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Building research capacity: A mentorship-centered approach to undergraduate training in regulatory science

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Abstract

Background

Regulatory science integrates scientific evidence, regulatory policy, quality systems, and public health to support the development, evaluation, approval, and postmarket oversight of healthcare technologies. Despite growing workforce demand across pharmaceutical, biotechnology, medical device, and digital health sectors, undergraduate exposure to the field remains limited. Structured research experiences may help introduce STEM students to regulatory and translational science while developing research skills and professional competencies.

Methods

This qualitative instructional study evaluated a scaffolded undergraduate research program in Regulatory Science from Fall 2018 to Fall 2026. STEM students participated in a competency-based model that progressively transitioned from faculty-guided learning to independent research. Outcomes were assessed through research products (abstracts, presentations, and reports) and annual reflective surveys, examining scientific communication, research independence, engagement, and perceived skill development.

Results and Discussion

Eighty students completed assessments between 2021 and 2026. Most reported improvements in presenting research findings (96.3%), confidence responding to research questions (95.0%), and research independence (93.8%). The largest gains were observed in literature review, methodology development, and presentation skills (96.3% each). Students also reported high engagement through faculty collaboration (96.3%) and scholarly networking (95.0%). Participation increased understanding of clinical research (97.5%) and regulatory science (96.3%), and 98.8% would recommend the program.

Conclusions

A scaffolded mentorship-based research model supported the development of undergraduate research competencies, scientific communication skills, and research independence in Regulatory Science. This approach may serve as a scalable framework for expanding undergraduate research opportunities and strengthening workforce preparation in the biomedical and health sciences.

Keywords:

Pharmacy Undergraduate, Scaffolding, Research, Regulatory Science, Critical Thinking, Mentorship

Conflict of Interest

None

Disclosures

None

Author Contribution

Terry David Church, substantial contributions, drafting and critical review, final approval, and accountability.

Karen Manrique, substantial contributions, drafting and critical review, final approval, and accountability.

Jeremiah Lee, substantial contributions, drafting and critical review, final approval, and accountability.

Eunjoo Pacifici, substantial contributions, drafting and critical review, final approval, and accountability.

Introduction

Undergraduate research experiences have become critical components; offering students early immersion in the practices, norms, and intellectual rigor of scientific inquiry, this is especially important for students in STEM programs(1-3). Increasingly, STEM undergraduates seek research opportunities that provide hands-on skill development, exposure to distinct and emerging scientific domains, and engagement beyond the traditional wet-lab environment, which represents an evolution consistent with broader shifts in STEM career pathways(4-11). Over the past decade, the conventional BS-to-PhD trajectory has diversified, with many students entering the workforce directly after earning their bachelor's degree or pursuing accelerated BS-to-MS programs designed to cultivate applied competencies relevant to the pharmaceutical industry, public health, and healthcare administration(12, 13). These trends underscore the growing importance of undergraduate research as a mechanism for building professional readiness, scientific literacy, and career adaptability. Many of these skills can be taught through scaffolding, wherein the learner develops required competence through independent performance.

A career area of growth that may appeal to undergraduates interested in science is Regulatory Science. Regulatory science is a discipline that bridges scientific innovation and public health by ensuring that medicines, biologics, medical devices, and other healthcare technologies are developed, evaluated, approved, and monitored according to rigorous standards of safety, efficacy, and quality(14-19). The field offers diverse career opportunities in regulatory affairs, clinical research, quality assurance, drug safety, medical device regulation, consulting, and government agencies. As biotechnology, pharmaceutical, and medical device sectors continue to expand, there is growing demand for professionals who can integrate scientific knowledge with regulatory and business expertise to guide products from discovery to patient use.

For undergraduates, regulatory science provides a distinctive research experience by connecting scientific inquiry with real-world healthcare challenges. Research opportunities often explore topics such as clinical trial design, drug and device safety, quality systems, health policy, and emerging technologies

including artificial intelligence and personalized medicine. This interdisciplinary focus appeals to students interested in science, medicine, public health, policy, and industry careers because it offers a direct view of how research and innovation improve patient outcomes.

Despite expanding opportunities, regulatory science remains an underexplored field for most STEM undergraduates, even though it represents a rapidly growing sector within the biomedical and life sciences workforce(20). At the University of Southern California (USC), students encounter Regulatory Science through coursework in the Pharmacy Undergraduate Program, peer-to-peer dissemination of research experiences, and University-wide promotion of emerging academic initiatives(21). USC is uniquely positioned to support early engagement in this field as the Alfred E. Mann School of Pharmacy and Pharmaceutical Sciences houses a dedicated Department of Regulatory and Quality Sciences[1], where faculty teach across undergraduate and graduate levels and actively mentor students in applied research. Within this ecosystem, the Regulatory Science (RegSci) Research Team has emerged as a structured, research-intensive opportunity that introduces undergraduates to regulatory and translational science through sustained scholarly engagement.

Regulatory science has emerged as a critical interdisciplinary domain that equips students with the knowledge and competencies necessary to navigate the complex ecosystem governing medical product development, evaluation, and oversight(16). As scientific innovation accelerates, particularly in pharmaceuticals, biotechnology, medical devices, and digital health, there is a growing need for professionals who can integrate scientific evidence, regulatory policy, and quality systems to ensure that new technologies reach patients safely, effectively, and efficiently(17). Undergraduate engagement in Regulatory Science provides early exposure to these translational processes, strengthening scientific literacy and preparing students for diverse career pathways across industry, government, and academia. As the biomedical landscape continues to evolve, early engagement in regulatory science equips students

[1] https://mann.usc.edu/departments/regulatory-quality-science-department/

with the interdisciplinary competencies necessary for leadership in an increasingly complex and globally interconnected health innovation ecosystem(16).

The RegSci Research Team provides a comprehensive research environment designed to strengthen students' methodological competencies, scientific communication skills, and professional development. Participants receive targeted instruction in research methodology, abstract preparation, public speaking, and academic rigor. A central feature of the program is collaborative learning: students present their work at bimonthly meetings, engage in critical dialogue with peers and faculty, and refine their projects through iterative feedback. Complementary workshops train students to evaluate scientific manuscripts, conduct constructive peer reviews, and apply best practices in scientific communication. During the summer, students participate in the Summerfest program, enrolling in graduate-level regulatory science coursework and attending seminars led by international scholars. These are valuable experiences that broaden global research networks and deepen understanding of regulatory and translational science.

