International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:3, No:1, 2009

The Experiences of South-African High-School Girls in a Fab Lab Environment

Nomusa Dlodlo, and Ronald Noel Beyers

***Abstract*—**This paper reports on an effort to address the issue of inequality in girls' and women's access to science, engineering and technology (SET) education and careers through raising awareness on SET among secondary school girls in South Africa. Girls participated in hands-on high-tech rapid prototyping environment of a fabrication laboratory that was aimed at stimulating creativity and innovation as part of a Fab Kids initiative. The Fab Kids intervention is about creating a SET pipeline as part of the Young Engineers and Scientists of Africa Initiative.The methodology was based on a real world situation and a hands-on approach. In the process, participants acquired a number of skills including computer-aided design, research skills, communication skills, teamwork skills, technical drawing skills, writing skills and problem-solving skills. Exposure to technology enhanced the girls' confidence in being able to handle technology-related tasks.

***Keywords*—**Girls, design engineering, gender, science, women.

I. Introduction

ALTHOUGH progress has been made in increasing the numbers of girls entering the SET pipeline, the great divide between girls and engineering remains due to a lack of familiarity with the nature and possibilities of engineering and engineering technology [13]. When choosing a career in scientific fields, girls tend to gravitate towards professions that help humanity; thus the fields of health and medicine are widely chosen by women [20]. According to Anderson-Rowland, the reason why women leave engineering and why the numbers of women in engineering is not increasing as rapidly as the numbers of women in medicine and law include the lack of engineering curriculum in secondary school, the lack of a positive public image of engineers, lack of a vision of what an engineer really is, and the lack of support for women to succeed in engineering [3]. South Africa recently introduced an Outcomes-Based Education Curriculum that also covers Engineering Graphics and Design, Mechanical Technology and Electrical Technology in order to provide the learners, including the girls, a more realistic image of science and engineering technologies [47]. A study by Mayer-Smith illustrates that sound pedagogical practices and social organisation in technology-enhanced secondary science classrooms can promote a gender-inclusive experience, where women and men participate and perform equally well [22]. It is with these issues in mind that this research was conducted.

The research was done on a group of thirty high-school girls in an effort to advance policies such as the National Policy framework for women's empowerment and gender equity [30], the Convention on the Elimination of all forms of Discrimination Against Women (CEDAW) [6], the Beijing Declaration [4], the SADC Declaration on Gender and Development [32], and the Millennium Development Goals (MDG) [24]. The National policy framework for women's empowerment recommends an institutional framework that aims to place gender issues at the centre of transformation process within all structures, institutions, procedures, practices and programmes of government, its agencies and parastatals, civil society and the private sector. CEDAW which was adopted in 1979 by the UN General Assembly defines what constitutes discrimination against women and sets up an agenda for national action to end such discrimination. The convention provides the basis for realising equality between men and women through ensuring women's equal access to, and equal opportunities in all spheres of life including education. The Beijing Declaration reaffirms the governments' commitment to ensure the full implementation of the human rights of women and of the girl child as an inalienable integral and indivisible part of all human rights and fundamental freedoms. The SADC Declaration on Gender and Development on the other hand recognizes that the vulnerability of women and the girl child and their retarded contribution to the development of such is made worse by the unresolved inequalities between the sexes within the southern African region. The eight MDGs adopted in 2000 by the international community include the third goal whose target is to "eliminate gender disparity in primary and secondary education, preferably by 2005, and to all levels of education no later than 2015 [24].

There are a number of initiatives undertaken worldwide to draw girls and women into SET education and careers. The University of Tennessee's program to address the gender gap in engineering and computer science emphasises hands-on engineering and computer activities through summer camps for girls and fairs conducted at schools and other public and private facilities in the community [41]. The University of Colorado's "techno-neutral" high school girls explore the potential for careers in engineering and technology through developing educational interactive multimedia software. The internship helps the girls become aware that a technology-based career can be creative and fun while serving the needs of the society [40]. To introduce the comprehension of their subjects and their pedagogical skills, Indonesian mathematics and science teachers are involved in an in-service teacher-training known as "piloting activities" (PA). PA involves school teachers and faculty members from three universities jointly developing lesson plans, putting these plans into practice in the classroom and then reflecting on the lessons [34]. Today the Internet has rich web sites for budding scientists and engineers to explore, including playing with games and fun experiments, a glimpse of science as a profession with profiles of real scientists doing interesting work, and online meeting places for girls who like science [31]. In South Africa, the University of the North's Science foundation year is a foundation programme in science at university level as an effort to increase the quality and quantity of entrants from previously disadvantaged communities into university science programmes [21]. Students undergo extra lessons in science in the first year of their university curriculum to strengthen their science base. The Expo for young scientists is an annual science fair where learners have a chance to show others projects about their own scientific investigations and discuss their work with a larger audience [50].

