SA learners learn basic hands-on electronics as facilitated by an IT learning environment

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SUNSTEP has been very successful the past five years in teaching 77028 learners in 6 provinces to understand basic hands-on electronics. SUNSTEP made an investigation to determine the extent to which basic electronics can be taught to learners as facilitated by the multimedia computer program, VirtualBookTM. The learners were able to assemble an electronic alarm kit, by first mastering the basic electronics theory and then soldering the correct components onto the printed circuit board until the buzzers beeped and the LED's flashed, indicating successful completion. It has been proven that the learners are able to independently assemble an electronic kit with the computer program as teaching aid. INTRODUCTION The SUNSTEP programme (Stellenbosch University Schools Technology in Electronics Programme) strives to introduce electronics into schools and expose children to basic electronic ideas in grades 6 to 9. It also aims to reinforce the fact that electronics offer a career opportunity accessible to far more students than those few that are currently studying in this field. This intervention especially focuses on previously disadvantaged communities where children come from poor homes, without access to technology. If this interest in electronics leads to the subject choice of Mathematics and Science in grade 10, the chances are reasonable that the learners will make their career choice in Science, Engineering and Technology (SET). The SUNSTEP methodology includes the training of educators to assemble, solder and understand various electronic kits and to understand the function of electronic components and the electronic circuit. These educators then transfer the knowledge to t! heir learners. (Botha & Myburgh 1998). SUNSTEP started 6 years ago as an intervention. Many public communication elements had to be employed to make principals, educators and parents aware of electronics and technology. The educators who were proactive and actively took part in the programme and introduced our electronic kits into their schools and encouraged their learners to build their kits into marketable and entrepreneurial applications, are the educators who were seconded to the WCED as Technology Curriculum advisors and Area Circuit Managers.

BACKGROUND

This programme originated at Stellenbosch University Electronic Engineering Faculty. In 1996 it became clear that learners and educators from 99% of South African schools knew nothing of electronics and were not able to design an elementary electronic circuit. SUNSTEP was introduced as an awareness programme. Since Technology has in the mean time become a subject, SUNSTEP progressed from an intervention to a necessity for most educators. Many of the educators did not know how to handle the electronics part of technology, as they received no formal technology training. To many it was a frightening experience as they were taken from other learning areas and told that they were now responsible for technology. SUNSTEP experienced a sudden explosion when schools and educators who were participants in our programme communicated their advantage to other schools in their circuits and districts. Numbers of learners reached increased dramatically and numbers of educators trained doubled.

Educator Technical Orientation

Educators are given high priority in the programme. They receive free technical orientation to equip them with the necessary skills and confidence to teach the learners from the General Education and Training Band in the assembling of electronic kits. Educators indeed have a crucial role to play in improving the standard of science and mathematics education in schools throughout the country. After attending a number of courses run by the SUNSTEP regional co-ordinators, they take the material to their schools. This ensures that they will succeed in the classroom when teaching their learners. If they need help in the schools, assistance is provided by the SUNSTEP co-ordinators. Each region has a co-ordinator who is responsible for the educator and learners workshops, marketing, kit distribution and media. The selection of schools for the project is based on the enthusiasm of the school and educators, as well as the commitment they display towards attending the free train! ing classes provided by SUNSTEP. All the Technology and Science Curriculum Advisors also came to SUNSTEP for training. This is to ensure that they and the educators in their circuits and areas speak the same language and see the subject and in particular the electronics from the same viewpoint. During adjudication sessions at schools, it became clear that during assessment visits made by the WCED, the few area managers who could not attend our electronic workshops, were pleasantly surprised to see the learners' work, the kits and portfolios.

Electronic Kits
The electronic kit has been designed with an educational purpose. It is relatively inexpensive, interesting to construct, of a high quality and has a high probability of functioning correctly the very first time it is assembled. Educators are encouraged to use the kits to illustrate important scientific concepts and to link them to other teaching and learning opportunities. The learners learn to understand the functionality of resistors, transistors, relay switches, capacitance and diodes, etc. and also to observe them in an electronic circuit. They gain practical and theoretical knowledge while having fun at the same time. The learners must apply this scientific knowledge that they have acquired by making an application for their alarm kit. Because the application can be completed at home, the parents now take notice of the task and help gather information or resources. Public awareness of technology and electronics circle wider and in the midst of it the learner ha! s to come up with something that is useful in his/her circumstances.

