

A RESEARCH APPROACH TO RECRUIT COLLEGE APPLICANTS IN SPECIALIZED SCIENCE TO BENEFIT GLOBAL TECHNOLOGY AND INNOVATION.

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Abstract

Over the past several years there has been a dramatic increase in the number of new interdisciplinary degree programs offered by colleges and universities. The curricula of these programs typically weave together selected elements of traditional disciplines into highly specialized fields of study such as bioinformatics and sustainability.

Because these fields are so specialized one of the great challenges facing academic administrators, particularly at the undergraduate level, is the recruitment of students. This challenge arises in part from the fact that virtually none of the prospective students receive any exposure to these subjects in their high schools. As a result, even those who are most likely to succeed in these programs have little understanding of the nature of the subjects, and they have no awareness of post-graduation opportunities for employment or advanced education. Without such information it comes as no surprise that very few choose to major in these subjects.

In an effort to address this shortfall and attract more students, the Chester F. Carlson Center for Imaging Science (CIS) at the Rochester Institute of Technology (RIT) established a comprehensive, nationwide educational outreach program. This program employed a variety of live classroom demonstrations, campus visits, summer internship and online technologies to expose over 1000 secondary school students each year to the wealth of opportunities available in this field.

The effectiveness of these various outreach initiatives has been tracked for several years. The data show that the payoff for most is very low, from 0%-2%. However the summer internship has historically returned a much greater payoff – about 13%.

The summer internship, during which high school students become paid employees of RIT for seven weeks, is now in its 10th year. It has given 100 high school students the opportunity to work side-by-side with faculty, staff, and imaging science students, graduate and undergraduate, on actual sponsored research projects.

Keywords - Innovation, high school education, college recruitment

1 INTRODUCTION

1.1 Imaging Science

The reliance of modern scientific and engineering research on imaging techniques has created the need for a new generation of scientists who can not only design and develop the optical systems, electronics, sensors, image processing algorithms, and integrated imaging systems of the future, but who can apply those systems to answer fundamental questions about ourselves and our universe, monitor and protect our environment, help keep our nation secure, and improve our medical care. The science of imaging encompasses a very wide range of subject areas, from the physics of optics and radiation sources, to the mathematics of statistics and topology, to the chemistry of materials, to the engineering of sensors, to the computer science of data mining, to the brain science of vision, to the psychophysics of perception. Imaging science addresses questions about every aspect of systems and techniques that are used to create, perceive, analyze, optimize and learn from images.

Twenty years ago, the Rochester Institute of Technology recognized the importance of imaging to a vast array of scientific endeavors and created the interdisciplinary Chester F. Carlson Center for

Imaging Science and its associated degree programs in Imaging Science (the Ph.D., the Masters of Science, and the Bachelors of Science degrees). RIT remains the only direct degree granting program in Imaging Science in the United States.

When RIT created the Center for Imaging Science as an interdisciplinary center in 1989 -- with strong ties to industry and national centers and with its own degree programs, and curricula --they were revolutionary. The faculty engaged in the Imaging Science programs and associated research activities come from the fields of physics, astronomy, chemistry, biotechnology, bioinformatics, environmental science, biochemistry, mathematics and statistics, computer science, computer engineering, electrical engineering, statistics, mechanical engineering, psychology, and of course, imaging science. With twenty years of experience and a growing network of research, collaborators, and students, the Center is in full bloom. Application areas of active research within CIS include: astrophysics, remote sensing, biomedical, environmental science, vision science, nano-technology, materials science, color science, computer graphics, archaeology/ancient documents, and microelectronic engineering.

Today, CIS has 35 faculty whose collaborative networks extend to research hospitals (University of Rochester Medical Center, Syracuse's Upstate Medical University, Rochester General Research Institute), national centers (e.g., the National Radio Astronomy Observatory, Los Alamos National Laboratory and Lawrence Livermore National Laboratory, the Rocky Mountain Research Center), many universities and over 30 industry partners.

