

TekkiKids: Technology clubs for children

Mario A. MARAIS¹, Andrew C. SMITH², Marcus DUVESKOG³

¹*Meraka Institute, CSIR, P O Box 395, Pretoria, 0001, South Africa*

Tel: +27 12 8413771, Fax: + 27 12 8414720, Email: mmarais@csir.co.za

²*Meraka Institute, CSIR, P O Box 395, Pretoria, 0001, South Africa*

Tel: +27 12 8414626, Fax: + 27 12 8414720, Email: ACSmith@csir.co.za

³*University of Joensuu, P O Box 111, Joensuu, 80101, Finland*

Tel: +27 12 8412935, Fax: + 27 12 8414720, Email: duveskog@cs.joensuu.fi

Abstract:

TekkiKids is a part of the The Young Engineers of South Africa (YESA) programme which is an initiative aimed at increasing the pipeline for the generation of more scientists, engineers and technologists by creating the necessary interest and involvement of learners. The aim of the TekkiKids project is to research hands-on, experiential learning via technology clubs for children aged 9 -12. Sponsored by DST and the Finnish Embassy, this research is done in partnership with the University of Pretoria and the University of Joensuu in Finland. The methodology used in Finland is being replicated in South Africa and adapted to local conditions. In the pilot phase of this three year project three groups of learners from well-resourced and less well-resourced schools were selected and exposed to science and technology via challenges and other fun activities that cover the design and building of simple structures right through to the building of robots. We discuss our initial experiences regarding the dynamics of pairing well-resourced and less well-resourced schools and the use of various technologies such as Lego Mindstorms and waste materials such as cardboard. Computer literacy proved to be a constraint that had to be addressed. The technology clubs proved to be a good testing ground for the use of novel ways of introducing concepts such as programming. The difficulty that some of the learners experienced in constructing devices using Lego and other materials highlighted the need for basic skills that can only be gained via experience. The implications of our experiences, in the design of a three year curriculum framework for technology clubs, is discussed.

Keywords: technology clubs, experiential learning, edutainment, concretizing tools, intelligent physical learning objects

1 Introduction

The TekkiKids project is a research project that is part of the Young Engineers of South Africa (YESA) research area within the ICT in Education, Youth and Gender research group at the Meraka Institute (CSIR). The aim of YESA is to increase the pipeline for the generation of more scientists, engineers and technologists by creating the necessary interest and involvement of learners. These interventions start at a preschool level with TekkiTots and continue in the primary school with TekkiKids, which involves learners in grades five

to seven. The project researches hands-on, experiential learning via technology clubs for children aged 9 -12. Sponsored by DST and the Finnish Embassy, this work is done in partnership with the University of Pretoria and the University of Joensuu in Finland. The University of Joensuu has been running what they call Kids' Clubs using technology activities, such as Lego robotic materials that they use to design, build and program various devices (see <http://cs.joensuu.fi/kidsclub/>). The methodology used in Finland is being replicated in South Africa and adapted to local conditions. This paper discusses our initial experiences in the pilot phase of this three year project with three groups of learners from well-resourced and less well-resourced schools. We are technologists without a formal background in education and therefore this paper is written from a technologist's point of view. We discuss the objectives of the project, our overall project approach, methodology, our experiences and preliminary conclusions and recommendations.

2 Objectives

The broad developmental objectives which are supported by the project are:

- To provide all young learners, especially those in disadvantaged areas, with the opportunity to engage with technology in a hands-on fashion;
- Improve the performance of all these learners, both at a school level and at a tertiary level in the fields of Science, Engineering and Technology, i.e., increase the number of science, engineering and technology graduates and postgraduates and thus the national competitiveness of the country;
- Provide researchers with an open, living laboratory, where research results can be tested or, more interestingly, novel innovation can be found in collaboration with the learners;
- Create a system of technological innovation within which learners are empowered and exposed to a problem solving approach while capitalizing on the power of group work;
- Expose these learners to different environments and contexts – specifically with regard to other countries and cultures; and
- Support a national network of innovation and learning for learners to share in the powers of collective collaboration.

