USE OF DESIGN PATTERNS IN DEVELOPING A COMPREHENSIVE PROGRAM ENCOURAGING WOMEN IN COMPUTING

Tom Gibbons and Jennifer Rosato
Department of Computer Science/Information Systems
College of St. Scholastica
Duluth, MN 55811
tgibbons@css.edu, jrosato@css.edu

Abstract

Despite advances in the early 1980's, participation of women in undergraduate computer science programs has decreased. The efforts of undergraduate institutions in recruiting and retaining women in computer science programs can be encouraged by developing patterns of activities that institutions can realistically implement to form a comprehensive recruitment and retention program.

These patterns address the needs of smaller institutions and clearly identify the resources and partnerships needed to implement them. We have also identified the elements of a comprehensive program designed to support women from the beginning stages of interest in computing to the final stages of graduation, research and employment. In this paper, we will show how design patterns are adapted to capture proven activities for recruiting and retaining women in computer science programs; the essential components of a comprehensive program; and how the patterns are organized into a system for identifying missing components of a department's existing program.

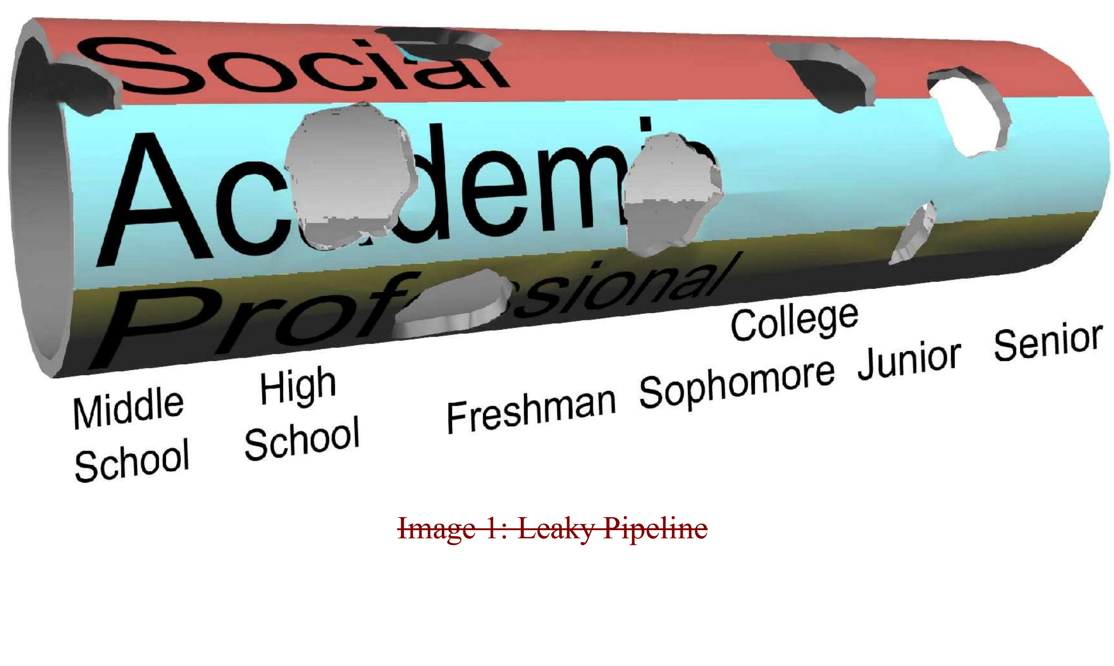
Introduction

While many other science disciplines have seen an increase in the percentage of women in past years, the percent of women entering the computer field has actually declined. "The female share of bachelor's degrees in computer sciences dropped from 37 percent in 1985 to 28 percent in 2001" (NSF, 2004, p. 18). The story is no better if you compare outside the science fields. "Women held half of all management, professional, and related occupations in 2004," (U.S. Department of Labor, 2005a, p. 1) but women only represented 27% of computer programmers and 31% of the computer and information systems managers in 2004 (U.S. Department of Labor, 2005b).

