Women Embrace Computing
in Mauritius

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INTRODUCTION

Studies like (Camp, 1997), (Gurer & Camp, 2002), (Sigurdardóttir, 2000), and (Vegso, 2005) have documented the declining percentage of women in computer science (CS) in the U.S. and other countries. While women are under-represented in the U.S. overall, there are cultural pockets within the U.S. that are exceptions to the rule. For example, (Lopez & Shultze, 2002) note that African-American women earned the *majority* of CS bachelors degrees each year from 1989 through 1997 at U.S. historically black colleges and universities. (Fisher & Margolis, 2002) and (Frieze & Blum, 2002) report some success in increasing the percentage of women studying computing at Carnegie-Mellon. (Camp, et al., 2001) points out that the problem is significantly worse for CS departments housed in a school of engineering compared to those housed in a school of arts and sciences – a phenomenon dubbed "the school of engineering effect." So while women are *on average* under-represented in CS in the U.S., such national averages can hide significant variance within a country's subcultures.

Outside the U.S., (Schinzel, 1999) notes that the situation in "Anglo-Saxon, Scandinavian, and German-speaking countries" (ASGs) is similar to that in the U.S., but female representation in CS is comparatively constant and high (45-50%) in Greece, Turkey, and the "Romanic" countries (e.g., France, Italy). Schinzel's

data is fragmentary, but it offers intriguing hints that culture plays an important role in encouraging or discouraging women from studying CS.

These and reports like (Galpin, 2002) indicate that there are non-ASG countries where women *are* equally represented in CS. This in turn suggests that the problem is one of *culture*: ASG cultures apparently in some way *discourage* women from choosing IT-related careers, while the cultures of these other countries apparently *encourage* women to do so. If the root of the problem is the *culture* in the ASG countries, then that is where we should focus our efforts.

What is it about the culture of the U.S. and other ASG countries that discourages women from studying CS? Trying to analyze the negative cultural factors *from within* an ASG country is rather like a fish trying to analyze the water in which it is swimming. A preferable approach is to become a "fish out of water" and visit a non-ASG country where women *are* studying CS. By identifying those cultural *differences* in non-ASG countries that are leading women to study CS, we can identify those aspects of ASG culture that are problematic.

In this article, we examine the country of *Mauritius*, a 25x40 mile island roughly 500 miles east of Madagascar that is home to 1.2 million people. Ethnically, its population is 68% Indo-Mauritian, 27% Creole-African, 3% Sino-Mauritian, and 2% Franco-Mauritian. Religiously, its people are 52% Hindu, 28% Christian, 17% Muslim, and 3% other. With this dynamic mix of people, Mauritius is one of the world's most culturally diverse countries.

BACKGROUND

Prior to 2001, the University of Mauritius (UoM) was the sole university in Mauritius, offering bachelors and some graduate degrees to roughly 4000 students.

The university is free, and admittance is based solely on standardized entrance-exam scores. With roughly 1.2 million people in Mauritius, admission is extremely competitive and the admitted students are highly capable.

Applicants to UoM indicate the program they wish to study, plus alternatives should their first choice be full. Beginning with the top-scoring students on the entrance exam, students are matched to programs using their first choices unless that program is filled, in which case they are matched to their alternative choices. Admission is thus based on merit, plus supply-and-demand for particular programs; UoM has no special admissions policy to increase under-represented groups.

UoM's *Department of Computer Science and Engineering* (CSE) provides the country's primary source of computing-related education. CSE offers bachelors degrees similar to those of a U.S. technical university, and has periodically updated its programs and curriculum to reflect technological changes. Since 1990, it has offered the following programs:

- 1990-1997: Bachelor of Technology in CSE (BT-CSE).
- 1997-2000: Bachelor of Engineering in CSE (BE-CSE).
- 2000-present: Bachelor of Science in CSE (BS-CSE).
- 2000-present: Bachelor of Science in Information Systems (BS-IS).
- 2001-present: Bachelor of Science in CS and Multimedia (BS-CSM).