The objectives of the project are to:

- Implement and adapt the Kids' Club model in South Africa as a means to get learners interested in Science, Engineering and Technology in a developing country context;
- Foster collaboration between researchers and participants in Finland and South Africa;
- To investigate how to implement a technology club so as to stimulate and encourage interest and innovation;
- Investigate gender issues;
- Investigate how technology clubs can assist in bridging digital and cultural divides;
- Investigate ways in which the methodologies can be packaged and aligned with the national curriculum, so that the findings can either be integrated into schools or made available via clubs as an extra-curricular school activity (on a national scale);

- Test and develop the technology club model in well-resourced and under-resourced schools in order to gain experience for massification;
- Function as a test bed/living laboratory for our own educational technology development, focussing on appropriate, viable and affordable technologies for massification; and
- Investigate potential massification and sustainability models for the clubs in a developmental context.

3 Project Approach

The project is planned for a duration of three years.

In Year 1 the TekkiKids clubs begins with six pilot schools, covering the spectrum of well-resourced and under resourced public and private schools. Six learners from each school, 36 in total, in three groups of 12. The Kids' Club activities in Finland proceed as normal with collaboration activities between the two countries starting towards the end of the first year.

In Year 2 there will be an extended pilot of 100 children in South Africa: well-resourced and under resourced schools (normal and special education); and extended Kids' Club activities in Finland (Kids' Club, normal and special education). Collaboration takes place via visits and workshops.

In Year 3 the TekkiKids activities is expected to be extended to other areas, encompassing at least 200 children (to be determined based on results of the previous two years).

Throughout the project multidisciplinary research is to be done in the fields of education and learning, educational technology and the developmental aspects such as massification challenges. In order to expose the learners to innovation in action, the plan called for investigating the possibility of hosting the clubs in environments such as the Innovation Hub in Pretoria which is an ICT Incubation initiative by the Department of Science and Technology and the Gauteng Province. This would also provide the opportunity for entrepreneurs to be exposed to the TekkiKids and create the possibility of joint activities. To support the development of models for massification, various ways of using existing Science, Engineering and Technology (SET) infrastructure will be explored.

The project was initiated in the second school term of 2006 and by the fourth term of 2006, 36 learners from five schools were involved in two-hour sessions held every two weeks. Two under-resourced public schools from predominantly black suburbs (Isaac More Primary and FF Ribiero Primary) were paired with a public (Lynnwood Laerskool) and a private school (Christian Brothers College), both situated in affluent, predominantly white suburbs and well-resourced. Six learners were selected from each school. The fifth school, Arcadia Primary, a fairly well-resourced public school, was selected on the basis of its diversity in learners, both in terms of ethnicity and affluence. A group of 12 learners was selected at this school. All of the sessions are held at the Meraka Institute of the CSIR, except for the group of 12 learners from the fifth school which meets at the school.

The selection of the learners varied. We made presentations to the children at two of the five schools and children could then indicate their interest to the local teacher. At other schools we did not interact with the children at all and the teachers made the selection. This

was based upon the preference of the school principal. However, we did provide criteria to be considered when making the selection. Criteria included the requirement to have a gender-neutral group, a commitment by the parents to a two to three year participation on a regular basis (two hours every two weeks during the school term), interest in science and technology, and performance levels at school (both poor and good performers were required). Learners in grades 5 to 6 were predominantly selected. In the case of one group, the Isaac More/Lynnwood group, Grade 6 and 7 learners from Isaac More were paired with Grade 5 learners from Lynnwood. This was due to the fact that the Lynnwood learners have had extensive exposure to computers, both at the school and at home.

We asked the learners to complete a profiling questionnaire to provide information about their interests, academic performance and exposure to Information and Communication Technology (ICT).

