TWiCE Undergraduate Experience in Research and Community Service

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ABSTRACT
TWiCE (The Women in Computer Engineering) is an innovative project which has proved effective on the retention of women in an undergraduate computer science engineering program. TWiCE helps participants develop a new perspective on career possibilities in computing. Women members of TWiCE apply their developing expertise in support of community non-profits and in researching new technology. At the same time, TWiCE participants serve as role models in their communities, breaking the inaccurate stereotypes of asocial, introverted, or isolated computer scientists.

Categories and Subject Descriptors
K.4.0 [**Computers and Society**]: Gender and Diversity Issues

General Terms
Human Factors

Keywords
Women, Computer Science Engineering, Diversity, Gender, Undergraduate Research, Computers in Community Service, Attrition, Recruiting, Retention

1. RATIONALE
TWiCE is an intervention designed to reverse declining enrollment and improve the gender imbalance in computing. Attracting more women to computing can increase both the numbers of undergraduates who choose a computing major and women's engagement in creating the technologies that will have a significant influence on the future of humanity.

Research findings suggest various approaches that could attract and retain more women in computing. Social relevance, role models, research experience and networking are four of the leading approaches that form the basis of TWiCE. In addition, Best Practices based on the experiences of leading proponents of women in computing were also incorporated into TWiCE.

1.1 Social relevance
Research on achievement-related behavior and on women college students studying computing suggest that there are potentially important gender differences in motivations and interests related to computing. In general, women are less interested than men in "… hacking for hacking's sake" [7]. Instead, female students are likely to report choosing a major that will make it possible for them to "help people" [6]. The extra value that women put on contributing to society suggests that recruitment efforts should emphasize the ways that computing allows them to do so. These findings underpin recommendations for providing opportunities to use computer science to solve real-life problems or volunteer computing in the community [1, 4, and 9]. TWiCE provides such opportunities by placing participants in non-profits and community service organizations.

1.2 Female role models
Research on the value of role models shows that course retention is higher when first-year women are taught mathematics and science by women faculty [13]. Such findings motivated Cuny and Aspray to note the importance of female role models in attracting and retaining women in Computer Science programs [5]. Likewise, Jepson & Perl recommended that female students be exposed to female computer scientists either as instructors or visitors to classes [10].

The young women members of TWiCE are both exposed to and serve as female role models. All project staff members are professional women either in the CS (computer science) field or specializing in IT research endeavors and serve as important role models to the program's undergraduate student members. In turn, the members of the group act as stepping-stone role models among their peers, clients, and in the community. By concentrating women together in this one organization, a perception of critical mass may be achieved [1].

1.3 Research experience
Research experience enhances student retention in science and engineering majors. Astin and Astin found that students who had opportunities to conduct independent research and become involved in faculty research were more apt to major in science as a career [2].

All members of TWiCE conduct seven weeks of self-guided research at the beginning of their employment. They are given assignments to read and review. They also must do significant research to solve the problems presented by their project. They

work in teams and are rewarded by seeing the results of their research applied to directly help women in the community. Whenever possible, they are encouraged to propose and present posters at regional conferences and other events.

1.4 Social networks

Girls and women in science can benefit from networking as early as primary school and continuing through graduate education and careers in business and industry [13]. The likelihood of a student choosing a career in the sciences and engineering is related to the proportion of the student's peers choosing the same major [2].

Cohoon makes several recommendations for a college outreach program that makes contact with high schools, as well as civic groups and the local population [4]. By connecting the institution of higher education with local groups, a pool of potential female computing majors may be identified. Programs like TWiCE also offer the opportunity to counter negative stereotypes about computing and market future educational and professional prospects.

2. DESCRIPTION

TWiCE was launched at the Ohio State University in 2003 to facilitate undergraduate women's exploration of industry and research careers in computing. It was largely modeled on the successful EPICS program at Purdue University.

Purdue created the Engineering Projects in Community Service (EPICS) program to alleviate perceived shortcomings of the engineering program. This program attracted a "… disproportionate number of women students" [9]. They believe that the key factors for success are: multidisciplinary teamwork, communication, and engineering in the context of community involvement. In order to specifically address the issue of low numbers of women in computing, we made a few adjustments to the EPICS model.

