Determining if an article is relevant is the first step in deciding to include an article in your paper. If after reading the introduction and conclusions sections of the article, you are still unsure, then ask your instructor for assistance. If my topic is on the problem of college student retention in STEM programs, then this article would be relevant as it discusses a solution to the problem. It also discusses some causes of the problem. However if my topic was college student retention in online programs, or with adult students, or some other sub group then this article is not relevant.

The KEYSTONE Program: A Model for STEM Student Success and Retention at a Small Liberal Arts College

By Merrilee F. Guenther, Jon L. Johnson, and Thomas P. Sawyer

This is a good example of some causes of the problem. ↓

Persistence to graduation for STEM students at Elmhurst College, much like for STEM students nationwide, was low, with the first- to second-year retention particularly problematic. The Elmhurst College KEYSTONE project, KEYs to Success Through year ONE, addresses the challenges specific to STEM first-years. The program is intended to serve as a template for STEM success and retention programs at other small colleges and is designed to increase the retention of first-year students and the number of students graduating in STEM disciplines. Key activities include special STEM-focused First Year Seminar classes, the use of peer mentors, a research-based January Term course, a seminar on STEM careers, and summer research for a select group of students. Key interventions to manage the difficulty of the course work include goal-setting exercises, meta-cognitive workshops, and the availability of peer mentors. A Course-based Undergraduate Research Experience in the January Term and summer research opportunities provide students with early research experience. A series of spring "STEMinars" introduce students to the breadth of career options in STEM fields and reinforce the developing STEM learning communities. There is evidence of reduced attrition, increased research activity, and a strengthened STEM learning community resulting from the KEYSTONE Program.

The 2nd column includes a good example of the scope of problem of retention of STEM students and why it is an important issue to resolve →

There has been a call to increase the number of STEM (science, technology, engineering, and mathematics) graduates in the United States, with a 2012 President's Council of Advisors on Science and Technology (PCAST) report predicting that, given current trends, over the next decade the country will produce one million fewer STEM professionals than needed to keep the United States at the forefront of science and technology (PCAST, 2012). This report states that fewer than 40% of students who enter college as STEM majors will go on to earn a degree in a STEM discipline (PCAST, 2012). Even a modest increase in retention of those STEM first-years from 40% to 50% would have a dramatic impact on achieving that goal of one million additional STEM graduates (PCAST, 2012). Initiatives targeted at improving STEM major retention are essential, but the obstacles to such retention are multifaceted and require a comprehensive approach.

Establishing a developmental series of interventions requires an examination of the causes of the problem. Fifty percent or fewer of students who intend to major in a STEM field will go on to graduate with a STEM degree (Ehrenberg, 2010). The "leaky pipeline" is a commonly used, often studied, and debated metaphor for the loss of potential STEM students throughout their education (Blickenstaff, 2005; Metcalf, 2010; Miller & Wai, 2015). Factors that can influence student success in STEM can include those of an academic nature, including issues of preparedness and exposure to active learning methods (Tai, Liu, Maltese, & Fan, 2006). Academic problems can derail student performance in introductory courses and are often a predictor of long-term retention and success in STEM (Rask, 2010).

Elmhurst College is a comprehensive college that combines professional preparation with the liberal arts tradition. Elmhurst College is located in the suburbs of Chicago and has 2,875 full-time undergraduate students and approximately 600 graduate students. The college offers nine different undergraduate STEM majors including: biology, biochemistry, chemistry, computer science, exercise science, geographic information systems, mathematics, physics, and experimental psychology. First-year interest in STEM majors has dramatically increased in recent years, roughly tripling from 2003 levels, when there were 55 total first-year STEM majors, to current levels of approximately 150 incoming STEM majors each year. In addition to increasing interest in STEM fields, the college has seen the demographics of its students change in recent years, with approximately 30% of the students now being from underrepresented minority groups. The college also has a student body that is approximately 60% female. As a result, Elmhurst College is well-positioned to help meet the growing demand for STEM majors, particularly in the

Chicagoland area, while also expanding the participation of women and underrepresented minority students in STEM fields.

In the past, Elmhurst College's efforts to increase STEM enrollments have included targeted recruitment by the Admission Office, increased visibility of STEM careers and opportunities through the Russell G. Weigand Center for Professional Excellence, and the Elmhurst College STEM Academy. The Elmhurst College STEM Academy is a long-running summer outreach program that has aimed to provide an exciting STEM experience to underrepresented minority high school students from the Chicagoland area.

