Can Women do Science, Mathematics and Engineering?

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Stereotypes of Women and their Intellect

Women, are more than a half of Sri Lankans. They have been left behind in Science, Mathematics and Engineering (SME). While the problem has engaged the attention of educators in the West, we in Sri Lanka have hidden behind the typical cliché of a science Dean in public, “Women just can’t do maths.” The problem has deep roots. In classical western education it was held that maths soiled women and was for merchants. Manu who influences all of us without our knowing it said, “A woman is not fit to be independent: As a child she must be under her father, as an adult under her husband and as an old woman under her son.” In more recent times, it was Rousseau the famous educationist who remarked that women’s brains are unfit for mathematics, while closer to home, Sir P. Ramanathan demanded that female education should be stopped.

And yet, we know of many women of accomplishment: 10 Nobel Prize winners in science beginning with Marie Curie. In computer science, we had Lady Ada Byron Lovlace who was the patron of Charles Babbage who invented an early form of the computer and with whom she wrote the first computer programming language appropriately named ADA after her. Further, some of the work by George Boole who invented Boolean Algebra on which computer arithmetic operates, was really his daughter Alice’s because women’s work received no respect.

Equity in Technology: Are Women Logged on or Left Out?

Given our common wisdom as indicated, our own attention was engaged by the issue when one of us started planning web-based education at the Open University and the other was charged with starting a new computer science programme under engineering at Peradeniya. Another factor was our daughter who was brought up carefully without over-emphasising pink clothes and Barbie dolls and with access to computers. She is good in her maths but is tuning it out and wants to do Literature. If women had difficulties with computers, is it then fair to ask them to learn other subjects using computers? Would computer science appeal only to a section of engineering students? Why do girls who do well in maths, opt out of it? Women presently control the secretarial and data entry job markets. But with the US Bureau of Labor Statistics predicting a sharp shrinking in such jobs and spectacular growth in higher level computer jobs, would women lose even their position at the lower end of the labour market?

This article describes our findings in searching for these answers and what we have done to address some of the equity issues. A study of the literature shows that the problem is well studied in the West while here in Sri Lanka there has been little interest in equity in relation to gender. Sri Lankan data supports western findings.

Is it the Genes?

That women indeed do not perform as well in SME is well established through sustained research from a variety of countries. But through special programmes their performance has been significantly improved in the US over the past 15 years. This establishes beyond doubt that it is not genetic since genes cannot change over 15 years. Despite the diminishing differences, such differences remain in complex mathematical tasks (but not arithmetic). Other differences include boys’ personal faith in mathematics and boys choosing mathematics when there is a choice. These differences get to be more pronounced with adolescence. Indeed, the psychological dimension is revealed by women who reject SME and go away with an abject sense of inadequacy having performance levels that are as high as those of the men who stay on in mathematics.

Learning Attributes

The reasons for the difference have been studied extensively and the causes identified. They are societal as well as having to do with how differently men and women learn. As for the societal reasons, two pieces of statistics tell almost the whole story: a) In 1990, 16% more male than female US tenth graders reported ever talking to their parents about Science and Technology and b) According to Mattel, the famous toy maker, for every 4 software programs parent buy for sons, they buy 1 for daughters! Another key factor is that every successful
woman in SME had a male role model who usually encouraged her. For instance, Hypatia (370-414 AD), the first great woman mathematician, was taught and encouraged by her father and, indeed, some of the best Sri Lankan women engineers and mathematicians have had high performing engineers or mathematicians as fathers or elder brothers. Combine this then with the finding that teachers call more on boys in SME classes to answer. In fact, they both praise and scold boys more. In answering, boys are comfortable phrasing their answer as they speak while girls, because of their attributing importance to image, need to phrase their answer in their heads before giving it. So the tilt towards the boys is steeper. And societal reasons alone therefore sufficiently explain the difference.

As for the other cause, it is now well established that men and women learn in different ways. Men perform well in a competitive environment, while women do better in a cooperative environment – because to women it is important how others perceive them, and for the same reason they have more exam stress. For, women feel the need to be agreeable, compliant, and feminine; whereas men to be aggressive, assertive and autonomous. Thus, women are passive in coed labs but engaged with their work in female college labs. Further, men by nature, as established in several studies, blame outside causes for failure, and women themselves. This explains why women drop out of programmes so easily. Furthermore, questionnaires have revealed that when men succeed, they say it is because they are clever and when they fail, it is because they were unprepared. In contrast women when they pass attribute it to luck and when they fail, put it down to their inability. Women want personal attention from the teacher, men don’t. Sexual harassment is a concern for women in SME, given that teachers are mainly male. Thus when a woman wants a teacher who is attentive to her educational needs and at the same time perceives him as a possible sexual predator, she has little chance of succeeding academically.