2.1 Context

The Ohio State University is a large, state-funded, PhD granting institution in the Midwestern United States. Average enrollment is between 55,000 and 60,000 students annually. The Computer Science and Engineering (CSE) department is within the College of Engineering, however it provides courses to undergraduate students pursuing Bachelor's of Arts and Bachelor's of Science degrees in Computer Information Science (CIS), Computer Science and Engineering (CSE), and Information Systems (Info Sys).

The CSE department has a Diversity enhancement program that provides special assistance to women and underrepresented groups through tutors and informational listservs. Students also have a choice of participating in a variety clubs, each with a distinct mission and focus, ranging from ACM-W to Upsilon Pi Epsilon, the New Technology SIG and OpenSource club. There is significant "cross-pollination" between TWiCE and ACM-W. Students often become acquainted with TWiCE through their participation in ACM-W, and vice-versa.

Undergraduate women form a very small minority within the CSE/CIS major at Ohio State University, around 10%. Without visible peers or role models, these students often feel that it is necessary for them to perform at the top of their class in order to merit the same level of respect that their male counterparts receive

naturally. They also lack "safe" options for forming social or study groups. They are sometimes anxious that that their interest may be misconstrued by male peers.

The TWiCE lab is a well-equipped, dedicated space where the students work on their projects. It is a "safe" environment in two respects. In the lab, the women are free to problem-solve using their own, often untraditional, processes. The students frequently consult with each other, and drift into unrelated tangents before resolving technical issues. The lab is also a secure space where schoolbooks can be stored, and women can work alone, even at night. The door is always closed and locked.

TWiCE Community projects benefit residents in the university district. This neighborhood is a highly transient community with a disproportionate amount of crime. The majority of the younger girls that will benefit from this project come from single female-headed households. Many of the girls' mothers work more than one job and are absent most of the day, evening and night. The girls from this area are on their own much of the time and consequently, they are at greater risk for a range of problems, including risk-taking behaviors.

2.2 Membership and Leadership

New members of TWiCE are recruited from first and second year undergraduates in computing majors within the institution. It has an all-female membership to ensure that TWiCE is a project that supports women specifically [3, 8], providing the resources typically available to male classmates only.

Every member of TWiCE works on her projects as a part of a team of two or more students. By being a part of a team, the students create partnerships that continue outside the lab and into the classroom. Effective communication with their community partner (client) and within the teams is critical for success.

Supervising the students means not only ensuring that they meet their work goals, but also mentoring them and supporting them in reaching their academic goals. We've found that a certain level of informality and flexibility works best, so a "triangle" model of supervision has evolved – with the student, the TWiCE Director and the community partner ("client") at each corner.

The student members of TWiCE submit their hours bimonthly, along with a report of their activities to the program director. They have informal, ad hoc meetings with her to discuss the status of their work several times each academic quarter. They also periodically participate in an anonymous survey about their experience with TWiCE that gives the director more information about how the program as a whole is doing. Most student assignments require them to go to a community site once or twice a week. Depending on the assignment, they usually meet with their "client" on site to receive additional direction and advice for the week's activities. Closing the "triangle", the TWiCE director also meets with each of the community clients on a monthly basis to gain feedback on the progress of each student and discuss any issues that may need attention.

TWiCE women are relay their positive experiences by conducting workshops for high school girls and other prospective students, which encourage more incoming women in CSE/CIS. They provide visible proof that computing is connected to community values, and that students' technical skills have economic value. They also act as role models and mentors to help girls gain a more favorable impression of computing careers.

2.3 Recruiting

Any undergraduate female in a computing related field may apply for employment in TWiCE.

2.3.1 Member Selection

The first year of the project, four undergraduate senior students were recruited directly from the executive council of the school's student chapter of ACM-W. They, in turn, identified friends from their classes, who were also encouraged to participate. These pioneering students helped establish many of the project's procedures and had a high personal investment in its success.

As these students graduated, their newly open positions in TWiCE were advertised on class newsgroups, and on bulletin boards. Departmental advising staff and instructors encouraged students to submit applications.

The most effective recruiting technique required targeting individual women and following up with extensive personal contact. Very few women self-nominated for positions in TWiCE, often citing feelings of under-qualification, or that they should let the positions go to someone more deserving. Also, the year-two group, who were mostly second year students, expressed reservations about nominating classmates for open positions. Typically, professors nominated women in their courses whom they thought would appreciate the opportunities that participation in TWiCE provides. Based on these nominations, individual emails were sent to each woman, mentioning the professor who had nominated her and inviting her to complete an application. If the student did not respond to the initial invitation, we sent a follow-up note. This tactic proved very effective, and all the women contacted this way ultimately joined the group.

