

Creative Inquiry Impacts Economic Development

Clemson University's Creative Inquiry (CI) program, a model for undergraduate research, provides large numbers of students in all disciplines with team-based, collaborative research experiences that address real-world problems. It also helps prepare them for jobs in the changing economy. Alumni of the program have stated that they were better prepared for jobs and felt that the experience made them more attractive to employers. Students in the CI program, for example, have developed business plans for start-up companies and participated in patent applications, in addition to presenting and publishing their work.

The model employs teams of students to address topics identified by faculty mentors, the students themselves, or spurred by external influences. Each project is embedded within one or more academic courses, and projects may be multi-disciplinary. Teams—each led by one or more faculty members—work on a given project for two or more semesters. Some projects have a natural ending point, while others continue to evolve for many years as new students replace those who graduate. For example, a performing-arts team dedicated two years to developing and producing an original play. An English team collaborated on a book. An interdisciplinary team worked for several years to design and install a water system for a village in Haiti. That team is continuing with related projects to boost economic development and the standard of living in the area.

Creative Inquiry is used by departments to attract and retain students in targeted fields, including food science, geology, and bioengineering. Students in all departments praise their experiences as valuable in terms of the research accomplished and the opportunities to gain insights into potential careers. The model is sustained by high levels of student and faculty interest, funding from the university, and a demonstrated record of accomplishments within both the academic and business worlds. The program has grown to the point that private donors and businesses now are sponsoring student research teams.

A key feature of the program is its flexibility. Students are encouraged to develop ideas for projects and then identify faculty mentors to refine the ideas and mentor the work.

The structure and duration of CI projects encourage students to develop critical thinking skills, acquire research abilities, learn to solve problems as a team, and hone their communication and presentation skills—abilities all vitally important in today's world. In an *Inside Higher Education* article (Epstein, 2007) Clemson's former provost Doris R. Helms commented "Employers want to hire graduates who are able to communicate, who have leadership skills, who work well in groups—the same things they need to do in Creative Inquiry groups."

Background Context

Clemson University is a selective, land-grant university with an enrollment of approximately 16,500 undergraduates and 4,200 graduate students. The university's mission statement says, "The core of Clemson's educational experience for undergraduate and graduate students is based on providing every student with a real-world, problem-based engagement experience or leadership opportunity within an environment that supports personal development and responsible citizenship. The University is committed to nurturing critical thinking, communication capabilities, and ethical judgment. The overarching goal is that graduates are creative and entrepreneurial but also are knowledgeable in a discipline and prepared for future opportunities in the global marketplace."

These values are manifest in Clemson University's long-standing commitment to high-quality research and undergraduate education. Clemson's achievements are recognized nationally, for example in the *U.S. News & World Report* rankings of colleges, which have ranked Clemson among the top 25 national public institutions for five consecutive years, and by the American Association of State Colleges and Universities, which featured Clemson in a 2005 report as an institution that does an "unusually good job" in retaining and graduating students. The organization recognized the institution for its "viable undergraduate research" program that contributes to the Clemson image as a "student-centered research university."

Building upon the institution's core commitments, Clemson President James F. Barker, FAIA, set the goal that every undergraduate would have a graduate-level research experience during his or her time at Clemson. In response, in 2005, with strong support from the provost, the CI program was developed, based on the work of a task force of faculty drawn from all of Clemson's colleges. As noted above, it was decided that the CI program would feature team-based undergraduate research in all academic disciplines. Sequences of courses specific to CI were developed in many departments. In others, existing courses were adapted for CI research. Several departments integrated CI within the requirements for their undergraduate degree programs. Over all, faculty members were encouraged to develop innovative research opportunities for students.

During the development process, faculty expressed a variety of concerns regarding how to manage large teams of students; the availability of facilities and supplies; how students would be accepted or selected for the teams; fears that CI would be universally required of all faculty and students (it is not); and how CI would fit into their workloads and career plans. Despite these concerns, to date more than 700 CI projects have been developed. In the 2012-2013 academic year, more than 3,500 students were enrolled in CI team projects.

Financial support from the provost's office has been key to the success of CI. Each team of six or more students receives \$2,000 per semester for project expenses such as supplies

and travel. Faculty mentors do not receive extra salary for CI. Incorporation of these courses within their workloads varies among departments; teaching a CI course does not consistently impact tenure and promotion decisions either positively or negatively. Many faculty members state that the best incentive to engage in CI is furtherance of their research programs, and that CI is a compelling addition to grant proposals. The CI office supports the faculty by promoting their projects, producing events, assisting with grant and other proposals, and providing funds for the CI research and students' travel to present project results at professional conferences.