The Young Engineers and Scientists of Africa [42] is an initiative which was incubated at the Meraka Institute Institute in South africa. Wigal, et.al [41] have also made a concerted effort to pilot a number of interventions aimed at addressing the SET pipeline in South Africa in all schools. There is an emphasis on previously disadvantaged schools, especially female and black students. The Fab Kids intervention is one such project that was designed to show school children that understanding technology through scientific lens can be stimulating, relevant, contextual and rewarding. When undertaking design and technology activities, children are provided with opportunities to create solutions to real-world problems in new and innovative ways. The mental processes involved in the generation of new ideas may be enhanced when children's attention is not focussed and is allowed to wander in a relaxed and uncompetitive environment [43].

The FabLab consists of a network of computers that runs open source software where OpenOffice Draw is used to capture two-dimensional design of the prototype. The FabLab is equipped with a range of output devices ranging from milling machines, laser and vinyl cutters, including a range of hand tools designed to process a variety of materials such as wood, cardboard and Perspex.

II. World Gendered Domains in Science and Technology

In the late 1990s, Japanese women comprised only 10% of scientists and engineers and less that 15% of the university science faculty. Furthermore, fewer than 7% of students enrolled in physics or engineering programmes were female. In 1970 the percentage of Japanese women enrolled in undergraduate science programs was 2.3% and by 2004 this percentage had not changed. Women increased in engineering from less than 1% in 1970 to nearly 6% in 2004. One effort to change this situation occurred in the early 1990s, when a survey of female scientists and engineers recommended the implementation of affirmative action programs in science and engineering, mentors for women in science and engineering departments and an increase in the number of female secondary science teachers. During this time the percentage of women in education and teacher training declined from 19% in 1970 to 8.5% in 2004 [36].

Women constitute 51.3% of the UK labour market and 55% of the graduates are women. Only 24.1% of all SET employees however are women despite the fact that one third of SET graduates are female. Women account for only 8% of the engineering workforce. 3.9% of full-time professors in engineering are women in the UK. 75% of women with SET degrees are not employed in SET compared with 60% men [15].

There were roughly 3.5 million college-educated graduates in the US in 1999 working in one of five broadly defined science and engineering fields – computer/maths, life sciences, physical sciences, social sciences and engineering, Women comprised just 24% of all science and engineering workers even though they constituted 46% of all U.S. workers and earned an average 22% less than men [14].

Nations in the Middle East and Asia displayed a lower representation of doctoral female recipients in science and engineering in the 2000/2001 year. Japan had 16% females, Iran 17%, Kenya 34%, European Union 30%, Russia 31% and the USA 38%. The numbers of female engineering researchers in academia in some of the countries stands at 8% in the USA and Germany, 12% in the European Union, 18% in Sweden and 14% in the UK. The UK and Sweden's indicators reflect progress in achieving a more equitable balance of women participating in science and engineering [25].

III. Science Education and Women in SET in South Africa

This section looks at SET education in South Africa and makes a case on the shortage of female skills in this sector. South Africa has three broad bands of education: General Education and Training, Further Education and Higher Education and Training. School life spans 13 years, from grade 0, otherwise known as Grade R or reception, through to grade 12 or matriculation level. General Education and Training runs from grades 0 through to grade 9. Further Education and Training takes place from grades 10 to 12 and also includes career-oriented education and training offered in other Further Education and Training institutions, that is, technical colleges and community colleges. Diplomas and certificates are qualifications recognised at this level. Higher Education and Training or tertiary education includes education for undergraduate and postgraduate degrees, certificates and diplomas. It is undertaken predominantly in the universities [1].

Science education in South Africa starts at primary school level. Outcomes-based education (OBE) forms the foundation of the curriculum in South Africa at grades R to 9 and sets outcomes to be achieved at the end of a process which encourages a learner-centred and activity-based approach to education while focussing on skills development. Science at this level is aimed at fostering an appreciation of the relationships between science, society and the environment, the development and use of science process skills and application of scientific knowledge. It covers mathematics, natural sciences, social sciences, management and economic sciences and technology, to name a few [26]. Between grades 10 and 12 learners are taught physical and life sciences. The physical sciences influence scientific and technological development. Scientific enquiry and problem-solving skills similar to those used by scientists at work are developed at this level. Pupils are able to understand relationships between science and technology, the society and the environment [29]. Life sciences involve the systematic study of life in the changing natural and man-made environment. This enables learners to understand biological, physiological, environmental, technological and social processes that impact on the environment [27].

Technical subjects, commonly known as trade subjects are taught at Further Education and Training (FET) schools. The new technology subjects focus on technological processes from conceptual design to practical problem-solving and the application of scientific principles. The technology subjects in the new National Curriculum statement include Electrical Technology, Mechanical Technology and Engineering Graphics and Design. These three subjects are referred to as manufacturing engineering and technology subjects [51].

