

Research Note

The Experiences of Girls in a Fabrication Engineering Environment

NOMUSA DLODLO AND RONALD NOEL BEYERS

The article 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 an awareness on SET among school girls in South Africa. Secondary school girls were exposed to a hands-on rapid-prototyping environment of a fabrication laboratory with the aim of imparting knowledge and familiarity with the nature and possibilities of the engineering field. The girls were exposed to various skills including electronics, computer-aided design, media ability, management, team-work, and problem-solving, peer-mentoring and communicating ideas. Exposure to technology enhanced the girls' confidence in being able to handle technology-related tasks.

Keywords: girls, engineering technology, gender, education, science

Introduction

Although progress has been made toward increasing the numbers of girls entering the Science, Engineering and Technology (SET) pipeline, the great divide between girls and engineering remains, most likely due to girls' lack of familiarity with the nature and possibilities of engineering and engineering technology (Gilley and Begolly, 2005). When choosing

Nomusa Dlodlo, Council for Scientific and Industrial Research, Meraka Institute, African Advanced Institute for Information and Communication Technologies, Box 395, Meiring Naude Road, Brummeria, Pretoria 0001, South Africa. Email: ndlodlo@csir.co.za
Ronald Noel Beyers, Council for Scientific and Industrial Research, Meraka Institute, African Advanced Institute for Information and Communication Technologies, Box 395, Meiring Naude Road, Brummeria, Pretoria 0001, South Africa. Email: rbeyers@csir.co.za

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a career in scientific fields, girls tend to gravitate toward professions that help humanity; thus, the fields of health and medicine are widely chosen by women (Koppel, Cano, and Heyman, 2002). According to Anderson-Rowland (2003), 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 curricula in secondary schools, 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.

A number of initiatives have been 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 emphasizes 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 (Wigal, Alip, McCullogh, Smullen, and Winters, 2002). 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 (Sullivan, Reaman, and Louie, 2003). 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 (Saito, Imansyah, Kubk, and Hendayana, 2007). 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 (Roncone, 2005). In South Africa, the University of the North's science foundation year is a foundation program in science at the university level that was established as an effort to increase the quality and quantity of entrants from previously disadvantaged communities into university science programs (Mabila, Malatje, Addo-Bediako, Kazeni and Mathabatha, 2006). Students undergo extra lessons in science in the first year of their university curriculum to strengthen their science base.

Table 1 shows that women are under-represented in SET fields of computer sciences, geological sciences, mathematical sciences, physical

Table 1
SET Graduates in South Africa (1991–98)

	<i>Women</i>	<i>Men</i>	<i>Women/Total Graduates</i>
Computer Science/IT	3,779	7,079	35 %
Geological sciences	686	3,323	17 %
Mathematical and statistical sciences	6,903	9,505	42 %
Biological sciences	11,951	11,831	50 %
Physical and chemical sciences	4,575	10,050	31 %
Engineering	1,467	30,897	5 %

Source: Department of Science and Technology, 2009b.

and chemical sciences and engineering in South Africa. Only five percent of engineering graduates during this period were women. Only in biological sciences does an equal representation of males and females exist.

The South African Institute for Civil Engineering (SAICE), in its Infrastructure Report Card (SAICE, 2006), confirmed that engineering skills—from professionals through to technicians and artisans—are in short supply in South Africa. SAICE found that 79 of the 231 municipalities had no civil engineers, technologists or technicians. It also reported a yawning gap between South Africa and several other countries in terms of the number of people per engineer. In China, the ratio is 130 people to every engineer; in Germany, it is 217 people to one engineer; in the UK, it is 389 people to one; in Australia, 455 people to one, and in South Africa it is 3,166 people to every engineer.

The Young Engineers of South Africa (Wishart, Oades, and Morris, 2007) which was incubated at the Meraka Institute (Wigal et al., 2002) has 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 (Department of Science and Technology, 2009) is one such intervention 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 focused and is allowed to wander in a relaxed and uncompetitive environment (Webster, Campbell, and Jane, 2006).

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

The Project

Sixteen Grade 11 girl learners participated in the Fab Kids session which lasted for half a day. The learners were given a design brief by the facilitator to produce a holder for pencils and erasers. The holder was to have a light-emitting diode that fits into it without any cables hanging outside the holder. That would mean that the girls had to design a circuit board powered by a Duracell battery.

The learners were divided into groups of four. Each group member was assigned a portfolio that is associated with certain responsibilities. They could either be a team manager, design engineer, electronics engineer or media specialist. The learners were exposed to a technology process of “investigate, design, make, evaluate and communicate”. Initially they had to search the Internet for ideas, discuss among themselves and come up with various design alternatives from which they would select one. The chosen design was captured onto a computer using Open office Draw Package and sent to a laser cutter which imprints these onto cardboard initially. This is to allow for “cheap mistakes” and their correction. The cardboard prototypes are tested and refined. The final design is then printed on Perspex.