The approach that has been used by the Kid's Clubs in Finland emphasises learning-by-doing, experiential learning and has been influenced by the work of Seymour Papert on constructionism¹. Learners are mostly left to learn on their own. Technical tutors are available to provide assistance, but the focus is on asking questions rather than providing answers. The aim is to facilitate a shift from being passive consumers of technology to being designers and developers of technology. In order to stimulate innovation and problem solving skills the learners are exposed to real problems from the local environment such as industry problems. This also serves to connect the club to local innovators. In our context we are interested in seeing what innovations can arise when learners from different backgrounds interact.

During the three terms of sessions that we have had to date (April 2007), the focus has shifted as follows:

Term 1:

- Introduction to Lego Mindstorms: The basic mechanical components (beams, plates, gears, pulleys, etc.) and the engines. The construction of simple machines from plans.
- Basic computer skills: using a mouse, keyboard, opening and closing files. Doing a basic presentation using photos.

Term 2:

- Introducing challenges where they have to design their own simple machines (e.g. a catapult)
- Introducing the use of non-Lego materials such as cardboard, wire and wood.

Term 3:

- Introduction to the concept of programming using technology developed at the Meraka Institute
- Introduction to the Lego programming environment
- Building programmable robots to plan
- Programming the robots

1 Constructionism is an approach to learning developed by Seymour Papert and his colleagues at MIT in Cambridge, Massachusetts. It is based upon Piaget's constructivism, but goes beyond it to assert that constructivist learning is enhanced when you are engaged in constructing something that is external to yourself such as machine, robot or a computer program. [1]

- A two session challenge to design a programme that will let the robot navigate a maze.

The plan for Term 4 is to go through the entire design cycle (design, make, evaluate, communicate) with the learners using the Fab Lab at the Innovation Hub in Pretoria to manufacture their designs in cardboard and acrylic materials.

We have started with the design of a three year curriculum framework for a total of sixty sessions. The framework engages with the existing technology curriculum in order to build upon what the learners are exposed to at school.

In terms of the research methods we are simply gathering information at present. We observe and take notes of what we deem to be significant interactions between the learners and other issues such as the variety of the designs and problem solving strategies. At the end of each session we normally ask the learners open-ended questions to elicit their response as to what they enjoyed or did not enjoy about the session. We also have a reflection session after the session with the teachers and tutors where we ask them what they observed that was significant to them. The teachers are our partners in the project, as active participants (researchers) in the project, their inputs are asked regarding the design of the sessions and the challenges and what facilitation techniques to use.

Each session is video recorded from the moment the first child arrives up to the moment the last teacher leaves. We have many tens of hours of material in broadcast-quality video. The video recording is done by a dedicated person. Still images are also captured using a digital camera. This task is shared amongst the facilitators with typically 40-80 photos being taken during a session. All of this is backed up onto a RAID disk, and also in DVD format at lower resolution for later analysis.

The sessions are also used as a living laboratory to test educational technology research. In the next section we report on the concepts that have we tested (the AfriGo Invention Set and the GameBlocks [2] programming environment). The challenge is to adopt and develop affordable technologies that fit the local context and supports massification.

In the next section we report on our experiences during these three terms with the three groups.

4 Experiences

The basic session design

We are “feeling our way” with regards to the design of the TekkiKids sessions. We started off with a very structured approach in the first session with the Isaac More and Lynnwood learners. We introduced them to the mechanical components of the Lego Mindstorms set and then posed a challenge: to build a device that will hoist bricks to the top of a roof. The Isaac More and Lynnwood kids were paired and the interactions in the pairs were rather limited and stiff. Subsequent sessions have been more loosely structured to introduce a fun element.

Based on that experience we started off the first sessions of the other groups with fun activities just to break the ice. They played with balsa wood aeroplanes, pre-built K-Nex structures and the Lego Mindstorms sets. In term 3 we held a fun day on a Saturday that was facilitated by a private technology club, the Lab Ratz.

Our approach varies, some sessions were well structured while others were open-ended. We have yet to determine the most beneficial approach to follow to create a balance between the security that structure provides versus the free flow of creativity in response to a challenge where you have to design a solution from scratch.

