

Academic Resources by Hallmarks

The DPC is a national research project in which the NIH collaborates with institutions implementing interventions and evaluative practices designed to understand effective approaches to mentoring, student engagement, research capacity building, faculty development and infrastructure development. To guide this evaluation, the DPC produced the Arc of Success, mapping the biomedical research career path.

STU (Student)-1 & 2: Self-Efficacy

Specific Focus: Introduction to Self-Efficacy

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, 84(2), 191-215.

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Bandura, A., and Adams, N. E. (1977). Analysis of self-efficacy theory of behavioral change. *Cognitive Therapy and Research*, 1(4), 287-310.

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Specific Focus: Academic Self-Efficacy

Bilgin, I., Karakuyu, Y., & Ay, Y. (2015). The effects of project based learning on undergraduate students' achievement and self-efficacy beliefs towards science teaching. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(3), 469-477.

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- Gore Jr, P. A. (2006). Academic self-efficacy as a predictor of college outcomes: Two incremental validity studies. *Journal of Career Assessment*, 14(1), 92-115.
- Honicke, T., & Broadbent, J. (2016). The influence of academic self-efficacy on academic performance: A systematic review. *Educational Research Review*, 17(1), 63-84.
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- Schunk, D. H. (1991). Self-efficacy and academic motivation. *Educational Psychologist*, 26(3-4), 207-231.
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Specific Focus: Career Self-Efficacy

- Betz, N. E., & Hackett, G. (2006). Career self-efficacy theory: Back to the future. *Journal of Career Assessment*, 14(1), 3-11.
- Betz, N. E., & Hackett, G. (1981). The relationship of career-related self-efficacy expectations to perceived career options in college women and men. *Journal of Counseling Psychology*, 28(5), 399-410.
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- Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, 45(1), 79-122.
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Specific Focus: Self-Efficacy (Generally) in STEM

- Ballen, C. J., Wieman, C., Salehi, S., Searle, J. B., & Zamudio, K. R. (2017). Enhancing diversity in undergraduate science: Self-efficacy drives performance gains with active learning. *CBE Life Sciences Education*, 16(4), ar56. DOI:10.1187/cbe.16-12-0344

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Specific Focus: Mentorship and STEM

Christe, B. (2013). The Importance of Faculty-Student Connections in STEM Disciplines: A Literature Review. *Journal of STEM Education: Innovations & Research*, 14(3), 22-26.

Specific Focus: Self-Efficacy for Underrepresented and/or Disadvantaged Groups (URGs)

Byars, A., & Hackett, G. (1998). Applications of social cognitive theory to the career development of women of color. *Applied and Preventive Psychology*, 7, 255-267.

Carpi, A., Ronan, D. M., Falconer, H. M., & Lents, N. H. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching*, 54(2), 169-194.

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Wilson, D., Bates, R., Scott, E. P., Painter, S. M., & Shaffer, J. (2015). Differences in self-efficacy among women and minorities in STEM. *Journal of Women and Minorities in Science and Engineering*, 21(1). ar34. DOI:10.1187/cbe.16-07-0211

Specific Focus: Research Self-Efficacy

Adedokun, O. A., Bessenbacher, A. B., Parker, L. C., Kirkham, L. L., & Burgess, W. D. (2013).

Research skills and STEM undergraduate research students' aspirations for research careers: Mediating effects of research self-efficacy. *Journal of Research in Science Teaching*, 50(8), 940-951.

Maton, K. I., Beason, T. S., Godsay, S., Sto. Domingo, M. R., Bailey, T. C., Sun, S., & Hrabowski III, F. A. (2016). Outcomes and processes in the Meyerhoff scholars program: STEM PhD completion, sense of community, perceived program benefit, science identity, and research self-efficacy. *CBE Life Sciences Education*, 15(3), ar48. DOI:10.1187/cbe.16-01-0062

Specific Focus: Research Self-Efficacy in the Biomedical Disciplines for URGs

Gibbs Jr, K. D., McGready, J., & Griffin, K. (2015). Career development among American biomedical postdocs. *CBE Life Sciences Education*, 14(4), ar44. DOI:10.1187/cbe.15-03-0075

Bakken, L. L., Byars-Winston, A., Gundermann, D. M., Ward, Ward, E.C., Slattery, A., King, A., Scott, D. & Taylor, R.E. (2010). Effects of an educational intervention on female biomedical scientists' research self-efficacy. *Advances in Health Sciences Education*, 15(2), 167-183.