The Center pioneered the approach of analyzing imaging processes from a systems perspective, also referred to as the "imaging chain", including the physical understanding, interpretation, modeling, fusion, display and perception of data from imaging systems. This systems approach depends on and engenders a tight collaboration between interdisciplinary imaging scientists and the many scientists and engineers who reside purely in the application disciplines. Thus, imaging science is both truly **interdisciplinary** in its content and **multi-disciplinary** in its applications. As such it provides an ideal gateway through which to introduce young minds to a range of fascinating pure and applied research problems, as well as an ideal medium in which to grow researchers who are facile working in a highly interdisciplinary research environment.

1.2 Defining the challenge

The singularly unique blend of technical disciplines which has helped to establish the Center as the world leader in imaging research and education has actually served as a 'double-edged sword' when it comes to recruiting students into the program, particularly at the undergraduate level. On the one hand, if a prospective student is interested in a career in the imaging industry, the Center provides the only opportunities for advanced studies in the field. But on the other hand, because imaging science is such a specialized discipline, prospective students are never exposed to it in high school. A student who displays an aptitude for math, science, and technology -- a student who might excel in an imaging science degree program -- may never even consider it as an option. Since the student's teachers, counselors, and parents will no doubt be unaware of imaging science, they will never urge their student to investigate the opportunities in the field. This problem is particularly evident in New York State, where the Center is located, and from which the majority of imaging science undergraduates originate. In 2002 New York State removed geometrical optics -- a foundational component of the imaging science curriculum -- was removed as an optional topic from the physics assessment (Regents exam) in 2002 [1]. Since then, New York State leaves geometrical optics (along with other topics) as content that provides for "horizontal and vertical enrichment". This content is not assessed, and therefore may not be covered by many schools around the state. It should come as no surprise that if the basis of image formation is removed from state assessments, the remainder of the imaging chain that is the core of imaging science becomes unknown.

Another hurdle is presented when the high school student is ready to take the Scholastic Aptitude Test (SAT) [2]. This test is one of the metrics that universities use for admission and placement of students. When registering for this exam, the student is asked to select a field of study from a limited list of options. Imaging science is missing entirely from the list of categories and subcategories. So even if a student selects physics, or engineering, or computer science as his/her first choice, and the enrollment cap for those academic departments is filled, nothing warranties that this student will be directed towards imaging science.

In summary, innovation runs against establishment. Because of this lack of awareness of imaging science at the high school level, the Center has struggled for years with low freshman enrollment in

the undergraduate program. In fact, between 1995 and 2009 an average of only 11.2 freshmen entered the program each fall. These low enrollments posed a significant challenge to the program during a time when global demand for graduates at all levels was rapidly increasing.

2 OUTREACH AND RECRUITMENT

2.1 Summer intern program

In 2000 the Center chartered an internal committee of faculty and staff to address the issue of low undergraduate enrollment. This committee developed a comprehensive strategy with three primary thrusts: 1) building upon and complementing the traditional recruiting work already being done by the Center's host college and RIT's Office of Undergraduate Admission, 2) building bridges to schools in the local area (western and central New York) by offering a wide range of educational and professional opportunities for students, teachers, and administrators, and 3) developing and offering in-depth summer experiences for students, including a high school intern program.

From the beginning, it was strongly felt that the intern program should focus on immersing the participants in the culture of scientific research. The approach would be to fully integrate a limited number of highly qualified high school students into the Center's existing research teams, working on projects sponsored by external funding agencies. In doing so, the participants would spend every day working side-by-side with both graduate and undergraduate students, as well as faculty and staff researchers, using state-of-the-art equipment to collect, process, and analyze scientific data. The intent was to give the students an authentic experience – one which they would be unable to get anywhere else, and one which would dramatically influence their decision regarding where to go to college and what to study.