In its report on the South African graduate statistics between 1991 and 1998 the Human Sciences Research Council reported the total numbers of people graduating in the various SET fields according to gender as follows [38]:

TABLE I
SET GRADUATES IN SOUTH AFRICA - 1991-98

	Female	Male	Female % of total graduates
Computer Science/IT	3779	7079	35%
Geological sciences	686	3323	17%
Mathematical and statistical sciences	6903	9505	42%
Biological sciences	11951	11831	50%
Physical and chemical sciences	4575	10050	31%
Engineering	1467	30897	5%

Table I shows that women are clearly under-represented in SET fields of computer sciences, geological sciences, mathematical sciences, physical and chemical sciences and engineering. Only 5% of engineering graduates in this period were women. Only in biological sciences does an equal representation of males versus females exist.

The South African Institute for Civil Engineering (SAICE), in its Infrastructure Report Card [33], confirmed that engineering skills, from professionals through to technicians and artisans, are in short supply in South Africa. The report found out that seventy-nine of the 231 municipalities had no civil engineers, technologists or technicians. The SAICE report also found a yawning gap between South Africa and other countries in terms of the number of people per engineer. In China the ratio is 130 people to every engineer; in Germany its 217 people to one engineer; in the UK its 389 people to one and in Australia 455 people to one.

In 2005, 42.3% of students at public higher education institutions in South Africa were enrolled for programmes of study in either teacher education or the broad humanities and social sciences, 29.1% of students were enrolled for programmes in business and management, while 28.6% of students were enrolled for science, engineering and technology reflecting low enrolments in SET [10].

In 1993 in South Africa, 470 948 pupils wrote matriculation exams at the end of grade 12 and 58% of these passed [11]. However, by 1998 the number of candidates had increased to 535 151 with only 51% of these passing the examinations The results at the end of 1997 were the lowest recorded since 1979 with only 47% of the pupils passing their matriculation examinations [12].

Specifically in mathematics the picture is very similar. In 1993, of 157 701 pupils who wrote the mathematics exam, only 80 050 (51%) passed representing 17% of the total number of candidates entering matriculation [11]. By 1998 when the enrolment figure had increased by 120 000 pupils, the pass rate had dropped to 42% [12]. The number of these students who passed higher grade mathematics stood at 28 305 in 2005 and less than half of these passed higher-grade mathematics with A, B or C symbols. Potential SET students are drawn from this pool [19].

In 2006 in South Africa, 528 525 pupils wrote matriculation exams at the end of grade 12 and 66% of these passed [52]. In 2006, of 169 118 pupils who wrote the mathematics exam, only 52% passed representing 32% of the total number of candidates entering matriculation [52]. By 2006 when the enrolment figure had increased by 120 000 pupils, the pass rate had dropped to 52% [12]. The number of these students who passed higher grade mathematics stood at 25 217.

Furthermore, Howie's research showed that there is little difference between grade 8 and grade 12 in the pupils' basic mathematical literacy level over the years despite the fact that more than 80% of the pupils receive four additional years of tuition in mathematics [18]. Of the learners who wrote Senior Certificate, only 8.5% wrote Higher Grade maths [48]. And of the total learners, only 5.1% passed Higher Grade mathematics. Under the Department of Education, the Dinaledi project [48] seeks to produce 50,000 mathematics and science graduates at senior certificate level by 2008. Dinaledi, established in 2001, is the main initiative of the Department of Education to improve the performance of the schooling system in respect of maths and science. Some schools are selected for Dinaledi status, and provided with additional resources for teaching these subjects. Currently 490 of 6264 secondary schools – or 7,8% - are part of the programme.

In 2005 there were fewer females than males in grades 1 to 7 (less than 50%), while the opposite was true for Grades 9 to 12. Grade 12 females (54.5%) accounted for the highest female enrolment in all the primary and secondary level grades. The percentage distribution of senior certificate examination pass and failure rates by gender in 2005 is as follows: of the total population that sat the exams, 54.1% were women and 45.9% were men; of these 67.2% of the women passed as opposed to 69.7% of the males. The pass rates in descending order in 2005 were: Accounting (87.3%), History (84.2%), Business economics (79.9%), Physical science (71.1%), Biology (68.1%) and Mathematics (55.7%). As can be seen science subjects appear at the bottom of the list. In terms of gender: in Accounting 88.3% females passed versus 85.9% males; in Biology 66.8% females passed versus 69.6% of the males; in Business Economics 79.8% females passed versus 80.1% males; in History 83.3% females passed versus 85.1% males; in Mathematics 51.0% females passed versus 61.1% males; and in Physical Science 69.8% females passed as opposed to 72.4% males [10].

