The Business-Higher Education Forum

Highly Effective Undergraduate Intervention Strategies

Literature Review Summaries

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Intervention: Undergraduate Research Internships

Definition of an Undergraduate Research Internship: an inquiry or investigation conducted by an undergraduate that makes an original intellectual or creative contribution to the discipline[1] on or off-campus of the home-institution.

From the research the following are components should be included in a best-practice research internship:

- **Beginning research internships earlier –** Begin during freshman or sophomore year, but change is most notable during sophomore year with significantly increased retention of STEM students, with African-American students with lower entry scores receiving the greatest benefit. (The effect for sophomore students showed an attrition rate of 4.3% while control group counterparts had an attrition rate of 9.5%, x2 (1, n = 553) = 4.963, p = .03).[2]
- **Increase duration of the experience -** The longer the research experience, the greater the perceived benefic (alumni perceived even one semester's experience in undergraduate research to be very beneficial, responses indicated that in general, the longer one had participated in research, the greater the perceived benefit (the mean benefit for those respondents who had been involved for one semester was 3.94; for two semesters it was 4.24; for six semesters it was 4.74, and for eight semesters the mean benefit was 4.90 (1=not at all important; 3= important; 5= extremely important).[3]
- **A student's research internship should take place in multiple environments, at the home institution and off campus -** working at an institution other than their regularly enrolled institution reported significantly higher mean values for "Clarification of a career path", "Skill in science writing", "Self-confidence", and overall evaluation of their experience. Students working at their home institution reported significantly higher mean values for "Skill in the interpretation of results", "Understanding of the research process", "Learning lab techniques", and performance of their supervisor.[4]
- **Require a presentation and poster conference -** Presenting an account of the summer's work to other students and faculty and offering a poster at a conference prompted a dramatic rise in professional confidence and identity (25% gain).[5]

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[1] NSF, 2003b, p. 9

[2] Nagda, B. A., S. R. Gregerman, J. Jonides, W. von Hippel, and J.S. Lerner. (1998). "Undergraduate student faculty research partnerships affect student retention." *The Review of Higher Education* 22: 5572.

[3] Seymour, E., Hunter, A.-B.,Laursen, S.L.,& DeAntoni,T. (2004).Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. Science Education, 88(4), 493 – 534.

[4] Lopatto, D. (2007). "Undergraduate research experiences support science career decisions and active learning." *CBE—Life Sciences Education* 6: 297-306.

[5] Hunter, A-B., S. L. Laursen, and E. Seymour. (2007). "Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development." *Science Education* 91: 36-74.

- **Encourage interns to return for multiple experiences -** Repeated research internships showed increasing gains (The benefit was strongly associated with the number of semesters that the alumni had been involved in research, with a mean enhancement of .96 for alumni with 1 or 2 semesters of research experience compared to 4.51 for alumni with 3 or more semesters of research).[6]
- **Mentors are a key component to any research internship -** Research suggests that contact with faculty outside the classroom, and the development of mentoring relationships, including with minority faculty, can decrease academic isolation, and contribute to positive outcomes.[7]

Studies have identified a broad range of benefits stemming from undergraduate research internships including:

- **Development of technical, problem-solving, and presentation skills -** interns rated all skills significantly higher at the end of the URE than they did at the beginning. The discrepancy between pre- and post-URE ratings are especially marked (mean differences of 0.75 or greater) for the following skills: interpret data, relate results to the bigger picture in their field, and orally communicate the results of research projects. By contrast, the differences were least pronounced (mean differences of 0.45 or less) for the following three skills: identify a question for investigation, observe and collect data, and understand the importance of controls.[8]
- **Increased interest in graduate education –** participating in undergraduate research increases the likelihood of students' attending graduate school (71 to 80 percent among research participants versus 59 percent for their non-participating counterparts).[9] Participation especially increased graduate-school attendance for African-American students (75percent of those who participated in research continued on to graduate school compared to only 8 percent of those who did not).[10] Research internships also generate new interest in graduate education (29% of the respondents indicated a "new" interest in graduate education).[11]

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[6] Zydney, A. L., Bennett, J. S., Shahid, A., & Bauer, K. W. (2002a). Impact of undergraduate research experience in engineering. Journal of Engineering Education, 91(2), 151 – 157.