The BS-CSE and BS-IS programs are very similar to computer science and information systems programs in the U.S. The BS-CSM blends traditional CS training with training in graphical design and multimedia applications. Where the BT-CSE and BE-CSE were 4-year programs, the BS-CSE, BS-IS, and BS-CSM are all 3-year "UK style" bachelors programs.

G E N D E R   I N   M A U R I T I U S

In this section, we explore the representation of women in the CSE department at UoM. More precisely, we present data showing the rates at which female students enroll in and graduate from CSE programs. These data show that the "gender and IT" situation in Mauritius is quite different from ASG countries. In an attempt to explain these differences, we conclude this section with some aspects of Mauritian culture that – in our opinion – are responsible for these differences.

Students Entering CSE Programs at UoM

Figure 1 presents the number of students enrolling in CSE programs each year:

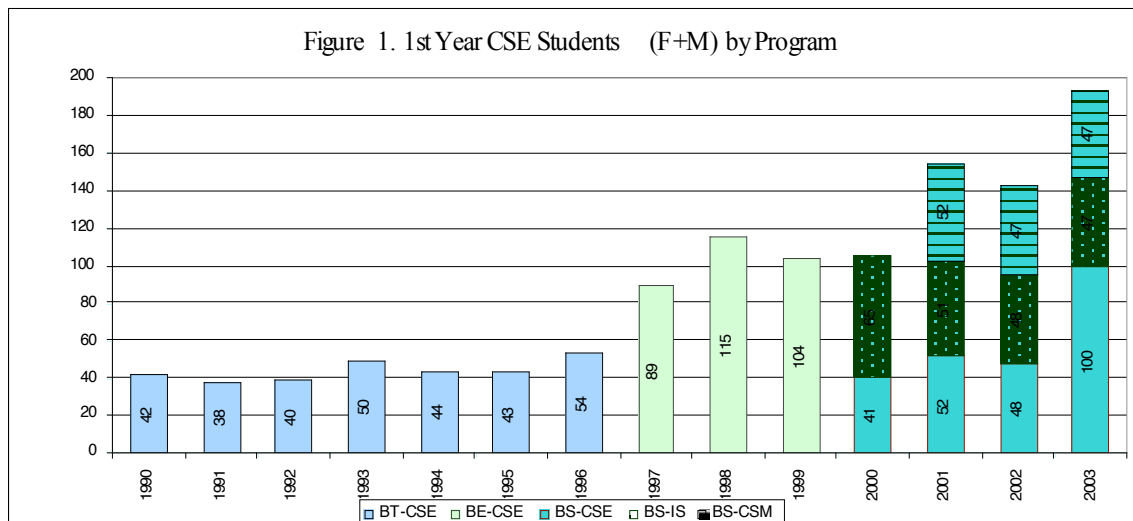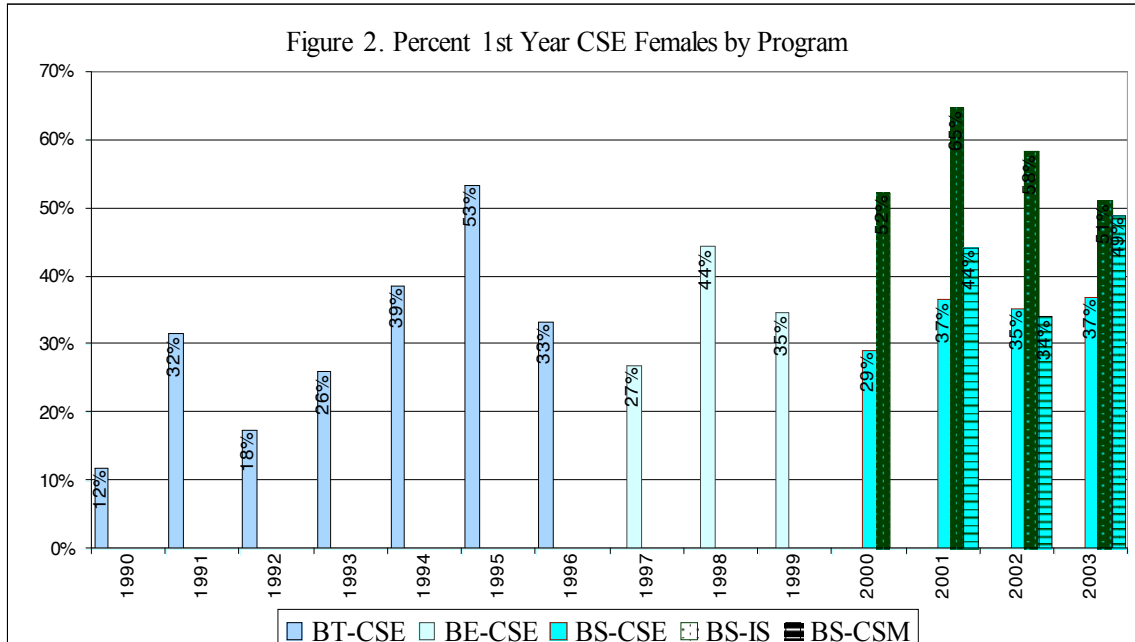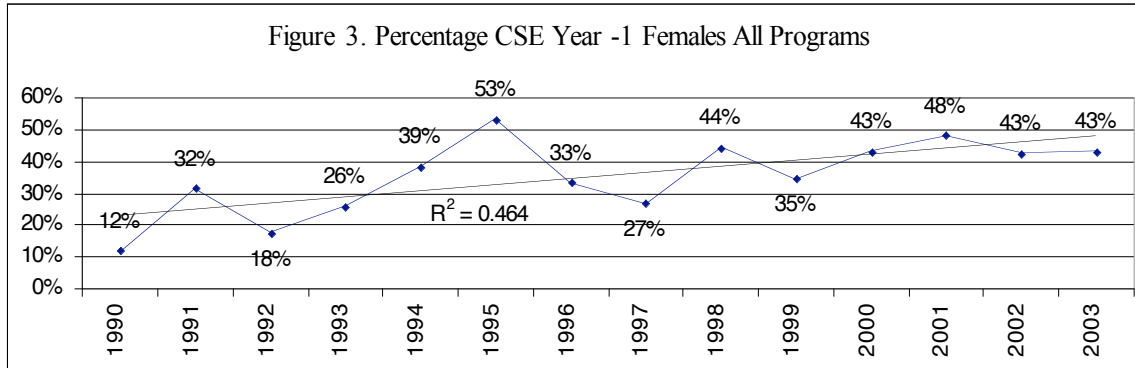Figure 1. 1st Year CSE Students (F+M) by Program