2.3.2 Rewards

The members of TWiCE are not volunteers, even when their project client is a non-profit or charity. They are paid by the program grants at the top of the scale for undergraduate research associates. Our intent is to build a sense of the value of the students' work by providing appropriate rewards and recognition. TWiCE members are frequently reminded that they are computing *professionals*. This status is an important distinction to make, especially among female undergraduates who frequently undervalue their skills.

2.3.3 Participation

In TWiCE's second year, the program has received more exposure as the women presented research posters, received mention in local media, and conducted workshops for incoming freshmen women in engineering. As a consequence, interest has been building. Approximately 1/3 of the total female enrollment participates in TWiCE. In 2004 (year one), the total number of women majoring in CSE/CIS was 35. That year there were eight applications and subsequent participants in TWiCE. In the second year, there were ten applications and subsequent participants. Enrollment data for 2005 is not yet available.

The size of the program is somewhat constrained by physical and regulatory factors. The members of TWiCE are assigned to share one of five workstations, which limits the number of participants to about ten. The other restriction affects non-citizen students that lack the necessary work visas for employment in the United States. In response, we accept non-citizen students as volunteers.

This status allows international students the opportunity to build work experience and community service credit that may help them gain sponsors for work visas.

The members of TWiCE are a diverse group of women; they have represented all races and many nationalities. During the program's first year, participants were mostly seniors. The second year, they were mostly sophomores and juniors. We only require that they have completed their first two courses in CSE. We have even accepted non-majors who had the appropriate coursework.

2.4 Training

TWiCE members initially undergo a self-guided training period where they are introduced to current computing and diversity-related research along with the lab platforms and development environment. This is a set of pre-packaged tasks, organized into weekly 5 to 10 hour modules. Each week, they have reading assignments from current research to summarize, plus one technical task. The technical tasks guide the student through the features of the lab environment and the specific tools that they will use for their project.

During the training period, TWiCE members also learn to submit weekly progress reports and adhere to other standards of professional behavior. Some students appreciate these opportunities to expand their skills outside the classroom. On her annual evaluation, one remarked, that she found her classes easier after learning so much from her project.

2.5 Projects & Activities

After training is successfully completed, each student is offered a choice of opportunities to 1) adopt local area non-profits and charities to provide technical support; 2) participate in a technology research project; or 3) work on an industry analysis project.

A community support component was added, and tested on a small scale in 2004-05 (year two). During this year, TWiCE formed partnerships with key groups in the 'University District' and focused on an enterprise zone that is characterized by single female head of households with typically low income levels. Their schools do not have computing facilities and their families can't afford to have computers at home. Girls in this neighborhood have few safe and wholesome after-school opportunities and even fewer role models.

The presence of young professional women in this environment had an immediate and positive impact. An independent evaluation of the computer club for girls facilitated by TWiCE undergraduates, found that the elementary school girls were enthusiastic and intended to apply the computer knowledge and skills they learned in the club. Unanimously, the girls affirmed that the club teachers taught them useful computer skills, made learning fun, cared about their learning, helped them when they had questions, believed they could learn computers, treated them with respect, were nice to them and served as good role models.

Other current projects besides teaching the computer club and mentoring 4th and 5th grade girls from a poverty-level school, included developing a learning-game for girls using a handheld computer, helping a neighborhood resource association put up a website to post job and training opportunities, and inventorying a neighborhood technology center to identify needs in hardware, software, and skills.

Favorite projects vary from year to year. In year one (before the community options were available), half the students favored industry projects that put them in direct contact with local businesses. The other half of the group worked on creating a pocketPC learning game that they called 'Jane's Domaze'.

In year two, we encouraged each woman to work on and evaluate two projects. After three months, almost all students decided to focus on just one. Four students continued to do research and work on 'Jane's Domaze'. However, new community projects captured the interest of the others.

In order to help reinforce the research objectives associated with their projects, each student was required to propose and present a research poster on their focus area at a regional conference [11].

3. INDICATIONS of EFFECTIVENESS

TWiCE is evaluated here in two ways – from the perspective of participants and according to official data on enrollment and retention. The results are very different, and point out the importance of careful evaluation.

3.1 Immediate Impact

TWiCE has had a strong positive impact on the students that participated. All seniors graduated in the major, and four of the five senior students (80%) applied to graduate school in the second year. TWiCE participants are self-selected, so it is not clear if these positive outcomes are attributable to their experience in the program.