The KEYSTONE (**KEY**s to **S**uccess **T**hrough year **ONE)** Program at Elmhurst College is a comprehensive initiative aimed at increasing the success rate and retention of first-year STEM majors with evidence-based practices. The project's guiding framework focuses on retention of first-year students in STEM and, as indicated by Sheila Tobias (1990) in *They're Not Dumb, They're Different: Stalking the Second Tier*, addresses the three main reasons why students switch out of the sciences: (a) course work is too difficult, (b) other fields appear more interesting, and (c) job prospects are better elsewhere. The KEYSTONE Program incorporates best practices and builds on previous research by increasing access to undergraduate research experiences (Bangera & Brownell, 2014; Lopatto, 2007, 2010; Seymour, Hunter, Laursen, & Deantoni, 2004; Tobias, 1990) and a strong learning community supported by peer mentors (Evans, Flower, & Holton, 2001; Freeman, Alston, & Winborne, 2008; Lake, 1999) and faculty mentors (Baker & Griffin, 2010; Griffin, Perez, Holmes, & Mayo, 2010).

We have designed and implemented a comprehensive program of interventions focused in the first year that targets strengthening the STEM learning community and exposing first-year students to research experiences. This program has increased the retention and success of STEM majors after the first year while establishing a model for STEM success at private liberal arts colleges and universities.

Program

The KEYSTONE Program began as a pilot program during the 2012–2013 academic year. This program utilizes a multifaceted approach to supporting first-years early and throughout their first two semesters (Table 1).

Goals and objectives of the program

The goal of the KEYSTONE Program is to ensure all prospective STEM students reach their potential. The interventions aim to increase the participation, retention, graduation, and career success of all populations of students, not just the most academically gifted. Students may participate in one, or all, of the interventions.

A key objective is increasing the percentage of entering first-year STEM students who continue in STEM in their third year from the 2011–2012 level of 56% to 65%. The program aims to achieve this objective through a series of supporting efforts. These efforts include: (a) increasing the number of students doing undergraduate research; (b) enhancing the STEM learning community experience by developing a more cohesive culture; (c) improving the STEM curricula through added emphasis on research and the scientific method in a January Term course; and (d) enhancing the STEM experience of students of all academic ability levels who are interested in STEM fields, with particular attention to academically qualified students who are not performing up to their potential.

←The highlighted sentence in the 2nd column shows that the KEYSTONE program has been a successful solution at this university.

STEM first year seminar

Interventions begin in the first semester with a STEM-focused First Year Seminar (FYS). Elmhurst College already has a one-credit (four semester hours) First Year Seminar

TABLE 1

KEYSTONE Program activities in the first year.

Summer before matriculation	Fall semester	January term	Spring semester	Summer	Fall semester of second year
Invitation to participate extended to all prospective STEM majors	KEYSTONE STEM First Year Seminar (1 credit–4 credit hours)	KEYSTONE J-Term Experience (1 credit–4 credit hours)	Career STEMinar (.25 credit–1 credit hour)	KEYSTONE Summer Research Experience	KEYSTONE Summer Research Poster Session
	Peer mentors		KEYSTONE Summer Prep Course (.25 credit–1 credit hour)		

that combines academic content with general college support curricula intended to ease students' transitions to college. The previously existing First Year Seminar was particularly focused on ensuring that students engage in campus life and form a connection to the college. STEM students typically struggle, not with integration into campus culture, but rather with integration into the STEM community and with academic challenges and the unexpected rigor of introductory STEM courses. The STEM First Year Seminar differs from the traditional Elmhurst College First Year Seminar in that it focuses on the academic challenges of the first year. The course includes instruction on study skills, metacognitive skills, study groups, and goal-setting exercises. Each STEM First Year Seminar is taught by a STEM faculty member and centers on a STEM specific academic topic such as "Native American Mathematics," "The Extinction of the Dinosaurs," or "The Science of Food." The First Year Seminar is the first step in establishing a STEM community in an incoming cohort. The presence of a STEM faculty in a context outside of an introductory course also provides an important potential student–faculty connection.