[7] Maton, K. I., Hrabowski, F. A., & Schmitt, C. L. (2000). African American college students excelling in the sciences: College and postcollege outcomes in the Meyerhoff Scholars Program. *Journal of Research in Science Teaching, 37*(7) 629-654.

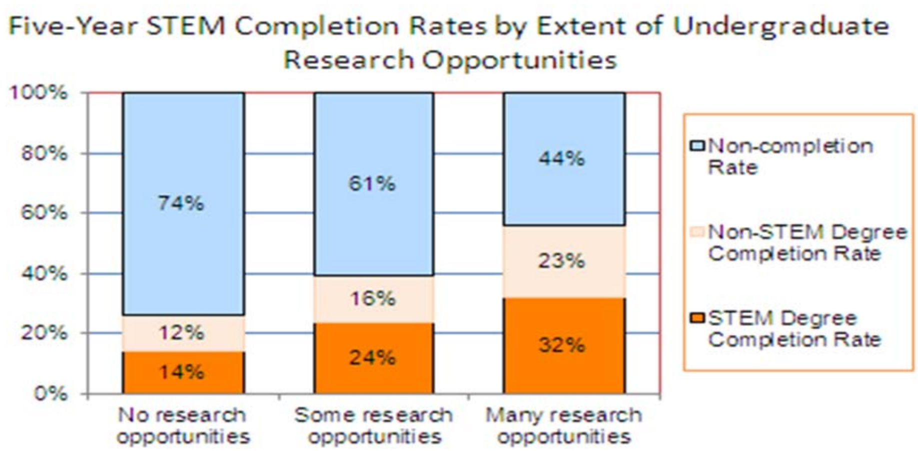
[8] Kardash, C. M. (2000). Evaluation of an undergraduate research experience: perceptions of undergraduate interns and their faculty mentors. *Journal of Educational Psychology*. 92, 191–201.

[9] Bauer, K. W., & Bennett, J. S. 2003. "Alumni Perceptions Used to Assess Undergraduate Research Experience." The Journal of Higher Education , 74(2),210-230.

[10] Foertsch, J., Alexander, B., & Penberthy, D. 2000. "Summer research opportunity programs (SROPs) for minority undergraduates: A longitudinal study of program outcomes 1986-1996."Council of Undergraduate Research Quarterly , 20(3), 114-119.

[11] Russell, S. H., M.P. Hancock, and J. McCullough (2007). "The pipeline. Benefits of undergraduate research experiences." *Science* 316(5824): 548-9.

- **Students who engage in undergraduate research are more than twice as likely to graduate with a STEM degree –** Students who participate in research, including underrepresented minorities, complete their science programs in greater numbers than those who do not.[12,13]
- **Increased student confidence and empowerment -** Data indicate that a research experience gives students confidence and a sense of empowerment.[14]
- **Increased interest in STEM career and confidence in research skills -** Student's interest in a STEM career and confidence in research skills increases with a research internship. (Of approximately 4500 students who had participated in the NSF programs 68% of the respondents reported an increase in interest in a STEM career, and 83% reported an increase in confidence in their research skills.[15]
- **Research internships increase GPA and the number of high-level science classes taken, in particular among women and minorities -** the graduation GPA showed that SURE participants took on average 0.97 more science classes and 0.92 more high-level science classes than their peers who did not participate in the program, and their senior year adjusted science GPA was higher by 1.38 points).[16]
- **Internships affect student's job offer acceptance rates –** In one study, 24 student interns at the company were eventually offered jobs in this time frame, and 21 (or 88%) accepted those offers to work full-time during the 14 year study period. When full-time jobs are available and offered to student interns, the acceptance rate is extraordinarily high because the students have been given opportunities to experience the job.[17]



[12] Summers, M., & Hrabowski, F. 2006. "Preparing minority scientists and engineers". Science ,311(5769),1870-1871 and Locks, A. M., & Gregerman, S. R. 2008. "Undergraduate research as an institutional retention strategy: The University of Michigan Model." In R. Taraban & R. L. Blanton (Eds.), *Creating Effective Undergraduate Programsin Science: The Transformation from Student to Scientist,* 11-32. New York: Teachers College Press.
[13] Jones, M., Barlow, A., and Villarejo, M. (2010). Importance of Undergraduate Research for Minority Persistence and Achievement in Biology. *Journal of Higher Education*, 81(1), 82-115.
[14] BIO 2010
[15] Russell et al. (2007)
[16] Junge, B., C. Quiñones, J. Kakietek, D. Teodorescu, and P. Marsteller. (2010). "Promoting Undergraduate Interest, Preparedness, and Professional Pursuit in the Sciences: An Outcomes Evaluation of the SURE Program at Emory University." *CBE—Life Sciences Education* 9(2): 119-132.
[17] "Student Interships Success Rate to Full-Time Employment. Insurance Company Home Office Long Term Study 1995-2008" http://invest.iiaba.net/Pages/Career-Center/Internship%20Study.aspx

