Retaining Students in Science, Math, and Engineering Majors: Rediscovering Cooperative Education

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Abstract

As researchers, practitioners, faculty, and administrators consider strategies to reduce attrition of science, math, and engineering students, cooperative education and its impact on student persistence has been relatively unexplored. This research examined the influence of cooperative education on the persistence of science, math, and engineering students. Supporting prior research (Avenoso & Totoro, 1994), results suggested that participation in cooperative education had a significant, positive effect on students' final cumulative GPA and their likelihood to persist. Students who participated in a co-op after their first-year of college were more than five times as likely to be retained as those who did not participate in such a program.

Index Terms - academic performance, cooperative education, retention, science, math engineering, STEM

The need to strengthen science and mathematics education in the United States was repeatedly highlighted in the 1980s by national organizations such as the Department of Education and National Science Foundation. Slaughter and Leslie (1997) noted that the exodus of bright students leaving these critical majors is detrimental to the future of the US economy and its ability to be a dominant player in the global marketplace. In the past two decades, a serious gap has been identified between the number of students who entered degree programs in science, technology, engineering and mathematics (STEM) and those who successfully completed them. In addressing the attrition of science, math, and engineering students, Seymour and Hewitt (1997) noted that 40% to 60% of students leave these majors within two years of completing their first science or mathematics course in college. In the past 10-15 years, organizations such as the National Science Foundation, National Institute of Health, and various education foundations have acknowledged the need to recruit more female students and students of color into STEM programs. By the early 1990s, the National Science Foundation had spent over $1.5 billion in an effort to increase minority participation in the sciences (Sims, 1992). These endeavors, in relation to recruitment of minority students, were fairly effective in increasing the enrollment of African Americans, Hispanics, and Native Americans in STEM disciplines; however, the result in terms of retention of students of color (other than Asian Americans) was less positive. For example, by 1994 the enrollment of first-year minority engineering students had increased five-fold over that of the previous 20 years; however, attrition rates remained the same (Seymour, 2002). The attrition rate for White students across all science, mathematics, and engineering programs (SME) was just over 27%, and the attrition rate for Asian American students was only 17%. In comparison, about half of African American and Native American students and two-thirds of Hispanic students left their SME majors. Analyses of data from the Integrated Postsecondary Educational Data System (IPEDS) on the cohort beginning in the fall of 2000 shows that, among students at four-year public institutions, only 39% of students who started college as a STEM major graduated with a STEM degree by the spring of 2006. Breaking the sample down by race/ethnicity shows that 41% of White students were retained in their STEM major while 40% of Asian American students persisted in a STEM discipline. Black students persisted at a rate of 35% whereas just 30% of Hispanic students who enrolled as STEM majors in 2000 completed a STEM degree by 2006. Although prior research has addressed both STEM and SME students and programs, the focus of this study is only on SME students, which does not include students with technology related majors.

As scholars and practitioners consider reducing attrition of students in these fields, cooperative education has not been fully explored as a potential strategy. This research explored the influence of

cooperative education on the six-year retention likelihood of first-year SME students. Additionally, the researchers examined the influence of completing a co-op experience on students' final cumulative GPA.

Background

College student retention is the most studied topic among higher education scholars (Braxton, Hirschy & McClendon, 2004). Much of this research has been prompted by governmental pressures on institutions to increase retention and graduation rates among undergraduate students (Commission on the Future of Higher Education, 2006). Defined as an institution's ability to have students remain continuously enrolled from admission to degree completion (Berger & Lyon, 2005), college student retention serves as a measure of institutions' success in connecting students to and integrating students into various aspects of the institution. Student persistence, on the other hand, usually refers to a decision at the individual level to remain enrolled at a particular institution. In general, persistence and retention are used interchangeably in the literature (Berger & Milem, 1999; Pascarella & Terenzini, 2005; Titus, 2004, 2006).

Understanding the factors that affect college student retention has important implications for administrators, policymakers, and the society at large. For administrators, discovering how to improve retention rates at their respective institutions has important implications for funding, particularly at public colleges and universities as state and federal policymakers have begun attaching accountability standards related to retention and graduation rates to appropriations (Burd, 2003; Burke & Minassians, 2001). Additionally, for the USA to remain competitive in the global marketplace institutions need to maintain, if not increase, production of degrees in general and science, mathematics, and engineering degrees in particular (Commission on the Future of Higher Education, 2006; Council of Graduate Schools, 2007).