While program organizers hoped that scores of brilliant students would immediately jump at such a unique educational opportunity, they realistically accepted the fact that for many teenagers, summer is a time to earn money for college. The committee needed to ensure that prospective applicants would not have to decide between the certainty of making money at a job they understood and were familiar with, and the possibility of gaining valuable experience through an internship with no financial incentive. It was therefore decided that participants would be paid an hourly wage in an effort to make the program even more attractive. Scheduling of the internship was also critical. Organizers decided it would run for seven weeks – starting immediately after the Independence Day holiday on July 4, and ending one week before school began. The hope was that once they returned to school the participants would tell their classmates and teachers about the experience and in doing so, serve to raise visibility of the department and opportunities available in the field of imaging science.

It was felt that the intern program should target students between their junior and senior years in high school. The committee concluded that the program should focus solely on this population in the belief that the program would have the greatest impact if it took place immediately before the participants began to make decisions about colleges and majors of study. Recognizing that a number of universities actively recruit students in the sophomore year of high school, the committee considered opening eligibility for the program to this population. However, given that participating students would be working on sponsored research programs, some consideration had to be given to the participants' academic preparation and level of maturity. Consequently it was decided to exclude sophomores from the program. While high school seniors – those approaching graduation – would be more likely to possess the requisite academic and social skills, it is also more likely (in fact, almost a certainty) that they would have already made their college decisions prior to participating in the intern program. As a result, they too were excluded for consideration.

Once these basic parameters of the program had been established in the spring of 2000, the Center made plans to run a pilot program that summer. With the help of the science coordinator at a local school district, program organizers identified a single high school junior who it was felt would benefit from the experience of spending a summer working in a research laboratory. This individual was hired and put to work in the Center's Digital Imaging and Remote Sensing Laboratory as the first high school intern. His work involved a variety of tasks supporting both lab and field measurements, as well as computer modeling and simulation. At the end of the summer program administrators sat down with the student and asked for feedback. His comments highlighted three main issues which would have to be addressed before expanding the program – 1) the faculty attitude about the program and the level of faculty involvement with the intern, 2) the nature of the assigned tasks, which could sometimes be

labor intensive, monotonous, and downright boring, and 3) the social aspects of the experience, as the only high school student on a team with college students, faculty, and staff.

Armed with this feedback, the program organizers set about making the necessary adjustments, and in January 2001 invited local school districts to encourage their juniors to apply for the first competitively-selected intern cohort. Five students from three schools were chosen and assigned to work in the Center's remote sensing and color science laboratories. In the fall of that year two of the five interns applied for admission to the imaging science BS program. This convinced program organizers that the high school intern program was a viable recruiting tool, and from that point on it has been the "crown jewel" of the Center's outreach program.

To preserve the quality of the internship experience a very thorough selection process is conducted, as can be seen from the number of accepted students and schools shown in Figs. 1 and 2. The students are asked to submit an application that includes an essay where they explain why they think this experience will be of value for their academic future. Some of them may have an idea of what they would like to major in, therefore they may ask to be considered for a particular research laboratory. They are also requested to submit their transcripts as well as letters of recommendation from two of their high school teachers. A first cut of the applications is done by the Associate Director and a series of interviews is scheduled with participating faculty. The final selection and assignment is done at a plenary session, where faculty discuss the merits of the applicants. More than once faculty have had to negotiate over a particular intern whose skills and interests fit more than one research laboratory.

In the years since this early success the program continued to grow and evolve and a full-time program coordinator (a high school physics teacher) was hired each summer to oversee the administration of the program and to orchestrate all intern-related activities.

Over time the intern program became highly visible both on and off of the RIT campus. The number of applicants grew steadily as past interns returned to high school for their senior year and told their teachers and classmates about the experience. The trend is shown in Fig. 1. The number of schools submitting applicants also grew, shown in Fig. 2, thanks to regular media coverage about the program in print and on TV.