In annual anonymous evaluations, the members all rate their TWiCE experience very favorably. All years, 100% have said that they would recommend participation in TWiCE to others. One woman noted, "Working with research groups such as TWiCE builds a list of references and contacts that is very helpful for continuing education or getting jobs …." She saw this experience as adding value to her undergraduate education.

The women rated access to a new technology and a workstation in a private lab as the best benefit of being a member of TWiCE. The few open labs that are available to the general population of CS students are often uncomfortably cold, and they lack storage and meeting space. The TWiCE lab offers better accommodations, which may account for students using them for more purposes than just working on their projects. Students use the TWICE lab for study and doing schoolwork, and sometimes they even hold class team meetings in the space. One member stated, "The lab space was a really great place to study, which helped for late night sessions."

Frequent contact in the lab seems to have promoted friendships that transcend their university underpinnings. The TWiCE students encourage and support each other – they once organized a successful "intervention" for a student who considered changing her major. Hearing from her peers that future courses would be easier to cope with persuaded this student to continue for "just one more quarter". She graduated with a BS in CIS shortly thereafter.

Students cite their TWiCE experience as contributing to a fresh interest in pursuing research after graduation, or a career in consulting. One student said, "I didn't think of going to grad school before, because I never knew what research was".

3.2 Secondary Impact

Early project assessment suggests that TWiCE may be having a positive impact on the rate of retention of women enrolled in computing at OSU. Not only were members of TWiCE retained in their CS programs during 2003-2006, but at the same time, the trends for all women's attrition rates moved towards parity with men's rates. Figures 1 and 2 show trends in Gendered Attrition for all CSE majors, before and after the introduction of TWiCE. Gendered Attrition is calculated as % Female Attrition - % Male Attrition.
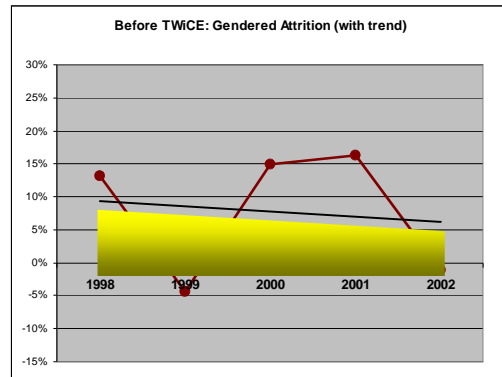

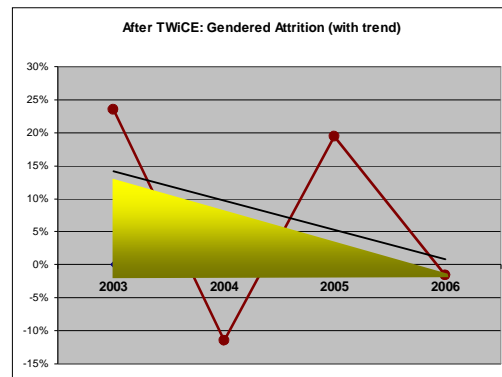**Figure 1. : Gendered Attrition from CSE (98-02)**

Figure 2. : Gendered Attrition from CSE (03-06)

On the other hand, the program does not seem to be increasing the proportion of women entering the program. The first Quarter Freshman numbers from 2000 to 2006 shown in Table 1 document a steady decline in the numbers of both male and female new enrollments and fluctuation in the female percent of those enrolled. The %Change row in Table 1 shows that the total number of students declaring a CSE/CIS major at OSU matched the national decline [14], although the percent of women has remained fairly stable.

Year	# F	# M	Total	% F
2000	20	183	203	10%
2001	12	168	180	7%
2002	14	143	157	9%
2003	11	99	110	10%
2004	9	127	136	7%
2005	8	119	127	6%
2006	12	107	119	10%
% Change	-67%	-71%	-71%	2%

Table 1. : New First Quarter Freshmen in CSE/CIS

DISCUSSION

Implementation of a project such as TWiCE requires considerable institutional and sponsor support. The departmental diversity initiative has been strengthened by the attention generated by this program, but it has also been strained by the resources devoted to TWiCE. The TWiCE lab requires office space that was originally designated for TAs and tutors. TWiCE also uses network connections and floor space in the systems operation center for its server. These resources have been donated by the department. Compensation, materials, and equipment costs have been borne by industry sponsors. Without these considerations, the support of faculty and the departmental culture, a program like TWiCE would have been impossible.

