A growing movement in higher education seeks to integrate authentic research experiences for students in traditional laboratory settings (Lopatto, 2010). These “course-based research” models have been successfully employed at several institutions (Boomer & Dutton, 2002; Brodl, 2005; Caruso, Sandoz, & Kelsey, 2009; Drew & Triplett, 2008; Elwess & Latourelle, 2004; Howard & Mislowski, 2005; Ronsheim, Pregnall, Schwarz, Schlessman, & Raley-Susman, 2009; Shaffer et al., 2010; Harrison, Dunbar, Ratmansky, Boyd, & Lopatto, 2011). Students report that their engagement in course-based research has enabled them to think like scientists, tackle new experimental methods with confidence, persevere in the data collection process, and approach coursework in other science courses with renewed enthusiasm. These benefits build upon those gains acquired through traditional undergraduate research in the sciences: competencies in research design, hypothesis formation, data collection and analysis, computing, and information literacy (Laursen, Hunter, Seymour, & Thiry, 2010; Bauer & Bennett, 2003; Hathaway, Nagda, & Gregerman, 2002; Hunter, Laursen, & Seymour, 2007; Kushar, 2000; Kremer & Bringle, 1990; Lopatto, 2004; Rauckhorst, Czaja, & Magolda, 2001; Russell, Hancock, & McCullough, 2007; Seymour, Hunter, Laursen, & DeAntoni, 2004). Course-based research is primed for implementation in an increasing number of colleges and universities, but the initiative faces challenges at institutions of higher education in order to balance the needs of students with staffing and funding shortages.

Fortunately, peer mentoring has emerged as an effective means to course-based research. Talented undergraduate students undergo training and supervision that enable them to help fulfill the duties that would traditionally go to dedicated laboratory technicians. Additionally, peer mentors assist with content mastery and participate on undergraduate research teams (Henderson, Buising, & Wall, 2008; Varma-Nelson, 2004). Several recent studies have reported on the merits of undergraduates serving as peer mentors. For instance, Lopatto (2009) reported on self-evaluation of peer mentoring experiences in undergraduate research groups. He found a range of benefits to both peer mentors and their student colleagues, including an increased understanding of the research, an increased sense of responsibility, an improvement in oral communication skills, and an increased enjoyment of teaching. Both
Peer mentors and the students they influenced reported larger learning gains from the research experience than did undergraduate researchers without a peer mentor in their group.

Peer mentoring does bring its own set of challenges to course-based research: faculty must be available to assist and advise the peer mentors as well as the students in the course, and the college must fund training and compensation for the peer mentors. Nevertheless, peer mentoring offers compelling benefits: leadership opportunities and specialized skill development not as widely available to undergraduate students in traditional course-based research models. Furthermore, the peer relationships that develop in peer mentor-supported, course-based research enhance the collaborative learning experience for mentors and mentees alike.

In fall 2008, Cabrini College’s Biology Department implemented peer mentoring in the research-driven phage genomics course. The development of the peer mentoring initiative at Cabrini has shed light on the trends associated with the role of peer mentoring in course-based research. The following article examines how Cabrini’s phage genomics course has built a relationship between course-based research and peer mentoring in a way that successfully benefits students in the course, peer mentors, and the institution as a whole. Katie Mageeney and Chris Catagnus share their personal experiences as peer mentors, while Amy Cimo, who completed the phage genomics course in spring 2011, provides insight into what students experience when working with peer mentors. Our hope is that the perspectives provided here will enable other institutions to examine peer mentoring as a viable avenue to both course-based research and new opportunities for collaborative learning in and beyond the sciences.

**Peer Mentoring and Course-Based Research at Cabrini College**

Academic year 2010-2011 marked the second year of a three-year period during which Cabrini College is involved with the Howard Hughes Medical Institute (HHMI) Science Education Initiative (SEA). The SEA provides funding and support for the phage genomics course, a freshman-level authentic laboratory research experience that leads to the discovery and identification of mycobacteriophages — a group of viruses that infect mycobacteria hosts. This year-long research-in-the-classroom course was described elsewhere (Caruso, Sandoz, & Kelsey, 2009; Musante, 2011) but will be described briefly here.