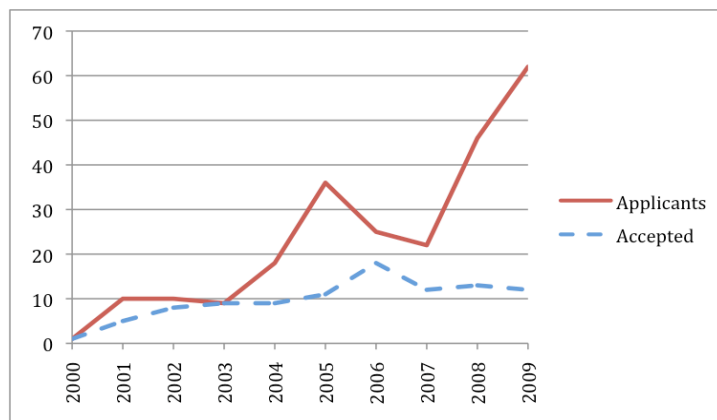


Fig. 1. Applicants and accepted students to CIS summer internship over the years.



Fig. 2. Number of schools that have submitted applications over the years.

A. Research plan

The usual day starts with a morning meeting with the program coordinator where experiences are exchanged, special announcements are made, etc. The interns then go to their respective laboratories for their daily activities.

There may be several ways in which an intern is expected to participate depending on the research group they are assigned to. In some laboratories the interns' work is more like small pieces that eventually will fit into a major puzzle. In others, the intern is presented with a stand-alone imaging problem that is for him/her to solve, obviously, with appropriate supervision. Their tasks may range from the simple, like inserting data into a spreadsheet, and doing some elementary plotting, to the involved –collecting data, programming, analyzing data. The scope of their work as well as their very valuable contributions can be seen from the record of peer-reviewed publications and conference presentations. A list of these is included in Appendix A at the end of this paper. (Note: names followed by a double asterisk are interns).

Two or three field trips to local companies in the imaging industry are organized during the internship to break away from the tedium which sometimes accompanies lab work, and to expose the interns to career opportunities in the field.

Opportunities to expose the interns to research conducted in other laboratories arise when there are experiments that require volunteers to evaluate visualization techniques. First, the interns are presented with a consent form previously evaluated and authorized by the Institute Review Board, IRB. Sometimes parent's permission is required. Once permission has been granted, the "resident" intern explains the experimental protocol to the volunteers and the experiment is conducted.

Other occasions of exposure to research being conducted elsewhere include attendance to weekly College of Science Undergraduate Research talks and the institute-wide Undergraduate Summer Research Symposium, an annual event on the RIT campus in which aspiring scientists have the opportunity to give oral presentations on the results of their research to the top professionals in their field. In fact, some of the interns have had an opportunity to present at these forums.

When web blogs appeared as a medium by which individuals could record and share their experiences online, daily blogging became a requirement for all interns.

The capstone experience is an oral presentation about their research at a symposium attended by their colleagues at the Center, including faculty, staff, undergraduate, and graduate students, as well as their teachers, friends, and parents.

Research sponsors and collaborators include the State of New York University (SUNY) Upstate Medical University, New York State Foundation for Science, Technology and Innovation (NYSTAR), the National Aeronautics and Space Administration, (NASA), the National Science Foundation (NSF), the Department of Defense (DoD), the Department of Energy (DoE), the National Oceanic and Atmospheric Administration (NOAA), the George Eastman House International Museum of Photography, the Walters Art Museum, the Library of Congress, Procter and Gamble, Hewlett-Packard, Universities Space Research Associates (USRA).

B. Effectiveness of the internship program

As of this writing, the imaging science intern program has now been active for 10 consecutive summers. In that time exactly 100 students from 31 different schools have served as interns, working on sponsored research projects in 11 different research laboratories, including visual perception, document restoration, biomedical imaging, remote sensing, color science, magnetic resonance imaging, astronomy, optics, and detectors. The program is widely viewed at RIT and across the local community as a glowing success. But does this perception of success arise from the program's ability to meet its stated objective – to recruit students for the undergraduate imaging science degree program – or does it arise as a result of other program outcomes? Program organizers may now have enough qualitative and quantitative data to draw some conclusions regarding the program's effectiveness.

At the highest level, it is easy to calculate the intern program payoff in terms of enrolled imaging science undergraduates. As shown in Fig. 3 of the 86 students who served as imaging science interns between 2000 and 2008 (the most recent year for which an intern could have applied and been accepted to the BS program), 12.8% of the total ultimately became matriculated imaging science undergraduates.