For emerging scientists, oral and poster presentations represent essential milestones in the development of scholarly identity(22, 23). These activities cultivate communication skills, facilitate intellectual exchange, and foster professional connections across scientific communities(24, 25). Preparing for academic presentations requires mastery of relevant literature, methodological clarity, and analytical precision. These competencies are foundational to independent research, advanced study, and future funding pursuits(26). As STEM career pathways continue to evolve, structured undergraduate research programs such as the RegSci Research Team play a vital role in preparing students for the demands of contemporary scientific practice.

Instructional Framework

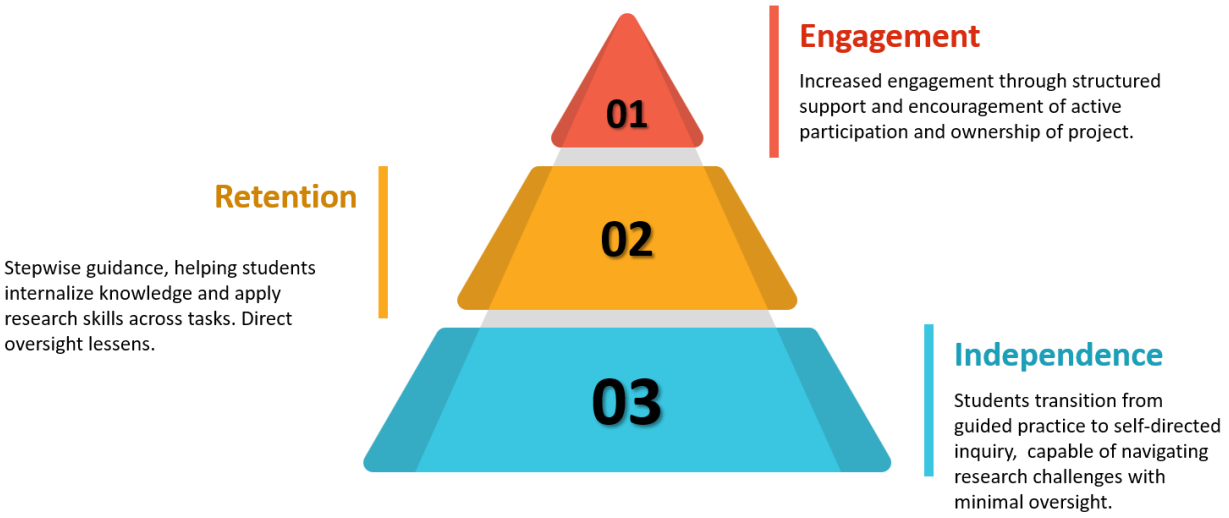
Undergraduate researchers in the RegSci Research Team engage in a structured, immersive training model designed to cultivate mastery of the methodological, analytical, and conceptual foundations required for high-quality scientific inquiry. The program emphasizes substantive intellectual contribution to student-selected research topics, which is a pedagogical strategy shown to enhance long-term engagement in clinical research and regulatory science. Each student collaborates closely with a faculty mentor and works alongside experienced research staff, graduate trainees, and peer undergraduate researchers. This team-based mentorship structure provides continuous guidance, real-time feedback, and authentic exposure to collaborative scientific environments(27-29). Through this model, students develop core research competencies, deepen scientific curiosity, and maintain sustained engagement across all phases of the research process.

A central feature of the RegSci Research Team's instructional approach is its use of a scaffolding model for research training(30, 31). Scaffolding, an established educational strategy, supports learners by providing structured assistance that is gradually withdrawn as students gain independence and proficiency(32-35). Within the RegSci context, faculty and staff initially offer high levels of support—demonstrating research tasks, modeling methodological decision-making, and guiding students through structured practice. As students build confidence and competence, this support is intentionally reduced, enabling them to assume greater autonomy in conducting literature reviews, designing methods, analyzing data, and preparing scholarly outputs. This progression ensures that learning remains accessible while appropriately challenging, thereby promoting both engagement and retention.

Three core features of scaffolding directly enhance the undergraduate research experience (Figure 1). First, increased engagement emerges through structured support that encourages active participation and fosters a sense of ownership over research projects(33, 36). Students become invested in advancing their work and seeing it through to completion(33). Second, improved retention is facilitated by stepwise guidance, which helps students internalize methodological knowledge and apply research skills effectively across tasks(37). Third, development of independence is achieved as students transition from

guided practice to self-directed inquiry, ultimately becoming capable of navigating complex research challenges without continuous oversight(34).

Figure 1: Educational Features of Scaffolding



Scaffolding thus functions as a dynamic, adaptive instructional approach that supports novice researchers while progressively cultivating independence, mastery, and critical thinking(35, 38). Within the RegSci Research Team, this model ensures that undergraduate researchers not only acquire foundational skills but also evolve into confident, capable contributors to regulatory and translational science.

Methodology

This research was approved by the University of Southern California Internal Review Board, under protocol UP-21-00581: *Pharmacy Undergraduate Programs: Development of an Adaptive Curriculum for Student Success*. All the data accessed for this study was provided in aggregate form, no student names or identifiers were available. This research was not funded, and the authors have no conflicts of interest to report.

This study employed a qualitative, instructional research design to examine how undergraduate participation in the Regulatory Science (RegSci) Research Team supports the development of

methodological competence, scientific communication skills, and research independence(4, 39, 40). The instructional framework guiding the program is grounded in a team-based mentorship model and a scaffolding approach to research training, both of which were systematically implemented and evaluated throughout the study period, Fall 2018 to Fall 2026(27, 41).

Undergraduate participants were recruited from STEM majors across the university and enrolled in a structured, yearlong research training sequence, with many students continuing for 2-3 years in the research team. Each student selected a research topic aligned with their interests in regulatory science, ensuring substantive intellectual ownership of their project. Students were paired with a faculty mentor and embedded within a multidisciplinary research team that included graduate students, research staff, and peer undergraduate researchers. This team-based model provided continuous guidance, real-time feedback, and exposure to collaborative scientific environments.

Students engaged in self-directed weekly research activities that included literature review, methodological planning, data collection, data analysis, and preparation of scholarly outputs. Bi-monthly research meetings served as checkpoints for progress, peer feedback, and faculty evaluation. In addition, students met with their faculty advisors and staff bi-weekly to provide research updates and obtain individual feedback. These meetings functioned as structured opportunities for students to practice scientific communication through oral presentations and iterative refinement of research ideas.