The percentage distribution of senior certificate examination pass and failure rates by gender in 2006 is as follows: of the total population that sat the exams, 54.2% were women and 45.81% were men; of these 65.5% of the women passed as opposed to 67.9% of the males. The pass rates in descending order in 2006 were: Accounting (86.0%), Business economics (83.5%), History (77.2%), Physical science (71.2%), Biology (68.1%) and Mathematics (52.2%). As can be seen science subjects appear at the bottom of the list. In terms of gender: in Accounting 85.9% females passed versus 84.6% males; in Biology 69.6% females passed versus 69.3% of the males; in Business Economics 80.1% females passed versus 84.0% males; in History 85.1% females passed versus 77% males; in Mathematics 61.0% females passed versus 57.4% males; and in Physical Science 72.4% females passed as opposed to 73.1% males [52].

IV. Methodology

A. Procedure

This was a qualitative research using a case study. Learners were exposed to the Technology process of “investigate, design, make, evaluate and communicate” inherent in the technology learning area of the National Curriculum Statements. As part of the Fab Kids intervention learners initially conceptualise their ideas on paper by discussing possible solutions among themselves, doing some research for more ideas on the Internet, and come up with various design alternatives from which they would select the most suitable one. The chosen design was then captured onto computer using Open Office Draw packages before being sent to a laser cutter. Learners are encouraged to make ‘cheap mistakes’ by first printing their designs onto thick cardboard. The cardboard prototypes are then tested and refined to eliminate all possible errors. The final design of the prototype is then produced from Perspex. The learners are only allocated one sheet of cardboard and one sheet of Perspex towards their design, which represents their “budget”. The limited budget meant that the learners had to be sure of their design before realising their final prototype. It is all about the management of limited resources available for production of the final prototype. It is also about working with hands, lateral thinking, problem-solving, creativity, innovation, acquiring computer skills, self esteem and research.

A design brief was given to the learners initially by the facilitator. In this instance the learners were tasked with designing a desk tidy for pencils and erasers. The group was divided up into teams of 4 per group and each was assigned a specific portfolio with associated responsibilities. In each group there was the Team Manager to manage the team through all aspects of the manufacturing process. The Design Engineer’s duty was to master the drawing package to capture the final solution on the computer. The Manufacturing Engineer in consultation with other members of the group was to manage the assembly process. The Media Specialist had to create a digital record of the process using pictures, video clips, music and a company logo and publish this information to a Google groups web page.

B. Participants

Sixteen grade eleven girls from the North West province of South Africa participated in this Fab Kids session. They were also part of a girl- learners’ project in the North West province organised by the Platinum Development Trust in the Brits area which is designed to empower girls in mathematics and science. The girls formed part of a group of sixty learners from different schools that were attending extra lessons over an extended period. They were selected on the basis of their potential abilities in key subjects. This supplementary tuition was designed to influence their decisions to take up careers in science and mathematics education. The course runs for 18 months with one session per week and at one and a half hours each for maths and science.

C. Data Sources and Analysis

Data were collected over the course of a single Fab Kids session where the primary author acted as the observer and the second author as the facilitator. The students’ activities and interactions were observed coupled with informal interviews while they were performing their various tasks. The roles of the students were noted together with other issues such as language and ownership of the technological process involved in the design and production of the prototype.

D. Research Questions

The primary research questions included:

Does the application of the Fab Kids approach have an impact on the girl learners’ interest in SET?

Does student gender influence motivation toward science and technology?

Does prior experience influence the ability and interest of girls in SET?

Are there any possible relationships between student interest in participating in this activity and student interest in pursuing other technology-related activities?

How do the applications of the design process impact on students’ problem-solving activities?

V. Findings

There are many skills that girls acquired as a result of participating in the Fab Kids session. The design-based approach was an integration of a number of subject areas. The approach looked into low-level computer-aided design; research skills since the learners had to search the Internet for information on the object to be designed; social skills in that the learners had to learn to communicate among themselves; mathematical analysis since they had to size their designs to fit onto a single sheet of cardboard or Perspex; technical drawing skills to design; writing skills since they had to produce a report at the end of the exercise; creativity in the design and technical and design skills. Working on a limited budget, by restricting them to a single sheet of material, was a way of imparting entrepreneurial skills.

In certain situations after cutting out the designs from the cardboard the learners discovered that their products did not meet their own specifications. The lesson learnt is that under normal engineering environments, errors cannot be tolerated and that designers have to do things right the first time round and that preplanning was important in design. Imagine building a bridge that eventually collapses. The learners had to redesign the prototypes that did not meet the specifications and were encouraged to learn from their mistakes as these were inevitable.

The final design was different for each group in terms of the appearance of the prototype and the creativity. Those with a technical drawing background reflected a quality design, as opposed to that opted for a more functional solution. In South African schools learners are introduced to technical drawing in Technology classes at Grade 7 level. Most of the girls indicated that they were put off technical drawing at school by the introductory course, which they found difficult. They therefore chose not to join a technical school which would have imparted further technical drawing skills to them. Also the girls indicated they did not choose technical schools because they had not been exposed to technology earlier in their lives, and fear of venturing into fields unknown was frightening for them.