Figure 1 shows rapid increases in CSE enrollments since 1997. Each year, the department has admitted the maximum number of students for which it had staff.

Figure 2 gives the percentages of these students who were women by program:

Figure 2. Percent 1st Year CSE Females by Program

While the data is "noisy," Figure 2 shows increasing representation of women overall. By 2003, women were choosing to enroll in computing-related UoM programs at levels most of us in ASG countries can only dream about: 37% for CSE, 51% for IS, and 49% for CSM. It also indicates that Mauritian women are more attracted to the BS-IS and BS-CSM programs than to the BS-CSE program. One possible explanation is that the BS-CSE has high school physics as an admissions prerequisite, but the BS-IS and BS-CSM do not, and Mauritian girls are less likely to have this prerequisite. Alternatively, it may be that simply having the word "engineering" in the name of the program is sufficient to discourage women – similar to the "school of engineering" effect noted in (Camp, et al., 2001).
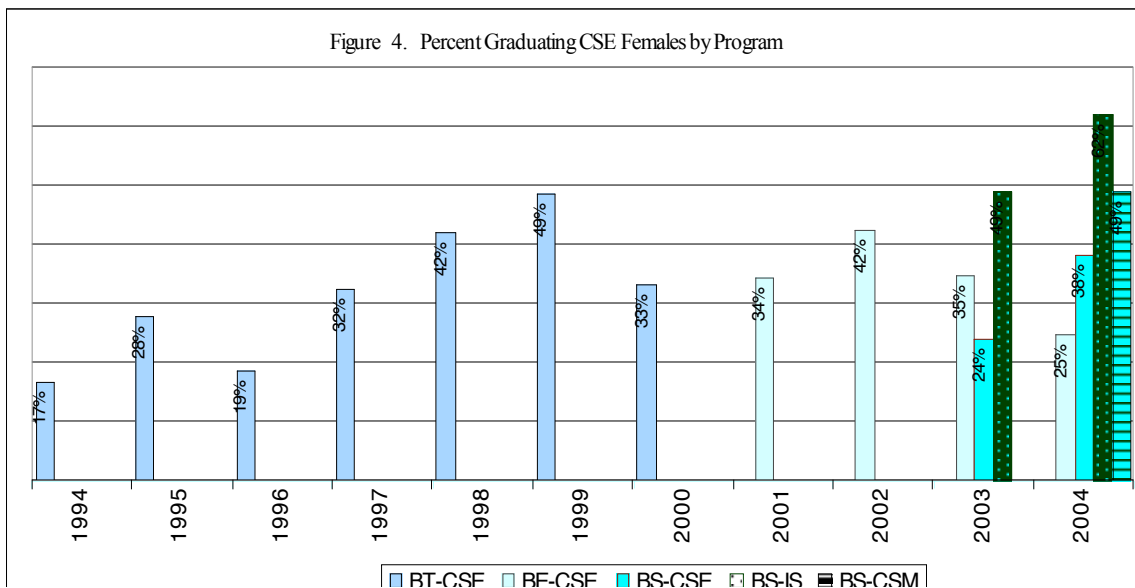
Figure 3 presents the percentage of first-year CSE students who were women across all three of the department's programs:

Figure 3. Percentage CSE Year -1 Females All Programs

Years (x-axis): 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003

Data values: 12%, 32%, 18%, 26%, 39%, 53%, 33%, 27%, 44%, 35%, 43%, 48%, 43%, 43%

$R^2 = 0.464$

The linear regression trend line in Figure 3 shows that the percentage of women entering a CSE program at UoM has steadily increased from 12% to well over 40%, even as this percentage has declined in ASG countries.

Students Completing CSE Programs at UoM

Figures 1 through 3 indicate that increasing numbers of women are enrolling in computing-related programs at UoM. What about their graduation rates? Analogous to Figure 2, Figure 4 presents the percentage of female students graduating from each CSE program at UoM:

Figure 4. Percent Graduating CSE Females by Program

Years (x-axis): 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004

Data values: 17%, 28%, 19%, 32%, 42%, 49%, 33%, 34%, 42%, 35%, 24%, 49%, 25%, 38%, 65%, 43%

Legend: BT-CSE, BF-CSE, BS-CSE, BS-IS, BS-CSM

Aside from the short-lived BE-CSE program, Figure 4 shows the percentage of women graduating from CSE's programs increasing over both the long-term and the short-term.

Figure 5 (analogous to Figure 3) presents the percentage of graduating students who were women across all of the CSE department's programs:

Figure 5. Percentage Female CSE Final Year
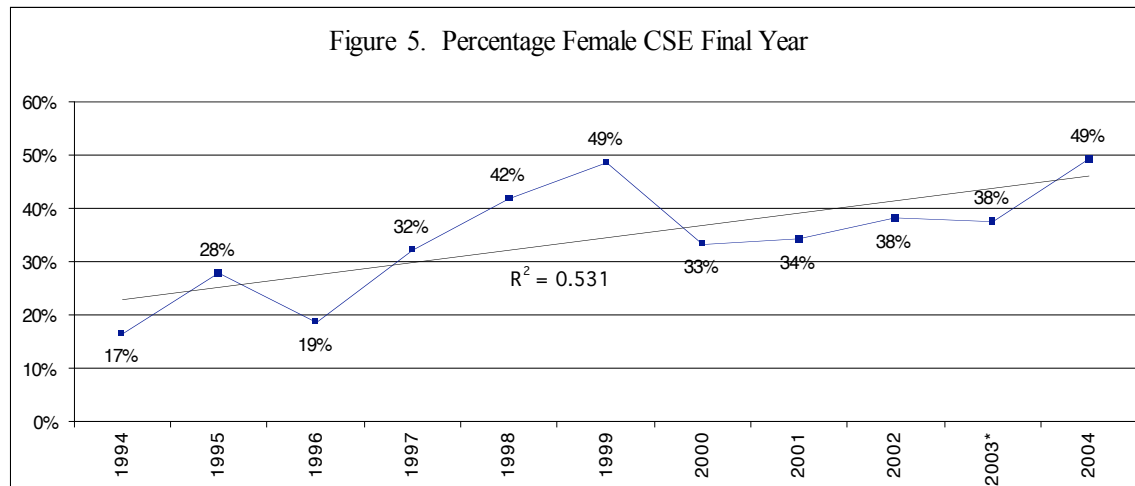
Once again, we see steady growth to levels approaching those of the population, during the same period of declining representation in ASG countries. When coupled with the increased intake of first-year students shown in Figure 1, Figure 5 implies very rapid growth in the number of Mauritian women choosing a computing-related program.

Are Positive Role Models The Reason?

The increase in the representation of CSE women at UoM described above *cannot* be attributed to abundant female CSE instructors serving as positive role models or mentors. From 1990–2003, the female-to-male CSE instructor ratios were 0/7, 1/5, 1/7, 2/11, 1/8, 1/9, 2/14, 2/13, 2/14, 2/12, 2/14, 2/15, 3/18, and 3/20, respectively. Figure 6 shows the percentage of female CSE instructors during these years, omitting 1990 (when there were no female CSE instructors):

Figure 6. Percentage Female CSE Instructors
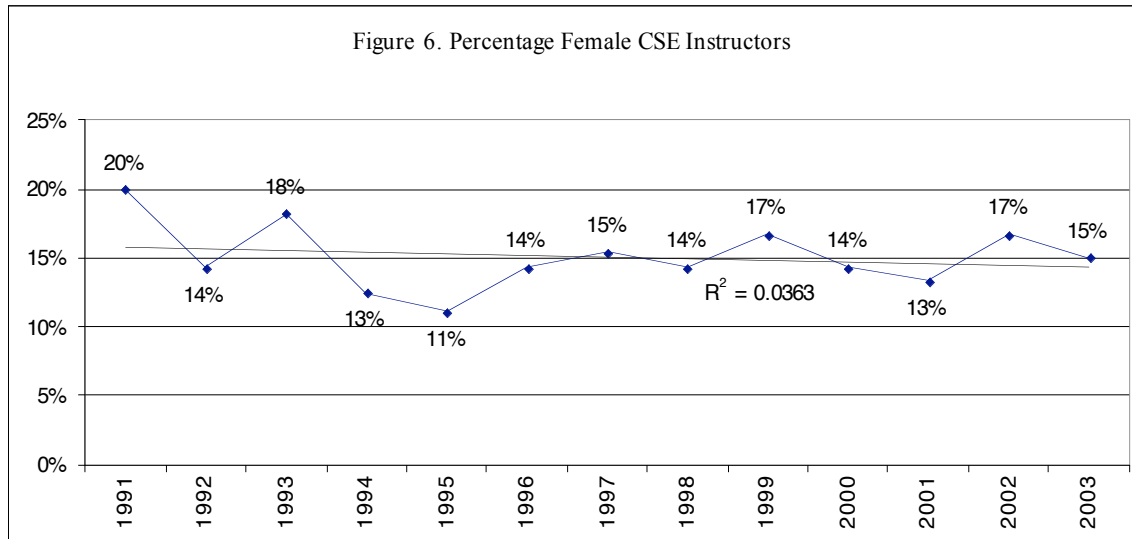
That is, the representation of women as a percentage of CSE instructors is low relative to the percentage of students who are women, and has *declined* slightly as the total number of instructors has increased. During these years, the *median* percentage of female instructors was 14% (*average*: 15%).