Subsidiary Research Questions
· To what extent does VirtualBookTM succeed in creating interest in basic electronics?
· To what extent will learners be able to work independently with a fair measure of understanding, while assembling an electronic kit as introduced by the VirtualBookTM programme?
· To what extent is the enjoyment and fun of a traditional electronic workshop retained in the multimedia conducted workshop?

LITERATURE REVIEW
SUNSTEP endeavours to find ways to expand its reach and make a greater impact on the learners in our country. As stated by Kwende (in Sadeck 2001:1) "The issue of Science and Technology is crucial for the future of the African continent, since all previsions indicate that science and technology plays a major role in the 21st century." The question that the researcher wants to answer is: Will VirtualBookTM be a good medium of instruction for technology in electronics? Sadeck (2001:2) is of the opinion that: "Observations at various schools and contact with various provinces have shown that there is an ever increasing gap in the knowing of Technology and the ability to deliver/teach Technology."

The co-ordinators throughout the six provinces in South Africa where SUNSTEP is active have reported that learners who assemble a kit for the first time and many more times after that find the experience enjoyable. De Swardt, Ankiewicz & Gross (2001) say that enjoyment encourages learning and Albrecht (in De Swardt et al 2001:2) describes enjoyment, as a functional thinking skill. The learners work together, helping each other and happily interact. According to De Swardt et al (2001) this interaction contributes to the motivation and it furthermore frees creative spirits. Learners have a need for socialization and group interaction. SUNSTEP learners must house their kit in an application that is useful, marketable, original and durable. Over a period of four years of application adjudication, SUNSTEP co-ordinators have come to the conclusion that they are in agreement with Ayan (in De Swardt et al 2001) who says that "being with, talking to and observing other people h! elps generate ideas, provide inspiration and stimulation." Every year the learners present applications for their electronic kits that show improvement on those of the previous year. At the SUNSTEP Annual Awards function, the learners and educators see what can be done, become inspired and produce equally good or better applications for their electronic kits of the following year. Zacharopoulos, Pallis & Athanasaki-Michailidou (2001:71) stated that as technology is "rapidly evolving, the market need for skilled and well-trained scholars is also increasing." This need becomes imperative in areas such as multimedia which demand continual training of future engineers." Moru & Rochford (1999) believe that one of the most important ways in which the teaching of science, engineering and technology can be improved in South Africa, is by introducing more real life skills, such as technical, manufacturing and technological skills.

During the electronic workshops, the learners construct the new learning material, merge it with the little knowledge they have of the electronics field and then relax and enjoy the challenge as their learning becomes meaningful. Hanley (in Laidlaw 1999:22) states that "the learner must actively construct new information into his/her existing mental framework for meaningful learning to occur." Learners change their understanding because of new data. During this assimilation process, the learners' ideas become more complex and powerful. The learners gain critical insight into how they think and what existing knowledge they already have. Co-operative learning allows learners to share their learning as they reflect on their own and their peers' ideas (Stromnen in Laidlaw 1999:22). In practice, this is very evident as the learners work together to understand their electronic kit in their determination to make it work. To these learners learning is an active experience. D! e Villiers (2001:23) states that " testing is integrated into the task." Part of the anticipation that learners experience, involves looking forward to seeing their alarm kit work. In the learner workshops, whether presented in the traditional way with the educator conducting the class, or the VirtualBookTM way, with the Book as the tutorial programme, emphasis remains on "teamwork to promote multiple perspectives" (De Villiers 2001:23). After completion of the workshop, the learners have to apply their newly acquired scientific knowledge into a useful application according to certain criteria. The learners now have to transfer their new skills to a problem-solving situation. The applications must make the learners' real world safer or easier. These problem-solving solutions must be practical and represent the real world in which the learners find themselves.