The RegSci Research Team implemented a scaffolding-based instructional strategy to support students' progression from novice to independent researcher(36, 42). Scaffolding was implemented as a structured, competency-based progression in which instructional support was calibrated to students' developing research skills. At the beginning of their participation in the research team, students received intensive guidance from faculty and staff. This included direct instruction in core methodological procedures, demonstrations of research tasks, and the use of structured templates to support early project planning. Faculty provided stepwise coaching during initial project development and offered targeted workshops on specific research techniques throughout the onboarding period.

As students demonstrated increasing methodological fluency, mentors gradually reduced the level of instructional direction. Guidance shifted toward facilitative questioning designed to prompt students to justify methodological choices, interpret emerging data, and troubleshoot challenges independently. This transition allowed students to assume greater responsibility for shaping the trajectory of their projects while still having access to mentor feedback when needed.

Once students exhibited sustained competence in managing their research activities, they were expected to operate with a high degree of autonomy. Faculty and staff limited their involvement to scheduled check-ins or student-initiated consultations. At this stage, students directed the day-to-day advancement of their projects, engaged in independent problem solving, and applied critical thinking to methodological and analytical decisions. Scaffolding thus functioned as a dynamic instructional mechanism that systematically shifted responsibility from faculty mentors to students as their expertise developed.

Data were collected through multiple sources to assess the effectiveness of the instructional model: 1) student artifacts (research plans, abstracts, presentations, and written reports) were evaluated using standardized rubrics aligned with program learning objectives; and 2) Annual survey of RegSci collected end-of-year reflections. These data provided qualitative insight into students' perceived growth, challenges, and skill development.

These data sources were analyzed to identify patterns related to skill acquisition, engagement, retention, and development of research independence. Primary outcome measures included: 1) scientific communication proficiency, measured through oral and poster presentation performance; 2) engagement and retention, evaluated through the development of research competencies and qualitative indicators of self-reported impact of research; and 3) independence and critical thinking, assessed through student self-report. Collectively, these measures provided a comprehensive assessment of how structured mentorship and scaffolding contribute to undergraduate research development within Regulatory Science.

Results and Discussion

Demographics

RegSci Research Team began in the fall of 2018 and has grown from 5 students, 3 faculty members, and 1 staff member to fall of 2026 with 14 students, 5 faculty members, and 2 staff members (Table 1). A total of 151 students, including 117 undergraduates, 13 Master's students, and 7 PharmD students have been part of RegSci Research Team.

Table 1: Student Demographics

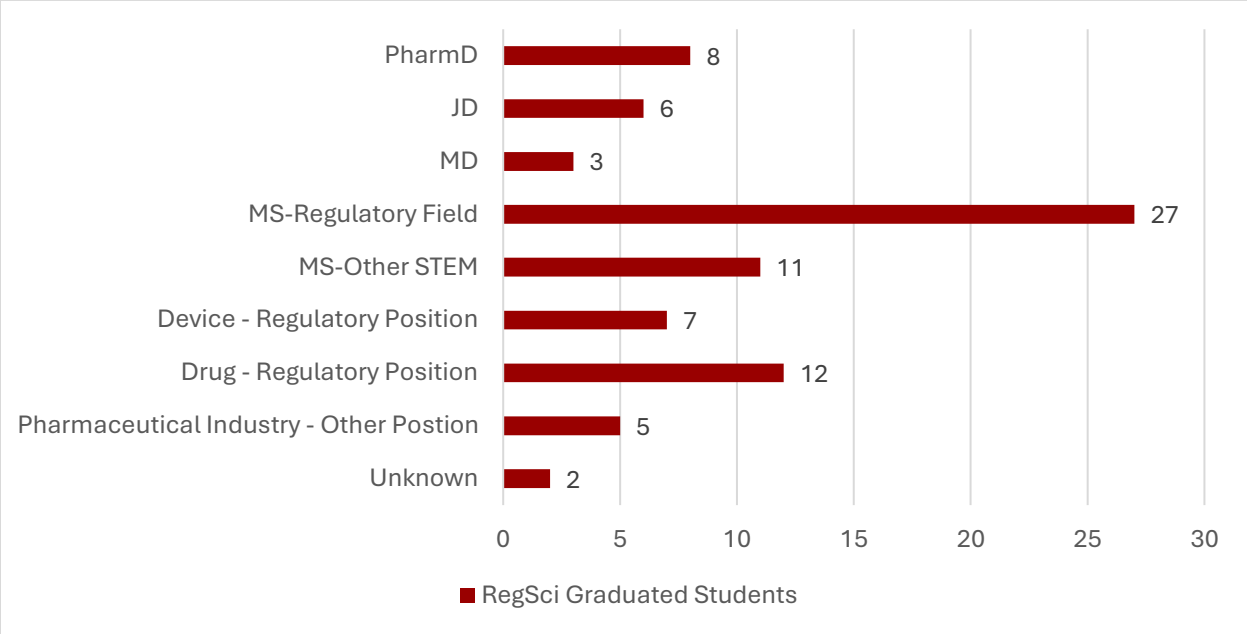
Category	**Total Number (2018-2026)**	**Number Fall 2026 Cohort**
Undergraduate Student	117	29
*Master's Student**	*13*	*2*
*PharmD Student**	*7*	*1*
Male	41	6
Female	76	23
Caucasian	22	6
African American	6	1
Hispanic	15	5
Asian	61	14

Other	13	3

* - Master's and PharmD level students are not the direct focus of this study; however, the RegSci Research Team does incorporate all learners

There have been 81 RegSci Research Team members who graduated from USC between 2018 and 2025. The outcome post-graduation for these students can be seen in Figure 2. The majority of graduated students from our research team have gone on to pursue their Master's degree in Regulatory Science, at 33% (27/81). The next largest destination for our graduated students was directly into the pharmaceutical industry, with 29% (24/81) employed either in drugs, devices, or other pharma industry positions. Advanced degrees were the third largest category for research team members who have graduated, which represents 20% (17/81) who have gone on to PharmD, MD, or JD degrees. A little over 13% (11/81) of students have gone on for Master's education in a STEM related field. There were a small group of graduated students whom were listed as unknown due primarily to loss of contact at 2% (2/81).

Figure 2: RegSci Post-Graduation Status (n = 101)



Funding Support

Another measure of the success of the program can be attributed to the number of students who have received USC Provost's Undergraduate Research Fellowships and in the number of faculty who have been awarded USC Undergraduate Research Associates Program Awards. Both sets of awards are highly competitive. Faculty and staff work with their RegSci Research Team students to prepare their applications, which includes a clear research design. Students can apply for stipends of up to $1,000 per semester (fall and spring) and $3,000 for summer research from the Provost's Office. The Undergraduate Research Fellowship awards require the submission of a research proposal, recommendation letter from the student's faculty mentor, and agreement to commit to 8-10 hours per week to dedicate time to pursuing their research topic. Students must further provide a summary of their research progress at the conclusion of each semester of funding.