During the fall semester, students choose an area on campus where a unique mycobacteriophage species can be easily isolated from which to collect soil samples. Students then proceed to characterize interesting biological properties of their mycobacteriophage, such as its shape and genetic characteristics. The HHMI SEA funds one student mycobacteriophage genomic DNA sample from each institution to be sent to a DNA sequencing facility for genomic DNA sequence determination. Based on students’ arguments and justifications on why their particular mycobacteriophage should be chosen for genomic sequencing, course faculty and peer mentors decide which phage DNA to submit for genomic DNA sequence analysis. During the spring semester, students work in groups to analyze sections of the genome sent for sequencing using established gene-searching tools. The students also compare the genome sent for sequencing to other phage genomes using software and a database ([www.phagesdb.org](http://www.phagesdb.org)) made available to SEA institutions through HHMI.
Since course instructors at Cabrini College do not have dedicated technicians to assist with laboratory prep work, the teaching faculty recruit talented and dedicated undergraduate students to serve as peer mentors for the phage genomics course. The term “peer mentor” encompasses a variety of student roles: peer mentors assist other students with content mastery in large lecture courses and may also have the opportunity to participate in an undergraduate research team (Henderson, Buising, & Wall, 2008; Varma-Nelson, 2004). Cabrini’s peer mentors have many duties, such as preparing all necessary reagents and solutions needed for student experiments as well as actively assisting students with their experiments. Peer mentors also demonstrate proper laboratory techniques to students and give mini-lectures on scientific concepts that help students understand why they are doing particular experiments. Many of the phage experiments require students to complete tasks outside of normal laboratory teaching times; peer mentors are expected to be available to assist students at these times, as well. The recruitment of dedicated undergraduates to serve as peer mentors was imperative for course success because Cabrini is an undergraduate teaching-focused school.

**Selecting, Training, and Implementing Peer Mentors**

Currently, Cabrini employs two peer mentors who support the phage genomics course. Katie Mageeney, the most senior peer mentor, began working with the class in her junior year. Katie says:

As a student majoring in biology with an interest in teaching, I see peer mentoring and course-based research as an opportunity to expand the definition of first-year college biology. As a student in the introductory biology course in college, I felt that I was redoing what I did in high school. I saw the opportunity to become a peer mentor for the phage genomics course as a way to show that science is not always reading facts from a book.

After Mageeney was selected to be the first peer mentor for the phage genomics course, she, along with one student from each SEA institution, received course training at the HHMI Janelia Farm Research Center over a one-week period during the summer prior to course implementation. During the training, these future peer mentors learned and mastered techniques to isolate a novel mycobacteriophage species — a task that the phage genomics students would have an entire semester to complete. Throughout the process of this “crash course” on mycobacteriophage isolation and identification, Mageeney and the other future peer mentors had valuable hands-on training in microbiological techniques, solution preparations, course logistics, and the many pitfalls first-year phage genomics students could expect to experience.

Between the fall and spring semester of first-year phage course implementation, Mageeney and faculty course instructors Dr. David Dunbar and Dr. Melinda Harrison were trained in the bioinformatics software tools used to characterize mycobacteriophage genomes. Once again, this training took place at the HHMI Janelia Farm Research Center over the course of a week, during which faculty and one peer mentor from each SEA institution learned how to find genes and other interesting genetic properties of mycobacteriophage genomes and to compare the genetics of different mycobacteriophages using sophisticated bioinformatics software. This prepared both peer mentors and faculty for the common mistakes and challenges frequently experienced by phage genomics students during the spring semester. This second stage of training also gave peer mentors a chance to converse with one another about their peer mentoring experiences at their respective institutions.

Chris Catagnus, who joined Mageeney as a peer mentor for the phage genomics course in its second year, did not receive the same training in research protocols and solution preparation that Mageeney received prior to the start of the course.
Chris says:

Despite the challenges presented by my lack of formal training, I used my experiences as a peer mentor to immerse myself in microbiological laboratory techniques as well as classroom teaching methods. The opportunity to work as a peer mentor appealed to me because the position seemed fun, fresh, and both personally and academically fulfilling. I was especially drawn to the opportunities to work directly with first-year students, who often seek guidance as they adapt to collegial expectations and protocols.

Mageeney and Catagnus received additional training on peer interactions in and out of the classroom through a one-credit peer tutoring seminar led by the staff of Cabrini College’s Center for Teaching & Learning (CTL). The course was developed in accordance with the requirements for Level 1 certification by the College Reading & Learning Association (CRLA) and introduced students to best practices for leading individual as well as group tutoring sessions. Peer mentors were required to complete this course so that they might be fully equipped to not only address students’ course-related questions but also provide broader academic guidance. Completing this course also served a remunerative purpose: the CTL formally employed Mageeney and Catagnus as classroom coaches, who provide in-classroom support to students and instructors, and as peer tutors, who provide individual and group support outside of class hours. While their peer mentor duties extended beyond the roles of classroom coach and peer tutor, Mageeney and Catagnus both received compensation through the CTL for their hours of direct student support.