As the program has grown, so has its visibility on and off campus. Students present their research results at Clemson's annual Focus on Creative Inquiry (FoCI) Poster Forum, thereby honing their communications skills as they present and discuss their work with other students, faculty, staff, and visitors from off-campus. By 2012, FoCI filled the available exhibition space on-campus, featuring close to 200 posters and interactive demonstrations. Future plans include splitting sessions and expanding to other locations in order to accommodate student demand. Programs for FoCI events are posted on the CI website.

In 2012, the visibility of the program was enhanced by production of a new magazine, *Decipher*, to highlight student accomplishments. *Decipher* is itself the product of a CI project. For the inaugural volume, five students interviewed



National Conference on Undergraduate Research (NCUR) is an opportunity for more than 3,000 undergraduate students to present their research, scholarly, or creative projects.

NCUR 2014 will be held April 3-5, 2014, at the University of Kentucky.

For more information, visit http://www.cur.org/ncur_2014/.

CI participants for magazine-style articles, and two graphic communications students designed the layout and produced the magazine. The student writers had prior experience in technical writing as members of a CI project called Popular Science Journalism, in which they produced articles on scientific topics, written for non-science audiences, for publication in Clemson's student newspaper and the printed *Tigra Scientifica* journal. *Decipher* will be published annually, in print and online formats, with each issue featuring approximately 40 CI projects. Copies of *Decipher* are available from the CI office at Clemson University or as a pdf download from the CI website: clemson.edu/ci/decipher/.

Structure and Institutional Support

The structure of CI encourages student and faculty participation, and it is beginning to attract the attention of outside industries interested in engaging college students in their research and development. Flexibility, financial support, and recognition are all key features in promoting CI both on and off-campus. Faculty members are invited to develop projects relevant to their research or to explore topics outside of their discipline, either alone or in concert with colleagues. Students are encouraged to initiate projects and then identify faculty mentors to refine the ideas and guide the work. The choice of topics is entirely open, bounded only by the imagination of the students and the faculty. In recent years, 83 projects have been co-mentored by faculty from more than one department; 38 by faculty from different colleges. Many more enroll students from multiple majors. For example, a team composed of students in mechanical engineering, nursing, bioengineering, business, and general engineering designed, built, and tested a pediatric arm stabilizer—a device that can be used by nurses to immobilize a child's arm during intravenous procedures. Team members agreed that the melding of talents was essential, with engineering expertise balanced by nursing students' perspectives on patient care and hospital procedures. The university filed a provisional patent for the device and is negotiating with a medical device manufacturer for production. A student on the team commented, "I am definitely glad that I took part in this Creative Inquiry because it not only gave me experience in my major, but it gave me something to be proud of."

Teams may begin in a single discipline and expand to become multidisciplinary as they mature. For example, the project to design a new water delivery and purification system for the small village of Cange, Haiti, began as a civil engineering project. Students at Clemson developed plans for the system and then traveled to Haiti to install it. As the project's focus expanded, students majoring in public health, English, and finance joined the team, each contributing his or her unique disciplinary expertise. The English students are developing a communications program for a vocational school, and finance students manage the project's complex budget. By 2012, when the new water system was dedicated, the project included 52 undergraduate students working in eight teams on various projects designed to boost economic development and the standard of living in the area. These CI student projects have been executed in coordination with several non-governmental organizations that have a long-term presence in Haiti.

The CI program, based in Clemson's Office of Undergraduate Studies, supports projects and provides management tools for faculty, who submit CI project descriptions online through the CI website. Projects are reviewed and approved by the CI program director or are returned to the authors with recommendations for improvement. After approval, a CI project is eligible for funding based on the number of students enrolled each semester, and the CI website collects student enrollment information in order to keep track of the number of students in each project. A separate budget account is assigned to each CI project, and faculty team leaders may use the website to check the daily balances in their accounts. CI funds support project costs such as books, computer programs and similar items, supplies, testing instruments, incentive payments for test subjects, or travel. CI funds may not pay faculty or staff salaries, but a portion of the CI allocation may be used for faculty professional development expenses such as travel or supplies. Competitive supplemental funds are available for student travel to present research results at professional conferences, student summer stipends, and extraordinary supplies expenses.