Faculty can apply annually for a USC Undergraduate Research Associates Program award. The intent with these awards is to engage undergraduate students in research. These awards are intended to provide collaborative research between undergraduate students and faculty members. Each award is ~$10,000. In addition to proposing a unique research question(s), the faculty applicant must include specific training and educational components within their application. The funds can only be used to support undergraduate research with no more than 10% of the total award being utilized for materials / supplies. None of these funds can be used for staff or faculty support.

Table 2: Student and Faculty Funding Awarded Via USC Provost's Office (2018-2026)

Category	Total Number Awarded	Total Amount of Awards
USC Undergraduate Research Fellowships	35	$61,100
USC Undergraduate Research Associates Program	26	$117,500

Scholarly Output – Scientific Research Communication Proficiency

Students who join the RegSci Research Team average 2 full academic years of research with our group. Many produce multiple iterations of their research via posters, oral presentations, and manuscripts (Table 3). The list of professional conferences where RegSci Research Team members have presented includes National LGBTQ Health Conference, American Society of Gene & Cell Therapy (ASGCT), Drug Information Association (DIA), Association for Clinical and Translational Science (ACTS), American Pharmacists Association (APhA), and Regulatory Affairs Professionals Society (RAPS).

Table 3: Scholarly Output by Activity

Category	**Total Number (2018-2026)**
Poster Presentation – Professional Meeting	84
Poster Presentation – USC Research Event	48
Oral Presentation – Professional Meeting	10
Oral Presentation – USC Research Event	3
Manuscript	4

In addition, RegSci Research Team members have been invited to deliver oral presentations at professional conferences based on their work. They have presented at ACTS, DIA, and National LGBTQ Health Conference. In terms of advanced scholarship, there have been 4 publications in peer reviewed journals with the students as lead authors of original work with the RegSci Research Team. The publications were included in Journal of Clinical and Translational Science, and Journal of American Pharmacists Association, and Therapeutic Innovation & Regulatory Science.

Annual Survey Data – Competencies and Skills Development, Engagement, and Impact of Research

Beginning in 2021, we implemented an anonymized assessment survey to evaluate the educational impact of participation in the Regulatory Science Research Team and to identify opportunities for continuous program improvement. The survey was intentionally designed around a scaffolding approach to undergraduate research training, in which students build knowledge and skills progressively

through structured experiences, guided mentorship, and increasing levels of independence. Rather than expecting students to master complex research competencies at the outset, the program provides a sequence of learning opportunities that gradually move students from foundational tasks to more advanced scholarly activities. To evaluate this developmental process, five survey items assessed research competencies through a matrix question asking students to indicate their agreement with the statement, "conducting research with the Regulatory Science Research Team has helped develop…" (Figure 3). Six additional items measured research skill development through agreement with the statement, "conducting research with the Regulatory Science Research Team has enabled me to…" (Figure 4). Three items examined student engagement through agreement with the statement, "conducting research with the Regulatory Science Research Team provides me with…" (Figure 5). Finally, four items explored the broader impact of research participation through agreement with the statement, "conducting research with the Regulatory Science Research Team has…" (Figure 6).

Overall, survey findings demonstrate strong support for the use of a scaffolded research model to engage undergraduates in regulatory science research. Between 2021 and 2026, 80 students completed the survey. Competency development was examined through measures that reflect the increasing independence expected as students progress through the research experience, including working independently, adhering to project timelines, responding thoughtfully to questions about their research, articulating a clear research purpose, and presenting findings to various audiences (Figure 3). These competencies are intentionally reinforced through embedded activities that allow students to apply skills repeatedly and in context(43). The competency receiving the highest level of agreement was students' ability to present research findings, with 96.25% (77/80) indicating that participation helped them develop this skill. The second highest level of agreement was for the ability to answer questions about their research thoughtfully at 95% (76/80). Students also reported substantial growth in their ability to work independently and articulate a clear purpose for their research, both of which received agreement from

93.75% (75/80) of respondents. Together, these findings suggest that the scaffolded structure effectively supports students as they transition from guided learning to increasingly independent scholarly inquiry.

A central goal of the research team is to engage undergraduates in the process of knowledge generation while simultaneously developing the research skills necessary for future academic and professional success(44). Research skill development was assessed through students' perceptions of growth in conducting literature reviews, improving scientific writing, developing research methodologies, refining research questions, creating visual representations of data, and presenting research findings (Figure 4). These skills reflect successive stages within the research process and align with the scaffolded learning experiences incorporated throughout the program. Three skill areas received the highest level of agreement: conducting critical literature reviews, developing research methodologies, and presenting research findings, each receiving agreement from 96.25% (77/80) of students. Improvement in writing, although still viewed positively, received the lowest level of agreement at 81.25% (65/80). These findings suggest that undergraduate researchers particularly value opportunities to engage in the conceptual and methodological aspects of research while gaining experience communicating findings to others.

Student engagement is an essential component of successful undergraduate research experiences because it strengthens persistence, motivation, and long-term participation in scholarly activities. Scaffolded undergraduate research environments not only support skill acquisition but also foster meaningful connections among students, faculty, and the broader research community(30, 32, 45). Engagement was evaluated through students' perceptions of their ability to build relationships with other scholars, collaborate with peers, and collaborate with faculty members (Figure 5). The highest level of agreement was observed for collaboration with faculty, with 96.25% (77/80) of respondents indicating that participation provided meaningful opportunities for faculty interaction. Building relationships with other scholars received the second highest level of agreement at 95% (76/80). These findings highlight the importance of mentorship and scholarly community in creating an engaging research environment that

encourages continued participation in research and supports student development within the field of regulatory science.

The survey also examined the broader impact of participation in undergraduate regulatory science research (Figure 6). Prior studies have demonstrated that undergraduate research experiences contribute to student learning, retention, career readiness, and academic achievement(43, 46). Within the RegSci Research Team, students reported substantial benefits across several impact measures, including broadening their understanding of regulatory science, increasing their understanding of clinical research, supporting progress toward future academic or career goals, and encouraging them to recommend research participation to other students. The strongest level of agreement was observed for willingness to recommend participating in regulatory science research to other students, with 98.75% (79/80) expressing agreement. Broadening understanding of clinical research received agreement from 97.5% (78/80) of respondents, while broadening understanding of regulatory science received agreement from 96.25% (77/80). Collectively, these findings suggest that scaffolded research experiences not only strengthen research competencies and engagement but, also, increase students' understanding of regulatory science and clinical research while reinforcing the value of undergraduate research participation as a pathway to future academic and professional opportunities.