This study is closely linked to the many-faceted SUNSTEP programme. A review of current literature indicates that SUNSTEP, together with VirtualBookTM, has the potential to expose learners to motivating learning material and information. An overview of VirtualBookTM indicates why it will accommodate learners' production of new knowledge. The potential of VirtualBookTM as a medium of instruction for effective learning is available to schools, learner groups and individuals who participate in the SUNSTEP programme. THE RESEARCHER'S INTEREST The researcher's interest lies in finding out if VirtualBookTM will:

· Enable learners to help themselves understand basic electronics.
· Extend the reach of SUNSTEP in SA.
· Enable learners to experience achievement brought about by using computer technology to complete a hands-on project in a new and interesting field.
· Integrate the task-based assembling of an electronic kit with the essential learning and thinking skills that go together with basic computer skills.
· Create the same interest in hands-on electronics that learners normally experience when they attend a workshop in the Technology classroom, facilitated by the educator.
· Enable learners to enjoy the workshop as facilitated by VirtualBookTM as much as they usually enjoyed the SUNSTEP practical workshops the way they were conducted in the past.

A DESCRIPTION OF VIRTUALBOOKTM

The VirtualBookTM is designed to simulate the look and feel of a traditional book. The student sees one page of a book on each screen. Users of VirtualBookTM have found that it promotes learning and memory processes and thereby helps the student to study effectively. Its multimedia-rich environment enables interactive learning, testing and customized web-based support. Material including graphics, sound, video clips and animation effects are easily incorporated into VirtualBookTM.

Table of Contents

The Table of Contents fascinated the learners, because they could move from there to any chapter at the click of the mouse. Page navigation is also driven by hyperlinks or by keyboard strokes (by clicking on the arrow bottom right or using the arrows on the keyboard). Quit and

Resume
When the quit button is pressed at the end of each study session, an electronic bookmark is inserted on the last page studied.

Highlighters
Several Highlighter colours help to render important text passages clearly visible. The highlighter icon is dragged across the relevant text. The whole paragraph can be marked or just a vertical line can be inserted in the margins to mark particular text.

Notes
Students usually write notes in the margins of their books. VirtualBookTM makes it possible to add electronic notes about important aspects of the study text. The note icon is dragged into the relevant paragraph and a note page to write on will open automatically. The note is then closed and the note icon is parked on the page.

Bookmarks
Bookmarks of differing colours are provided to mark pages of interest in study material. These bookmarks can be labelled by the student, so that s/he sees the name when moving the mouse over the bookmark.

Video and Animations
For powerful presentations, video clips with accompanying sound may be included - the user will be able to stop, pause and rewind video clips that are included in VirtualBookTM. To play the video, learners click on the static picture. Animated diagrams, for instance from an engineering course, may be included.

Requirements
The important issues are that the school should have a Pentium II PC running Windows 95/98/2000/NT with 64 megabytes of Random Access Memory (RAM) and a CD Rom drive. The Virtual BookTM 2.0 Reader will require approximately 12.8 MB of free disk space. The VirtualBookTM Reader requires that Javasoft's Runtime Environment version 1.3.0_02 (which will require an additional 30 Megabytes), is installed. It can be installed from the CD. NATURE OF THE STUDY MATERIAL The SUNSTEP VirtualBookTM consists mainly of three units of a tutorial nature. The alarm kit worksheets are broken up into modules. The first module demonstrates and explains how the transistor works. It also demonstrates how the base bias resistor influences the current. The base bias resistors are resistors connected to the base of the transistor. They ensure that enough energy is supplied to the base of the transistor to make it switch on. Learners see for themselves that, if they put a large value resistor (R2 = 680 kilo ohm) in the base circuit, it will offer a large resistance to the energy trying to reach the base. It will not let through enough energy to switch on the transistor. LED D2 will not light up. If they put a smaller value resistor (R3 = 470 ohm) in the base circuit, it will let through enough energy and D2 will light up. By changing the value of the base resistor, they will be able to control the energy in the collector circuit. This knowledge is then! related to an everyday experience, as this is exactly what happens when you turn the volume control on your radio. More base current gives more loudness because more current is flowing in the collector circuit which is coupled to the loudspeaker. The second module demonstrates the action of charging a capacitor and how it might be of use to us. The third module is the actual Alarm. METHODOLOGY For two mornings, 40 learners from two schools were invited to SUNSTEP. On the first day they had to answer a question paper on basic electronics. Then they were shown how to navigate their way through VirtualBookTM. A video on how to solder was shown to them. They studied 131 pages of electronic theory on the computer, inserting notes, bookmarks, naming them and highlighting text. After the three-hour study period, the learners wrote the post-test. The following day, the learners assembled the electronic burglar alarm by following the instructions on the computer. During the whole process, all theory, explanations and practical instructions came from the IT program. No educator was involved. The learners collaborated with each other and together they worked out the resistor values. The few whose kits did not work the first time, found a fellow learner to help with the