STU (Student)-3: High Science Identity

(*last updated 10-15-2019)

Estrada, M., Woodcock, A., Hernandez, P. R., & Schultz, P. W. (2011). Toward a model of social influence that explains minority student integration into the scientific community. *Journal of Educational Psychology*, 103(1), 206-222.

Kelman, H. C. (2006). Interests, relationships, identities: Three central issues for individuals and groups in negotiating their social environment. *Annual Review of Psychology*, 57(1), 1-26.

Kelman, H. C. (1958). Compliance, identification, and internalization three processes of attitude change. *Journal of Conflict Resolution*, 2(1), 51-60.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44(8), 1187-1218.

Chang, M. J., Eagan, M. K., Lin, M. H., & Hurtado, S. (2011). Considering the impact of racial stigmas and science identity: Persistence among biomedical and behavioral science aspirants. *The Journal of Higher Education*, 82(5), 564-596.

Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological Science*, 18(10), 879-885.

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STU (Student)-4: Satisfaction with Quality of Mentorship

(*last updated 10-15-2019)

Specific Focus: Quality, Quantity, & Satisfaction/Perceptions

Allen, T. D., Eby, L. T., & Lentz, E. (2006). Mentorship behaviors and mentorship quality associated with formal mentoring programs: closing the gap between research and practice. *Journal of Applied Psychology*, 91(3), 567.

- Estrada, M., Hernandez, P. R., & Schultz, P. W. (2018). A longitudinal study of how quality mentorship and research experience integrate underrepresented minorities into STEM careers. *CBE Life Sciences Education, 17*(1), ar9.
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- Hayes, A. R., & Bigler, R. S. (2013). Gender-related values, perceptions of discrimination, and mentoring in STEM graduate training. *International Journal of Gender, Science and Technology, 5*(3), 254-280.
- Hernandez, P. R., Estrada, M., Woodcock, A., & Schultz, P. W. (2017). Protégé perceptions of high mentorship quality depend on shared values more than on demographic match. *The Journal of Experimental Education, 85*(3), 450-468.
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- Kendricks, K. D., Nedunuri, K. V., & Arment, A. R. (2013). Minority student perceptions of the impact of mentoring to enhance academic performance in STEM disciplines. *Journal of STEM Education: Innovations & Research, 14*(2), 38-46.
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- Van Eps, M. A., Cooke, M., Creedy, D. K., & Walker, R. (2006). Student evaluations of a year-long mentorship program: A quality improvement initiative. *Nurse Education Today, 26*(6), 519-524.
- Xu, X., & Payne, S. C. (2014). Quantity, quality, and satisfaction with mentoring: What matters most? *Journal of Career Development, 41*(6), 507-525.
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<https://doi.org/10.1186/s40594-016-0043-2>.

STU (Student)-5: Perceived Sense of Belonging Within the Research Community

(*last updated 10-15-2019)

- Bollen, K. A., & Hoyle, R. H. (1990). Perceived cohesion: A conceptual and empirical examination. *Social Forces, 69*(2), 479-504.
- Hoffman, M., Richmond, J., Morrow, J., & Salomone, K. (2002). Investigating “sense of belonging” in first-year college students. *Journal of College Student Retention: Research, Theory & Practice, 4*(3), 227-256.
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STU (Student)-9: Persistence in Biomedical Degree or other Formal Research Training Program

(*last updated 10-15-2019)

Specific Focus: Persistence in Biomedical/STEM Baccalaureate Attainment

- Allen, J., & Robbins, S. B. (2008). Prediction of college major persistence based on vocational interests, academic preparation, and first-year academic performance. *Research in Higher Education*, 49(1), 62-79.
- Chang, M. J., Cerna, O., Han, J., & Saenz, V. (2008). The contradictory roles of institutional status in retaining underrepresented minorities in biomedical and behavioral science majors. *The Review of Higher Education*, 31(4), 433-464.
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Specific Focus: Persistence in Biomedical/STEM Graduate Programs