Intervention: Cognitive Tutors

Definition of Cognitive Tutors: Educational software containing an artificial intelligence component where the software tracks students' progress and challenges toward learning, tailoring feedback to their individual needs. The design of the environment is based on *cognitive* principles and the interaction with students is based on that of a (human) *tutor* - i.e., making comments when the student errs, answering questions about what to do next, and maintaining a low profile when the student is performing well.

From the research the following are components should be included in a best-practice implementation of cognitive tutors:

- **Progression of Problems Based on Student Responses –** Unlike standard quizzes and tests with a set sequence of questions, cognitive tutor programs determine a progression of problems based upon students' previous responses. Subsequent problems may increase in difficulty, address weaker content areas, or decrease in difficulty depending on a student's prior performance.
- **Immediate Feedback** - Cognitive tutor software also provides immediate responses to students' answers. Timely feedback is a frequently cited effective instructional practice, as students can work to clarify content or address problems earlier.
- **Adaptable to a Range of Skill/Knowledge Levels** - College courses are often comprised of students with a range of backgrounds. Thus, cognitive tutors should be capable of being used by students with varying knowledge levels. Cognitive tutor programs have been particularly effective with students in remedial courses, [18,19].
- **Cognitive Tutors Supplement Classroom Teaching/Other Assignments –** Cognitive tutor programs are most effective when integrated with course learning goals and concepts taught in classes and labs.

Studies have identified a range of benefits stemming from cognitive tutors including:

- **Increased Learning Gains –** College students in science and math courses show improved ability to solve word problems and applications with regular use of cognitive tutor software. In a study of students in a remedial math course, 78.1 percent of students surveyed said cognitive tutor software (TiPS) helped them to understand word problems.[20] 51.2 percent of students surveyed said they learned to solve word problems through cognitive tutoring software. In another study involving students in a

[18] Atkinson, R.K. (2003). An Experimental Evaluation of Tutorials in Problem Solving (TiPS): A Remedial Mathematics Tutor. Office of Naval Research.

[19] Koedinger. K. R., & Sueker, E. L.F. (1996). PAT goes to college: Evaluating a cognitive tutor for developmental mathematics. In Proceedings of the Second International Conference on the Learning Sciences, Charlottesville. VA Association for the Advancement of Computing in Education.

[20] Atkinson, R.K. (2003). An Experimental Evaluation of Tutorials in Problem Solving (TiPS): A Remedial Mathematics Tutor. Office of Naval Research.

developmental math course, students using cognitive tutor software (PATS) scored 50 percent higher on performance-based assessments than peers who did not use the software[21]. Students in a statistics course scored an average 18 points higher on final exams when using cognitive tutor software. Students using cognitive tutors also mastered course material at a faster pace than peers who did not utilize cognitive tutors.[22]

- **Enhanced Student Engagement and Satisfaction –** In a questionnaire about the TiPS cognitive tutor learning experience, 48.8 percent of participants agreed or strongly agreed that they were interested in learning about word problems, and 61 percent agreed that learning was fun using the software[23].
- **Improved Course Grades –** After using the TiPS Cognitive tutoring software for four hours, students in a remedial math course scored an average of 15 points higher on a posttest in comparison to their pre-test scores. After completing 125 problems using cognitive tutoring software, students in a college level genetics course averaged pretest-posttest learning gains of 18 percentage points[24].

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[21] Koedinger. K. R., & Sueker, E. L.F.(1996). PAT goes to college: Evaluating a cognitive tutor for developmental mathematics. In Proceedings of the Second International Conference on the Learning Sciences, Charlottesville. VA Association for the Advancement of Computing in Education.

[22] Lovett, M., Meyer, O. & Thille, C. (2008). The Open Learning Initiative: Measuring the Effectiveness of the OLI Statistics Course in Accelerating Student Learning. *Journal of Interactive Media in Education.*

[23] Atkinson, R.K. (2003). An Experimental Evaluation of Tutorials in Problem Solving (TiPS): A Remedial Mathematics Tutor. Office of Naval Research.