defaulting. All the learners had a working alarm kit when they walked out. With the research qu! estion and three subsidiary questions in mind, the learners had to answer a questionnaire.
RESULTS It is clear from comparing the results of the pre-test to those of the post-test that the learners improved considerably between the two tests. They were not able to answer most of the questions during the first test, but were able to remember what they had learned in the three hours and/or were able to find the answers quickly for the second test. The learners would not have been able to find the answers if they had not studied the material prior to the second test.
The pre-test results show that the learners from Rylands High School had an average mark of 20% compared to the learners from Stellenbosch High School who scored 10% average for the pre-test. The Stellenbosch High School learners improved more dramatically with 74% compared to Rylands High School, who improved with 50%. To what this can be contributed is difficult to say, as the Stellenbosch High School learners did not insert many bookmarks or highlights. It seems as if the number of bookmarks and colourful highlights did not increase test performance.
The Stellenbosch High School learners did, however, organise the instructions into notes and seemed to assemble the kit with ease due to that.
The learners, who collaborated with one another, did seem to enjoy assembling the kit more than the quiet ones. Due to working together, learners pointed out each other's mistakes before they could be soldered into the PCB. This led to an immediate feeling of success once the battery was connected and the buzzer sounded, together with the two LED's flashing alternately. Most of the learners indicated that they would love to assemble other electronic kits in the same manner.
How did the learners experience the assembling of a kit?
The learners' response to their own learning is tabulated separately after each question. The learners gave their own version of how they experienced the practical. Observation validated these results as the researcher and assistants noted the interest and excitement. The majority of the learners seemed to worry at some point whether they would be able to do what was expected of them. To some it was a surprise that it was actually easier than it seemed at first.   The learners were so taken up on what they were doing, that most of them became oblivious of their surroundings.

Was it easy or did they need help?
The learners could indicate how easy or difficult they found the practical and the theory in a questionnaire. Only a few found it difficult including the soldering technique. There were a few mistakes made by the learners such as:
a) Twisting the transistor legs so that the base, collector and emitter were forced out of position.
b) Inserting one LED with correct polarity and the other not.
c) Connecting one wire between E and F on the Printed Circuit Board instead of two (or cutting it in half). If the two wires are connected, the alarm will not sound, but if the trip wires are separated (by a burglar) the buzzer will go off.
All these mistakes could have been avoided by following the VirtualBookTM instructions.
Components inserted with wrong polarity can be ascribed to negligent reading or hasty actions.
Learners who collaborated with one another, could point out each other's mistakes before components were soldered into the PCB, which gave them an immediate feeling of success when the circuit worked perfectly. More of the learners would have made mistakes, but they assisted each other by comparing their understanding of the instructions. The learners knew they had to depend on themselves, the computer and work together. The faster learners acted as leaders and assistants. The facilitator only needed to be there to give support and encouragement. The learners enjoyed the book qualities, the bookmarks, highlights, speed and interactivity. Others enjoyed the independence and ability to learn in one's own time. Some enjoyed finding what they needed and learning about resistors and colour codes. Others enjoyed the practical soldering as well as the difference to normal study methods, such as no writing and no stationery. Learners responded favourably to the VirtualBookTM program that explained everything clearly, it was up to them to read and do. The learners were proud of the new soldering skill they had acquired and enjoyed working on the computer. The majority of the learners enjoyed assembling the kits and found it an exciting project. Their feelings alternated from being nervous to being very proud of their achievement. This experience was a challenge, which they enjoyed and mastered. After

their electronic experience, however, all the learners rated their interest in electronics as higher than before.