Sri Lankan Data

As a result of the problem of gender-equity not being recognised in Sri Lanka, examination data being tightly guarded and projects being encouraged only with the patronage of those in authority, this study has found it difficult to obtain data as defined by project criteria. Instead we have had to rely on published data in whatever form for the past 10 years from the UGC and that kindly supplied by the Commissioner of Examinations.

What we have obtained shows similarities to the reported international findings with some startling points:

a) Girl pass rates have climbed to over 50% at the ALs (arts and science combined) while boy pass rates have also climbed but to levels below 50%. b) At the upper end, a larger percentage of boys consistently get 4 As. That is, while overall girls are faring better, the high performers are the boys. This better performance at the high end therefore is reflected in the UGC data for university admissions: a) While more than a half the girls do arts, the high demand fields of management and commerce from the same examination requiring mathematically oriented subjects like accounts and economics are dominated by boys b) While girls get 20-30% of the places for the physical sciences, in the same competition based on the same ALs, they garner only 10-18% of the highly competitive engineering places. Even within the sciences, where a choice is possible, women seem to go for fewer maths-based courses. The figures for the biosciences are better with women getting just over a half the seats (50-60%) but again they lose in medicine at the high end getting only 40-45%.

What we have done

Within our sphere of powers, the following have been implemented to level the playing field. Some of these are recommendations by the New England Consortium for Undergraduate Science Education (NECUSE) and published by Brown University. In web-based teaching trials we ensured that participants had already been exposed to the Open University’s computer literacy course. This ensured that any weakness on the part of females through reduced exposure to computers before university, did not affect performance. At the Peradeniya Engineering Faculty’s Computer Sciences Department we have moved wherever possible from formal lectures to teaching in the computer lab to enhance communication. In our laboratories, women have first pass at computer bookings so that they do not work after dark except by choice. Some machines are reserved for women since they are not aggressive enough in asking males staying beyond their allotted time to move. Escort to Halls of Residence is guaranteed for women working after hours. To address any possible concerns about sexual harassment, office doors are always kept open and where air-conditioning is involved, we go for glass partitions. Further, at least 2 instructors are in after hours labs in case a girl needs to work alone. We monitor computers for those who are always there and rarely there since both are signs of failure, with those
who are there all the time usually failing other subjects. Instructors monitor how partners function to ensure that a male does not play a dominant role. Rules on computer use and turns are posted. Instructors watch for girls who are lost but shy to call for help.

Guidelines for lecturers include using a variety of teaching styles to cater to male and female learning styles, allowing a wait time (of 2-3 seconds as suggested by NECUSE) before taking answers so that girls are not left out, being very conscious of whom we call to answer our questions in class, personalising the class and thereby easing girls and especially girl-school students into a male environment, promoting discussion with neighbours, stressing group efforts, avoiding competition and acknowledging female accomplishments in science when possible. Since the recruitment of instructors is largely a departmental decision, we have an openly stated preference for female instructors to serve as role models – not that we have many of them in a scarcity area like computer science.

*What we wish to do but cannot*

Besides the above measures, our study indicates the need to do other things that we cannot do, given institutional obstacles. These are giving lecturers access to marks so as to advise students better and give them feedback on examinations, varying the exam structure, instituting more pass/fail courses in the first year than graded courses so that students from both highly coached and rural self-study environments with very different entrance marks can adjust to the common standard without stress.

We would also recommend admitting more women into SME in the universities (affirmative action) – later on it would be a zero sum game since admitting more into computer science say, would mean fewer in mechanical engineering and so on. This proposal being controversial we will try to justify it. It is now roundly accepted that a highly coached student from Colombo has not necessarily proven himself better than a self-study student from say Ratnapura with lower marks. We all confirm the correctness of regional quotas. Now, girls cannot go out so easily for tuition classes, and they do not internalise the laws of physics by riding bicycles and playing with other machines as boys do. Nor do they have all the disadvantages revealed by the above studies. Therefore, an AL aggregate of 300 by a girl is clearly superior to a 300 by a boy. If regional preferences are fine, then is it not also correct to argue for gender preferences in doing admissions as now done routinely in the US? As an aside, we point out that our studies indicate that regional quotas come at the expense of women. This is because when say Colombo admissions are reduced and Ratnapura admissions increased, female numbers will fall since city girls do better than rural girls at the ALs in the sciences. That is, addressing one problem worsens the other.