Much of the research on college student retention draws from Tinto's (1975, 1993) college student departure framework and from Bean's (1980, 1990) student attrition model. Tinto (1975, 1993) suggests that retention rates can be improved by integrating students into the academic and social spheres of the institution. Bean's (1980, 1990) framework supports academic and social integration but also acknowledges that environmental pull factors, such as working off campus and family responsibilities, affect student retention. Drawing from these two frameworks, researchers have found that retention is often linked to students' background characteristics (e.g., prior academic achievement and socioeconomic status) (Trusty & Niles, 2004), finances (Paulsen & St. John, 2002), involvement in a variety of academic and social activities on campus (Astin, 1993; Berger & Milem, 1999; Titus, 2006), sense of belonging to the college campus (Hurtado & Carter, 1997), decision to live on campus (Oseguera, 2005; Titus, 2004, 2006), and hours worked each week (Titus, 2004), among other variables. Although Bean (1980, 1990) posits that working off campus negatively affects students' likelihood to persist, previous research has found no significant relationship between off-campus employment and student retention (Titus, 2004, 2006).

This present work aims to address a gap in the retention literature by examining how participation in cooperative education experiences affects a student's likelihood to persist. Although Titus (2004, 2006) found no significant relationship between retention and off-campus work and Bean (1980, 1990) suggests working off-campus negatively affects students' chances of persistence, the present study posits that off-campus work that is directly relevant to students' academic and career goals may have a positive effect on their likelihood to remain enrolled at their institution.

Cooperative education, hereafter referred to as co-op, provides students the opportunity to realize life and career options by connecting their present experience to future career possibilities. Research has established that student participation in co-op programs improves interpersonal relations; assists with the development of autonomy, self-confidence, and self-esteem; increases skills related to the application of theory to practice; and provides greater meaning in one's studies (Fletcher, 1991; Wilson, 1987). Other research (Kerka, 1989) has revealed such student benefits as clarification of career goals and increased relevance of learning and motivation for study. Although limited research has explored the effects of co-op on student persistence, initial work in this area provides support for this study. In a comparison of co-op and non-co-op students, Somers (1986) found that co-op students were more likely to graduate. Carrell and Rowe (1993) discovered co-op students were better socially adjusted and were more closely connected to their institution than non co-op students. Avenoso and Totoro (1994) found that students who participated in co-op experiences as freshmen and sophomores were more likely to remain enrolled through their junior year than students who did not participate in co-op programs. Avenoso and Totoro's work addressed retention of liberal arts students; however, it did not specifically address students in science, math, and engineering.

Studies by Smith (1965) and Lindenmeyer (1967) addressed academic performance and persistence to graduation. The lack of sophisticated data analysis and dated nature of these works suggest additional research is necessary. Neither of these studies utilized any form of regression, nor did either study draw from a

theoretical or conceptual framework. Finally, a survey of co-op program administrators and researchers by Stull, Crow and Braunstein (1997) noted that retention was an important future research topic for co-op researchers to consider.

As faculty attempt to provide students with more hands-on, practical experience, there is potential for increased implementation of co-ops in the areas of science, math, and engineering. Initiatives such as problem-based learning, co-ops, and service learning are examples of pedagogical tools that require more engagement of students. Research reports in the late 1990s called for faculty in SME programs to rethink their approach to teaching undergraduates, as SME programs suffered from high attrition rates among all types of students (NRC, 1996; NSF, 1996; Seymour, 2002; Seymour & Hewitt, 1997). Seymour (2002) suggested that, as high numbers of students from all backgrounds and ability levels left SME majors, faculty in SME programs shifted their focus from teaching to learning by providing more hands-on, collaborative activities and assignments to promote greater levels of engagement among students. Yet, many types of collaborative experiences can put additional demands on limited resources. Cooperative education is often less expensive than other programs in relation to the resources invested by faculty and programs.

The change in SME programs to promote more collaboration among students also attempted to reduce the level of competition within these programs. Seymour and Hewitt (1997) and Daempfle (2003) found that high levels of competition in SME classrooms inhibited collaboration among students and prompted students to switch majors or leave the institution altogether. To alleviate the sense of competition in SME classrooms, faculty have begun implementing more group assignments within their courses (Springer, Stanne & Donovan, 1999; Wise, Lee, Litzinger, Marra & Palmer, 2004). Springer et al. found that these small-group, hands-on, activities improved students' persistence rates as well as their overall academic performance in the SME program. While these pedagogical changes were aimed at making SME classrooms more welcoming environments and have led to improved persistence rates among SME majors, collaborative learning taking place in a classroom cannot substitute for the real-world learning that students receive through co-op experiences. Co-op experiences provide students with an opportunity to apply knowledge from the classroom in real-world situations as well as enhance students' engagement. Continuing to identify strategies to improve and enhance engagement in SME courses is important to long term influences on persistence to graduation.