Data were collected over the course of a single session where the primary author acted as an observer and the second author a facilitator. The students’ activities were observed coupled with informal interviews while the students were performing their tasks.

Results

The girls were exposed to various skills including electronics, computer-aided design, media ability, management, entrepreneurship, and team work, problem-solving, and communicating ideas.

Electronics was a new field to most of them and hence, more interesting. They had to connect wires, resistors, and capacitors and generate light.

At school, learners are introduced to simple circuitry during physical science lessons; hence, learners were not prepared for this level of operation. Troubleshooting skills were required, should the light bulb not function, in order to identify where the soldering components were not linking. The girls also learnt how to move a program from the computer to the micro controller memory in order to light the bulb. Those girls who had an interest in careers in electronics through exposure to information had an opportunity to try things out.

The media specialists had the task of interviewing their peers in various groups on their choices of designs, take pictures and produce written reports in Open Office Write. They also had to design a logo to go on the report. The fact that they had to collate information and put it into a meaningful form was a test of their writing skills. Lack of previous exposure to this sort of exercise before this made the task a challenge.

The problems that the learners had to solve required team work. From observing their activities, it was concluded that the girls found no problem working in teams. A lot of open communication had to take place among members of the teams in order to solve the challenge. Learning should take place in an environment that supports collaboration, social negotiation, and interactions because as the learner gains experience in a social situation, this experience may verify a learner's knowledge constructions or it may contradict these instructions (Hadjerrouit, 2005). Problem-solving and discussions stimulate situational interest. It has the potential to make learners aware of their inadequacies and inconsistencies of their previous knowledge of the topic, thus, increasing covert or overt activity aimed at exploring concepts and further ideas (Del Favero, Boscolo, Vidotto, and Vicentini, 2007).

The Fab Kids approach is a classic case of peer mentoring. In peer-mentoring, responsibility for teaching and learning is placed on the learners. The positive aspects that predominate in such an environment include enhancement of learning skills/ intellectual gains and personal growth (Yuen Loke and Chow, 2001).

Working on a limited budget by restricting them to a single sheet of cardboard material or perspex was a way of imparting entrepreneurial skills to the learners. In certain situations, after cutting out their designs from the cardboards and testing those, the learners discovered that their products did not meet their own specifications. The lesson they learned was that under a normal engineering environment, designers have to do

things right the first time round, and that preplanning was important to avoid wastage of resources.

The approach used in the Fab Kids lab is based on a real-world situation. In elementary science method courses, connecting to the “real world” is vitally important in engaging children in science learning. However, teachers struggle to create science in “real-world” activities along with science concepts, that is, children exploring the world through hands-on activities (Howes, 2007). To keep the learners interested, the learning activities must be fun. This approach to learning is known as “constructivism”, a philosophy of learning based on the premise that knowledge is constructed by individuals through their interactions with the environment (Rovai, 2004). As an alternative to memorization, constructivism permits children to build knowledge, engaging in activities closer to the “real world”. It generally involves group work and a lot of discussion and negotiation.

How concepts are introduced to learners makes a big difference. The learners said that the introductory phase of the activities which consisted of explaining to the students was difficult to understand. Their eyes were opened when they started implementing the practical aspects. In the Fab Kids lab, the learners are introduced to theory and then given the opportunity to apply that theory in the form of the design and production of the prototype. At school on the other hand, most of the time the teacher demonstrates the experiment and the students are denied the opportunity to try out their own ideas. At the same time, the learner can experiment until they grasp the concept. In school the main actor is the teacher, and yet in the Fab lab, the main player is the student. The teacher is just there as a facilitator.

Lack of self-confidence among the girls occasionally reared its head. In some cases, girls stood back and indicated the task was difficult before they had even started to use the equipment. They left it to the team member with 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 may become 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 attempts to cut short the necessary use of computers. One survey carried out showed that there are decreasing reductions in computer anxiety scores from the group with the shortest to the group with the longest reported length of time using computers. Increased computer experience leads to a reduction in computer anxiety (Bozionelos, 2001). Research generally supports the finding that women have less overall experience with computers, and are more likely than men to have negative attitudes toward computers (Schumacher and Morahan-Martin, 2001).

Conclusion

This research is an initiative to raise awareness regarding science, engineering, and technology among secondary school girls through hands-on activities in a rapid prototyping environment. This is necessitated by the fact that women are under-represented in SET not only in South Africa, but worldwide as well. The experience indicates that exposure to a rapid prototyping environment is an effective approach in providing learners with varied skills. But many more such environments could be developed that put emphasis on various areas of SET. The issues that came up as reasons for the poor participation of girls can then be looked at and addressed in 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.

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