Club rules: we followed the example set by Joensuu University in engaging the children in formulating the club's rules. Some of the rules were easy to agree on, at other times we imposed the rule even though there wasn't consensus (for example, encouraging the sharing of ideas when competing). However, the rules aren't currently strictly enforced and merely serve as a guideline. Discipline sometimes seems to be an issue.

We learnt a great deal from the teachers regarding some of the key issues to focus on. Our first session plans did not include a material list, now they do! They developed a rubric for us and showed us how to assess the completeness of a design². We were reminded to keep our instructions clear and to explain the technical terms that we used. In terms of a “holistic” approach: we also provide a healthy lunch – you can't work on a hungry stomach!

The impact of producing a competitive element

Most sessions have posed some form of a challenge. At first, we did not offer any rewards or measure the performance of the design, we simply asked the learners to share their knowledge gained in doing the design. We then started to experiment with the introduction of a competitive element. The session would end with a competition. The designs were tested and assessed and hand-made prizes were awarded for the best performance (e.g. the catapult that could throw a marble the furthest) and the most innovative design (e.g. the design using the flex of the bamboo skewer versus all the elastic-powered designs).

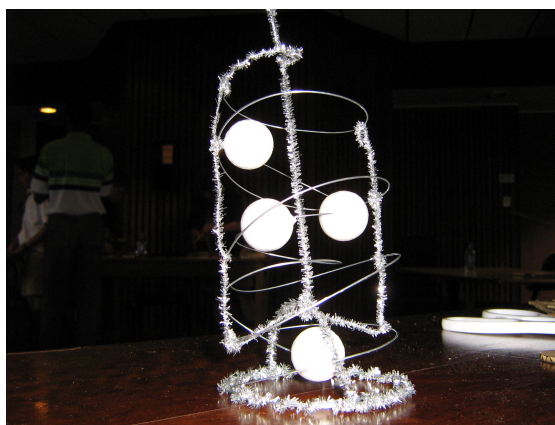


Figure 1: Prize for best performing implementation

² A design should have the following elements: Material to be used, Explain how it works, Show views, Size (MESS).

We found that children were the most engaged in their activities when a challenge was posed and a prize offered for the best performing implementation of the solution. We need to find a balance between the competitive element and the feeling of being a poor performer. The design of the challenges should encourage competition to motivate all learners without some learners feeling they are at a disadvantage, can never win, which could harm their self-esteem? We have also observed that the competitions seem to engage the boys more than the girls, although there were exceptions. There are definite differences in interest- some learners would be very focussed on the competition, others would show more interest in decorating their design than improving its actual performance. This is hard for scientists and engineers such as ourselves to understand: how can you allow your colourful pipe-cleaner to jam the gears!

Competition also lead to interesting dynamics such as the protection of the design, of the “intellectual property”. Some learners used their Lego set's case to hide their design from the others, others covered up the screen of their laptops to hide their programme. This is natural, but went against our Open Source ideology at Meraka! We tried to encourage sharing of ideas and discourage simple copying of designs. At the end of the session all the different designs would be discussed and shared.

Communication and language issues

The pair dynamics is a challenge as pairing students from well-resourced schools and less-resourced schools has resulted (mostly) in limited communication between the students from different schools. It seems to put the students from the well-resourced schools in a leading role. Their familiarity with Lego and personal computers gives them an advantage. The strengths of these students comes to light but seldom the strengths of the other students. This might influence self-confidence negatively and widen gaps in skill levels rather than narrowing it? Interventions such as assigning different phases of the challenge to different members of the pair had limited success. We also paired boys and girls together and this may also have had an influence. There are a few all girl pairs and the communication between the partners in these pairs seem to be better than in the boy/girl pairs.

For one group, English is the second language of both schools and this could also affect their ability and willingness to communicate. In order to encourage learners to communicate their ideas in the feedback part of the session, we have asked them to use their mother tongue with the teacher translating.