In a qualitative study, Rhoads, Murphy and Trytten (2005) found that increasing students' engagement in science, math, and engineering programs positively influenced students' satisfaction and likelihood to persist. After conducting 41 interviews with men and women in engineering programs at Oklahoma University, the authors concluded that students perceived their academic departments as friendly and focused on students. Students reported being actively involved in their learning through an apprenticeship-like culture in the department, as men and women alike participated in research projects and co-presented with faculty members at professional conferences. The authors also suggested that the students in this study were more likely to persist to degree completion in their engineering programs because of their engagement with faculty members and academic departments.

Students' connections to their faculty and institution not only predict a greater likelihood of persistence but also higher academic achievement. Research has suggested that many factors influence students' college academic performance. Prior academic achievement (e.g., high school GPA, SAT scores), parent education, socioeconomic status, instructor expectations, degree aspirations, and institutional effects represent a handful of the factors that have been linked to students' college academic performance (Nye, Hedges & Konstantopoulos, 2000; Pascarella & Terenzini, 2005; Ting & Robinson, 1998). Students' academic and social involvement on campus also has a significant effect on their level of academic achievement in college (Astin, 1993). As students become more engaged inside and outside the classroom, they tend to find greater levels of success (Astin, 1993).

To the extent that students become more involved in their learning, co-op experiences positively contribute to students' academic achievement, which is directly related to persistence. Daily hands-on learning enables students to connect concepts that they learn in the classroom to real-world applications. With co-op opportunities closely tied to students' learning objectives, students' overall academic performance, particularly within their major, increases by participating in a co-op (Nasr, Pennington & Andres, 2004; Thiel & Hartley, 1997).

The timeframe when students engage in a co-op experience may have particular relevance on co-op participation effect on academic performance. Co-op participation in the first two years of college may facilitate a stronger sense of maturity among students, giving them the confidence to greater levels of academic success (Nasr, Pennington & Andres, 2004). Early co-op experiences may elicit a stronger commitment to the academic major, as students decide if a particular field suits their career aspirations.

Conceptual Frameworks

Astin's (1984) involvement framework provides a conceptual perspective to examine how participation in a co-op influences students' likelihood to persist. Defining involvement as the amount of physical and psychological energy put forth by a student, Astin suggests that participation in academic and social opportunities in college positively affect students' personal development and learning. Completing a co-op enables students to establish connections between their institution and the professional field of their academic discipline. These connections to the institution and to the outside world facilitate formal and informal interactions among students, faculty, and co-op employers. As students interact more with one another and with faculty, they become more likely to develop a strong sense of satisfaction with their college experience, which leads to a greater likelihood of degree completion and higher levels of academic achievement (Astin, 1993).

Bean's (1980, 1990) model of student attrition contributes to better understanding the role of a co-op experience in a student's decision to remain enrolled in higher education. Bean proposes that environmental pull factors (i.e., finances and off-campus work) directly influence a student's decision to persist. The co-op experience offers students an opportunity to obtain academic credit for a paid job experience. By earning while learning, students complete degree requirements and offset some of their financial needs. Thus what might be mislabeled as an environmental pull factor (off-campus employment), a co-op provides students with paid work experience and a connection to their academic discipline. Tinto's (1975, 1993) concepts of academic and social integration also help inform this research. Tinto's theory suggests that rewarding encounters with the formal and informal academic and social systems of the institution presumably lead to greater student integration in these systems and thus to persistence (Pascarella & Terenzini, 2005).

In terms of students' integration into the social and academic cultures of an institution, Tinto (1993) suggests the first two years of enrollment represent the most critical time for students' connections to their institution affect their likelihood to persist. Thus, students' participation in co-op experiences represents an important area to consider in student persistence, as students tend to engage in co-ops earlier in college than traditional internships and other types of experiential education. It would seem that as students gain practical experience through co-op employment, they begin making important connections to their major, their faculty, and their institution at a much earlier point in time.

As students establish meaningful ties to the various components of collegiate life, their overall satisfaction with their learning environment represents a significant factor in their likelihood to persist (Bean, 1980, 1990). The impersonal nature of science, math, and engineering programs leaves students feeling dissatisfied with their experience (Daempfle, 2003), which may affect persistence. Dissatisfaction with one's learning environment is one of the important predictors of departure in Bean's (1980, 1990) model of student attrition, as Bean parallels students' decisions to leave an institution with turnover in work organizations. Bean suggests that students leave because of the discontent with their current learning environment. In his model, Bean considers student background characteristics, socialization into various facets of the institutional community, students' attitudes, and external factors as contributors to students' decisions to leave an institution. Co-op programs have the potential to help students better understand their discipline through practical work experience and thus reconnect them to their learning environment, which could lead to increased persistence.