Figure 3: Competencies Development – Annual Student Survey (n = 80)

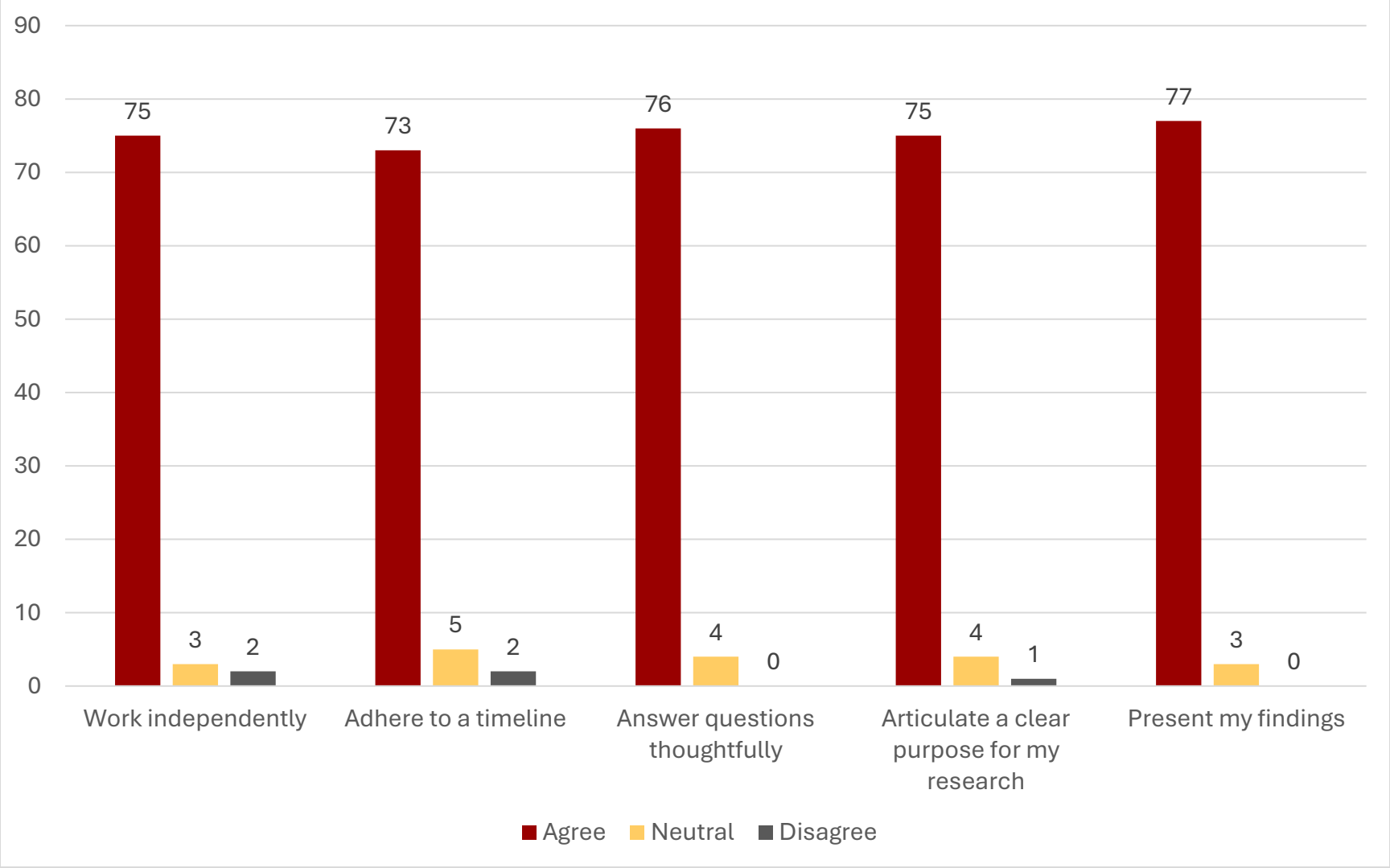


Figure 4: Skills Development - Annual Student Survey (n=80)