Problem solving skills

The preferred mode of problem solving of the learners is trial and error. In most challenges we asked the children to design a solution on paper before proceeding with the construction thereof. Most designs were very basic or non-existent. Some of the designs did not take into account the components and materials that were available. Where they were good, the final implementation varied significantly from the design, without the design being updated. The trail and error method was especially visible in the maze challenge. The learners were asked to design a programme that will navigate a robot through a maze. The learners were

asked to draw a plan of the maze and measure the maze. The learner then had to put down on paper the steps of the programme, e.g. forward for three seconds, turn right, forward for 10 seconds. Very few learners entered the complete programme. They preferred to get the first leg of the maze right through incremental adjustments of the running time after a trial run of the programme. To force a bit more thinking and planning we asked the learners to record the number of trial runs and announced that the winner would be the one who navigated the maze after the least number of trial runs. This did lead to a more planning by some of the groups, others simply seemed to enjoy the excitement of letting the robot loose on the maze! The teachers did remind us that we were expecting a lot from learners in this age group regarding planning skills.

Educational Technology Development

The educational technology that we tested was the AfriGo Invention Set and the GameBlocks [2] programming environment. The GameBlocks was evaluated by the children for the intuitiveness of the symbols used on the top surface of the blocks.

The AfriGo Invention Set

Supplemental to the plastic, commercial Lego sets, we have developed the AfriGo Invention Set. It is made from recyclable cardboard and can be customised to local requirements. AfriGo was designed for manufacture in a Fab Lab (of which there are currently five in South Africa). The two-dimensional parts are designed to be assembled to form three-dimensional structures. The AfriGo Invention Set was used as resource in a challenge where the children had to design and build the best performing catapult.

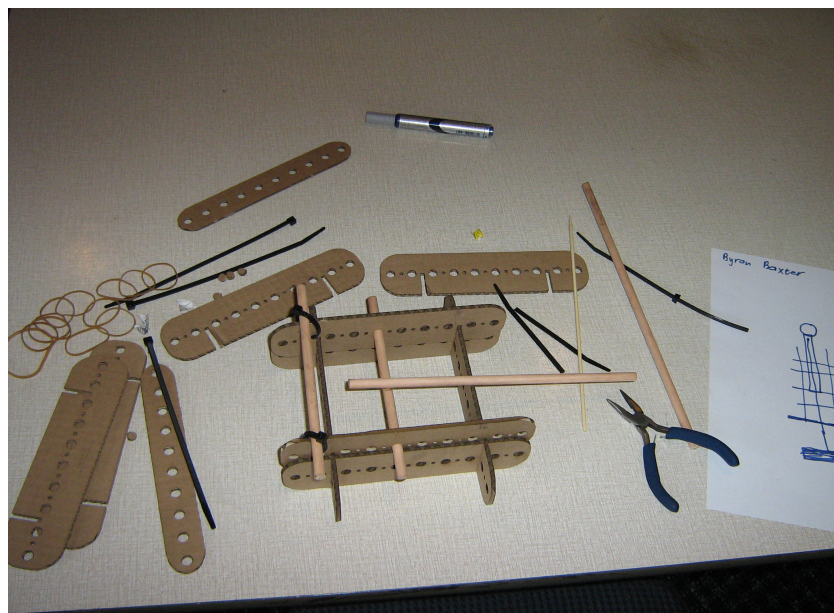


Figure 2: AfriGo Invention Set

GameBlocks

Introducing young children to computer programming has traditionally required a trip to the school's computer laboratory. GameBlocks is a research project that aims to remove the need for an expensive computer when children are first introduced to computer programming. Instead of requiring computer skills such as using the keyboard and mouse, saving and retrieving a file, overcoming the phobia/fear of using an expensive piece of equipment such as the computer, children are first exposed to computer programming using components which are robust and well known to many children. GameBlocks consists of three-dimensional blocks with icons printed on the top surface. The blocks are made from soft foam and the icons represent programming instructions. The current GameBlocks implementation consists of 12 blocks, representing six instructions. The instructions are: move forwards/backwards, turn left/right, play two simple musical tunes. A child composes a programme by placing the blocks in sequence on a "programming" mat. In turn, associated electronics interprets the blocks and sends appropriate commands to a toy robot for execution. With GameBlocks, a child can compose a programme to control a toy robot without having mastered the complicated procedures required when using a desktop computer.