Another reason for preferential female admissions has to do with ensuring the success of the few women admitted. It is the experience of elite US colleges that white children predominate. At a college where one of us taught, Blacks were some 2-3 percent and they consistently failed the first year although they had the same performance measures at admission. When Blacks were preferentially recruited, they succeeded despite their lowered admission scores. The reason was networking. They had a network for information and this provided study groups so that they were able to succeed. The same argument holds for women. At Peradeniya for example, all boys in engineering stay at Akbar-Nell Hall. They can find friends with whom they can be comfortable and they are well-informed on all the ropes. The few girls in engineering on the other hand are distributed across various halls. Indeed, while we have not rigorously tested this, the girls who are properly networked are those who have found boy-friends. Increasing female admissions is therefore one way to make more girls succeed.

Likewise, for mentoring and role-model reasons, we would recommend recruiting females to the SME faculty preferentially, but this again will be difficult given the traditions. In this regard, it would be useful to paraphrase Dr. Devanesan Nesiah, a former CCS officer, from his OUP book [*Discrimination with Reason*]: To treat unequals equally, you must treat them unequally.

*A Little of our Personal Experience: Sri Lankan Versus the US*

Having taught in the US once and now teaching here, we would like to finish by contrasting our experience there and here. In giving this we qualify what we say by noting that the Sri Lankan experience may not be as uniform as our US experience since faculty regulations here tend to vary. But broadly our experience should be instructive.
In the US we found that as a result of handing out graded assignments on a weekly basis, we knew most of our students by name in the first 3 weeks and almost all of them by the end of the semester. After mid-term exams we used to distribute the answer-scripts and discuss with students where they went wrong. We wrote words of encouragement on the scripts for the students to read even if they were sure to fail. Occasionally students pointed out if a friend of theirs got a point more for the same answer and we immediately corrected ourselves. More often, there would be no mistake and when it is explained to the student, the student went away with the feeling that everything was just. In the light of the research reported above, the system was very girl-friendly: female students had personal contact and access. The exams had varying components left to our discretion – projects, papers, multiple choice questions, class participation, take-home exams, untimed exams, final exam, etc., so that no one method of learning and answering is stressed.

In contrast in this system, the conventional Sri Lankan system, teachers see themselves, not by choice but by how the system is organised, not as persons who ensure that their students learn and thereby succeed. Rather, we see ourselves as people who deal with a bunch sent to us by the UGC to whom we give some lectures and then classify for purposes of employment as first class, second class, failure, etc. At the end of a course we would not have spoken to most of our students. In fact some expect us to be so impersonal that if students raise systemic problems with one of us, some colleagues at the Faculty Board resent it and ask why the students came to us instead of raising it officially. We usually do not know how each student fared at exams since we deal with index numbers and after the exam we are not allowed to look at the mark sheet. We cannot therefore know their intellectual ups and downs to help them. (We have always wondered about the accuracy of the reference letters that are written and now understand why such letters often tell little more than the degree certificate). This system is defended on grounds of integrity – conveniently ignoring the fact that if we really are crooked enough to help a candidate then we would feel no shame in asking him for his index number. In this system we must nearly always examine by one 3 hour examination even if it is a course involving a project. So we must not give project-based courses (which are girl-friendly, particularly in their report-writing aspects) since different students have different projects and no one paper will fit all into the 3-hour format. And worst of all – the antithesis of a liberal university mind – there is no rescrutiny of exam scripts because “we are never wrong!” The positive thing here is that grades here are fixed by the marks obtained rather than on a curve as usually done in the US whereby a student’s grade goes down if the class as a whole does well and vice versa. The latter is male-friendly since girls are known to, generally, avoid a competitive system.

The redeeming thing is that with the modular course unit system being pushed by government policy, the system is set to become more flexible. Our concern is that the way the new system is being set up, it appears to limit the biggest advantages of the course unit system – students’ choice in what courses they follow and teacher discretion in teaching and examination methods.

Concluding thoughts

Where do we go from here? We are aware that these ideas are being raised probably for the first time at least in public. They involve the well-being, development and flowering of more than half our population. The ideas we have expressed may run counter to our entrenched views about how accurate our examination system is. We do not go so far as some feminists in saying there is a completely different mathematics called Feminine Mathematics which is different from the male mathematics that is now taught. Indeed we reject it as the same rubbish as the ideas of Eastern Science and Western Science. But beyond the rhetoric and vitriolics of feminist argument, the evidence that women learn differently and therefore single-format examinations do not always examine accurately is very strong. If we can get serious men and women, academics and policy-makers to discuss these, then we would have achieved something.

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