Unlike the three-dimensional (3D) computer-aided design (CAD) software the learners may have been exposed to, the open source software used in the Fab Kids session is restricted to two dimensional (2D). This meant that although girls had to conceptualise their product in 3D, the components had to be designed in 2D. The laser cutter only produced 2D components, hence parts of the prototype have to be developed separately and then assembled. Lack of technical drawing skills made it difficult for girls to conceptualise this idea as a 3D object.

Factors such as access to the technologies and qualified teachers in the school context have a major impact on children's achievements and progression in technology. The way the teacher introduces a concept could also influence the attitude of the child on the subject as mentioned where the pupils were put off technical drawing because of the way the teacher approached the subject. A survey conducted among nursing students revealed that they rated teacher knowledge as most important, followed by feedback and communication skills in influencing their interest in a subject [8].

From observing their activities it was concluded that the girls found no problem with working in teams. A lot of open communication had to take place among the members of the teams in order to solve the challenge at hand. The initial discussions and brainstorming sessions were opportunities where they could share their ideas with others and suggest novel solutions to the problem. The learners displayed creative ideas, with innovative solutions. They interacted with each other and discussed problems as they arose. This informal classroom structure was successful as it encouraged the generation of new ideas and provided opportunities to observe how their peers solved similar problems. Good ideas put together resulted in good products. From the observation they also learnt the skills to listening to each other.

Both problem-solving activities and discussions stimulate situational interest. Problem-solving has the potential to make learners aware of their own inadequacies and inconsistencies of their previous knowledge of a topic, thus increasing covert or overt activity aimed at exploring concepts and ideas further. When discussing, learners are engaged in a task that allows them to express their ideas and reflections freely [9]. The Fab Kids learning approach is a classic case of peer mentoring. Peer mentoring involves students helping each other to learn where the responsibility for teaching and learning is placed on learners. Positive experiences predominate in such an environment. The positive aspects include enhancement of learning skills/ intellectual gains and personal growth [45]. In the research to make nutrition education more meaningful, Abusabha, et. al. [2] facilitated group discussions, wherein learners generated specific topics to be addressed and knowledge shared through discussions. The educator became the facilitator who rather than lecturing encouraged clients to discuss freely among themselves.

Some of the girls could not communicate well in English resulting in those with better communication skills tending to dominate the group discussions. English was the medium of instruction for the Fab Kids session. In cases where it was necessary to communicate, those with poor English skills were encouraged to express themselves in their local dialects. This is an advantage when in a homogenous community, which was the case because all students could understand the local language/s. The readiness of students to communicate or participate in activities is regarded as "active attitudes [34], but in this case it could be affected by the language skills level.

The learners were highly motivated and responded positively to the challenge provided. The introduction of group activities brought a change in students' learning interest that even those who are apparently indifferent to learning were willing to participate. The experience of "doing and seeing" has the potential to impact on the students' attitudes to science and technology in a positive manner. This "constructivist approach" recognises learning as active development of personal meaning through the interaction of current conceptions and ongoing experience. A constructivist approach expects the active engagement of students in the acquisition (construction) of knowledge where learners are active explorers of learning environments.

Constructivist designers claim that the educational setting should be full of interesting things to do and learn [16]. Active learning aims at creating a community of learners according to constructivist theories of learning, where the learner is an active participant in the learning process, constructing knowledge through social interaction, negation and cooperation [7]. The combination of instructor flexibility and course requirements for electronic communication among students led to the evolution of a learner-centred approach. Learning became a collaboration in which personal experiences of learners served to enrich the learning situation and foster construction of personal knowledge [44]. These principles are at the foundation of the Fab Kids methodology.

The facilitator provided the initial design brief after a brief introduction. Thereafter the learners had to work independently in teams, asking for assistance where necessary and were allowed to take ownership of the whole process. The lesson drawn from giving the learners the opportunity to do work independently can be summarised through the following example. In a computer-based learning strategy to assist in introducing and teaching water quality modelling to undergraduates in civil engineering the students felt that because they were able to complete the project with minimum supervision they acquired a better understanding of water quality modelling as a result [46].

A division of labour was applied where learners were careful to allocate portfolios based on their own individual skills. Those who took on the design engineer portfolio were expected to have some computer experience while those with good written and communication skills were expected to become the media specialists. A division of labour is an important component in learning. In a related example of an educational game, Treasure Hunt, 3rd and 4th graders were mixed. Arithmetic goals that were created differed as labour became divided in their activity. Two findings of interest were (1) differences in divisions of labour as a function of players' grades and grades of opponents led to the construction of different arithmetic goals and (2) differences in goals led to different sequences in children's strategic developments [35].