[24] Corbett, A., Kauffman,L., Maclauren, B., Wagner, A., & Jones, E. (2010). A cognitive tutor for genetics problem solving: Learning gains and student modeling. *Journal of Education Computing Research*, 42(2), 219-239.

Intervention: Student Learning Communities (cohort and residential)

Definition of a Freshman laboratory-based research course: A defined group of students taking two or more classes together, where the courses are often organized around a common theme and may require students to be involved in out-of-class activities. Some learning communities include a residential component.

From the research the following are components should be included in a best-practice Learning Community:

- **Early in Undergraduate Studies –** Many learning communities are designed for first and second year college students. This time is critical for student engagement and concept mastery in coursework. For STEM majors in particular, the first two years are heavy with prerequisite coursework/introductory courses critical to future success in the major(s).
- **Engage Students in an Academic and/or Residential Community –** A learning community should serve to connect students with a supportive community of peers, faculty, and staff. This community can serve as both an academic resource and a social outlet.
- **Faculty Involvement and Collaboration –** Faculty teaching courses associated with learning communities create a cohesive learning experience by planning course topics and projects together. At least one faculty member often resides in living and learning communities with students to link the academic and extracurricular elements of these programs.
- **Facilitate Cognitive Development -** Enable students to connect material, concepts, ideas, and skills across courses.[25,26]

Studies have identified a broad range of benefits stemming from Learning Communities including:

- **Retention –** Learning Communities have a number of indirect, positive effects on student persistence. By facilitating frequent faculty-student contact, peer interactions, and academic engagement, learning communities provide conditions that lead to increased student persistence.[27] Learning Community students have greater first-year retention rates

[25] Gabelnick, F., MacGregor, J., Matthews, R.S., and Smith, B.L. (1990). Learning communities: Creating connections among students, faculty, and disciplines. *New Directions for Teaching and Learning*. San Francisco: Jossey-Bass.
[26] Taylor, K., with Moore, W.S., MacGregor, J. and Lindblad, J. (2003). *Learning Community Research and Assessment: What We Know Now.* National Learning Communities Project Monograph Series. Olympia, WA: The Evergreen State College, Washington Center for Improving the Quality of Undergraduate Education, in cooperation with the American Association for Higher Education.
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than their peers in traditional coursework (.34-.60 effect size).[28] Learning communities have a positive effect on persistence among STEM majors specifically.[29]

- **GPA-** Controlling for SAT scores and other pre-college variables, students involved in learning communities report higher GPAs than students in traditional courses (.03-.10 effect sizes).[4,30] Women in STEM Living-learning communities also earned higher GPAs than peers in other programs.[31]
- **Satisfaction with College –** Students involved in learning communities report greater satisfaction with their experiences in college than their peers (.25 effect size).[32] Women in STEM Living-Learning Communities reported a stronger sense of belonging to their college or university in comparison to students in other residential settings.[7]
- **Increased Confidence in STEM Courses and Careers –** Women in STEM Living-Learning Communities expressed feeling more confident in their math and engineering courses and greater confidence in their future professional success in comparison to their counterparts living in traditional residence halls.

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[28] Stassen, M.L.A. (2003) The Impact of Varying Living-Learning Community Models. *Research in Higher Education*, 44(5), 581-613.
[29] Barrows, S., and M. Goodfellow. 2005. Learning community effects on first-year student success in a general chemistry course. *Journal of the First-Year Experience* 17(2), 11-22.
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[31] Inkelas, K. K. (2011). Living-Learning Programs for Women in STEM. *New Directions for Institutional Research*, 157, 27-37.
[32] Zhao & Kuh, G. (2008). Adding value: Learning communities and student engagement. *Research in Higher Education*, 45(2), 115-138.

Intervention: Bridge Programs

Bridge programs are a cohort-style series of courses, activities, and learning experiences intended to help students make a smooth transition from high school to college. In some cases, bridge programs support students transitioning from one postsecondary institution to another. Some common goals of Bridge programs include enhancing students' academic skills, orienting students to campus life and culture, helping students develop goals, and developing academic and social networks. Bridge programs are often residential, and typically take place during the summer before the freshman year.