Embedding Projects in Courses

Each CI project is embedded within one or more existing or new academic courses. The Creative Inquiry office approves the projects, but not the courses, which are approved by department, college, and university-level curriculum committees. Many of the courses, however, are structured to accommodate a diversity of research topics. Students are graded and receive academic credit as they would in any course. To qualify as Creative Inquiry, a project must engage students in sustained inquiry or research through two or more semesters. Annual surveys indicate that students remain in CI projects for an average of two semesters, but some report participating in CI for up to 10 semesters, and some students leave CI after only one semester.

Departments have developed new courses and sequences specifically for CI at the 100, 200, 300, and 400 levels. For example, in geology the students progress through a six-semester sequence beginning with one-credit courses each semester in the sophomore (Introduction to Research) and junior (Introduction to Research Methods) years, graduating to four-credit Research Synthesis courses each semester of their senior year. This course sequence provides students with classroom instruction on research strategies, techniques, communications, and ethics, and then guides them in putting these skills into practice in geology field investigations (Wagner et al. 2010). The College of Health, Education and Human Development established a sequence of courses, (HEHD 199, 299, 399, and 499) used for various departmental and interdisciplinary projects. Several such projects integrate the knowledge of Clemson faculty with that of student-affairs staff members. For example, in one current project a team is designing and testing a wellness course for Clemson students.

In other administrative units, a single course with multiple sections is used for all CI projects. In the food science major, students enroll in a variable credit Creative Inquiry course for up to ten credits from the freshman through the senior year, selecting research topics based on their disciplinary interests. In the management major, students may enroll in CI courses for up to six credits. Recent projects explored businesses' use of social media and mobile information-technology devices. In psychology, a team-based research

course may be repeated each semester for up to 18 credits, allowing students to explore diverse topics or focus on one topic for several years. Departments may also embed CI projects within existing courses or independent study sequences. This flexibility allows departments with rigid curricula to offer their students a Creative Inquiry experience through required courses.

Departments have found that CI is helping them attract and retain students. After adding the three-year sequence of research courses in geology, the number of majors rose by 150 percent from 2006 to 2012. Though no definitive studies positively link the increased number of student majors with the research sequence, the department believes that CI has been key to the increase. Similarly, the Department of Food, Nutrition and Packaging Science prominently advertises its "Student-Centered Research Initiative—Creative Inquiry" online as a recruiting tool. In bioengineering, a novel project pairs freshmen with seniors involved in capstone research, thereby offering the freshmen a window into their future. A student comment emphasizes this recruiting value: "Creative Inquiry is one of the main reasons why I chose to attend Clemson and has been more fulfilling than I imagined before I came here. The value of the CI program is so important and gives Clemson students a great edge for life after school."

Many students have stated their appreciation of their CI experiences. A bioengineering team is redesigning medical simulators that more accurately mimic human body responses. Health care providers will use these simulators to practice medical techniques before they use them on human patients. A student on this team commented, "When I graduate in the spring, I will have two patents, a paper and a company under my belt. How many undergraduates can boast the same?"

CI projects can also enhance faculty careers. Faculty and students participating in CI projects acknowledge that they can be more work than a lecture-style class, but find the rewards worth the additional work. One faculty team leader remarked, "It's a wonderful way to teach, because it comes from the students. It's not a lecture from the teacher. When you get these students working on these interesting projects, then you bring them out to the world, the world pays atten-

tion!" From the beginning of the program, faculty members have been encouraged to structure CI projects to advance their own scholarship and career goals. For example, after guiding performing-arts students as they developed and produced two original plays in a CI project, one of the faculty team leaders received a prestigious national playwriting award. An English professor worked with students to collect and publish slave narratives from South Carolina; in the published book, the professor is the editor and each essay is co-authored by a student. A food science CI team's work on popular food myths—such as the "five-second" rule for dropped food or the hazards of "double-dipping" (chips into dips)—attracted the attention of national media. Science and engineering faculty have used CI results as the basis for grant proposals to continue the research.

In the team environment, students receive guidance from the faculty team leaders and also learn how to mentor each other. As a faculty mentor noted, "When you first enter one of our teams, you're learning how to conduct research in a lab, you're learning the procedures. Then you become the expert and you teach the new people. So it's very common in our lab to have the experienced undergraduate students teaching new graduate students."