In the usage of computers to design the prototype varied behaviours emerge. There is a course in computer applications [28] that is offered in schools, but it is restricted to relatively few learners that take the subject and to those schools that offer the course due to a shortage of computers and qualified staff. In the design process those learners that had computer skills assisted others while those that had just been introduced to the computer were willing to accept help. The computer-literate learners tended to dominate the group during the design process. In most cases where all learners in the group had computing skills, there was a clear division of labour; contributing equally to the final design.

A cooperative work environment was encouraged even between the various groups. Those that had finished their work before hand would join the others who were still working. This served to confirm the findings of other researches. Researchers who have examined the outcomes of cooperative learning consistently report improvement in student problem-solving abilities, more favourable attitudes towards school, greater self-esteem, increased willingness to try new and difficult tasks, enhanced sense of belonging, better appreciation of cultural and racial differences, support for the principles of democratic behaviour, reduction of misbehaviour and better relations with classmates. Maturity is also implicated by gaining teamwork skills such as listening to others, encouraging team mates, demonstrating empathy; negotiating conflict and helping peers comprehend lessons [39].

The Media specialists were given the mandate to interview various groups on why they had selected a particular design, take pictures and generate a short written report to be captured using OpenOffice Write. The learners from the various groups who were selected as media specialist chose to work as one group instead of separately. Confidence in being able to carry out the work as individuals was a possible factor here. This group felt it was difficult to collect and collate this information but they never gave up though. Presenting the information in an understandable format was the main factor as it involved capturing the information, as a newsworthy report involving the application of their language. This group of learners eventually invited someone from outside their group who had faster typing skills to complete the task. It is felt that the learners' backgrounds may have also been a contributing factor especially the fact that they were English second language learners.

Although the girls were from a maths and science background as mentioned earlier, it didn't automatically follow that they would be interested in SET. According to Meece, et.al, gender differences in motivation are examined using 4 contemporary theories of achievement motivation including attribution, expectancy value, self efficacy and achievement goal perspectives. Across all theories, findings indicate girls' and boys motivation-related beliefs and behaviours continue to follow gender-role stereotypes. Boys report stronger ability and interest beliefs in mathematics and science, whereas girls have more confidence and interest in language arts and writing [23].

Lack of self confidence among the girls reared its head occasionally. In some cases girls stood back and indicated the task was difficult before they could even start using the equipment. They left it to the team member who has the computing skills to design on the computer, for instance. They felt threatened by the technology, especially if paired with those who had previous access to technology. There was one case in which a learner was not participating in the design at all. The reason given was that she would rather be afforded the space to work alone and understand technology before working as part of a team. Some of the girls did not participate fully because of the fear of letting down their team mates by ruining the team's design. Therefore the fear of computers for girls without early exposure to technology is a potential problem and maybe an issue when it comes to self-confidence.

Computer anxiety refers to negative emotions and cognitions evoked in actual or imaginary interaction with computer-based technology. This involves avoidance of computers, excessive caution with computers, negative remarks about computers and/or attempts to cut short the necessary use of computers. A survey carried out showed there is decreasing reductions in computer anxiety scores from the group with the shortest to the group with the longest reported time length of computer use. Increased computer experience, leads to a reduction in computer anxiety [5]. Research generally supports that females have less overall experience with computers and are more likely than males to have negative attitudes towards computers. A survey of incoming college students to assess Internet experience and skills levels in 1997 showed that the overall competency and comfort level for students was significantly higher for computers than for the Internet: 19% of the students did not feel competent/comfortable with the computer compared to 36% with the Internet, with females reporting higher levels of incompetence [37].

Persistence is one attribute that was lacking among this group of learners. Of the four groups of learners, two groups failed to achieve the task in the stipulated time and they eventually handed over to the technician to complete it for them on time. They admitted it made them feel like failures, but they felt encouraged that at least they had made an attempt. Where there was a shortage of skills it reflected in the final product. In his research on the importance of practical skills, Steen [49] concluded that to achieve software product quality, professional skills and knowledge is important. For instance where only one student in the group had computer experience and worked in isolation, it reflected on the performance of the group. The group had to be assisted by the technician in more cases than in groups where a larger number of the girls were active participants.

The Fab Kids session was a unique learning experience in comparison to what traditional schools offer. The flexibility of doing things at one's pace reduces the stresses and pressures that are found in a normal classroom environment where the learning situation is more stimulating and less-boring. Learners are given the opportunity to express themselves more openly working to their own specifications rather than be restricted by a teacher.

The girls indicated that this was an interesting session that stimulated their interest in computers and technology. They indicated that they were keen to learn more about computers as a result of this stimulating exposure. They were excited by the sense of achievement in their ability to design a product from scratch and produce a high-quality prototype in such a short period of time. This brought them a degree of satisfaction.

