

## **ARC: A Computer Science Post-Baccalaureate Diploma Program that Appeals to Women**

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### **Abstract**

This paper describes our experiences in developing the ARC two-year diploma program that was jointly launched in 1998 at the University of British Columbia and Simon Fraser University. ARC aims to address the low participation of women in information technology careers, as well as the intense shortage of highly skilled personnel in this field. More specifically, the goal of ARC is to provide a rapid and cost-effective path into information technology careers for highly motivated individuals with a bachelor degree in any field, an excellent academic record, but little or no programming experience. In addition, the ARC design goals include being attractive to women, providing a paid work experience in industry, and incorporating typical undergraduate computer science curricula so that students can continue on to complete standard university degrees in computer science if so desired. To date the ARC program has encountered a wide variety of challenges, but has been extremely successful in most respects. The experiences and preliminary outcomes reported in this paper should be of use to others planning similar programs.

*Key words: women, computer science diploma program, mature students, co-op program*

### **1. Introduction**

With the world becoming more and more computerized each day, the information technology (IT) industry is predicted to continue to experience an exceptionally strong demand for highly trained people over the next decade. In the United States the Bureau of Labor Statistics predicts that demand for workers in this field will grow more rapidly than in any other [1]. Both Canada and the United States are already experiencing a major shortage of IT workers. Despite the many highly paid job opportunities, current participation by women in the information technology field is low at all levels from undergraduate education to the workforce. In fact the percentage of undergraduate majors in computer science who are female has declined from 30-40% in the 1980's to 15-20% today [2]. Moreover, computing is the only science and engineering field to experience a decline in participation by women over this period. In order to address the skills shortage and low participation by women, in December 1997 the University of British Columbia (UBC) and Simon Fraser University (SFU) joined forces with the IT industry and government to develop an innovative fast-track computer science diploma program that offers students a combination of academic computer science education and industry experience.

The first group of ARC students started in September 1998, and a second group will start in January 2000. We can report success in many respects. Over 70% of the first group and almost 60% of the second group are women. The 1998 ARC students received higher grades in their academic courses than the regular computer science majors and are doing superbly in their industry work terms. Fund-raising for the second round of ARC has been substantially easier than for the first. However, these successes mask the many mistakes we made and the emotional toll those mistakes took on students, instructors, and administrators. In this paper we describe the key aspects of the ARC program, namely the academic program, funding model, application process, and student body. Even more importantly we describe the problems we encountered and the subsequent revisions to ARC that were made to try to avoid these problems in the future.

### **2. What is ARC?**

Alternate Routes to Computing (ARC) is a two-year diploma program comprised of four four-month terms of university level courses (primarily in computer science) and an eight month term of paid work

experience in industry following the first two academic terms. ARC is primarily intended for highly motivated individuals with a bachelor degree in any field, an excellent academic record, but little or no programming experience. In addition, ARC was designed with the goal of being attractive to women (including mature students who may have been out of the work force for some time), and is based on standard undergraduate computer science courses so that students can continue on to complete university degrees in computer science.

The typical schedule for ARC students is:

- Eight months of first and second year undergraduate computer science and math courses in which ARC students are taught as a cohort in some smaller than usual classes and receive substantial extra support from teaching assistants. The smaller classes and extra support are to compensate for the students' lack of background in computing and math, and their lower confidence in these areas. Almost all ARC students take the same courses in this phase.
- Eight months of paid work experience in a high-tech company or organization. Most of the companies are financial sponsors of the ARC program.
- Eight months of third and fourth year undergraduate computer science courses. ARC students take these courses together with the regular stream of computer science students, and these are primarily taught in large classes (100 – 200 students). ARC students have substantial flexibility in choosing courses in this phase.

Table 1 shows the current ARC schedule at SFU. The schedule at UBC is generally similar.

Academic Term 1	Course or Topic	Credit
	Principles of Computer Programming	3
	Introduction to Discrete Structures	3
	Calculus I	3
Academic Term 2	Introduction to object-oriented design and data abstraction	3
	Computer Design	3
	Discrete Structures part II	3
	Computers and Society	3
Work Term 1	Paid industry co-op term	0
Work Term 2	Paid industry co-op term	0
Academic Terms 3 & 4	Software Engineering I	3
	Operating Systems I	3
	Data Structures and Algorithms	3
	Database Systems I	3
	4 additional upper level Computer Science courses	12
	2 upper-level electives	6

**Table 1: Typical ARC course outline**

In addition, students are required to attend "bridging" workshops periodically during terms 1 and 2. These workshops are designed to teach students to effectively transfer their skills from the university to the workplace.