Peer mentors

Also available in the first semester are student peer mentors, typically second- or third-year former participants in the KEYSTONE Program. These peer mentors are tied to both a KEYSTONE First Year Seminar section and sections of introductory STEM courses, such as General Biology, General Chemistry, and Calculus, and are financially compensated. The peer mentors are both academically gifted and possess an "ambassador skill set." They are responsible for holding office hours, establishing study groups, and building the STEM learning community. The peer mentors are more than tutors meant to share academic content; they serve as a resource for students, helping them navigate the unspoken culture of STEM and sharing wisdom about successful study habits and professional behavior. This can be especially helpful for first-generation students. The peer mentors model behaviors conducive to STEM success and can seem more accessible to first-year students than faculty instructors. Though focused on first-year students, peer mentors are broadly available to any student in an introductory STEM course. Peer mentoring benefits both the student community and the peer mentors themselves through the development of leadership skills that can further strengthen the learning community (Carragher & McGaughey, 2016; Leidenfrost, Strassnig, Schütz, Carbon, & Schabmann, 2014; Yomtov, Plunkett, Efrat, & Marin, 2017).

January Term CURE

Elmhurst College has a January Term, a 4-week term during which students may take a single course at no additional cost. The January Term offers a space for pedagogical innovation and flexibility. During this January Term, the KEYSTONE Program continues with a course on the scientific method (Majka, Bennett, Sawyer, Johnson, & Guenther, 2018). This is a Course-based Undergraduate Research Experience (CURE) and is intended to guide students through the process of experimental design, execution of an experiment, and the presentation of findings. This course exposes students to the realities of doing original research outside of major courses and builds enthusiasm for science by shifting the focus from academic content to process. The course begins with an introduction to hypothesis generation and literature review and proceeds through the scientific process. The experience emphasizes the importance of effective communication, both orally and in writing, to the scientific process. Students write a paper and present a poster of the results of their experiments at the end of the 4-week course. The CURE allows students to recognize the realities of original scholarship, which can involve failures and uncertainties and often requires troubleshooting, and how those challenges can be matched by the satisfaction of new discoveries. The course gives students a low-stakes opportunity to gain confidence as a researcher and develop their STEM identities (Bangera & Brownell, 2014). This CURE can also serve as a conduit, leading students to future undergraduate research experiences, including KEYSTONE's own Summer Research Experience.

STEMinar

Attrition for STEM students can result from a loss in interest or disillusionment in a chosen STEM career. Many students consider STEM majors with a very specific career in mind, failing to understand the value and broad potential of a STEM degree. The spring "STEMinar" introduces students to a range of STEM careers, many of them unfamiliar to first-years, and presents options to students reconsidering their initial STEM career. STEMinar events include graduate school panels made up of alumni attending graduate school locally, STEM careers in government, interdisciplinary fields such as medical physics, and more. The STEMinar offers an opportunity to meet professionals from a variety of STEM careers and can be a student's first opportunity to network. The STEMinar is organized as an informal question-and-answer session with a panel of professionals and graduate students.

When possible, a panel made up of a combination of senior professionals and newer graduates gives the students a more comprehensive view of a field and how it is changing. When possible, inviting alums to participate helps students to connect their specific undergraduate experience at a small liberal arts school with demonstrated success in the professional world. It is an important early lesson that changing careers does not have to mean leaving STEM fields and encourages students to keep an open mind.

Summer Research Experience

The culmination of the KEYSTONE Program is the Summer Research Experience. The Summer Research Experience is a traditional research internship (Auchincloss et al., 2014). Undergraduate research experiences have become more widely available and have demonstrated impact on student success (Brewer & Smith, 2011; Graham, Frederick, Byars-Winston, Hunter, & Handelsman, 2013; Jones, Barlow, & Villarejo, 2010; Linn, Palmer, Baranger, Gerard, & Stone, 2015; Russell, Hancock, & McCullough, 2007; Strayhorn, 2010). Up to 20 students are chosen to do original research with Elmhurst College faculty members over the summer. The Summer Research Experience actually begins in the spring semester with a .25 credit (one semester hour) course that enables faculty mentors and students to plan their summer projects and ensures that the students have the experience transcripted. Applicants must have participated in the January Term CURE course and exhibit enthusiasm for research, as well as academic competency. This Summer Research Experience is not reserved only for the highest achievers, but rather is a mechanism for helping a wider range of students reach their potential by increasing access to early research experiences (Bangera & Brownell, 2014). The research is done on the Elmhurst College campus, typically for 20 hours per week for 5 weeks, and students receive a stipend.