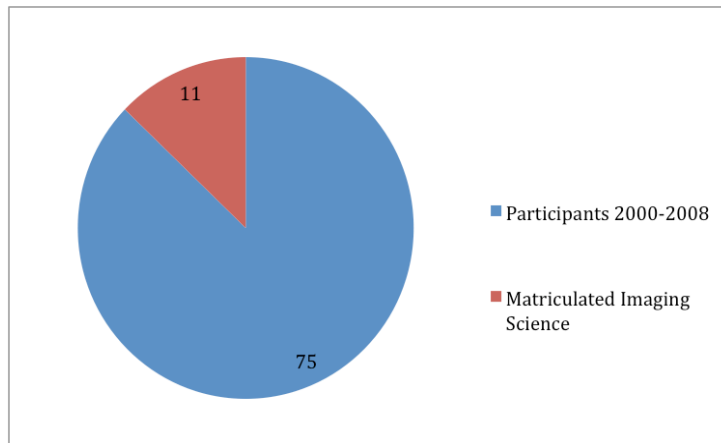


Fig. 3. High school interns that have matriculated in imaging science over the years.

None of the interns who have applied for admission has ever been turned down. Six of these students are female and five are male. Since 53.5% of the interns have been males and 46.5% have been females, the conversion rate for males is therefore 10.9%, while for females it is 15%.

The intern program could also be credited with influencing some students' college decisions *even though those students did not serve as interns*. In one documented case, a high school senior decided to enroll as an imaging science undergraduate after his twin brother participated in the intern program. There may be other instances in which the existence of the program was responsible for making a prospect aware of imaging science even though that individual did not serve as an intern. While this secondary effect of the intern program has clearly impacted enrollment in a positive way, it is difficult to quantify this effect when determining the overall program effectiveness.

There are two points worth noting with respect to these figures. First, a conversion rate of 12.8% may not appear sufficiently high to warrant continuation of the program. However this figure must be assessed within the context of the other elements of the comprehensive imaging science recruitment program. These efforts are discussed in Section 2.1.C and returns are shown in Fig. 9.

The second point worth noting is that while the intern program is the most effective recruiting initiative employed by the Center, it is also the most expensive. The costs associated with the program include the salaries of the interns and the program coordinator (who are all hired as temporary full-time employees for the summer), bus transportation associated with up to three field trips, and other miscellaneous expenses. There are no direct costs to the program associated with faculty involvement. The estimated cost of the program over the first nine years was approximately \$231,000. This comes to approximately \$2700 for each participant, but considering that only 11 of the participants ultimately enrolled in the undergraduate program, the cost per enrolled imaging science student is over \$21,000.

The figure of \$21,000 per enrolled imaging science student may at first seem like a significant amount of money, but in fact the cost per intern is offset by the value of the work the students did in their research laboratories while serving as interns. Quantifying this value is extremely difficult. As expected, not all interns perform at the same level. In spite of the rigorous selection process which attempts to assess which of the applicants would "fit" best in each of the research groups, sometimes the committee gets it wrong and the intern produces little work of value. On the other hand, some interns far exceed expectations and end up doing work comparable to upper class undergraduates, or occasionally, graduate students. So clearly the Center reaps benefits from the intern program which go beyond enticing prospective students to enroll in the undergraduate imaging science program.

While the primary objective of the intern program was to encourage students to apply for admission to RIT's undergraduate imaging science degree program, from the university's perspective, the program has also been effective if, as a result of working on campus all summer as an intern, a participant applies for admission to *any* of RIT's degree programs. In fact the data reveal that approximately 58% of all interns apply for admission to some RIT program, whether imaging science or something else. While it is possible to also determine how many of these applicants were accepted and ultimately enrolled, it is questionable as to whether these statistics should be considered when assessing program effectiveness. The rationale here is that while participation in the intern program can affect

student *attitudes* about the Center and RIT in general, the internship can not impact that student's *suitability* for admission to a particular program. So the case could be made that the intern program has accomplished its goal any time a participant simply *applies* for admission, and it should not reflect negatively on the program if an applicant is subsequently denied admission.