Another challenge has been evaluation and assessment. Statistics showing retention by major are hard to come by, so comparisons of TWiCE participants with other Ohio State computing majors and with the national undergraduate populations are only approximations. We are unable to determine if the retention of TWiCE participants is due to selection bias rather than positive effects of the program. It is unclear which specific elements of this project work or do not work. For example, the social interaction among women in TWiCE might eventually lead them to work together for the benefit of all women in their department. Their actions could increase retention, even though they would not be part of the formal TWiCE program.

In other words, TWiCE might create an environment where positive change can happen without directly increasing recruitment and retention. Alternatively, the entire framework of programs, including diversity tutoring, ACM-W, and TWiCE, could raise awareness among students and faculty and result in better support for all students, especially women.

4. SUMMARY

By applying current research findings and best practices, and adopting relevant features of an established program at a peer institution, TWiCE was created to correct the problem of low numbers of women in computing. Preliminary results are promising in some respects but not in others. All participants were retained in the major until graduation, and several women applied to graduate school. TWiCE strengthened participating students' commitment to achieving their educational goals by providing them with 1) female role models and chances to become a mentor; 2) socially relevant opportunities to apply their growing skills; 3) research experience that demonstrates the broad impact of computing; and 4) social networks that sustain their interest and provide support. However, further objective evaluation is necessary.

6. REFERENCES

[1] AAUW Educational Foundation Commission on Technology, Gender, and Teacher Education. *The computer science classroom: Call it "oceanography" and they will come.* In Tech-Savvy: Education girls in the new computer age. Washington, DC: American Association of University Women Educational Foundation. (2000) Available online: http://www.aauw.org/member_center/publications/TechSavvy/chapter4.pdf.

[2] Astin, A. W., & Astin, H. S., *Undergraduate Science Education: The Impact of Different College Environments on the Educational Pipeline in the Sciences*. Final Report (No. ED362404). (1992) Los Angeles: California University.

[3] Balcita, A. M., Carver, D. L., & Soffa, M. L., *Shortchanging the future of information technology: The untapped resource.* (2002, June) SIGCSE Bulletin, 34 (2), 32-35.

[4] Cohoon, J. M., *Recruiting and retaining women in undergraduate computing majors*. (2002, June) SIGCSE Bulletin, 34 (2), 48-52.

[5] Cuny, J., & Aspray, W., *Recruitment and retention of women graduate students in computer science and engineering.* Report of a workshop, June 20-21, 2000, organized by the Computing Research Association. (2002, June) SIGCSE Bulletin, 34 (2), 168-174. Available online: http://www.cra.org/Activities/craw/projects/best_practices.html.

[6] Eccles, J.S., *Understanding women's educational and occupational choices: Applying the Eccles et al model of achievement related choices,* (1994) Psychology of Women Quarterly, 18, 585.

[7] Fisher, A., & Margolis, J., *Unlocking the clubhouse: The Carnegie Mellon experience.* (2002, March) SIGCSE Bulletin, 34 (2), 79-83.

[8] Gurer, D., & Camp, T., *An ACM-W literature review on women in computing.* (2002, June) SIGCSE Bulletin, 34 (2), 121-127.

[9] Jamieson, L. H., *Expanding the pipeline. Women, engineering, and community*. (2001, May) Computing Research News, 2, 16. Available online: http://www.cra.org/Activities/craw/projects/expnd-pipeline.html.

[10] Jepson, A., & Perl, T,. *Priming the pipeline*. (2002, June) SIGCSE Bulletin, 34 (2), 36-39.

[11] OCWIC, *Ohio Celebration of Women in Computing* (2005), Available online: www.cse.ohio-state.edu/ocwic/program.html.

[12] Robst, J., Keil, J., & Russo, D. (1998). *The effect of gender composition of faculty on student retention.* Economics of Education Review, 17(4), 429-439.

[13] Thom, M. (2002). *Balancing the equation: Where are women and girls in science, engineering, and technology?* New York, NY: National Council for Research on Women.

[14] Vegso, J., *CS Bachelor's Degree Production Grows in 2004; Poised for Decline*, Computing Research News, Vol. 17/No. 3. (May, 2005) Available online: http://www.cra.org/CRN/articles/may05/vegso.