Methods

Sample Selection

Cooperative education in this study was defined as spending at least one semester away from the university in a real-world professional work experience. This study analyzed data collected from the 1997 and 1998 entering cohorts of science, math, and engineering students at a large, public university in the southeast USA. The study institution operates an Office of Cooperative Education, which monitored students' co-op experiences. In the public university system of the state, the study institution is historically considered the leading engineering and agricultural university, thus a primary draw for SME students. The original combined dataset included 4,311 unique student-level files, as approximately 2,150 students comprised each entering cohort of science, math, and engineering majors in 1997 and 1998. The institutional research office provided all of the information contained in the dataset. Student data included demographic information, prior academic achievement, cooperative education participation, semester of cooperative education participation, first-year grade point average (GPA), final cumulative GPA, and final enrollment status in 2004. For this study, the primary variable of interest is students' participation in a co-op experience, which serves as an indication of the connection among students, their institution, and the outside world.

Data Analysis

This study used a chi-square test to identify racial/ethnic differences in persistence. Additionally, the analyses included logistic regression to predict how participation in a co-op program influences students' likelihood to persist. Logistic regression was appropriate for this analysis because of its predictive ability of the dichotomous dependent variable (retained).

The final analytic sample included 4,311 students. Racial classification was dummy coded for African American, Hispanic, Asian, and Native American students, with White students as the reference group. Gender was recoded as a dummy variable with male as the reference group. The analysis included participation in a cooperative education program as a dummy variable with non-participation representing the reference group. Math and verbal SAT scores, high school GPA, and GPA after students' first year were included in the final model as continuous variables. To improve the interpretability of the continuous variables, SAT scores and the GPA variables were standardized to have a mean of 0 and a standard deviation of 1 (Agresti & Finlay, 1997).

For the dependent variable, students who had either completed their degree or were still enrolled in 2004 were classified as retained. Students who were no longer enrolled and had not completed their degree were coded as not retained. Logistic regression was used to determine the predictive ability of the independent variables on students' likelihood to persist. Equation 1 represents the final logistic regression model.

$$\log\left[\frac{\phi}{1-\phi}\right] = \beta_0 + \beta_1 * Black_i + \beta_2 * Asian_i + \beta_3 * Hispanic_i + \beta_4 * NativeAmerican_i + \beta_5 * Female_i + \beta_6 * CoOpParticipation + \beta_7 * MathSAT_i + \beta_8 * VerbalSAT_i + \beta_9 * HSGPA_i + \beta_{10} * FirstYearGPA_i + \mu_i \quad (1)$$

Limitations

This study was limited in several ways. The analytic sample originated from a single institution, which limits the generalizability of the findings to dissimilar institutions. Additionally, by attending the same institution, the students in this study may have had unobserved homogenous characteristics that bias the results. Sample sizes of diverse populations presented another concern, as a limited number of under-represented minorities were included in the analytic sample. Despite the limitations, this research offers a new and undeveloped avenue to consider when studying science, math, and engineering majors. Cooperative education is a relatively unexplored area in the persistence literature within the past 10 years, and this issue has not been examined specifically for science, math, and engineering majors. This research thus provides a foundation for future studies addressing similar topics.

Findings

Table 1 (Appendix A) presents descriptive statistics for the variables included in the analysis. Descriptive statistics showed that the sample contained more men (64%) than women (36%), and White students represented an overwhelming majority in this population (82.3%). African American (10.2%), Native American (0.7%), Asian American (5.2%), and Hispanic (1.6%) students comprised the racial minorities in the sample. Nearly 27% of the students who entered the sample institution in 1997 and 1998 dropped out before completing their degrees. The six-year retention rate (73%) is high for this sub-sample of students at the study institution, as the average six-year retention rate nationally is approximately 64% for students who enter a four-year college or university (National Center for Education Statistics [NCES], 2005). Similarly, the retention rates for the full 1997 and 1998 cohorts of students were 63% and 67%, respectively (IPEDS data, retrieved October 19, 2007). The chi-square test revealed that African American and Native American students differed significantly in their persistence rates compared to Asian American, Hispanic, and White students. African American and Native American students had persistence rates of 59% and 53%, respectively, across six years, while Asian American, Hispanic, and White students had average persistence rates of 76%.

The variables in the earlier equation were regressed on retention. Of the 10 independent variables, six proved significant ($p < 0.05$). Beta coefficients and odds-ratios were used in reporting the results of the logistic regression. The results included odds-ratios because these values provide a more informative means of interpreting their effect on the outcome variable. Odds-ratios indicated how a one-unit change in the independent variable, controlling for the other independent variables, affect the odds of degree completion (Allison, 1999). Values greater than one indicated an increase in the odds of being retained. Values less than one suggested a decrease in the chance of being retained. Table 2 presents the results of the logistic regression (see Appendix B).