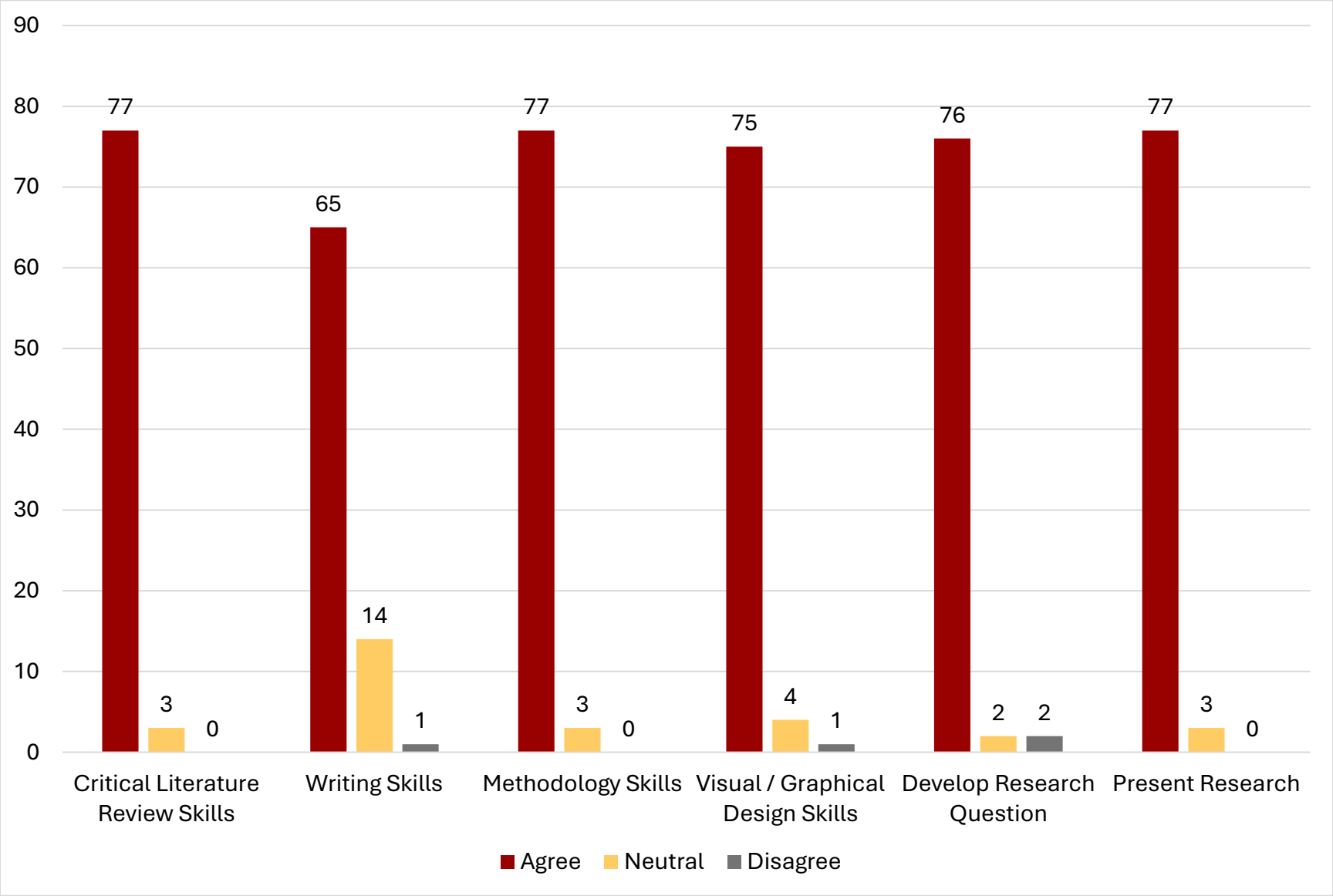


Figure 5: Engagement – Annual Student Survey (n = 80)

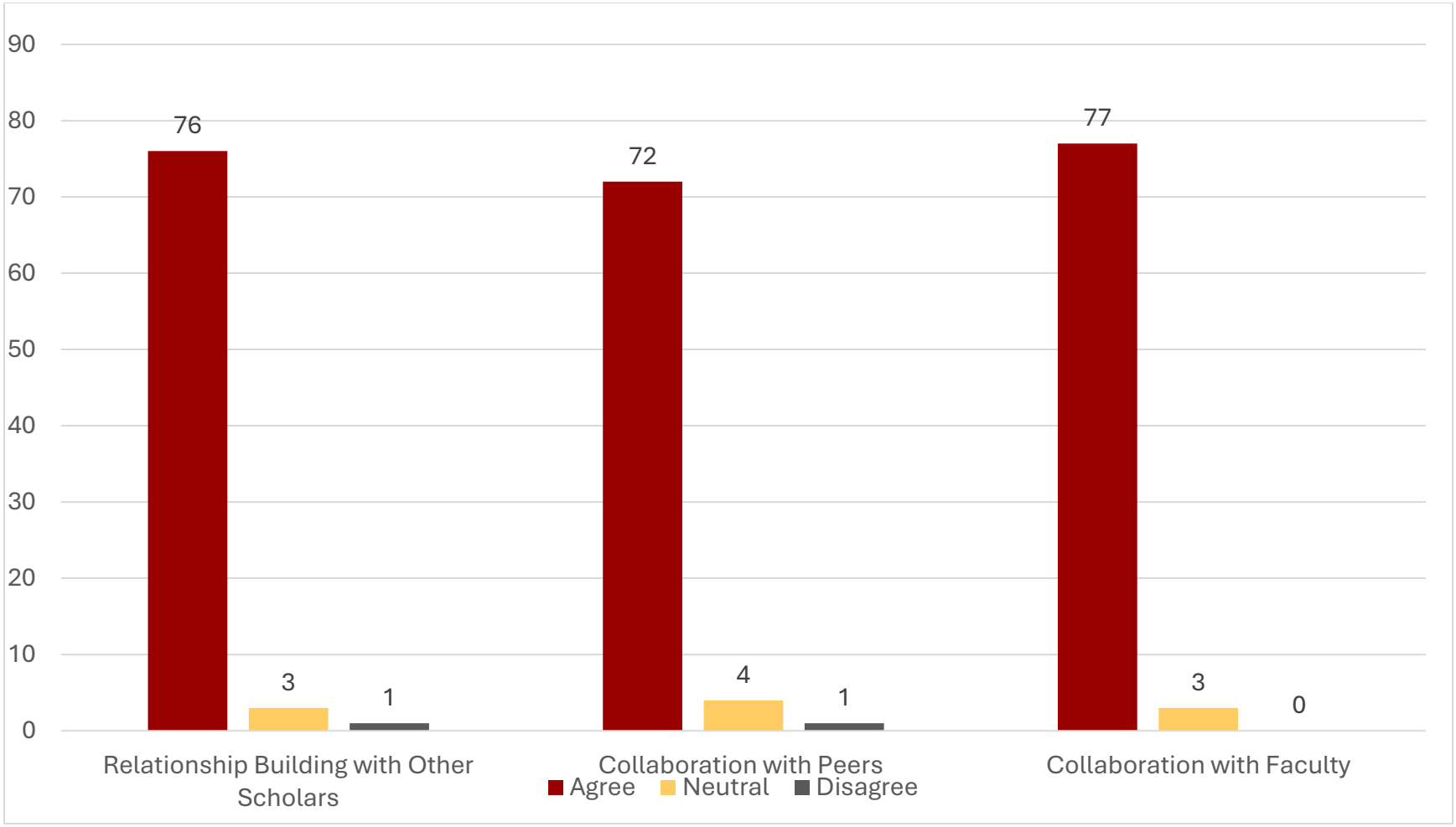
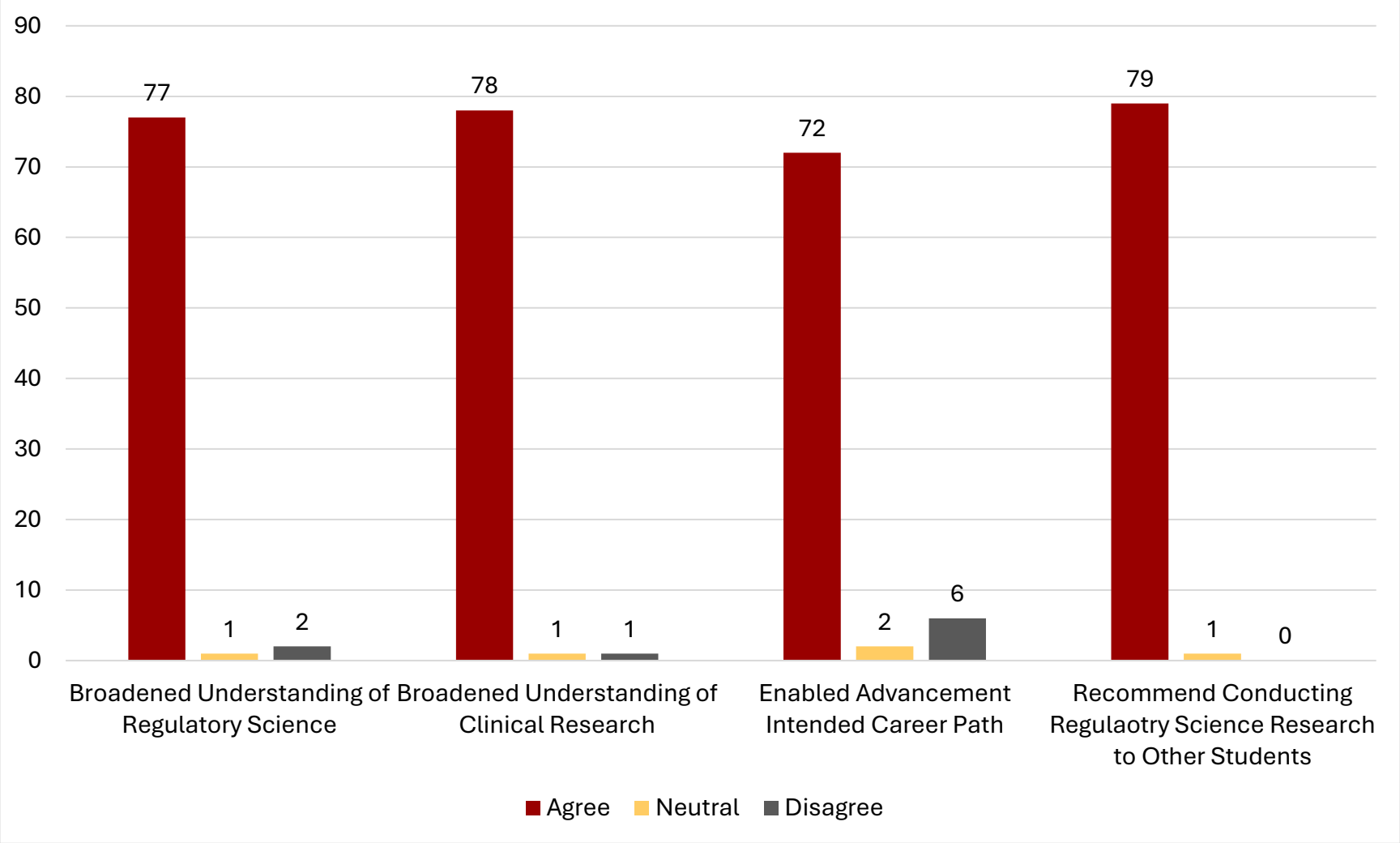