Becoming an active learner is an essential component to being a successful STEM student. An immersive research experience allows students to take ownership of their education and scholarship and can be a transformative experience. Applying what was learned about the scientific method during January Term to a piece of a faculty member's ongoing project facilitates a student's academic maturity and furthers the development of science identity. Summer Research Experiences allow students to see themselves and faculty differently. A mentor–mentee relationship is quite different from an instructor–student relationship, and being seen as a colleague that can contribute is valuable for the students.

Participation of a variety of faculty across many STEM disciplines ensures a rich experience for the students and a strong learning community. Approximately 25 Elmhurst STEM faculty have mentored first-year KEYSTONE students. Projects have included bioinformatics research on cancer, reconstructing ancient ecosystems with fossils, examinations of the bacterial fauna of the hot springs of Yellowstone National Park, research on the energy of food, experiments about the chemistry of soap, studies of the seasonal changes to newt physiology, examinations of perception of large corporations, research on situational predictors of happiness, number theory problems, computer science projects involving parallel processing, mathematical studies of discrete dynamical systems, and many more.

The Summer Research Experience can greatly expand the amount of research experience students may have during their undergraduate studies. Providing first-year students with research experience can be a springboard that allows them to apply for Research Experiences for Undergraduates (REU) programs in their sophomore year, or to continue work with a faculty mentor for 3 full years. Multiple KEYSTONE students have been accepted into REUs in their sophomore year and many have been able to continue in-depth work with their original KEYSTONE mentor for 3 years, resulting in conference presentations and publications. Exposure to research early in their education can also introduce them to the possibilities and realities of a research-based career (Adedokin et al., 2012).

Summer Research Poster Session

Building on an idea introduced in the January Term course, that effective communication is essential, students present work from summer research projects during the KEYSTONE Summer Research Poster Session, which takes place in early fall semester of their sophomore year. This poster session allows students to continue becoming comfortable with presenting their research. It is also an important chance for incoming first-years to come to the poster session, learn more about the KEYSTONE Program, and be encouraged to join the January Term course and the Summer Research Experience.

Conclusions

Since the pilot program, the KEYSTONE Program has evolved to better meet student needs. Preliminary analyses have demonstrated that the program has significantly impacted student attrition. The most successful pieces of the program have been the peer mentors, January Term course, and Summer Research Experience. As the program

←The highlighted sentence shows that the KEYSTONE program has been a successful solution at this university.

has progressed, we have made significant changes in the manner in which the program seeks to connect with first-years, shifting the focus from the First Year Seminar courses to the introductory STEM courses. The goal-setting exercises have also been modified, becoming more strictly guided and purposeful. The role of the peer mentors has also changed, and has hopefully increased the visibility of the peer mentors and their utility for the students.

Key observations have improved the program: **Listen to the students:** The peer mentors were in the perfect position to critically look at the program through a student's eyes and give unfiltered first-year student opinions as to what was successful and what was not. **Encourage career exploration early:** Encouraging students to explore their career options and exposing them to unfamiliar careers can lead them to plan, network, and set career goals more thoughtfully. **Recruit effective student leaders:** Our most effective peer mentors have had skill sets beyond academic success. They have leadership qualities; have self-confidence; and were personable, excited about their major, and wished to help others succeed. **Track students and analyze/discuss the data:** The survey and other data received from Information Services (the College's institutional research office) are very informative. They provide benchmarks on progress and need to be analyzed and discussed so as to better the project. **Interventions should be specific and early:** During the course of the program it became clear that the students benefit most from early interventions at the beginning of their first semester. Through experiences with the goal-setting piece, we have also learned that interventions should be specific and require a proactive approach on the part of the student. **Efforts need to reach as many STEM students as possible:** Our initial plan of tying peer mentors and KEYSTONE interventions in the first semester to First Year Seminar sections was limiting. Linking the program to gateway courses increases the access, utility, and visibility of the program for our incoming first-years.

Finally, this was a great opportunity not only to welcome first-year students into the STEM learning community, but also to further encourage faculty and student collaboration and to increase enthusiasm for STEM disciplines. This model provides room for adaptation, and we look forward to the continued evolution of the program. ■

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