Many people are working on ways to improve this disparity based on the principles of equality and fairness, but given the "rising crescendo of voices sound alarm about the sharp downturn in young people selecting a computing field for their careers" (Denning & McGettric, 2005) many people are also looking at women as key for filling the growing disparity between the number of students and the needs of the field.

The common analogy used by programs aimed at increasing the number of women in the computer field is the "leaky pipeline." (Camp, 1997). The flow of future professionals into the educational system is seen as a pipeline. "Science careers are like a leaky pipeline: at various segments of the pipeline, people drop out but rarely drop in. Unfortunately, the dropouts are disproportionately female." (Sonnert & Holton, 1995).

There has been significant research on methods for trying to patch this leaky pipeline and most schools have tried various activities designed to fix particular leaks in the pipeline. The problem with patching leaks is that gains attained by patching one leak are often lost through another leak.



~~Image 1: Leaky Pipeline~~

The leaky pipeline can be thought of as having two dimensions. The first dimension along the length of the pipe represents the time in a student's life. The second dimension is around the circumference of the pipe, which represents different aspects of a student's development such as their academic, social, and professional development. A comprehensive model needs to look at activities that address leaks along both dimensions.

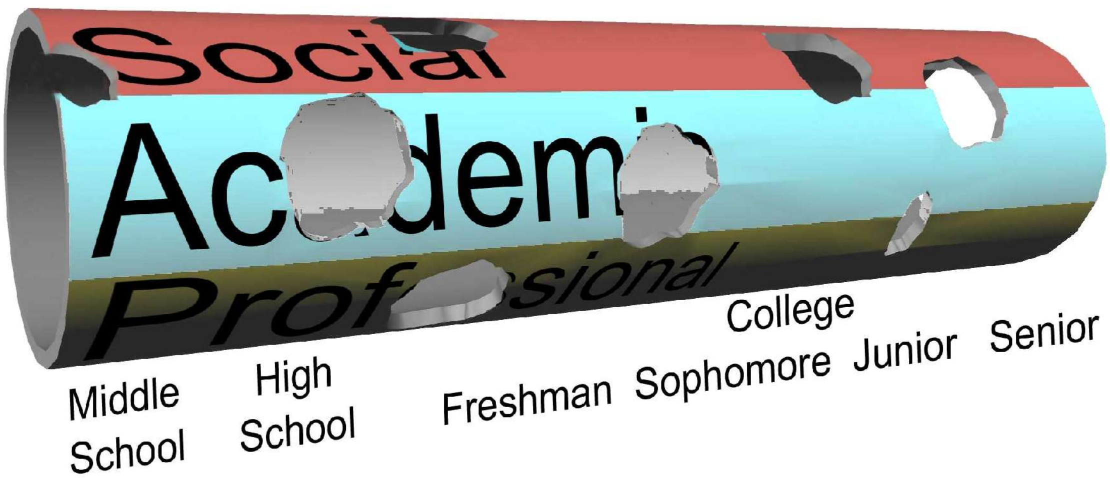


Image 1: Leaky Pipeline

Large universities have been able to implement comprehensive programs to encourage women in the computer field such as Carnegie Mellon University's Women @ School of Computer Science and Stanford's Women in Computer Science programs. Unfortunately, many smaller schools have limited resources to research, develop and implement a comprehensive plan for encouraging women. This is important because of all computer science and mathematics bachelor degrees awarded in 2002, 52% were from small colleges – liberal arts and comprehensive institutions identified by their Carnegie classification (NSF, 2006b). Thus small colleges play a significant role in encouraging women in the computer field, but how can these small colleges find the time and resources to research, develop, and implement a comprehensive plan?

Design Patterns

Activity design patterns identify reusable activities and their associated resources and partnerships. They are flexible to allow their use in a variety of situations, and yet they provide specific recommendations that facilitate their implementation. Activity design patterns are aimed at particular periods in the recruiting-retention timeline and aspects of a student's development. Because of this, they will serve a critical role in moving piecemeal recruitment and retention plans towards comprehensive plans by filling in identified holes in the piecemeal plans.