THE FOUR RESEARCH QUESTIONS

Were the learners able to master hands-on electronics successfully as facilitated by the learning environment VirtualBookTM? The post-test and practical results indicate that the learners did succeed in their self-study and kit assembling. A minority of the learners made a mistake while assembling their kit. They were able to debug it themselves and had quick insight into how to fix it. The few Rylands High School learners who had soldering problems, found it to be a good learning experience. They now know how to solder and will not have dry joints again. If they have to debug a kit in future, the first thing they will do is to flip over the PCB to see the soldering side and to check for bad soldering.

Did VirtualBookTM successfully create interest in electronics? The majority of the learners would like to learn more about electronics. In almost all the relevant questions asked in the questionnaires, the learners at some stage indicated that they found this an interesting project. Evidence from the video clips show that the learners were engrossed in what they were doing. Observation and learner feedback during the informal interviews validated these results.

Will learners be able to assemble a kit independently and have a fair measure of understanding of the electronics? The majority needed no help and those who said that they "did not really need help" or "not much" in actual fact, were collaborating with a friend. Together they worked it out until they grasped the point. Those learners who found the explanations easy to follow, showed evidence of self-reliance and understanding. Their behaviour, observed during the program, supported the positive responses.

To what extent was there an element of fun and enjoyment?

The Stellenbosch learners openly enjoyed themselves. Watching the video, taken of them while they were working, is a pleasure to the viewer. In almost all instances, answers to the questions at some stage indicated how much learners from both schools enjoyed the event. It can be concluded that they experienced this learning event as being exciting and interesting. The pre-test set out to establish the learners' pre-knowledge of electronic concepts and the post-test showed the level of improvement. The learners found the two mornings very interesting. Most decided that it was a new, but enjoyable experience for them. The majority were amazed at the different things they could do on the computer and found the freedom of movement within VirtualBookTM very satisfactory. On the whole this was a project much enjoyed by the learners.

CONCLUSION

VirtualBookTM has been found to be a successful tool for teaching basic electronics to grade 9 learners. It was found to be an effective method of instruction. The learners were able to acquire theoretical knowledge of electronics and were able to couple practical construction and soldering of an electronic kit. The learners obtained the expected outcomes and would gladly repeat this learning experience with another kit. The learners experienced technological accomplishment. Children learn when they understand the value of the learning process. VirtualBookTM succeeded in emphasizing this concept on both cognitive and affective levels. VirtualBookTM fits well into the educational set up and can be used to teach technology in electronics to schools. Schools that want to come on board the MTN-SUNSTEP programme can be accommodated by means of multi media material developed to make it easier for good education to be duplicated and knowledge of technology to be spread. It can be taken to the less privileged learners once computer systems are in place. Teaching and training done by the educator can be bettered and extended by using VirtualBookTM. In addition, the disadvantaged can be assisted to become more computer literate and skilled. The SUNSTEP programme empowers technology educators in a field where a great gap in knowledge still exists. Technology is a new subject, with many an educator unsure of how to go about teaching it. SUNSTEP has proven itself as a medium for introducing and teaching electronics in schools. VirtualBookTM and SUNSTEP can transfer basic and extended learning principles to schools in distant provinces or countries. Judging by their enthusiasm, it is reasonable to assume that the learners who assemble more SUNSTEP kits by means of VirtualBookTM and attend an electronics club, will one day enter a career in technology. To assist the educators, a further resource will be given to them in 2003. All the kit training workshops will be on an interactive CD. The educator can switch between a video, written theory files and photographs. They are no longer restricted to the workshop, but can go home and make sure that they understand what it is they have to teach the learners. This e-communication will also be distributed to the regional co-ordinators to assist them in distributing the basic knowledge of electronics.

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