The analysis suggested that African American students in science, math, and engineering were significantly less likely (odds-ratio = 0.65, $p < 0.001$) to be retained at the sample institution than White students. Likewise, Native American students were less likely to persist at this institution compared to their White classmates (odds-ratio = 0.46, $p < 0.042$). The results for Asian American and Hispanic students were not significant; similarly, women and men did not differ significantly in their odds of persisting (odds-

ratio = 0.89, $p < 0.153$). Higher verbal SAT scores appeared to be associated with significantly decreased odds of persisting at the sample institution (odds-ratio = 0.84, $p < 0.001$). Math SAT scores were not significant in the model. High school GPA was a significant, positive predictor of persistence (odds-ratio = 1.18, $p < 0.001$).

Participation in a co-op program in college had a positive and significant effect on students' likelihood to persist. Students who participated in a co-op program were more than five times as likely to be retained compared to their peers who lacked a co-op experience (odds-ratio = 5.43, $p < 0.001$).

Additionally, students' academic achievement during their first year was a significant and positive predictor of retention (odds-ratio = 2.04, $p < 0.001$). The overall model was modest in its ability to predict persistence among students in this sample, as the dataset did not provide controls for classroom activities and other forms of involvement experienced by students in the study. The independent variables in the logistic regression model correctly classified approximately 74% of the observations.

Interaction effects between various ethnicities and participation in a co-op were tested for significance; however, no interaction effects between co-op participation and race/ethnicity emerged as significant in the logistic regression model. This finding suggests that participation in a co-op did not make any one ethnicity more likely than another to persist in college. The limited number of underrepresented minorities participating in a co-op experience may have contributed to the lack of significance of the interaction variables. Table 3 presents cross-tabulations of gender and ethnicity with participation in a co-op (see Appendix C). In the aggregated sample, only 86 of the 763 non-White students in the sample participated in a co-op.

Similarly, tests for interaction effects between co-op participation and gender were not significant, suggesting that co-op participation did not differentially affect women's likelihood of being retained. Only 96 out of 1,550 women in this sample reported having engaged in a co-op experience. Such a small sample of women in co-op opportunities may have contributed to this interaction term's lack of significance in this analysis.

An ordinary least-squares regression model was run to determine the predictive ability of participation in cooperative education on students' six-year cumulative GPA. Ethnicity, gender, SAT scores, high school GPA, and participation in a co-op were regressed on final cumulative GPA. Table 4 presents the results of the linear regression (see Appendix D).

The results suggested that African American students had a significantly lower GPA than White students (b = -0.19, $p < 0.001$). Similarly, Native American students had a lower mean GPA compared to their White counterparts. Being Asian American or Hispanic had no significant effect on cumulative GPA. Women in this sample appeared to have higher final GPAs than their male classmates (b = 0.22, $p < 0.001$).

SAT math (b = 0.11, $p < 0.001$) and verbal (0.06, $p < 0.001$) scores had a significant and positive impact on final cumulative GPA. High school GPA was significant in predicting final cumulative GPA in college with this sample (b = 0.19, $p < 0.001$). Participation in a co-op was significantly and positively related to students' final GPA (b=0.40, $p < 0.001$). This finding suggests that cumulative GPAs of students who participated in a co-op were 0.40 points higher than their peers who did not have a co-op experience. This model explained a modest amount of the variation in cumulative college GPAs among students at the sample institution ($R^2 = 0.19$).

Discussion and Conclusions

Cooperative education has been part of higher education since 1906, yet campus administrators, policymakers, and researchers know little about the value it holds for science, math, and engineering students in relation improving persistence and academic performance. This research looked at the effects of participation in cooperative education on students' six-year persistence. It also explored the relationship between co-op participation and students' final GPA. Academic performance, measured as first-year GPA in our study, was shown to be a significant factor in predicting persistence of students; thus, including some measure of academic performance as a predictor variable is central to a study of persistence (Titus, 2004, 2006). Given the significant concern of retaining science, math, and engineering students, this research expanded Avenoso and Totoro (1994) work on liberal arts students by specifically focusing on SME students. Increasing graduation rates among SME majors has been identified as a significant priority for maintaining the USA's global competitiveness in these fields (Committee on Prospering in the Global Economy of the 21st Century, 2006; Council of Graduate Schools, 2007), so investigating significant predictors of retention specific to this sub-group of students represents an important area of inquiry.

This research found that participation in a cooperative education program had a positive and significant effect on students' final cumulative GPA and their odds of being retained at the institution. Students who participated in a co-op after their first-year of college were more than five times as likely to be retained as those who did not participate in such a program (odds-ratio = 5.43, $p < 0.001$). Furthermore, since this research suggested that African American

students (odds-ratio = 0.65, $p < 0.001$) and Native Americans (odds-ratio = 0.46, $p = 0.042$) in SME are significantly less likely to persist at the sample institution than White students, participating in a cooperative education program could become a critical component of the persistence puzzle. Although there were insufficient data to detect any significant differential effects of co-op participation on the retention of racial/ethnic-minority and female students, this exploratory study has laid a foundation future research in this area.