### 3. The Story of ARC 1998

The possibility of creating a program like ARC was first suggested in the fall of 1997 by James Lau, Director of the IBM Canada Pacific Development Centre, as a potential initiative for the SWIFT (Supporting Women in InFormation Technology) project. SWIFT is the project centred around the

NSERC-IBM Chair for Women in Science and Engineering for BC and the Yukon (for more information, please visit <http://taz.cs.ubc.ca/swift>) held by Maria Klawe, the Dean of Science at UBC. In addition to the goals described above, Lau was interested in rapidly increasing the number of people in the IT work force who combined a significant level of knowledge and expertise in domains outside IT (e.g., biology, languages, and social work) with sufficient technical knowledge and expertise to be able to contribute to the development of software applications for those domains.

The computer science departments at UBC and SFU agreed that there were many benefits to trying to create such a program jointly. Because UBC and SFU are the two major universities in the Vancouver region, industry and government respond more favourably to joint requests for funding than individual ones. By working together the two departments could collaborate on tasks such as fund-raising, program design, and recruiting and selecting students. Moreover the departments could play off their university bureaucracies against each other (e.g. "If the other university is flexible enough to handle a certain situation why can't we be?"). Thus a steering committee to develop the program was formed with key representatives from both universities and industry. The university members included both department chairs and faculty members with major responsibilities for undergraduate programs from each university. The committee also included a variety of senior staff and faculty from the university co-op offices, fund-raising units, student services, and the women students' office, as well as several female computer science graduate students. In addition to James Lau, industry was also represented by Sonja Norman, a highly successful senior partner in an IT consulting company who had retrained in IT after several years as an elementary school teacher. Representatives from government organizations with responsibility for joint university-industry initiatives in IT (the National Research Council, and the BC Advanced Systems Institute) were added some time later.

Over the next three months the steering committee designed the program and estimated the minimum levels of marginal funding necessary to offer the program. Aspects of the program that were chosen to be particularly attractive to women included:

- Charging regular tuition fees (approximately \$2250 Canadian or \$1500 U.S. per year) and including a paid work term so that students would not have to accumulate significant levels of debt.
- Guaranteeing that at least 50% of the students in the ARC 1998 group would be female.
- Providing additional support and mentoring from teaching assistants and at least one small class restricted to ARC students for each of the first two terms.
- Requiring absolutely no mathematics or computer science prerequisites.

By early March 1998, the steering committee had decided to aim to start with an initial group of 30 students in September 1998, with 15 students attending each university. The estimate of additional funding needed to provide the extra teaching assistants, instructors, equipment and other resources to handle these students was \$Cdn 150,000 or \$US 100,000. The next step was to raise these funds and obtain student applications by mid May to provide sufficient time to select and register the students in time for a September start.

Aggressive advertising of ARC began in mid March, with a May 15 application deadline. Although we had no funds to pay for advertising, the energetic efforts of the steering committee resulted in a variety of newspaper and magazine articles, TV and radio interviews, e-mail announcements, posters, brochures, web pages, and seminars. The response was mild at first, but after an interview on a popular local radio show during the Easter weekend, the ARC organizers were swamped with inquiries from potential applicants.

In parallel with the efforts to recruit applicants, the steering committee went on a fund-raising blitz with the goal of having at least 80% of the funds committed by July 1. Our first major successes were with the provincial government (the Ministries of Advanced Education and Women's Equality) and with IBM. Each committed to provide approximately 20% of the total budget. We raised the remaining funds needed by asking companies to sponsor student places in the program. To sponsor a single student companies were asked to provide a cash contribution of \$Cdn 3000, and to commit to hiring an ARC student for the eight month work term at a monthly salary of \$Cdn 2,500. Sierra Systems Consultants (Sonja Norman's company) sponsored three places, and a small number of others sponsored two places, but the vast majority were only willing to sponsor a single student. Some companies were only willing (or able) to provide the

cash contribution which we accepted because we were desperate to reach the funding target in time to commit to the program. By mid July we had achieved our goal of 80% of the total funding needed.

