROACH." Stamford, CT: Ablex. ED 407 074., 1989.

Technical report No. 2

Taylor, P., Black, A. and Caley, R., The architecture of the Festival Speech Synthesis System, (pdf, html) 3rd ESCA Workshop on Speech Synthesis, pp. 147-151, Jenolan Caves, Australia, 1998

Works Cited

- Chu, K. (2014, 03 11). *Building research capacity in Africa*. Retrieved 05 26, 2014, from <http://www.plosmedicine.org/>:
<http://www.plosmedicine.org/article/info%3Adoi%2F10.1371%2Fjournal.pmed.1001612>
- IDA (International Dyslexia Association). (2000). *IDA Fact Sheet*. USA: IDA.
- Jurkiewicz, T. (2013, 01 01). *Harvard Family Research Project*. (H. F. Project, Editor, H. F. Project, Producer, & Harvard Family Research Project) Retrieved 10 21, 2013, from Designing Quality Assessment Tools in Early Childhood Education and Youth Development: <http://www.hfrp.org/evaluation/the-evaluation-exchange/issue-archive/evaluating-out-of-school-time-program-quality/designing-quality-assessment-tools-in-early-childhood-education-and-youth-development>
- Kopko, K. (2006). <http://www.human.cornell.edu/hd/outreach-extension/upload/temple.pdf>. Retrieved 2014, from <http://www.human.cornell.edu>: <http://www.human.cornell.edu/hd/outreach-extension/upload/temple.pdf>
- SQATester. (2000). *Testing Risk Assessment*. Retrieved 0422 2014, from <http://www.sqatester.com>:
<http://www.sqatester.com/methodology/TestingRiskAssessment.htm>
- WETA. (2006). http://www.visd.com/depart/specialprograms/dyslexia/dyslexia_handbook_teacherstrategies.pdf. Retrieved 04 05, 2014, from <http://www.visd.com>:
http://www.visd.com/depart/specialprograms/dyslexia/dyslexia_handbook_teacherstrategies.pdf
- Wiegers, K. (2012, 09 18). *The Five Dimensions of a Software Project*. Retrieved 10 21, 2013, from Business Analyst Times: <http://www.batimes.com/articles/the-five-dimensions-of-a-software-project-part-1.html>
- Zhang, W. (2012). Software Engineering and Knowledge Engineering: Theory and Practice. In W. Zhang, *Software Engineering and Knowledge Engineering: Theory and Practice* (p. 352). Springer.