There has also been significant instability in the set of female CSE instructors:

• In 1992, the sole female CSE instructor was a visitor from the U.S.; she was also one of the two instructors in 1993, after which she returned to the U.S.

• In 1996, one of the female instructors was on leave.

• In 1997, both female instructors were on leave.

• In 1999, one female instructor was on maternity leave.

• In 2001, one female instructor was new; the other was on leave without pay.

• In 2002, one female instructor was new; another was on maternity leave.

• Under pressure to balance graduate work, family responsibilities, and teaching obligations, these female instructors had very heavy workloads.

This instability in the set of female instructors, coupled with their comparatively low percentage (Figure 6) indicate that abundant, positive female role models are not responsible for the increasing participation and retention of women in

computing-related programs at UoM (Figures 3 and 5). While abundant, positive female role models are likely a good thing (see (Pearl, et al., 1990), (Townsend, 2002), and (Bettenger & Long, 2005) for contrasting views), the data from Mauritius indicates that they are *not a necessary condition* for attracting young women to or retaining young women in computing-related programs.

Cultural Factors

We believe that cultural factors are why increasing numbers of women are studying computing in Mauritius. Table 1 lists few that seem especially relevant:

Table 1: Some Mauritian and ASG Cultural Differences

- Economic level (developing vs. first-world)
- Governmental promotion of IT
- Family emphasis on importance of education and career
- Gender-separate-but-equal secondary education system
- Limited ability to change major program in university

The most obvious difference is that Mauritius is a developing country, whereas most ASG countries are first-world countries. The needs and priorities in a developing country are necessarily different from those of the first-world. That is, where a first-world country is *maintaining* its existing infrastructure, a developing country is *building* its infrastructure. The cultural imperatives of a developing country are thus different from those of a first-world country. For example, IT is seen in Mauritius as fresh, modern, challenging, and *the* path to rapid social advancement and national development. Negative words like "geek" and "nerd" are non-existent in the Mauritian cultural vocabulary.

Relatedly, the Mauritian government is actively and visibly working to build its national IT infrastructure. In the late 1990s, the government began a national IT

initiative to turn Mauritius into a "cyber-island" (Ackbarally, 2002). This initiative has further elevated the importance of computing and IT in the national consciousness, making them prestigious (and even patriotic) subjects to study. (The rapid post-1997 increases in CSE admissions visible in Figure 1 are one result of this initiative.)

Another related difference is that Mauritian families place a strong emphasis on the importance of education in preparation for a career. From an early age, most Mauritian parents teach their children that education is the path to a good career and a better life. The merit-based admission to the free university creates a highly competitive environment. To improve their children's chances of admission, a high percentage of Mauritian parents to send their high-school-age children to after-school tutoring sessions, and pressure them to study hard.

Another major cultural difference is that Mauritian boys and girls are taught in separate-but-equal high schools. Research suggests that girls attending such schools have higher self-confidence and achieve greater career success than those attending co-ed schools (Coursten & Coleman, 1996). We believe that such separation creates an environment that frees Mauritian girls to discover their academic strengths. The evidence for this is that Mauritian girls do at least as well as boys on the standard entrance exam, and have equal chances for admission to the program of their choice at UoM. Moreover, computing-related programs are not perceived as "male" disciplines, because girls have the chance to discover their aptitudes in this separate, nurturing environment.