The fact that the Center has benefitted from the intern program in ways that had not been anticipated when the program was initiated implies that a broader interpretation of "effectiveness" should be applied when evaluating the program. Indeed, instead of narrowly focusing on the number of interns who ultimately enroll in the undergraduate imaging science degree program, the assessment of the intern program should also consider its impact on the reputation of the Center. In that case, the relevant question would be, "Has the intern program contributed in a positive way to the general perception of the Center for Imaging Science as an institution?" Some insights can be gained by looking at the pool of applicants for the intern program each year. Here the data show that over time that both the number of students applying, and the number of feeder schools from which those students come, are growing, as was shown in Figs. 1 and 2. In fact, for the 2009 intern program the number of applicants was approximately 50% greater than the previous maximum. These trends could imply that the reputation of the Center is increasing over time, but it may also be the case that other factors, such as the economy, are influencing students' decision to apply. More information is needed to more accurately assess perceptions of reputation.

One recent attempt to collect such data involved an effort to reconnect with previous interns through an online survey. With the help of a current intern, program administrators constructed and posted an informal survey which solicited both qualitative and quantitative data regarding their experiences and perceptions of the program. The goal was to have all 86 of the previous interns participate in the survey. Because some of the e-mail addresses used to make contact were no longer valid, only 72 invitations were sent. A total of 35 surveys were completed. The question which most directly addressed the issue of reputation was, "Would you/have you recommended this program to someone?" Of those who responded (33), 91% answered in the affirmative, see Fig. 5.

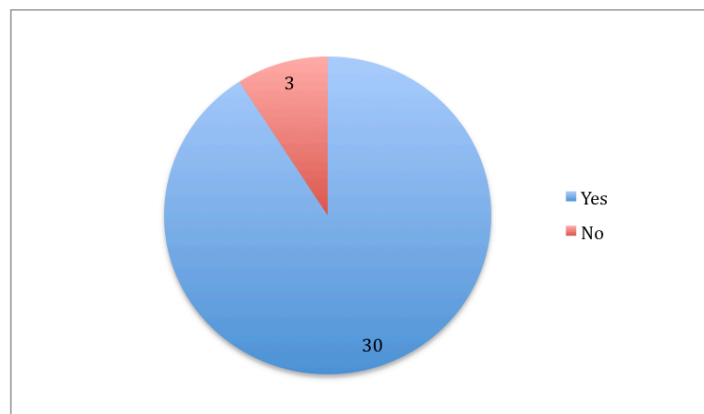


Fig. 5. Would you/ have you recommended this program to someone?

Those who chose to elaborate with written comments made statements such as:

- "It was perfect – the support from faculty, the learning experience, and the pay."
- "I believe the program is an absolutely priceless opportunity for hard working and exceptional youth to gain a greater understanding of research and technology in the college setting. I think the benefit to the students who participate and the positive image it portrays of RIT and its interaction with the community makes the program valuable to both community and college."
- "It was a truly great experience."
- "This program was one of a kind and an incredibly valuable experience for me."
- "I think the internship was a great taste of research and had a healthy amount of competition for applicants. I felt better prepared for future interviews and jobs in my field."
- "I learned a tremendous amount and obviously it influenced my decision in major and university."

Figs. 6, 7, and 8 show more results from this survey. All of them pointing towards positive outcomes.