From the research the following components should be included in a best-practice Bridge Program:

- **Ongoing Contact with Students** - The advising and support provided to students during bridge programs should be continued during the freshman year and beyond. This can be accomplished through agreements with academic departments, mandatory advising for bridge participants, and extended programming.
- **Exposure to Rigorous College-Level Coursework –** Summer Bridge courses that mirror the workload, pace, and expectations of introductory STEM courses prepares students for the rigors of a full-time course load. These courses will enable students to develop study habits and skills that will help them succeed in coursework for their respective majors.
- **Clustered Course Registration –** The benefits of peer networks developed during bridge programs can be extended by clustering bridge students in designated sections of introductory science and math courses during the Fall and Spring semesters. This will enable bridge students to study together and support one another in courses that may otherwise be intimidating and isolating.
- **Introduce Resources** - Bridge participants benefit from exposure to campus resources to support their academic success and personal wellness. Workshops, campus tours, and guest speakers are all effective ways to expose students to campus resources.
- **Collaboration with Academic Departments –** Bridge programs with support from academic departments are particularly effective, as they are able to offer courses for credit toward students' majors, arrange for special registration permissions, and link students with faculty and staff in their majors.
- **Connect Students with a Network of Supportive Peers, Faculty, and Staff –** Early opportunities to meet future classmates, upperclassmen, faculty in their respective departments, and support staff with a vested interest in students' success helps develop a supportive environment for incoming STEM students.

Studies have identified a broad range of benefits stemming from Bridge Programs including:

- **Increased Retention –** Students who participate in Summer Bridge programs are retained in their majors and college overall at higher rates than their peers who do not participate in Bridge Programs (12-36% increases).[33] In a study of a mathematics bridge program, participants had 3-year retention rates 28.57 higher than their peers who did not participate in bridge programs.
- **Higher Graduation Rates –** Controlling for individual student characteristics, Summer Bridge program participants graduate at rates higher than their peers who do not.[34]
- **GPA-** Summer bridge program participants at BGSU had GPAs averaging 0.5 points higher than their peers who did not participate in Bridge programs over seven semesters.[35]
- **Success in Introductory Courses –** Among students in developmental Bridge programs, participants were 4.4% more likely to pass introductory math courses than their peers.[36]

[33] Gleason, J., Boykin, K, Johnson, P., Bowen, L., Whitaker, K., Micu, C., Raju, D., and Slappey, C. (2009). Integrated engineering math-Based summer Bridge Program for student retention. *Advances in Engineering Education*, American Society for Engineering Education.

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Intervention: Course Redesign to Induce Active Engagement

Definition of Course Redesign to Induce Active Engagement: Redesigning introductory courses from standard instructor-centered, lecture-homework-exam format to a student-centered format that uses interactive engagement, project-based learning, and other approaches to achieve better learning outcomes.

From the research the following are components should be included in a best-practice course redesign:

- **Focus on redesign of introductory courses –** Fewer than 40% of undergraduates who begin college with the intention of majoring in a STEM field complete a STEM degree[37]. Many leave these majors after taking introductory classes[38 39]. Introductory courses in math and science departments are often required for STEM majors and serve as prerequisites for more advanced courses. Students report that these classes are often large lecture-style courses and perceive that these classes are intended to "weed out" students[40]. Both faculty and students have frequently reported an over-reliance upon lectures in these courses[41].
- **Encourage the use of Innovative Pedagogical practices –** Students benefit from pedagogical practices that extend beyond lecture to include applications of course topics, problem-based learning[42], collaborative/cooperative learning[43], and active learning[44]. Faculty institutes and workshops have led to sustained improvements in teaching practices in introductory courses[45].
- **Maximize student/faculty interaction –** Small class sizes, small-group learning, and opportunities to engage in undergraduate research all provide increased opportunities for students to have positive interactions with STEM faculty[46]. More frequent interactions with faculty lead to improved problem-solving abilities[47].

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[37] U.S. Department of Education, National Center for Education Statistics, 2003-04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09)

[38] Seymour, E. and N. M. Hewitt. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Boulder, CO: Westview Press.

[39] Brainard, S. and L. Carlin. (1998). A six-year longitudinal study of undergraduate women in engineering and science. *Journal of Engineering Education,* 87(4):), 369-375.

[40] Seymour, E. & Hewitt, N.M. (1997). op.cit.

[41] Finkelstein, M. J., Seal, R. K., and Schuster, J. H. (1998). The New Academic Generation: A Profession in Transformation B.altimore: Johns Hopkins University Press.