A total of 205 complete applications were received by the May 15 deadline, with slightly over 60% coming from women. Each application consisted of an application form, transcripts, a resume, and two reference letters. Based on these materials, the steering committee selected 78 potential ARC students for interviews. Of the 78 applicants chosen for interviews, 66% were women, although gender was not a determining factor in the selection process. In addition to the interview, these applicants took a standard IBM aptitude test to assess their ability to work with logic and symbolic patterns. The purpose of the interview was to assess each applicant's communication skills, level of motivation and maturity, and ability to succeed in a program demanding exceptional levels of time commitment and persistence. Forty students who had done well in both the interview and the aptitude test were accepted into the program. Although gender was again not used as a factor in the selection process, over 70% of the accepted students were women.

The accepted students' ages ranged from 22 to 51 with a mean age of 31. Their educational backgrounds included: anthropology, biology, business, chemistry, economics, engineering, English, geography, geology, genetics, nutrition, journalism, kinesiology, law, linguistics, mathematics, music, neuro-physiology, Spanish, paleontology, political science, and psychology.

In addition to the program aspects listed above, other possible reasons for the high number of women who applied to the program are:

- ARC had an impressive list of sponsors that included two BC government ministries and several large IT companies, and was offered by two highly respected universities. The two factors led applicants to expect that they would be successful in getting good jobs after completing the program.
- The advertising materials emphasized that ARC was aimed at individuals who had never considered a computer-related career but were creative, bright, hard-working, had excellent communication and people skills, and were able to take on challenges and learn to succeed in a totally new culture.
- ARC was initiated under the auspices of a project (SWIFT) that was focused on supporting women in information technology.

Although 40 students had been accepted, two women withdrew early in the program because of changes in their personal lives. After a one-day orientation session, the remaining 38 students began their classes in September with half the students at each of UBC and SFU. In addition to special class sections, extra teaching assistants and tutorials, regular feed back sessions were held during which faculty members and teaching assistants listened to student problems and suggestions for improvements. The steering committee continued to meet approximately every two weeks to solve problems, complete the fund raising, and plan the industry work term assignments. At the beginning of the second term four ARC student representatives joined the steering committee to participate in all aspects of ARC's development, with the exception of resolving issues specific to individual students.

Despite enormous efforts by students, instructors, administrators, and industry representatives, the first eight months of the program were extremely stressful for all involved. The rushed implementation had left many details to be resolved, such as elements of the work-term assignment process and the formal approval of the diploma program at UBC. A few students at each university felt that the level of difficulty in the courses was well beyond their ability to cope in spite of the extra support from teaching assistants. Most students found the workload was much heavier than they had expected and reported needing to spend eighty to ninety hours per week. This caused problems with their family and other obligations. Some students were very upset with the instructors and organizers for the difficulties they encountered. Other students were angry at these students for not appreciating the efforts being made by the instructors and organizers, and the unusual opportunity being offered by ARC. Because of the small size of the group at each university, a handful of students experiencing difficulties could create emotional dynamics that had much more impact than would have occurred in larger groups.

As the months passed nine more students withdrew for various reasons. Some withdrew because they decided they really did not like computer science. Some could not cope with the combination of ARC and their other commitments, and one was simply too homesick. Of the remaining 29 students who started their eight month industry work terms in May 1999, there were 21 women, still over 70%.

#### **4. The Problems with ARC 1998**

In this section we list some of the main difficulties encountered by students and organizers.

- Many students had great difficulty with the math classes and the mathematical portions of computer science classes. These students felt they really needed to have had a math refresher course before starting ARC.
- Students who had no experience in using computers at all had initial difficulties with simple operations like e-mail, printing, and cut-n-paste operations. This resulted in a significant lack of confidence and feelings of being behind that persisted throughout the first two terms. These students they felt their difficulties could have been avoided by taking a computer literacy course before starting ARC.
- Despite our best efforts the students report we did not adequately inform them of the time commitment needed for ARC. Stating it on the web page, in the interviews and in the orientation session was not enough.
- We did not adequately stress the fact that each student had to take significant responsibility for their own success in the program. Instead, our stressing the fact that we were committed to trying to help each student succeed resulted in some students believing that every difficulty they encountered was due to an inadequacy in the design of the program.
- There did not appear to be any correlation between performance on the aptitude test and performance in the program.
- In order to get space in the appropriate math classes several students were enrolled in evening classes, which was particularly difficult for students who were parents with school age children.
- The ARC web page and other widely circulated information about the program had stated a minimum salary for the work term of \$2500 Canadian per month, and the ARC sponsors who had committed to hire ARC students had agreed to this minimum. However due to a number of problems, the total number of work term spaces offered by ARC sponsors was only 24 whereas places were needed for 29. Normal Co-op placements are not forced to meet this monthly salary.
- ARC sponsors had been promised that they would have the first opportunity to hire the ARC students which necessitated running a separate matching process before the regular co-op process. However, since there were not enough places available with sponsors the students knew that some would have to participate in the regular co-op process as well. This caused great worry and uncertainty among the students, as well as a great deal of extra work for the organizers.
- In a number of cases the sponsor commitment had been made by a senior executive in the company, but the human resources staff were often not informed about ARC. Consequently, some companies found it difficult to offer a work term placement corresponding to the skills and abilities of ARC students. In some cases, mismatches were caused by unrealistic expectations of very specific programming environments knowledge; while in other cases the problem was lack of challenge and real work to be undertaken. As a result the members of the steering committee had to work very hard to juggle shifting commitments on the part of sponsors and to find workable matches of companies with students.
- Splitting the ARC students into separate groups at each university resulted in small group dynamics with some definite negative consequences. Moreover, it was very expensive as it required duplication of effort and resources.
- We under-estimated the staff resources needed for selection, advising, administration, and work term placement process and supervision.