The pedagogical approach that was employed through facilitation had a positive impact on the students' interest in SET but not assessed. The fact that the approach was based on a real-world situation and a hands-on approach made a difference. In elementary science method courses, connections to the "real world" are vitally important in engaging children in science learning. However teachers struggle to create science instructions that engage children in real-world activities along with learning science concepts: children exploring the world through hands-on activities [17]. In a related real-world experiment 9-12 year-old pupils were exposed to Internet safety in a motivating and challenging environment called Net-Detective through on-line role playing. They empathised with others, gaining an understanding of the motivations and practiced the ICT skills being taught quite well through hands-on activities [42].

VI. Conclusion

The work describes an initiative to address the issue of inequality in girls' access to SET education and careers. Girls and women are under-represented in SET due to a number of reasons including a lack of familiarity with the nature and possibilities of SET. This research aimed at raising an awareness of SET among secondary school girls through hands-on activities in a rapid-prototyping environment. It also brings to fore the local factors that have an influence on girls' participation in SET in an effort to influence policy.

The research tends to indicate that this exposure to a rapid prototyping environment is an approach that is effective in producing learners with a new curricular approach. The girls were exposed to many skills as a result of participating in a Fab Kids session. Team work, research skills, communication skills, design skills, technical drawing skills, entrepreneurial skills, computer skills, creativity, innovation, thinking out of the box and cooperative learning in an environment that is different from the class were some of the skills acquired.

The issues that came up as the causes for the poor participation of girls can be then looked at and effected into the schools curriculum. Further work would involve making a follow up on the girls to assess the impact of the research on their career choices and interests and also as a way of cementing the work that was started by this project.

References

[1] About SA – Education, www.info.gov.za/about sa/education.htm.
[2] Abusabha, R., Peacock, J., Achterberg, C., How to make nutrition education more meaningful through facilitated group discussions, Dietetic Association, Vol. 99. No. 1, pp. 72-76, 1999.
[3] Anderson-Rowland, M.R., Why aren't there more women in engineering: can we really do anything, ASEE Annual conference proceedings, pp. 7295-7307, 2003.
[4] Beijing Declaration, www.un.org/womenwatch/daw/beijing/platform/
[5] Bozionelos, N., Computer anxiety: relationship with computer experience and prevalence, Computers in Human Behaviour, Vol. 17, pp. 213-224, 2001.
[6] Convention on the Elimination of all Forms of Discrimination against Women (CEDAW) (1979), www.un.org/womenwatch/daw/cedaw
[7] Chacko, I., Studies in educational evaluations, Vol. 33, pp. 338-354, 2007.
[8] Claudette, K., Students' perceptions of effective clinical teaching revisited, Nurse Education today, Vol. 27, pp. 885-892, 2006.
[9] Del Favero, L., Boscolo, P., Vidotto, G., Vicentini, M., Classroom discussion and individual problem-solving in the teaching of history: do different instructional approaches affect interest in different ways?, 2007.
[10] Education statistics in South Africa at a glance in 2005, Department of education, www.education.gov.za, 2006.
[11] Education Foundation, Edusource data News no. 7, December 1994.
[12] Education Foundation, Edusource data News no. 24, March 1999.
[13] Gilley, J., Begolly, J., Great progress, great divide: The need for evolution of the recruitment model for women in engineering, ASEE Annual conference and expose, pp.7003-7013, 2005.
[14] Graham, J.W., Smith, S.A., Gender differences in employment and earnings in science and engineering in the US, Economics of education review, pp. 341-354, 2005.
[15] Haataja, M., Leinonenn, E., Tervonen, M.R., Exploring mechanisms to stimulate increased participation in science, engineering and technology: international experiences, 2006.
[16] Harskamp, E.G., Suhre, C.J.M., Improving mathematical problem solving: a computerised approach, Computers in Human Behaviour, Vol. 22, pp. 801-815, 2006.
[17] Howes, E.V., Educative experiences and early childhood science education: a Deweyan perspective on learning to observe, Teaching and teacher education, 2007.
[18] Howie, S, Plomp, T., Mathematical literacy of school leaving pupils in South Africa, International Journal of Educational Development, vol. 22, pp. 603-615, 2002.
[19] James, T, Smith, R., Roodt, J., Primo, N., Evans, N., Women in the ICT sector in South Africa, 2006.
[20] Koppel, N.B., Cano, R.M., Heyman, S.B., An attractive engineering option for girls, Proceedings – Frontiers in education conference, Vol. 2, pp. F1C/2 – F1C/7, 2002.
[21] Mabila, T.E., Malatje, Addo-Bediako, A., Kazeni, M.M.M., Mathabatha, S.S., The role of foundation programmes in science education: the UNIFY programme at the University of Limpopo, South Africa, International Journal of Educational Development, vol. 26, pp. 295-304, 2006.
[22] Mayer-Smith, J., Pedretti, E., Woodrow, J., Closing of the gender gap in technology enriched science education: a case study, Computers and Education, vol. 35, pp. 51-63, 2000.
[23] Meece, J.L., Glienke, B.B., Burg, S., Gender and motivation, Journal of School Psychology, Vol. 44, pp. 351-373, 2006.
[24] UN Millenium Development Goals, www.un.org/milleniumgoals/goals, 2000