A final difference is that when a Mauritian student has been admitted to the university, she cannot easily change her major program. To change one's major program, a student must leave the university and re-apply for admission to the new program the following year. This, coupled with UoM's competitive, merit-based

admission process helps the CSE department retain its students (both male and female), because once admitted, most students are loath to jeopardize their prospects by re-entering that fierce competition.
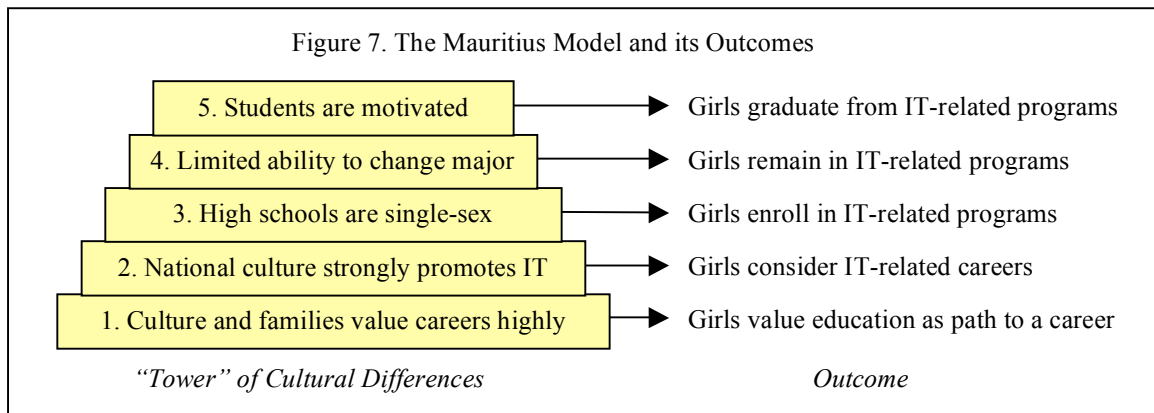
The Mauritius Model

We can summarize and enumerate the Mauritian cultural differences as follows:

1. Mauritian families see education as the key to a good career and life. This is an essential foundation for any country seeking to become stronger.

2. The Mauritian government has actively and visibly promoted computing with its IT initiative to become a "cyber-island." This has impressed the importance of IT on their national culture, making IT studies and careers honorable, prestigious, and patriotic. It has also encouraged increasing numbers of Mauritian women to *consider* a computing-related career.

3. Mauritian students are taught in single-sex high schools. This allows Mauritian girls to discover their aptitudes and interests in an environment that is free of gender-based distractions. Because of this and the preceding differences, Mauritian girls are *applying* to computing-related UoM programs in increasing numbers.

4. Once admitted to a UoM program, students cannot easily "change major." Because of this, students who are dissatisfied with their CSE program (e.g., female students discouraged by sexist male peers) are less likely to switch to a different program. This in turn helps the CSE department *retain* the young women who begin its programs.

5. Access to a university education is not guaranteed in Mauritius. This motivates students admitted to UoM to make the most of the opportunity they

have been given. This and the preceding differences are helping Mauritian women *graduate* from CSE programs in increasing numbers.

We like to visualize these five differences as a "tower" in which each level builds upon the ones beneath it to produce a positive outcome, as shown in Figure 7:

Figure 7. The Mauritius Model and its Outcomes

"Tower" of Cultural Differences	Outcome
5. Students are motivated	→ Girls graduate from IT-related programs
4. Limited ability to change major	→ Girls remain in IT-related programs
3. High schools are single-sex	→ Girls enroll in IT-related programs
2. National culture strongly promotes IT	→ Girls consider IT-related careers
1. Culture and families value careers highly	→ Girls value education as path to a career

We conjecture that each of the outcomes in Figure 7 must be achieved to increase the representation of women in IT. For example, if a girl values education but will not consider an IT career, she will not enroll in an IT program. Similarly, if she enrolls in but does not remain in an IT program, she will not graduate from an IT program. Taken together, the achievement of these outcomes forms a "pipeline" that guides a girl toward the successful completion of an IT program.