The significant and positive relationship between co-op participation and students' final cumulative GPA supports Astin's (1993) findings that students' connections to the institution and to the outside world positively influenced their academic performance. Cooperative education could allow students to connect theory to practice in a 'real world' work setting. Co-op students may become more academically integrated as they better understand and see the application of their subject matter. In fact, this study showed that students who participate in co-op programs obtained higher final GPAs than students who did not participate in such programs. This work also suggested that, contrary to Bean's (1980, 1990) idea of environmental pull factors (i.e., off-campus work), which negatively affected student retention, off-campus work, if connected to the academic program, can be a positive predictor of retention. Bean's (1980, 1990) model of student attrition would classify the co-op experience as off-campus work and therefore a factor that may reduce students' likelihood of persistence. This study demonstrates that not all off-campus employment can be categorized in the same way, as Bean's model suggests. The co-op experience offers students an opportunity to obtain academic credit for a paid work experience, which positively affects a student's decision to persist.

Rhoads, Murphy and Trytten (2005) found that increasing students' engagement in science, math, and engineering programs positively influenced students' satisfaction and likelihood to persist. Students in their study reported being actively involved in their learning through an apprenticeship-like culture in the department. Co-op experiences as previously defined by the literature (Wilson, 1971) support the idea of active engagement of students in connecting classroom learning to practical work situations.

Future research should include students from multiple institutions. A multi-institutional sample may increase the sample size of underrepresented minorities, which may provide for more representative analyses. Additionally, including multiple institutions will allow for more complex analyses, such as hierarchical linear modeling, to determine how institutional factors, including size, selectivity, and strength of programs, influence the effects of co-op participation on persistence and academic performance. Additional research will also benefit from qualitative approach, as there could be a number of reasons why students choose to participate in cooperative education or not. Furthermore, in a qualitative study, students will also be able to provide a more detailed, rich perspective on the value of cooperative education in relation to their major and college experience.

Seymour and Hewitt (1997) addressed the attrition of science, math, and engineering college students, and they noted that 40% to 60% of students leave SME majors within two years of completing their first science or mathematics course. The authors suggested that the lack of persistence among SME students posed concerns for the future demands of these fields, as fewer SME graduates translates into fewer trained scientists and engineers. At present, most institutions do not require cooperative education experiences. Faculty and administrators should engage in conversation about the value of requiring co-ops as part of the curriculum. Such experiences not only have the potential to improve retention rates, but they also may produce better-trained graduates, as students would have at least a semester's worth of practical experience related to their major.

Cooperative education remains an untapped resource to address retention issues among science, math, and engineering students; however, co-op experiences can be used in conjunction with other engaging teaching practices, such as those identified by Seymour (2002). Institutions have an opportunity to improve the persistence rates of their SME majors by creating both engaging, welcoming classrooms and meaningful opportunities to practice conceptual knowledge in real-world situations.

References

Agresti, A., & Finlay, B. (1997). *Statistical methods for the social sciences.* Upper Saddle River, NJ: Prentice Hall.

Allison, P.D. (1999). Comparing logit and probit coefficients across groups. *Sociological Methods and Research, 28*(2), 186-208.

Astin, A.W. (1984). Student involvement: A developmental theory for higher education. *Journal of College Student Personnel, 25*, 297-308.

Astin, A.W. (1993). *What matters in college? Four critical years revisited.* San Francisco: Jossey-Bass.

Avenoso, E., & Totoro, K. (1994). Comparison of retention rates of first and second year co-op and non-co-op students at a small liberal arts college. *Journal of Cooperative Education, 29*, 6-13.

Bean, J.P. (1980). Dropouts and turnover: The synthesis and test of a causal model of student

retention. *Research in Higher Education, 12*, 155-187.

Bean, J.P. (1990). Why students leave: Insights from research. In D. Hossler & J.P. Bean (Eds.), *The strategic management of college enrollments* (pp. 147-169). San Francisco: Jossey-Bass.

Berger, J.B., & Lyon, S.C. (2005). Past to present: A historical look at retention. In A. Seidman (Ed.), *College student retention* (pp. 1-29). Westport, CT: Praeger.

Berger, J.B., & Milem, J.F. (1999). The role of student involvement and perceptions of integration in a causal model of student persistence. *Research in Higher Education, 40*(6), 641-664.

Braxton, J.M., Hirschy, A.S., & McClendon, S.A. (2004). *Understanding and reducing college departure*. San Francisco: Jossey-Bass.