## **5. The Positive Outcomes of ARC 1998**

Despite the long list of problems in the previous section, virtually everyone involved in creating ARC now feels the program is, overall, a great success. The 29 students remaining in the program have done well academically, achieving a grade-point average about 6% higher than the average achieved by students in the regular computer science programs (which is already highly selective). The ARC students are also doing exceptionally well in their work terms. Almost all are finding the work experience extremely enjoyable and rewarding, and not nearly as difficult as their two previous academic terms. Employers are delighted with their performance. They particularly appreciate the students' maturity, willingness to take on challenges, and eagerness and ability to learn. For the ARC organizers the most rewarding aspect is that the majority of students feel that ARC has fundamentally changed their lives for the better, opening doors that they never believed were there for them. The ARC 1998 students will return to UBC and SFU for academic courses in January 2000. They will be outstanding mentors for the new group of ARC 2000 students following in their footsteps.

## **6. Moving on to ARC 2000**

Because of the continuing demand for programs like ARC as well as its overall success, the ARC steering committee decided to accept another group of ARC students in January 2000. Several changes were made to the program to attempt to address the problems listed in section 4, including:

- An application fee of \$100 is charged. This helps cover the administrative costs and ensures applicants are serious.
- The web page emphasizes the intense level of challenge and time commitment involved in the program.
- All work term placements will be handled through the regular co-op process, with no promise of a \$2,500 minimum monthly salary. ARC students are required to take bridging workshops to help them succeed in the regular co-op process, and in transferring their skills to their new working environment.
- More adequate funding is provided for staffing resources needed for the application, advising, and work term placement components.
- All ARC 2000 students will attend classes at UBC for the first academic term and at SFU for the second academic term. This change makes the program more efficient by combining resources, as well as minimizing the possible problems resulting from small group dynamics. It will also have the advantage of creating a more cohesive group overall.
- Applicants who do not have credit for at least four university math courses must complete a grade 12 math refresher course within the two years period prior to their acceptance in the program.
- Applicants must have familiarity with basic computer operations before starting the program.

We received 89 applications for ARC 200 with 50% coming from women. 62 students were accepted into the program with women making up 56% of the total. The age range of the ARC 2000 applicants is 23 to 52 with an average age of 31.9. Although the number has decreased compared to the 1998 intake, the applicants have significantly higher qualifications. We believe the lower number of applicants is partly due to the timing of the announcement and advertising (June to mid August versus March to mid May), and to the changes to the program (application fee, math and computer literacy prerequisites, emphasis on time commitments and challenge). We believe these changes are also probably responsible for the lower percentage of women applying.

## **Conclusion**

With more than 100 people involved and two years in the making, ARC has gone from a proposal to train a few history students in computer science, to a university program opened to talented and enthusiastic people with little experience in computing. Although the program has been through some significant

challenges, 29 people who never previously considered computing as a career are now headed to join the Canadian IT work force. This number will increase as the program continues. In order to improve the program, admission requirements were raised which, unfortunately, cuts down on the number of potential applicants. This is an unavoidable draw back for the first few years of the program; ARC currently relies on sponsorship from government agencies and IT companies, and therefore the quality of students must be excellent to ensure the continued funding and survival of ARC. We hope that this description of the evolution of ARC will help universities and companies who are interested in creating similar programs close the gap of the skill pool shortage.

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