Figure 6: Impact of Regulatory Science Research – Annual Student Survey (n = 80)



Conclusion

Structured mentorship and intentional scaffolding have proven to be effective pedagogical strategies for cultivating a thriving undergraduate research environment in Regulatory Science. These approaches have enabled students to engage deeply in research, communicate their findings with increasing sophistication, and apply newly acquired competencies as they transition into advanced academic or professional pathways. Importantly, the mentorship model described here is both scalable and adaptable, making it feasible for institutions of varying sizes to implement similar structures that promote undergraduate research engagement.

Despite these strengths, several limitations warrant consideration. First, the sample size for this study is relatively small, which may constrain the generalizability of the findings. Second, the program's duration, less than a decade, limits long-term assessment of sustained outcomes and alumni trajectories. Third, the model requires consistent faculty and staff involvement, which may pose challenges for institutions with limited personnel resources. Although our institution provides Provost-level funding to support student participation, these funds do not extend to personnel support. Finally, the program has benefited from the participation of highly motivated students who entered with strong curiosity and a desire to learn; similar programs implemented elsewhere may encounter different levels of student readiness or engagement. These contextual factors should be acknowledged when considering broader adoption.

Even with these limitations, the RegSci Research Team at USC has demonstrated a meaningful impact on undergraduate development. Students have gained substantive research skills, strengthened their scientific communication abilities, and grown as independent, critical thinkers. The program's emphasis on individualized mentorship and alignment with student interests has contributed to high retention and sustained engagement. Students succeed because they can experience science in a

supportive environment that honors their intellectual autonomy while providing structured guidance from dedicated faculty and staff.

References

1. Friesen R, Cimetta A. Facilitating Departmental and Institutional Change for Expanding Undergraduate Research Experiences: The Effectiveness of a Microgrant. Journal of College Science Teaching. 2023;52(5):61–9.
2. Walkington H, Ommering B. How does engaging in authentic research at undergraduate level contribute to student well-being? Studies in Higher Education. 2022;47(12):2497–507.
3. Lent DD, Estes KM, Hansen AK. Increasing faculty involvement in the undergraduate interdisciplinary learning experience. Integrative and comparative biology. 2021;61(3):1002–12.
4. Hsu Y-S, Lai T-L, Hsu W-H. A design model of distributed scaffolding for inquiry-based learning. Research in Science Education. 2015;45(2):241–73.
5. Bettencourt GM, Wells RS, Auerbach SM, Fermann JT, Kimball E. How STEM Undergraduates Choose, Navigate, and Integrate Interdisciplinarity in College and Beyond. The Journal of Higher Education. 2023;94(2):174–99.
6. Bloodhart B, Balgopal MM, Casper AMA, Sample McMeeking LB, Fischer EV. Outperforming yet undervalued: Undergraduate women in STEM. PLoS One. 2020;15(6):1–13.
7. Davis JE. Commentary on Black Boys and Men in STEM. Journal of African American Males in Education (JAAME). 2020;11(2):7–11.
8. Freeman JB. Measuring and Resolving LGBTQ Disparities in STEM. Policy Insights from the Behavioral and Brain Sciences. 2020;7(2):141–8.
9. Miriti MN. The elephant in the room: Race and STEM diversity. Bioscience. 2020;70(3):237–42.
10. Haeger H, Bueno EH, Sedlacek Q, Shortlidge E. Participation in undergraduate research reduces equity gaps in STEM graduation rates. CBE - Life Sciences Education. 2024;23(1-12).
11. Batty L, Reilly K. Understanding barriers to participation within undergraduate STEM laboratories: towards development of an inclusive curriculum. J Biol Educ. 2023;57(5):1147–69.
12. Park JJ, Kim YK, Lue K, Parikh RM. What's Next? Soon-to-be STEM Graduates on Their Post-graduate Plans. Research in Higher Education. 2022;63(8):1343–67.
13. Mason S, Fernandez F, Sharp S, Chavira G, Khachikian C, Kwan P, et al. Enhancing graduate education pathways: A case study of a STEM undergraduate research experience program. Studies in Graduate and Postdoctoral Education. 2026;17(3):331–45.
14. FDA. Advancing Regulatory Science Through Research Silver Spring, MD: US. Department of Health and Human Services; 2024 [cited Y - 2026.
15. FDA. Advancing regulatory science at FDA: Focus areas of regulatory science (FARS) Silver Spring, MD: U.S. Department of Health and Human Services; 2022 [cited Y - 2024. 36].
16. Liberti L, Uniyal A, Church TD, Succar T, Pacifici E. Regulatory Science Education as a Foundational Health Policy. https://mann.usc.edu/news/white-paper-regulatory-science-education-as-afoundational-health-policy/: University of Southern California; 2026.
17. Richmond FJ, Church TD. Graduate Training Capacity for Regulatory Professionals at US Universities: Are We Facing a Talent Crisis? Therapeutic Innovation & Regulatory Science. 2020;54:947–52.
18. Volpi L, D'Agosto M, Melvin T, Sickmüller B, Thimm JS. Regulatory Science: exploring an emerging scientific discipline in health care. Frontiers in Medicine. 2026;Volume 13:1–7.