Burd, S. (2003, January 3). Education department wants to create grant program linked to graduation rates. *The Chronicle of Higher Education*, Retrieved 19 October, 2007, from http://chronicle.com

Burke, J.C. & Minassians, H. (2001). *Linking state resources to campus results*: *From fad to trend: The fifth annual survey*. New York: The Nelson A. Rockefeller Institute of Government.

Carrell, S., & Rowe, P. (1993). Effects of cooperative education on student adaptation to university. *Journal of Cooperative Education, 29*, 33-40.

Commission on the Future of Higher Education. (2006). *A test of leadership*: *Charting the future of US higher education.* Washington, DC: US Department of Education.

Committee on Prospering in the Global Economy of the 21st Century. (2007). An Agenda for American Science and Technology, National Academy of Sciences, National Academy of Engineering, Institute of Medicine (2007). *Rising above the gathering storm: Energizing and employing America for a brighter future.* Washington, DC: National Academies Press.

Council of Graduate Schools. (2007). *Graduate education*: *The backbone of American competitiveness and innovation.* A report from the Council of Graduate Schools Advisory Committee on Graduate Education and American Competitiveness. Washington, DC: Council of Graduate Schools.

Daempfle, P.A. (2003). An analysis of the high attrition rates among first year college science, math, and engineering majors. *Journal of College Student Retention, 5*(1), 37-52.

Fletcher, J. (1991). Field experience and cooperative education: Similarities and differences. *Journal of Cooperative Education, 27(2),* 46-53.

Hurtado, S., & Carter, D.F. (1997). Effects of college transition and perception of the campus racial and social climate on Latino students' sense of belonging. *Sociology of Education, 70*(4), 324-345.

Kerka, S. (1989). *Cooperative education*: *Characteristics and effectiveness*. (ERIC Document Reproduction Service No. 312455).

Lindenmeyer, R. (1967). A comparison study of the academic progress of the cooperative and four-year students. *Journal of Cooperative Education, 3,* 8-18.

Nasr, K., Pennington, J., & Andres, C. (2004). A study of students' assessments of cooperative education outcomes. *Journal of Cooperative Education, 38*(1), 13-21.

National Center for Education Statistics. (2005). *Enrollment in postsecondary institutions, Fall 2003; Graduation rates 1997 & 2000 cohorts; and financial statistics, fiscal year 2003.* Washington, DC: US Department of Education.

National Research Council. (1996). *From analysis to action*: *Undergraduate education in science, mathematics, engineering and technology.* Report of a convocation. Washington, DC: National Academy Press.

National Science Foundation. (1996). *Shaping the future*: *New expectations for undergraduate education in science, mathematics, engineering and technology* (NSF 96-139). Washington, DC: National Science Foundation.

Nye, B., Hedges, L.V., & Konstantopoulos, S. (2000). The effects of small classes on academic achievement: The results of the Tennessee class size experiment. *American Educational Research Journal, 37*(1), 123-151.

Oseguera, L. (2005). Four and six-year baccalaureate degree completion by institutional characteristics and racial/ethnic groups. *Journal of College Student Retention, 7*(1-2), 19-59.

Pascarella, E.T., & Terenzini, P.T. (2005). *How college affects students*: *A third decade of research* (2nd ed.). San Francisco: Jossey-Bass.

Paulsen, M.B., & St. John, E.P. (2002). Social class and college costs: Examining the financial nexus between college choice and persistence. *Journal of Higher Education, 73*(2), 189-236.

Rhoads, T.R., Murphy, T.J., & Trytten, D.A. (2005, October). *A study of gender parity*: *Department culture from the students' perspective*. Paper presented at the 35th ASEE/IEEE Frontiers in Education Conference, Indianapolis, IN.

Seymour, E. (2002). Tracking the processes of change in US undergraduate education in science, mathematics, engineering, and technology. *Science Education, 86*(1), 79-105.

Seymour, E., & Hewitt, N. (1997). *Talking about leaving*: *Why undergraduates leave the sciences.* Boulder, CO: Westview Press.

Sims, C. (1992). What went wrong: Why programs failed. *Science, 258*(5085), 1185–1187.

Slaughter, S., & Leslie, L. (1997). *Academic*

capitalism: *Politics, policies and the entrepreneurial university*. Baltimore, MD: John Hopkins University Press.

Smith, H.S. (1965). The influence of participation in the cooperative program on academic performance. *Journal of Cooperative Education*, *3*, 7-20.

Somers, G. (1986). How cooperative education affects recruitment and retention. *Journal of Cooperative Education*, *22*, 72-78.

Springer, L., Stanne, M.E., & Donovan, S.S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of Educational Research*, *69*(1), 21-51.

Stull, W., Crow, D., & Braunstein, L. (1997). An investigation to identify needed research in cooperative education. *Journal of Cooperative Education*, *32*, 30-35.