[42] Lipson, A., Epstein, A.W., Bras, R., and Hodges, K. (2012). Students' perceptions of Terrascope, a project-based freshman learning community. *Journal of Science Education and Technology*, 16(4), 349-364.

[43] Cabrera, A.F., Colbeck, C.L., and Terenzini, P.T. (2001). Developing performance indicators for assessing classroom teaching practices and student learning: The case of engineering. *Research in Higher Education*, 42(3), 327-352.

[44] Pascarella, E. T., and Terenzini, P. (2005). *How College Affects Students.* John Wiley, San Francisco, CA.

[45] Pfund C, et al. (2009). *Summer Institute to Improve Biology Education at Research Universities. Science,* 324, 470-471.

[46] Perna, L., Lundy-Wagner, W., Drezner, N., Gasman, M., Yoon, S., Bose, E., & Gary, S. (2009). The contribution of HBCUs to the preparation of African American women for STEM careers: A case study. *Research in Higher Education*, 50, 1-23.

- **Develop spaces that facilitate student engagement –** The designs and equipment available in classroom spaces can aid instructors in delivering engaging lessons. Specifically, spaces with movable furniture can facilitate group work, and the availability of updated technology such as clickers for student responses enable instructors to actively engage students throughout their classes[48].
- **Shift to Student-Centered learning environments –** Students respond positively to lessons tailored to their individual interests, experiences, and learning styles. Students also respond to learning environments where they are permitted to serve as contributors of knowledge and instructors are not considered the sole source of information[49].

Studies have identified a range of benefits stemming from course redesign including:

- **Improved student performance and satisfaction –** Small-group learning and other engaging teaching practices lead to greater academic achievement, improved attitudes toward learning, and increased persistence in STEM majors[50]. In a study of course redesign in an introductory biology course, students in the redesigned student-centered, web-enhanced course scored higher on assessments than peers in traditional lecture-based courses.[51]
- **Student gains in professional competencies –** Interaction with faculty and the use of collaborative learning practices leads to self-reported gains in students' group skills, problem-solving skills, and occupational awareness (by 23, 31, and 22 percent, respectively)[52].
- **Enhanced instructor confidence and sustained improvements in teaching –** After a summer teaching institute for instructors of introductory biology courses, participants reported increased confidence in their ability to try new instructional methods in their classes (98 percent), sustained changes in their pedagogical practices (68 percent), and improved student performance over a two-year period[53].

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[47] Springer, L., M. E. Stanne, and S.S. Donovan. (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.
[48] Smith, M., W. Wood, W. Adams, C. Wieman, J. Knight, N. Guild. (2009). "Why peer discussion improves student performance in class." Science 323: 122-124.
[49] National Research Council. (2005). How Students Learn: Science in the Classroom. Washington, DC: National Academy Press.
[50] Springer, L., M. E. Stanne, and S.S. Donovan. (1999). op.cit.
[51] McDaniel, C.N., Lister, B.C., Hanna, M.H., and Roy, H. (2007). Increased learning observed in redesigned introductory biology course that employed web-enhanced, interactive pedagogy. *Life Sciences Education*, 6(3), 243-249.
[52] Cabrera, A.F., Colbeck, C.L., and Terenzini, P.T. (2001). op.cit.
[53] Pfund C, et al. (2009). op.cit.

Intervention: Scholarships for Service

Definition of Scholarships for Service: Direct financial aid to students pursuing a relevant degree, where upon graduation the award recipient has a post-degree service requirement commensurate with the length of the received award.

From the research the following are components should be included in a best-practice scholarship for service program:

- **Financial support based upon students' individual need and cost of attendance –** STEM degree programs are often more costly than other majors due to differential tuition practices, laboratory fees, expenses of textbooks and materials, and extended times to degree.[54] Thus, a students' perception of aid amounts may differ based upon their context.
- **Complements academic needs and resources available on campus –** Despite benefits of financial support, academic support remains a key element of student persistence.[55,56] Corporations and Agencies can provide support while students are still enrolled by partnering with universities to offer work opportunities and other resources on campus, or offering summer internships that complement undergraduate coursework.
- **Lessens financial burdens on students–** Debt from student loans is negatively associated with persistence.[57,58,59] Low SES and underrepresented minority students are especially sensitive to debt from student loans, and are often more reluctant to go into debt.
- **Offered early in the undergraduate program-** Financial aid during the first year of college is positively associated with degree completion.[60]
- **Service component that provides career insight or addresses a societal need –** The service component may help students refine their interests and stay in a STEM-based career after college. Scholarships for service may also encourage students to pursue majors/careers that address societal/workforce needs.