The format of an activity design pattern is based on the format used in software design patterns, with modifications that provide additional details specific to activities. Each activity design pattern contains the following fields:

Field	**Description**
Name	Specific handle or name to refer to the activity or resource
Timeframe	Specified time period in the recruiting-retention timeline: Middle School, High School, College Years 1 & 2, College Years 3 & 4
Classification	Aspect of student development: Academic, Professional, Service, Social, Image
Intent	Purpose of the activity
Motivation	Why the organization is sponsoring the activity or resource
Applicability	Description of what characteristics are needed to implement the pattern
Consequences	Results and trade-offs of applying the pattern
Participants	People who are involved
Implementation	Directions to follow in applying the pattern
Investments	Resources needed to implement pattern (monetary, time, facilities, etc.)
Partnerships	Other departments, institutional organizations, and outside agencies which can be partnered with to implement this activity.
Keys to Success	Crucial factors needed for pattern to be successful based on real-world experience.
Additional Information	Resources with more details (websites, schools, articles, etc.)

Table 1: Activity Design Pattern Fields

On the surface, the use of activity design patterns may simply look like reusing proven activities; however, there are significant differences. Using a proven activity as a base, a design pattern is created by analyzing the activity to extract the basic components while retaining the keys to success learned through real-world experience. This abstraction will allow the activity to be easily used in a wide variety of institutions. Finally the design pattern is placed within the context of the comprehensive plan by identifying the time frames and student development aspects it targets.

The following is true of every activity design pattern:

- Based on tested activities where real-world experience has been used to refine the specifications.
- Founded in research documenting proven results.
- Abstracted so it can be applied to a wide range of institutions.
- Targeted towards one or more specified time periods in the recruiting-retention timeline.
- Associated with specific aspects in the student development spectrum.

Looking at a concrete example of a design pattern is useful in understanding how it can be used. The following sample pattern defines one-on-one peer mentoring.

Pattern Name: One-on-one Peer Mentoring
Time Frame: College Years 1-2
Classification: Academic, Social
Intent: "Mentors pass on valuable help and advice in a field where male students thrive and seem to be members of a computing 'fraternity'. Mentoring can alleviate women's sense of being 'left out' and provide more tangible benefits as well: graduate school or career planning, for example." (Townsend, 2005)
Motivation: One-on-one mentoring provides much more quality time and promotes a closer relationship between mentor and mentee than group mentoring.
Applicability: Interested upper level, female majors and lower level students.
Consequences: Improved retention of majors.
Participants: Mentors (upper level students) and mentees (lower level students).
Implementation: At the start of the year, first-year computer science students are voluntarily paired up with upper class computer science majors based on similar interests. Mentors are expected to meet with their mentee on a weekly basis, possibly for lunch or a social activity.
Investments: Mentors are paid $200 a semester. The coordinator of the mentors is paid $500 a semester. (Townsend, 2005)
Partnerships: This can often be done in conjunction with other departments such as math, engineering, etc.
Keys to Success: Make sure that someone in the group is made explicitly responsible for driving group activities, so momentum begins early and keeps going.
Additional Information:

- Townsend, G.C., Ball, S. and Kuh, L. (2005). One Hundred One Ideas for "Women in Computing" Groups. Retrieved March 9, 2006, from Ohio State Web site: http://www.cse.ohio-state.edu/acmw/101tips.pdf
- Carol Luckhardt Redfiel, St. Mary's University, credfield@stmarytx.edu heads a group called WISE - Women in Science and Engineering who does mentoring.

Comprehensive Model

The Recruitment/Retention Timeline

One of the problems with any recruitment and retention effort is that gains made during one point in time can easily be lost in other points in time. While a school which sends female speakers out to local high schools and hosts a high school science day for women may see an increase in women applying to their program, these new students may be lost in the leak created by a restrictive CS1 course. Similarly, a school which targets the retention of female students with mentoring and curriculum design, may be frustrated by middle school and high school stereotypes which cause many females to drop out of the pipeline before they even reach college.

Because of the sequential nature of a student's progress from childhood to working professional, it is crucial that a comprehensive model address each point in the recruiting-retention timeline. Programs need to start in the elementary/middle school and continue through preparation for graduate school and professional careers addressing each point in the recruitment/retention timeline along the way.