[25] Mody, P.N., Brinard, S.G., Successful international initiatives promoting gender equity in engineering, Women and ICT proceedings, Baltimore, MD, 2005.
[26] National curriculum statement Grades R-9 (schools) policy, Natural Sciences, Department of Education, Republic of South Africa, 2002, ISBN 1-919917-48-9
[27] National curriculum statement Grades 10-12 (General), Life Sciences, Department of education, Republic of South Africa, 2003, ISBN 1-919975-62-4.
[28] National curriculum statements Grades 10-12 (General), Learning programme guidelines – Computer Applications Technology 2005, http://wced.wcape.gov.za/ncs-fet/CAT-LPG.pdf
[29] National curriculum statement Grades 10-12 (General), Physical Sciences, Department of education, Republic of South Africa, 2003, ISBN 1-919975-61-6
[30] National policy framework for women's empowerment and gender equity http://www.info.gov.za/otherdocs/2000/gender.pdf.
[31] Rocone, K., Child's play: using the Internet to learn about science and engineering, JOM, vol. 57, no. 10, pp. 12-15, 2005
[32] SADC Declaration on Gender (1999), www.sardc.net/widsaa/sgm/1999/sgm-genderdec.html.
[33] SAICE Infrastructure report card 2006, 2007, http://www.civils.org.za/
[34] Saito, E., Imansyah, H., Kubk, I., Hendayana, S., A study of partnership between schools and universities to improve science and mathematics education in Indonesia, International Journal of Educational Development, vol. 27, pp. 194-204, 2007.
[35] Saxe, G.B., Guberman, S.R., Studying mathematics learning in collective activity, Learning and instruction, Vol. 8, No. 6, pp. 489-501, 1998.
[36] Scantlebury, K., Baker, D, Sugi, A., Yoshida, A., Uysal, S., Avoiding the issue of gender in Japanese science education, International Journal of Science and mathematics Education, Vol. 5, pp. 415-438, 2007.
[37] Schumacher, P., Morahan-Martin, J., Gender, Internet and computer attitudes and experiences, Computers in Human Behaviour, Vol. 17, pp. 95-110, 2001.
[38] Shapiro, Y., Jacobs, J., South African graduate statistics 1999: profiles and recent trends. Labour market analysis, ISBN-0-7969-1923-2, South Africa, 1999.
[39] Strom, P.S., Strom, R.D., Moore, E.G., Peer and self-evaluation of teamwork skills, Vol. 22, pp. 539-553, 1999.
[40] Sullivan, J.F., Reaman, D., Louie, B., Girls embrace technology: a summer internship for high school girls, Proceedings – Frontiers in education conference, Vol. 1, pp. T4D6 –T4D11, 2003.
[41] Wigal, C.M., Alp, N., McCullogh, C., Smullen, S., Winters, K., ACES: introducing girls to and building interest in engineering and computer science careers, Proceedings – frontiers in education conference, Vol. 2, pp. F1C/8 – F1C/13, 2002.
[42] Wishart, J.M., Oades, C.E., Morris, M., Using on-line role playing to teach Internet safety awareness, Computers and Education, Vol. 48, pp. 460-473.
[43] Webster, A., Campbell, C., Jane, B., Enhancing the creative process for learning in primary technology education, International Journal of Technology Design Education, vol. 16, pp. 221-235, 2006.
[44] Yakimovicz, A.D., Murphy, K.L., Constructivism on the Internet: a case study of a graduate class experience, 2007.
[45] Yuen Loke, A.J.T., Chow, F.L.W., International Journal of Nursing Studies, Vol. 44, pp. 237-224.
[46] Zigic, S., Lemokert,C.J., Development of a computer-based learning strategy to assist in teaching water quality modelling, Computers and Education, Vol. 49, pp. 1246-1257.
[47] Revised National Curriculum Statement, Department of Education, South Africa.
[48] Doubling for growth: Addressing the maths and science challenge in South African skills, CDE Research 15, Centre for Development and Enterprise, 2007, www.cde.za/article.php?a_id=24.
[49] Steen, O., Practical knowledge and its importance for software product quality, Information and Software Technology, Vol. 49, pp. 625-636, 2007.
[50] Eskom expo for young scientists, www.exposcience.co.za, 2008.
[51] Mokgato,M., New technology curricula for South African FET schools (grades 10-12), World Transactions on Engineering and technology Education, Vol. 2, No. 3, 2003.
[52] Education Statistics in South Africa 2006, Department of Education, South Africa, 2008.