CI projects and faculty are recognized and rewarded. Each year, the Bradley Award for Mentoring in Creative Inquiry, funded through a private donation, is presented to one faculty member, based on students' nominations and reviews by a faculty committee. The winner receives a cash award, a plaque, and an invitation to be the plenary speaker at the following year's FoCI event. University public-affairs staff members promote CI off campus through press releases and other announcements. In 2012, CI was featured in 25 Clemson University press releases.

Assessment

In order to formally assess the projects' impact, the CI office maintains records of student and faculty participation, administers annual surveys, and tracks accomplishments. Most students remain in the same project for at least two semesters; approximately 33 percent report participating in two or more CI projects. Most students (85 percent) participate in CI projects in their own colleges. Students participate in CI at all levels of their undergraduate careers—55 percent

of them as seniors, 25 percent as juniors, 16 percent as sophomores, and 4 percent as freshmen. Graduate students participate as co-mentors and unofficial members of the research teams.

CI students praise their experiences as valuable in terms of the research accomplished and the opportunities to gain insights into potential careers. A survey administered to CI students each year assesses their attitudes toward undergraduate research and CI and provides information on their projects. In recent surveys, CI students strongly agreed that teaching undergraduates how to conduct research should be an important goal of the university. The great majority of students (91 percent) were satisfied or very satisfied with what they learned from their CI experiences and their involvement with their CI mentors. Students assessed their learning outcomes, reporting that they have moderately high to complete confidence in their abilities to: work collaboratively and independently; identify a problem based upon existing information; collect data/information relevant to a research problem; apply distinct techniques or research methods; and communicate findings clearly and effectively.

The productivity of the CI projects provides additional evidence of their effectiveness. As of Spring 2013, CI projects had produced at least 130 publications in professional journals, 288 presentations at professional conferences, 40 awards, 3 apps (including a virtual tour of the Clemson campus); 5 instructional DVDs, and 9 provisional patents and patent disclosures. In addition, 23.8 percent of student participants stated that they had authored or co-authored a piece of work that was submitted for publication or presentation at a conference. At least one student launched an independent business from an idea generated in her CI group.

Most students (53 percent) described their projects as emanating from a faculty member or graduate student's research; 12 percent stated that the CI project was entirely the idea of the undergraduate students on the CI team. Some students describe their CI projects as extending beyond the geographical boundaries of the university. At this land-grant institution, 13 percent of CI students reported using off-campus facilities or farms for their research, and 45 percent reported using non-university (community, state, national, or international) locations such as K-12 schools, museums, industrial sites, community organizations, hospitals, camps,

or municipal offices. Twenty-three current projects address international topics.

An informal survey of CI alumni, conducted via email, demonstrated the power of CI in advancing students' careers, graduate-school applications, and employment. Students noted that job and graduate-school interviewers remarked that their CI experiences helped them to stand out from other applicants. One student commented, "I definitely think that Creative Inquiry helped with getting a job. Everyone I talked to was really impressed with the research and the conferences that we attended. I spent the majority of the interviews explaining our project." A student interviewing for graduate school had a similar experience, saying "Gaining research experience through a Creative Inquiry team was essential when I applied to PhD programs in psychology. Potential advisors want to know not only if you are a good student, but whether or not you are capable of running studies, analyzing data, and conceptualizing ideas. After presenting several posters through FoCI and regional conferences, I became a rather accomplished undergraduate researcher."

Conclusion

Implementation of CI at Clemson University has been a success due to consistent and strong administrative support, faculty willingness to embrace novel research methods, and student enthusiasm. The success of the CI program is closely tied to financial support—institutional funding encourages CI faculty to take on teams of students and to offer students opportunities such as presentations at national professional conferences. CI has opened up research opportunities to students in all disciplines. Although the numbers of projects and students participating are largest in the science and engineering disciplines, hundreds of students in each of Clemson's five academic colleges participate in CI each year. Students are intensely supportive of CI; of the more than 700 comments on the 2012 annual survey, most were overwhelmingly positive.

The long-term impacts of CI are currently assessed through documentation of products such as publications, presentations, performances, awards, patents filed, and other accomplishments. We also plan to do further analyses that include tracking students' progress through research projects

and surveys distributed to graduates, faculty mentors, and employers. One student summed up the impact thus far this way: "My CI experiences have been amazing. I have been on the same team for 5 semesters, and it has just given me that opportunity to think outside of the box. I would not trade this experience for the world."

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