- Foltz, L. G., Gannon, S., & Kirschmann, S. L. (2014). Factors that contribute to the persistence of minority students in STEM fields. *Planning for Higher Education*, 42(4), 1-13.
- Gazley, J. L., Remich, R., Naffziger Hirsch, M. E., Keller, J., Campbell, P. B., & McGee, R. (2014). Beyond preparation: Identity, cultural capital, and readiness for graduate school in the biomedical sciences. *Journal of Research in Science Teaching*, 51(8), 1021-1048.
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- Hall, J. D., Harrell, J. R., Cohen, K. W., Miller, V. L., Phelps, P. V., & Cook, J. G. (2016). Preparing postbaccalaureates for entry and success in biomedical PhD programs. *CBE Life Sciences Education*, 15(3), ar27. <https://www.lifescied.org/doi/pdf/10.1187/cbe.16-01-0054>
- Pacheco, W. I., Noel Jr, R. J., Porter, J. T., & Appleyard, C. B. (2015). Beyond the GRE: Using a composite score to predict the success of Puerto Rican Students in a biomedical PhD program. *CBE Life Sciences Education*, 14(2), ar13. <https://www.lifescied.org/doi/pdf/10.1187/cbe.14-11-0216>
- Palmer, R. T., Maramba, D. C., & Dancy, T. E. (2011). A qualitative investigation of factors promoting the retention and persistence of students of color in STEM. *The Journal of Negro Education*, 80(4), 491-504.
- Reichert, W. M. (2006). A success story: Recruiting & retaining underrepresented minority doctoral students in biomedical engineering. *Liberal Education*, 92(3), 52-55.
- Remich, R., Jones, R., Wood, C. V., Campbell, P. B., & McGee, R. (2016). How women in biomedical PhD programs manage gender consciousness as they persist toward academic research careers. *Academic Medicine* 91(8), 1119-27.
- Rohrbaugh, M. C., & Corces, V. G. (2011). Opening pathways for underrepresented high school students to biomedical research careers: the Emory University RISE program. *Genetics*, 189(4), 1135-1143.
- Wilson, M. A., DePass, A. L., & Bean, A. J. (2018). Institutional interventions that remove barriers to recruit and retain diverse biomedical PhD students. *CBE Life Sciences Education*, 17(2), ar27. <https://www.lifescied.org/doi/pdf/10.1187/cbe.17-09-0210>

Specific Focus: Measurements of Persistence

- Byars-Winston, A., Rogers, J., Branchaw, J., Pribbenow, C., Hanke, R., & Pfund, C. (2016). New measures assessing predictors of academic persistence for historically underrepresented racial/ethnic undergraduates in science. *CBE Life Sciences Education*, 15(3), ar32. <https://www.lifescied.org/doi/pdf/10.1187/cbe.16-01-0030>

Specific Focus: Undergraduate Research Programs

- Alfred, L. J., Atkins, C., Lopez, M., Chavez, T., Avila, V., & Paolini, P. (2005). A science pipeline pathway for training underrepresented students in the biomedical sciences. *Journal of Women and Minorities in Science and Engineering*, 11(1), 45-60.
- Carter, F. D., Mandell, M., & Maton, K. I. (2009). The influence of on-campus, academic year undergraduate research on STEM Ph.D. outcomes: Evidence from the Meyerhoff Scholarship Program. *Educational Evaluation and Policy Analysis*, 31(4), 441-462.
- Ghee, M., Keels, M., Collins, D., Neal-Spence, C., & Baker, E. (2016). Fine-tuning summer research programs to promote underrepresented students' persistence in the STEM pathway. *CBE Life Sciences Education*, 15(3), ar28. <https://www.lifescied.org/doi/pdf/10.1187/cbe.16-01-0046>

Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A. B., & Handelsman, J. (2013). Increasing persistence of college students in STEM. *Science*, *341*(1), 1455-1456.

Hurtado, S., Cabrera, N. L., Lin, M. H., Arellano, L., & Espinosa, L. L. (2009). Diversifying science: Underrepresented student experiences in structured research programs. *Research in Higher Education*, *50*(2), 189-214.