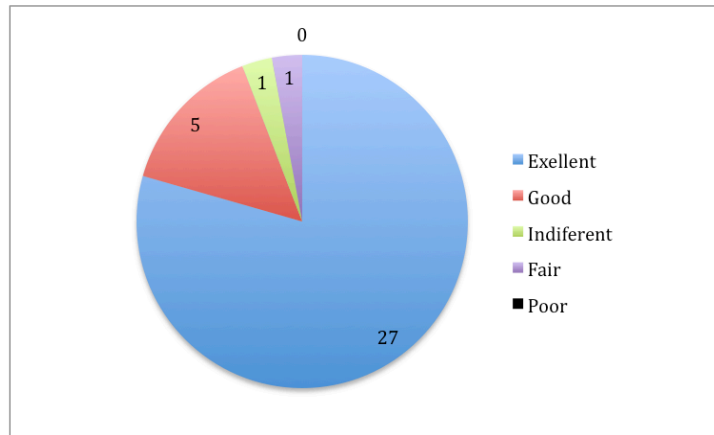


Fig. 6. Was the internship beneficial to you?

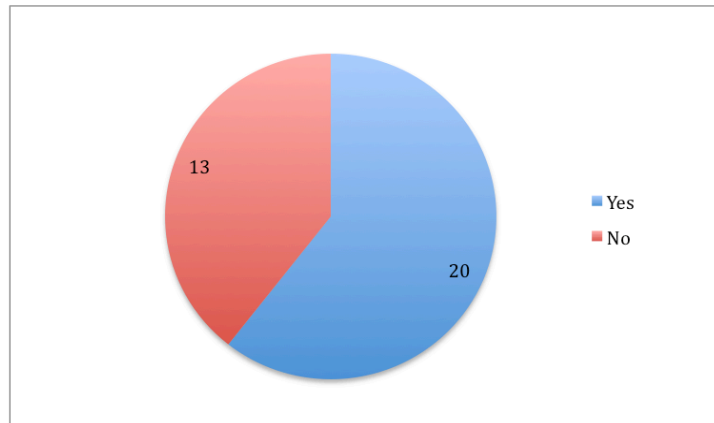


Fig. 7. Did the internship influence your career?

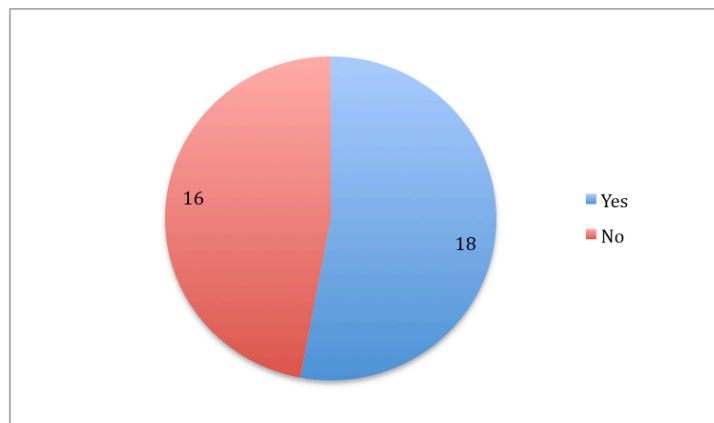


Fig. 8. Did the internship make RIT a college of interest to you?

C. Comparison with other recruiting initiatives

The value of the intern program becomes even more apparent when its effectiveness is compared with that of other recruiting initiatives undertaken by the Center. For example, each year the Center participates in an Institute-wide recruiting event called College and Careers sponsored by the Office of Undergraduate Enrollment in which school students are given the opportunity to participate in a variety of hands-on workshops in an effort to learn more about specific disciplines or degree programs.

Historically 140-160 students choose imaging science as one of their workshops each year. The data show that in a *good* year, less than 2% of those students will enroll as imaging science undergraduates.

A limited data set implies that online recruiting events may do marginally better, with conversion rates as high as 4%, but the numbers of participants in such events has been small so this figure may not be statistically significant. One of the least effective recruiting approaches appears to be direct interaction with entire classes of students at their schools. It is not unusual for Center faculty and staff to have contact with approximately 1000 prospective students in a given year through in-class demonstrations or lectures. While this approach will occasionally attract a student to the imaging science degree program, the payoff is still well below 1%.

At the very bottom of the list in terms of effectiveness is the use of printed materials – posters and flyers. The Center has no data to show that this approach has ever resulted in attracting a single student. In fact, when promotional posters were sent to the principals of all 1650 high schools in New York State with specially tracked web URL's on them, only 10 hits were recorded after one year, and no inquiries were ever received. A comparison of all recruitment efforts is shown in Fig. 9.