Figure 3: GameBlocks programming

Use of different materials

As stated above we used the AfriGo parts in addition to the Lego components. We also supplied wooden dowels, split-pins, wooden skewers (as used for kebabs) and elastic bands to be combined with Lego components in projects to construct interesting machines such as cranes. We encouraged children to modify the design to incorporate their thinking.

It was obvious that children had varying prior exposure to various technologies. Some were proficient in the use of Lego building blocks, while others have never encountered them before. When using AfriGo and other materials such as wire and dowels, a hot glue gun and a pair of pliers are very handy. We noticed that some children have never used these tools before. We had assumed that the use of the AfriGo set would “level the playing field” since none of the learners had prior experience of it. This did not quite prove to be the case. The best performing catapults were constructed by the learners from the well-resourced schools. In terms of innovation, some of the most innovative designs were from learners from under-resourced schools. Overall, the variety of the designs was greater than we had seen previously when just Lego was used.

We found that children enjoyed decorating their catapults made from AfriGo using feathers, pipe-cleaners and other colourful parts. In general the learners used the “art materials” to decorate the other Lego-based constructions as well.

Impact on schools

At one school a technology club was started by the senior phase technology teacher. It runs on alternate weeks to the Tekkikids sessions. Some of the teachers who participate have had limited exposure to computers and are very keen to improve their computer skills. They participated enthusiastically in special computer courses that were held by one of the teachers for the group of learners that partnered with their school. Teachers have enquired as to how they can use the Lego kits at their schools.

We would like to acknowledge the contributions of the teachers: Brian Barger, Coenie Esterhuizen, Héndre Visser, Busisiwe Mthethwa, PJ Smit, Roni Morgan, Joe Petje, Ntombi Leah Ntaka, Emmah Mashigo and the supportive role played by the principals of the schools.

5 Conclusions and Recommendations

The pilot phase of the project has provided us with some experience which we can use in planning the further phases of the project and in the development of a curriculum framework. We have to slow down the pace of the sessions and at the same time diversify the nature of the challenges to allow for the different interests of the learners. The variation in the skill-levels of the learners means that challenges should be designed with different levels of difficulty. The use of 'scaffolding' [3] needs to be looked at in the overall design of the year plans. The balance between structured and open-ended sessions remain elusive, but it is clear that we need to retain and enhance the fun element! As researchers we tend to get

locked-in to the objectives that we want the learners to achieve and hence may constrain the creativity of the group. The amount of concepts that we cram into the five sessions of a term is also probably too much. We need to allow time for reinforcement.

We underestimated the impact of the culture, language, and gender differences. We have been hesitant to re-group the pairs as we have not yet researched the dynamics which exists between the existing pairs. However, to avoid further frustration among the children we will in the near future experiment with different combinations and also see what will happen if we allow free association. The natural tendency that we have observed is that learners prefer a partner of the same gender from their school.

The initial results of the use of the alternative materials and the AfriGo Invention Set has been enticing and we need to explore the use of these materials further. It challenges the design and construction skills of the learners and creates space for innovation. It is also important for long-term sustainability and massification strategies since Lego is simply too expensive for most of the schools in South Africa and the rest of Africa. The use of the GameBlocks has shown the usefulness of introducing difficult concepts using tangible learning objects.

We need more structured feedback from the learners and a solid research base. To this end assessment strategies are being developed (both short-term and long-term) and researchers are being invited to participate in the project.

6 References

- [1] Papert, S. (1992). *The Children's Machine: re-thinking school in the age of the computer*. New York, BasicBooks.
- [2] Smith, A. C. (2006). "Tangible cubes as programming objects", In Proc. ICAT 2006, ISBN-13: 978-0-7695-2754-3, IEEE Computer Society, Order Number P2754, pp. 157-161.
- [3] Vygotsky, L.S. (1978). *Mind and society: the development of higher mental processes*. Cambridge, MA: Harvard University Press.