Jones, M. T., Barlow, A. E., & Villarejo, M. (2010). Importance of undergraduate research for minority persistence and achievement in biology. *The Journal of Higher Education*, *81*(1), 82-115.

Myers, C. B., & Pavel, D. M. (2011). Underrepresented students in STEM: The transition from undergraduate to graduate programs. *Journal of Diversity in Higher Education*, *4*(2), 90-105.

Vieyra, M., Gilmore, J., & Timmerman, B. (2011). Requiring research may improve retention in STEM fields for underrepresented women. *Council on Undergraduate Research Quarterly*, *32*(1), 13-20.

STU (Student)-10: Frequent Receipt of Mentoring to Enhance Success in the Biomedical Pathway

(*last updated 10-15-2019)

Gregerman, S. R., Lerner, J. S., Von Hippel, W., Jonides, J., & Nagda, B. A. (1998). Undergraduate student-faculty research partnerships affect student retention. *The Review of Higher Education*, *22*(1), 55-72.

Hathaway, R. S., Nagda, B. A., & Gregerman, S. R. (2002). The relationship of undergraduate research participation to graduate and professional education pursuit: An empirical study. *Journal of College Student Development*, *43*(5), 614-631.

Pfund, C., Byars-Winston, A., Branchaw, J., Hurtado, S., & Eagan, K. (2016). Defining attributes and metrics of effective research mentoring relationships. *AIDS and Behavior*, *20*(2), 238-248.

STU (Student)-11: Participation in Mentored or Supervised Biomedical Research

(*last updated 10-15-2019)

Boyington, J. E., Maihle, N. J., Rice, T. K., Gonzalez, J. E., Hess, C. A., Makala, L. H., Jeffe, D.B., Ogedegbe, G., Rao, D., Dávila-Román, G., Pace, B.S., Jean-Louis, G., & Boutjdir, M. (2016). A perspective on promoting diversity in the biomedical research workforce: The National Heart, Lung, and Blood Institute's PRIDE Program. *Ethnicity & Disease*, *26*(3), 379-386.

Byington, C. L., Keenan, H., Phillips, J. D., Childs, R., Wachs, E., Berzins, M. A., Clark, K., Torres, M.K., Abramson, J., Lee, V., & Clark, E. B. (2016). A matrix mentoring model that effectively supports clinical and translational scientists and increases inclusion in biomedical research: Lessons from the University of Utah. *Academic Medicine*, *91*(4), 497-502.

Chopin, S. F. (2002). Undergraduate research experiences: The translation of science education from reading to doing. *The Anatomical Record*, *269*(1), 3-10.

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- Estrada, M., Hernandez, P. R., & Schultz, P. W. (2018). A longitudinal study of how quality mentorship and research experience integrate underrepresented minorities into STEM careers. *CBE Life Sciences Education*, 17(1), ar9. <https://www.lifescied.org/doi/pdf/10.1187/cbe.17-04-0066>
- Gregerman, S. R., Lerner, J. S., Von Hippel, W., Jonides, J., & Nagda, B. A. (1998). Undergraduate student-faculty research partnerships affect student retention. *The Review of Higher Education*, 22(1), 55-72.
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- Ognibene, F. P., Gallin, J. I., Baum, B. J., Wyatt, R. G., & Gottesman, M. M. (2016). Outcomes from the NIH Clinical Research Training Program: A mentored research experience to enhance career development of clinician-scientists. *Academic Medicine*, 91(12), 1684-1690.
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- Sweeney, J. K., & Villarejo, M. (2013). Influence of an academic intervention program on minority student career choice. *Journal of College Student Development*, 54(5), 534-540.
- Taylor, B. E., Reynolds, A. J., Etz, K. E., MacCalla, N. M., Cotter, P. A., DeRuyter, T. L., & Hueffer, K. (2017, December). BUILDing BLaST: Promoting rural students' biomedical research careers using a culturally responsive, one health approach. *BioMed Central Proceedings*, 11(Suppl 12), 13. DOI 10.1186/s12919-017-0092-7
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