The Spectrum of Student Development

"Girls are often turned off of computers for a host of social, psychological, attitudinal, and environmental reasons." (Koch, 1994, p 1). Because of this, any comprehensive model designed to encourage women in the computer field needs to cover a broad spectrum of a student's development. Research at Carnegie Mellon University has identified problems areas in recruiting women that range from curriculum and pedagogy to peer culture(Blum, 2001).

The activity design patterns for this comprehensive model are broken down into five categories largely based on the categories from *One Hundred One Ideas for "Women in Computing" Groups* (Townsend, Ball & Kuh, 2005). These categories for student development are:

- **Academic:** Related to the academic performance of the college students including issues related to class work, curriculum, and learning.
- **Social:** Involves social interactions in an informal setting and often has a fun or food component.
- **Professional:** Promotes career and employment exploration or graduate school preparation including research related activities.
- **Service:** Provides assistance to others outside the department and often outside the college and is generally free of charge.
- **Image:** Promotes the image of women in computing to a wide range of people or counters stereotypes of computing and the computing profession.

These are certainly not all the aspects of student development; those working in student support services or retention would most certainly include emotional and family aspects of student development, but these have been chosen because of their relationship to efforts to increase the number of women in the computing field.

It should be noted that these are not exclusive aspects. Many activities can be classified into multiple categories. For example, if upper level students meet weekly with lower level students for pizza and tutoring as part of a mentoring activity, this activity would cover both the academic and social aspects of student development.

The Comprehensive Model

In creating a comprehensive model based on design patterns, each pattern is classified by the points in the recruiting-retention timeline and the aspects of student development it addresses. Activity design patterns may cover multiple time periods or aspects of student development, but each pattern will be related to at least one point in the timeline and one aspect of student development.

A simple method of organizing activity design patterns is to use a grid with the points in the recruiting-retention timeline along one axis and the aspects of student development along the other axis. This is shown in Table 2 with some sample design patterns in *italics*.

	Recruiting: Elementary & Middle School	Recruiting: High School	Retaining: 1st & 2nd Year	Retaining: 3rd Year and after
Academic			*Bridge Course*	*Research*
Social				
Professional	*Career Day*			*Mentoring*
Service				
Image				

Table 2: Comprehensive Model Grid

A comprehensive model for increasing the number of women in the computing field should include activities covering multiple areas of student development at each point in the timeline.

Program Preliminary Evaluation

Using the comprehensive model grid shown in Table 2, it is possible to evaluate a school's piecemeal program of activities by simply placing the school's activities on the grid. A program should have multiple activities in each column of the grid,

~~corresponding to activities that~~ addressing multiple ~~aspects of student development at each~~ points in the timeline. Programs should also have some activities that address each aspect of student development, so there should be at least on entry in each row of the grid.

Based on these guidelines, a completed grid showing the schools current activities can be analyzed to look for trends and spot weaknesses. Are all the school's activities focused only on the academic aspect of student development? Do the school's activities target only a portion of the recruitment/retention timeline?

Once the holes in the leaky pipeline are identified as gaps in the comprehensive model grid, design patterns can be selected that target those areas and make use of the resources available to the department. One of the problems facing most smaller institutions is limited resources. While smaller institutions often lack the faculty time and financial resources needed implementing more activities in a comprehensive model, these factors also contribute to their difficulties in researching what activities they could be doing. In a small survey of regional institution, small colleges listed the lack of knowledge of the best activities to encourage and support female students as an important of factor as lack of faculty time and financial resources.

Choosing activities takes up valuable resources, since it involves both researching what activities have been shown to work and learning how to best implement these activities. The goal of activity design patterns is to provide this research to institutions so they can easily determine what proven activities to implement given their resources. Patterns also provide specific recommendations for how to implement activities with limited resources by providing suggestions on how to partner with other departments, institutional organizations, and outside agencies.

Using the comprehensive model grid and a database of activity design patterns, an institution can quickly identify gaps in its program and activities that could be used to fill those gaps. The activity design patterns can identify activities that make use of the resources the institution has available and also identify partnerships that will reduce the resource needs. Once activity design patterns are identified, the information in the patterns can be used to quickly implement activities.