Assessment of Peer Mentoring’s Impact on Students

The motivation to implement course-based peer mentoring programs in general has risen in recent years. Postsecondary institutions are facing increased student enrollment and decreased external funding, which increases class size and instructor workloads and can therefore significantly reduce the quality of education (Miller, Groccia, & Miller, 2001). In order for course-based research to be highly effective at small liberal arts institutions such as Cabrini College, peer mentors like Mageeney and Catagnus are essential. During its formative years, the peer mentoring initiative at Cabrini drew upon the existing literature on the merits of peer mentoring, including recent studies that have demonstrated the merit of undergraduates serving as peer mentors in the biological sciences (Henderson, Buising, & Wall, 2008; Harmon, 2006). However, the guaranteed continuation of peer mentoring at Cabrini required additional assessment to compensate for the dearth of reported benefits of peer mentoring within course-based research models.

To this end, Cabrini’s course instructors were interested in assessing the impact peer mentoring had on students. What was found is that students valued very highly the advantages of having peer mentors for the course (Harrison et al., 2010). Students rated the peer mentors particularly highly in the categories of helpfulness and assistance with laboratory techniques. Students also gave the peer mentors high scores for after-class availability. Interestingly, students as a whole gave somewhat lower scores for wanting to become peer mentors themselves. However, students individually either gave very low scores or very high scores for wanting to become peer mentors. These results suggest that although students valued the support provided by peer mentors, they also realized the amount of work that goes into being a peer mentor.

A Student’s Perspective on the Benefits of Peer Mentoring

The outcomes of the Cabrini peer mentoring assessment were additionally supported by Amy Cimio, who completed the phage genomics course in the spring of 2011.

Amy says:

When I enrolled at Cabrini, I felt I was better suited to the traditional introductory biology laboratory than the phage genomics
laboratory because of my high school background. Having had no prior experience in a laboratory, I was initially unsure whether I wanted to stay enrolled in the phage genomics course. The peer mentors convinced me to persevere. I, along with the other 15 students in the class, frequently sought both Katie’s and Chris’ guidance because we recognized that the peer mentors understood the pressure of being a student researcher. I found the peer mentors helpful during class but especially appreciated how they made themselves available outside of class for research, laboratory procedures, and questions. I think peer mentors are the most beneficial learning tool that professors can offer undergraduate researchers.

Cimo completed the course successfully and was chosen by her peers to present the class’s work on mycobacteriophages at the annual spring 2011 HHMI SEA Symposium. Cimo claims that the peer mentors’ guidance instilled in her the confidence to present the work at the symposium, an event attended by several hundred undergraduates, faculty, and mentors from over 30 institutions across the country. (Figure 1 shows Cimo presenting the class work at the HHMI SEA Symposium.)

Benefits of the Peer Mentoring Experience

Both Mageeney and Catagnus have applied their peer mentoring experiences to other academic pursuits. Mageeney, who initially planned to attend medical school after completing her bachelor’s degree, has instead decided to pursue a Ph.D. in molecular genetics.

Katie says:

My experience helped me to shape my future plans. Through my peer mentoring experience, I discovered that I really enjoyed teaching concepts and laboratory techniques to students. I also felt that peer mentoring helped me to become a more confident scientist, as it encouraged me to think more independently with my own undergraduate research experiments. I used some of the data that first-year students generated as a catalyst for my own research project in which I conducted experiments on “Marvin,” the phage isolated by the phage genomics class during the first year I served as a peer mentor. My work with phage Marvin has recently led to a manuscript that was accepted for publication in the prestigious Journal of Virology (Mageeney et al., 2012).

Like Mageeney, Catagnus has reconsidered his initial plan to attend medical school.

Chris says:

Prior to my peer mentoring experience, I did undergraduate research in soil chemistry in the lab of a science professor not associated with the phage genomics class. More recently, I have embarked on an interdisciplinary research project of my own, looking at mycobacteriophage species diversity in different types of soil samples — a project that would not have been possible without my experience as a peer mentor. As an upperclassman and a student of biology at Cabrini College, I often found myself searching for opportunities to gain as much laboratory experience as possible before completing my degree. Even though it added greater time commitments and responsibilities to my already rigorous schedule, peer mentoring played an essential role in allowing me to achieve my goals.

Advice from Katie Mageeney and Chris Catagnus for a Successful Peer Mentoring Experience

As we develop our understanding of the benefits and challenges of using peer mentors to support course-based research, we
continue to find that some of the greatest insights come from the peer mentors themselves. Katie Mageeney and Chris Catagnus share the following advice with students who hope to become peer mentors, whether at Cabrini or another institution.