Thiel, G., & Hartley, N. (1997). Cooperative education: A natural synergy between business and academia. *SAM Advanced Management Journal*, *62*, 19-24.

Ting, S.R., & Robinson, T.L. (1998). First-year academic success: A prediction combining cognitive and psychosocial variables for Caucasian and African American students. *Journal of College Student Development*, *39*, 599-610.

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research*, *45*, 89-125.

Tinto, V. (1993). *Leaving college*: *Rethinking the causes and cures of student attrition* (2nd ed.). Chicago: University of Chicago Press.

Titus, M.A. (2004). An examination of the influence of institutional context on student persistence at four-year colleges and universities: A multilevel approach. *Research in Higher Education*, *45*(7), 673-699.

Titus, M.A. (2006). Understanding the influence of the financial context of institutions on student persistence at four-year colleges and universities. *The Journal of Higher Education*, *77*(2), 353-375.

Trusty, J., & Niles, S.G. (2004). Realized potential or lost talent: High school variables and bachelor's degree completion. *The Career Development Quarterly*, *53(1)*, 2-15.

Wilson, J.W. (1971). Historical development. In A.S. Knowles & Associates (Eds.), *Handbook of cooperative education* (pp. 3-17). San Francisco: Jossey-Bass.

Wilson, J.W. (1987). What students gain from cooperative education. In K.G. Ryder, J.W. Wilson & Associates (Eds.), *Cooperative education in a new era*: *Understanding and strengthening the links between college and the workplace* (pp. 269-284). San Francisco: Jossey-Bass.

Wise, J.C., Lee, S.H., Litzinger, T., Marra, R.M., & Palmer, B. (2004) A report on a four-year longitudinal study of intellectual development of engineering undergraduates. *Journal of Adult Development*, *11*(2), 103-110.

Appendix A

Table 1. Descriptive statistics of independent and dependent variables for co-op SMEM

Variable	Observations	Mean	Std. Dev.	Min	Max
Female	4311	0.36	0.48	0.00	1.00
White	4311	0.82	0.38	0.00	1.00
Black	4311	0.10	0.30	0.00	1.00
Native	4311	0.01	0.09	0.00	1.00
Asian	4311	0.05	0.22	0.00	1.00
Hispanic	4311	0.02	0.13	0.00	1.00
SAT-Math	4311	609.58	79.24	370.00	800.00
SAT-Verbal	4311	577.71	79.72	320.00	800.00
High School GPA	4311	3.82	0.39	2.320	4.50
Co-Op Participation	4311	0.11	0.31	0.00	1.00
Six-Year Persistence	4311	0.73	0.44	0.00	1.00
Cumulative College GPA	4307	2.78	0.80	0.00	4.00

Source: University's institutional research office.

Appendix B

Table 2. Logistic regression of six-year enrollment status for co-op SMEM (n=4307)

Variable	Odds Ratio	Std. Err.	Z	P>z
Female	0.89	0.07	-1.43	0.153
Black	**0.65**	0.08	-3.55	0.001
Native American	**0.46**	0.18	-2.04	0.042
Asian American	0.85	0.15	-0.94	0.347
Hispanic	1.10	0.34	0.32	0.748
SAT-Math	0.95	0.00	-0.92	0.356
SAT-Verbal	**0.84**	0.00	-3.68	0.001
High School GPA	**1.18**	0.16	4.09	0.001
Freshman Year GPA	**2.04**	0.27	15.83	0.001
Participation in Co-op	**5.43**	1.18	7.82	0.001

Pseudo R^2 = 0.11. 74% of cases were correctly classified
Source: University's institutional research office.

Appendix C

Table 3. Cross-tabulations of co-op participation by gender and by ethnicity for co-op SMEM (n=4307)

Variable	Participated in co-op	Total observations
Women	96	1550
Men	365	2761
Black	30	439
Native	2	32
Asian	49	224
Hispanic	5	68
White	375	3548

Source: Institutional research office data

Appendix D

Table 4. Linear regression of final cumulative college GPA for co-op SMEM (n=4307)

Variable	Coef.	Std. Err.	T	P>t
Female	**0.22**	0.03	8.87	0.000
Black	**-0.19**	0.04	-4.89	0.000
Native	**-0.31**	0.13	-2.38	0.017
Asian	0.01	0.05	0.22	0.826
Hispanic	-0.03	0.09	-0.35	0.724
SAT-Math	**0.11**	0.02	7.68	0.000
SAT-Verbal	**0.06**	0.01	4.30	0.000
High School GPA	**0.19**	0.01	15.44	0.000
Co-Op Participation	**0.40**	0.04	9.69	0.000
Constant	2.70	0.13	-3.37	0.001

Source: Institutional research office data