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[58] Nora, A., Barlow, L., & Crisp, G. (2006). Examining the tangible and psychosocial benefits of financial aid with student access, engagement, and degree attainment. *American Behavioral Scientist,* 49(12), 1636-1651.
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[60] Bradburn, E. M. (2002). Short-term enrollment in postsecondary education: Student background and institutional differences in reasons for early departure, 1996-98 (NCES 2003153). Washington, DC: U.S. Government Printing Office.

Studies have identified a range of benefits stemming from scholarships including:

- **Improved retention and degree completion–** Numerous studies have linked various forms of financial aid to increased student persistence.[61,62]
  - Gift Aid: Gift aid in the form of scholarships and grants has a particularly positive effect on student retention, and debt associated with student loans has a negative effect on persistence.[63,64,65] STEM majors receiving gift aid have higher retention rates than those receiving only loans or a combination of loans and gift aid.[66]
  - Aid in Exchange for Work/Service: Working on campus, or working fewer than 14 hours per week is also positively associated with degree completion.[67,68,69] For students working on campus, the likelihood of completing an undergraduate degree increases 2% for each year of work.
  - Need-Based Aid: Scholarships have the greatest effect on degree completion when awarded to students with outstanding financial need.[70] In contrast, in Florida and Georgia, after implementing state merit-aid programs, there have been only marginal increases in STEM enrollment and degree completion. (Zhang, 2011). Findings from another study predicted that many recipients of merit-based scholarships would have completed degrees in STEM regardless of whether they received scholarships or not.[71]
- **Greater likelihood of pursuing graduate study –** Underrepresented minorities in STEM majors are more likely to use student loans to fund their undergraduate degrees, and less likely to go into greater debt to pursue graduate degrees.[72] Therefore, scholarships may lessen financial burdens that would deter students from furthering their education.

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Intervention: Combination of Interventions

Programs that combine a number of interventions for compounded effects.

Descriptions of some successful Combination Programs:

- **The Meyerhoff Scholars Program –** Based at the University of Maryland, Baltimore County, this program provides financial aid, student learning communities, summer bridge programs, mentoring, personal advising and counseling, and research internships in one comprehensive program. The program is designated for undergraduate students, with a focus on women and minority students pursuing STEM degrees.
- **The Louis Stokes Alliances for Minority Participation (LSAMP) –** This national program was established in 1991 by the National Science Foundation (NSF) to develop strategies to increase the quality and quantity of minority students who successfully complete baccalaureate degrees in STEM fields, and who continue on to graduate studies in these fields. The program incorporates undergraduate research internships, student learning communities, summer bridge programs, scholarships, and financial aid.
- **The Freshman Research Initiative (FRI) –** Based at the University of Texas, Austin, this program provides on-campus research experiences to first year students in STEM majors. Participants are paired with faculty and peer mentors, participate in a learning community with other FRI participants, and engage in outreach activities intended to expose K-12 students to research in STEM fields. The program is funded by the National Science Foundation and the Howard Hughes Medical Institute.

Studies have identified a broad range of benefits stemming from Combination Programs including:

- **Increased STEM Retention and Graduation –** Meyerhoff Scholars were more than twice as likely to graduate in a STEM major, in comparison to equally talented peers who turned down the program.[73,74]
- **GPA-** Participants in LSAMP programs had higher undergraduate GPAs in comparison with national samples of peers who did not participate in LSAMP.[75] Similarly, Meyerhoff Scholars earned higher GPAs than other peers in STEM majors.[70] Research on

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the Freshman Research Initiative at the University of Texas also has also shown consistent findings, with increased GPAs among research participants.[76]

- **Graduate Coursework and Degree Programs –** A national sample of LSAMP participants took graduate coursework at a rate 20 percent higher than their peers in STEM nationwide.[72] These students were also 20 percent more likely to complete their graduate degrees in comparison to their peers who did not participate in LSAMP.[71] Meyerhoff Scholars were more than 35 percent more likely to enter graduate or professional degree programs than peers who did not participate in the Meyerhoff program.[70]

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