**Katie says:**

The Number 1 piece of advice I would offer someone taking on the role of peer mentor would be to make sure that you have enough time to perform the necessary prep work, attend class, help students outside of class, and still have time for your own school work and social life. As a peer mentor, you must also know and love the material for the course you are peer mentoring. Students expect the peer mentor, along with the faculty, to be the expert. It is also a good idea to admit when you do not know something; if students are given the wrong answers, they will be upset. If you do not know the answers to students’ questions, you can guide them to a resource where they can find the information. In this way, students gain the skills to look up information on their own.

Furthermore, remember that because most of the students you will work with are only a few years your junior, you’ll likely become more approachable to the students than the course instructors. I have also found that it is important for a peer mentor not only to talk to the students about the course you are peer mentoring but also to make sure to discuss the students’ other classes and their lives outside of schoolwork. By talking to the students about topics other than coursework, the students will become more willing to talk to you and address course-related problems. Finally, I believe a future peer mentor must develop a good relationship with the professors that teach the course. This makes peer mentoring the class easier and also ensures that the job is being done correctly.

**Chris says:**

The most important piece of advice that I can give to a future peer mentor is not to be afraid to ask questions and seek assistance during the course. Even for students who have already taken the course being taught, material in such a lab-based course can often be challenging. The instructors will be more than happy to collectively offer assistance should there be any uncertainty on a peer mentor’s part. I was fortunate enough to have prior experience in a chemistry lab at Cabrini College. This allowed me to feel comfortable in the lab setting. However, professors do understand that most students do not have advanced laboratory skills. This should not be a reason to deter future peer mentors from the position. Simply seeking assistance from one of the instructors is all that you need to do in order to accomplish a difficult task. Additionally, do not hide the fact that you were a peer mentor. Use this experience to your advantage. Many graduate programs and managers of companies would love to hear about this experience.

The same holds true for students. Freshmen will often be confused about certain lab processes in the course, so I would advise a future peer mentor to be patient with these students while offering assistance to them as often as possible. I have seen many mistakes because of confusion on the part of students. Some students will be too shy to ask for help at first; as a peer mentor, simply showing that you care can be enough to help students overcome their apprehension.

Prospective peer mentors should also plan to keep in touch with instructors. Merely helping the students and leaving when the class is over is not enough to help run the course successfully, and sending a simple email about the class can be an effective way to keep up with the course material. As long as the mentor stays organized, managing the coursework should not be a problem. Although it may seem challenging, the job of a peer mentor is fun and very rewarding. Working with younger students is refreshing and helps mentors to reinforce knowledge that they learned in previous undergraduate classes. As long as the peer mentor actively collaborates with instructors, has patience, and stays organized, he or she will easily be able to make the most of this great opportunity.
Conclusion

For those institutions wishing to involve as many undergraduates as possible with undergraduate research experiences, course-based research is an attractive means to do so. However, for primarily undergraduate institutions, classroom-based research is difficult for faculty with an already heavy teaching load. One way for faculty at institutions with high teaching demands to embrace course-based research more fully is to employ the use of dedicated undergraduate peer mentors. Peer mentors clearly lighten the teaching load for the professor and allow for greater lab accomplishments when there are additional experienced hands in the lab. The peer mentor assisting with laboratory course prep work and assisting students with their work during both normal class time and outside of scheduled class is an attractive model. We have already demonstrated the benefits of peer mentoring for their student colleagues (Harrison, 2010; Musante, 2011). We have now shown, through the firsthand accounts of two peer mentors, the ability of this model to transform the peer mentor her- or himself.

As the peer mentoring program continues to benefit the Cabrini community, we face both challenges and opportunities for growth. An ongoing difficulty with our peer mentor program at Cabrini College is that compensation does not match the efforts of the peer mentors required by our phage genomics course. As the continued success of our phage genomics course relates to the efforts of our peer mentors, we expect that college administrators will increase their attention to the program so that students will be more fully compensated. Mageeley and Catagnus have indicated to course instructors that a credit-bearing model would advantageously supplement the payment they currently receive for their direct support to students. Meanwhile, the instructors of the phage genomics course will continue to work with the CTL staff in order to provide ongoing training and support for peer mentors and to develop new opportunities for student leadership in and beyond the classroom.

Our continued exploration of the benefits of peer mentoring to students, faculty, and institutions not only affirms its merits within the biological sciences but also supports the initiative’s applicability across the disciplines. With appropriate training and oversight, the peer mentors can be given a unique opportunity to develop as student leaders and to fully engage in the foundational practices that underlie research and scholarship in any field. We hope that our students’ positive experiences with peer mentoring in the phage genomics course encourage other institutions to adapt Cabrini’s model to their needs. As institutions look to make new progress in the wake of economic challenges, peer mentoring emerges as a beacon of opportunity, illuminating new paths to collaborative research and engaged learning.

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Works Cited