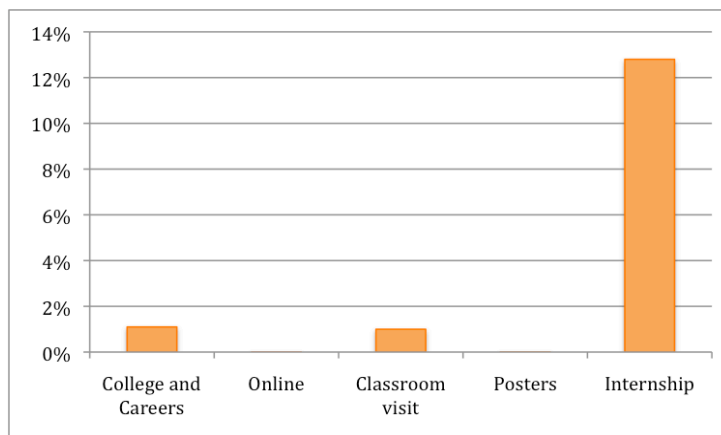


Fig. 9. The effectiveness of the summer internship program as a recruitment tool.

3 CONCLUSIONS AND FUTURE DIRECTIONS

In spite of the challenges, the experience of RIT's CFC Center for Imaging Science has clearly shown that a high school intern program can be an effective tool for encouraging students to enroll in an emerging interdisciplinary degree program – far more effective than other, more traditional recruiting approaches. Through such a program prospective students are immersed in an authentic research environment, working side by side with professional scientists and current college students on projects sponsored by external funding agencies. This immersion serves to enculturate the prospective student, enabling them to see themselves as members of this unique community of scientific practice. While this enculturation comes at a significant price, the cost is offset not only by the value of the work that the interns do, but also by the value of the enhanced visibility and reputation of the organization.

While the information collected so far suggests that the intern program has been successful both in terms of its stated objective of recruiting students to the undergraduate imaging science degree program, and in terms of improving attitudes and perceptions of RIT and the Center, the program will still face a number of challenges going forward.

One of the challenges facing the intern program in the future is that of growth. It became apparent in the fifth and sixth years of the program that there was a definite limit to the number of internships that the Center would be able to award each summer, while still ensuring that the program provided the participants with a quality experience. This “cap” came about because of limitations in the ability of the Center's faculty to provide meaningful tasks for the interns, and sufficient oversight and direction of their efforts. With a limited number of research projects underway each summer, and with a significant portion of the effort on these projects being done by currently enrolled college students, there are only so many tasks available to assign to high school interns. Thus the intern program can only grow if it accompanies growth in the research program within the Center. It is only by adding new research groups, new projects, and new faculty that the number of internships can be increased.

The issue of growth is also tied to the challenge of securing the resources needed to run the program. As was already mentioned, the annual cost to operate the intern program at the current level is more than \$40,000 per year. These costs have been covered over the years by funding from a number of sources. Some of the money has come from philanthropic contributions from corporations and individuals. Some has come from revenues received as a result of customized corporate training programs provided by the Center. And some has come from discretionary funding available to the Center Director through "returned overhead" from sponsored research projects. Regardless of whether or not the program grows in the future, it is very clear that finding the funding to pay for the program will be an ongoing challenge.

One last challenge facing the intern program going forward has to do with faculty attitudes about the program. Experience has shown that the relationship between an intern and his or her faculty supervisor is absolutely essential to ensuring that the intern comes away from the program with a positive perception of the experience. Therefore, the attitudes and expectations of the faculty members who volunteer to serve as supervisors are critical. It is important for these faculty members to accept the fact that serving as a supervisor for a high school intern will likely consume substantially more time than overseeing the work of a college student. It is a significant commitment, especially considering that to date, the faculty who have served as intern supervisors have done so without any release time from their assigned duties, or without any additional financial compensation.

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