We believe that the "tower" of cultural differences shown in Figure 7 is how Mauritius achieves these outcomes. This "tower" thus forms a model – *the Mauritius model* – of one way to increase the representation of women in IT.

Some pieces of this model could be adopted in ASG countries (e.g., national IT initiatives, gender-separate-but-equal high schools). Other pieces of the Mauritius model seem harder to adopt in ASG countries, at least in the U.S. (e.g., limiting the ability of a student to change her major).

If we cannot use a given piece of the Mauritius model to achieve a given outcome, we in the ASG countries must find an alternative means of achieving that

outcome. For example, special IT programs for middle school girls might provide an alternative means for ASG countries to get girls to consider an IT-related career. Special IT programs for high school girls might provide a means of getting girls to enroll in an IT-related program. Positive female role models and mentoring relationships might provide a means of attracting young women to and retaining young women in IT-related programs.

FUTURE TRENDS

Since 1990, the University of Mauritius has done very well at increasing the representation of women in its computing-related programs. This achievement is all the more remarkable because admission to UoM is based solely on a student's merit and area of interest. Put differently, there are no special programs at UoM to increase the representation of women or other under-represented groups. We hope that this happy accident of increasing representation will continue in the future.

Unanswered questions that could benefit from further study in Mauritius include the following:

o UoM students are admitted to the *unfilled* program that is highest on their list of choices. It would be interesting to know the number of CSE women for whom CSE was their first choice, the number for whom it was their second choice, and so on. This would provide a more precise gauge of how interested Mauritian women are in computing-related studies.

o In the late 1990s, the Mauritian government began its IT initiative to make Mauritius a "cyber island." One part of this initiative was the September 2001 opening of a new fee-based *University of Technology, Mauritius* (UTM) to expand the country's ability to train IT professionals. UTM offers bachelors

degrees in *Computer Applications* (CA), *Software Engineering* (SE), *Information Technology Enabled Services* (ITES), *Business Informatics* (BI), and *Computer Science with Network Security* (CSNS). The first students graduated from UTM's SE and BI programs in 2004, with about five students graduating from each program. We have no other data from UTM, so it would be interesting to see how the gender representation at UTM compares with that at UoM.

o   The authors are computer scientists, not sociologists, so the preceding *Cultural Factors* and *Mauritius Model* sections are conjectural. We would welcome a less conjectural analysis of the Mauritius phenomenon by a sociologist.

C O N C L U S I O N

Women in Mauritius are choosing and graduating from computing-related disciplines in increasing numbers, even as those numbers are dropping in ASG countries. Mauritian culture is different from that of ASG countries in several ways, including:

1. Mauritian families see education as the key to success.

2. The Mauritian government is aggressively promoting IT.

3. Mauritian students are taught in single-sex high schools.

4. Mauritian students cannot easily change their major program.

5. Mauritian students are highly motivated and career-oriented.

Together, these differences form a model that explains why young Mauritian women consider, enroll in, remain in, and graduate from the CSE programs at UoM at rates far exceeding those of ASG countries.

To increase the representation of women in IT in ASG countries, we must succeed in getting academically-serious young women to consider, enroll in, remain in, and graduate from our own IT-related programs.

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Terms and Their Definitions

ASG country: A country whose primary ethnicity or culture is Anglo, Scandinavian, or Germanic; or that has its origin in one of these regions.

CSE: The *Department of Computer Science and Engineering* at the *University of Mauritius*.

IT Initiative: A multifaceted national program sponsored by the government of Mauritius to turn the country into a "cyber island."

Mauritius: A 25 mile by 40 mile island nation of 1.2 million people, located about 500 miles east of Madagascar.

Mauritius Model: Five Mauritian cultural differences, the combination of which have increased the percentage of women in computing-related programs at UoM.

UoM: *The University of Mauritius*; until 2001, the sole university of Mauritius, and its main source of its IT professionals.

UTM: *The University of Technology, Mauritius*; a university opened in September 2001 by the government of Mauritius to help the country expand its population of IT professionals as part of its IT Initiative.