Program Assessment

In order for a program to determine if it is successful, assessment needs to be done. The goal of assessment is two-fold. First, to measure the specific goal of the program: to increase the number of women in the program. Second, to determine areas of improvement within the program.

The first area of assessment is relatively straightforward in that a program can track the number and percent of women entering a program and graduating from a program. Successful programs should see both of these numbers increase, though the full impact of some activities takes years to be felt. This is certainly true of activities targeted to the early periods in the recruitment/retention timeline. An activity working with 6th grade middle school students will not impact college entry numbers for six years.

Because of this, programs might want to measure participation levels at various points along the recruitment/retention timeline besides college entry and graduation. A successful 6th grade activity should increase participation among the same group of students two years later at an 8th grade activity. If participation levels are measured at multiple points in the timeline, then increases in the number of students in the pipeline should be measurable sooner.

The second area of assessment targets the improvement of activities within the program. Surveying students who participate in an activity is the standard method for assessment which targets activity improvement. A final exit interview could also be given to graduating women.

A key area that is very hard to assess are students that drop out of the major. Often there is no contact from the student or other administrative offices that the student has switched majors or transferred to another school. Without the ability to track students who leave the program, conducting exit interviews or surveys are impossible. One solution to this is to rely on periodic surveys or surveys tied to activities which should catch students who are considering leaving the program.

By utilizing both types of assessment, formative and summative, effects of the program can be measured and program activities can be improved to provide a better learning environment for all students.

Implementation Plan

Further development of the Comprehensive Model and the database of activity design patterns is contingent upon receiving funding. Specifically, we are applying to the National Science Foundation's Broadening Participation in Computing solicitation (NSF #06-540). Following is the program synopsis (NSF, 2006a).

> The Broadening Participation in Computing (BPC) program aims to significantly increase the number of U.S. citizens and permanent residents receiving post secondary degrees in the computing disciplines. Initially, its emphasis will be on students from communities with longstanding underrepresentation in computing: women, persons with disabilities, and minorities. Included minorities are African Americans, Hispanics, American Indians, Alaska Natives, Native Hawaiians, and Pacific Islanders. The BPC program seeks to engage the computing community in developing and implementing innovative methods to improve recruitment and retention of these students at the undergraduate and graduate levels. Because the lack of role models in the professoriate can be a barrier to participation, the BPC program also aims to develop effective strategies for identifying and supporting members of the targeted groups who want to pursue academic careers in

computing. While these efforts focus on underrepresented groups, it is expected that the resulting types of interventions will improve research and education opportunities for *all* students in computing.

Funding requested by the College of St. Scholastica is for completing the development of an evaluation tool and a set of design patterns that will help smaller universities evaluate their current activities as well as implement additional activities for encouraging women in the computer sciences field. The evaluation tool and activity design patterns will first be tested out at the College of St. Scholastica and then at the diverse regional institutions. After this assessment phase, the program will be made available to all.

Activities & Timeline

If we are awarded grant funding this year, our timeline is as follows:

- 2006-2007 – Evaluate St. Scholastica's program, define a complete set of design patterns, test ~~some~~ selected activity patterns at CSS.
- 2007-2008 – Evaluate ~~associated school~~the programs of three selected schools~~s~~, define new patterns based on current activities at ~~associated~~ these associated schools, implement ~~some suggested~~selected activities at associated schools.
- 2008-2009 – Refine evaluation tool and patterns based on evaluations, disseminate work to a wide audience.

During the last year, we plan to make the tools available online. This includes providing downloadable versions of the evaluation tool and the comprehensive program grid. We also plan to provide an online, searchable interface to the database of activity design patterns. Our goal is to make it easier for other smaller schools to ~~start~~ move to more comprehensive programs focused on recruiting and retaining women thereby encouraging more schools to do so.

We are interested in hearing about your experiences with recruiting and retaining women. Do you have activities that have worked? Would you like to contribute to the database of activity design patterns? Are you interested in implementing the program at your own institution when it's available? If so, please contact us at the information provided in this paper. We would be pleased to consider your activities or keep you informed about the project's progress.

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