19. Moghissi AA, Steen TY, Calderone RA, Auffret JP, Jaeger L, Xu LS, et al. Regulatory Science: The Maturation of an Evolving Scientific Discipline. Journal of Regulatory Science. 2023;11(1):1–15.

20. RAPS. Global Regulatory Affairs Professionals Workforce Report. www.RAPS.org: Regulatory Affairs Professionals Society; 2024.

21. Church TD, Burkhardt A, Phan T, Davies D. Pharmacy Undergraduate Programs: Development of an adaptive curriculum for student success. Heliyon. 2023;9(2):1–14.

22. Gokulakrishnan K, Srikumar BN. Poster Presentation at Scientific Meetings. In: Jagadeesh G, Balakumar P, Senatore F, editors. The Quintessence of Basic and Clinical Research and Scientific Publishing. Singapore: Springer Nature Singapore; 2023. p. 785–90.

23. Church TD, Barrington-Trimis J, Williams V, Boelke J, Leventhal AM. Elevating Early-Career Voices in Addiction Science. Substance Use & Addiction Journal. 2026;0(0):https://doi.org/10.1177/29767342261448436.

24. Young J, Bridgeman MB, Hermes-DeSantis ER. Presentation of scientific poster information: Lessons learned from evaluating the impact of content arrangement and use of infographics. Currents in Pharmacy Teaching and Learning. 2019;11(2):204–10.

25. Rauschenbach I, Keddis R, Davis D. Poster Development and Presentation to Improve Scientific Inquiry and Broaden Effective Scientific Communication Skills. Journal of Microbiology & Biology Education. 2018;19(1):1–9.

26. Balon R, Guerra E, Meador-Woodruff JH, Oquendo MA, Salloum IM, Casiano DE, et al. Innovative approach to research training: research colloquium for junior investigators. Acad Psychiatry. 2011;35(1):11–4.

27. Guise J-M, Geller S, Regensteiner JG, Raymond N, Nagel J. Team Mentoring for Interdisciplinary Team Science: Lessons From K12 Scholars and Directors. Acad Med. 2017;92(2):214–21.

28. Karsai I, Knisley J, Knisley D, Yampolsky L, Godbole A. Mentoring interdisciplinary undergraduate students via a team effort. CBE—Life Sciences Education. 2011;10(3):250–8.

29. Balleisen EJ, Howes L, Wibbels E. The impact of applied project-based learning on undergraduate student development. Higher Education. 2024;87(4):1141–56.

30. Masava B, Nyoni CN, Botma Y. Scaffolding in health sciences education programmes: An integrative review. Medical Science Educator. 2023;33(1):255–73.

31. Vaughan M, Baxley TP, Kervin C, editors. Connecting the dots: A scaffolded model for undergraduate research. National Forum of Teacher Education Journal; 2017.

32. Azzaroiha C, Redhana IW, Suma K. The effect of scaffolding strategies on learning outcomes in science learning: A systematic literature review. Jurnal Penelitian Pendidikan IPA. 2025;11(1):45–55.

33. Gunawardena M, Wilson K. Scaffolding students' critical thinking: A process not an end game. Thinking Skills and Creativity. 2021;41:100848.

34. Lange C, Costley J, Han SL. Informal cooperative learning in small groups: The effect of scaffolding on participation. Issues in Educational Research. 2016;26(2):260–79.

35. Keebaugh A, Darrow L, Tan D, Jamerson H. Scaffolding the science: Problem based strategies for teaching interdisciplinary undergraduate research methods. International Journal of Teaching and Learning in Higher Education. 2009;21(1):118–26.

36. Dennen VP. Cognitive apprenticeship in educational practice: Research on scaffolding, modeling, mentoring, and coaching as instructional strategies. In: Jonassen D, Driscoll M, editors. Handbook of research on educational communications and technology. London: Routledge; 2013. p. 804–19.

37. Großmann N, Wilde M. Experimentation in biology lessons: Guided discovery through incremental scaffolds. International Journal of Science Education. 2019;41(6):759–81.

38. Fisher S, Justwan F. Scaffolding assignments and activities for undergraduate research methods. Journal of Political Science Education. 2018;14(1):63–71.

39. Richey RC, Klein JD. Developmental research methods: Creating knowledge from instructional design and development practice. Journal of Computing in Higher Education. 2005;16(2):23–38.

40. Govindasamy MK, Kwe NM. Scaffolding problem solving in teaching and learning the DPACE model--A design thinking approach. Research in Social Sciences and Technology. 2020;5(2):93–112.

41. Young B-R, Williamson HJ, Burton DL, Massey OT, Levin BL, Baldwin JA. Challenges and benefits in designing and implementing a team-based research mentorship experience in translational research. Pedagogy in health promotion. 2015;1(4):233–46.

42. Belland BR. Instructional scaffolding: Foundations and evolving definition. In: Belland BR, editor. Instructional Scaffolding in STEM Education: Strategies and Efficacy Evidence. Cham: Springer International Publishing; 2017. p. 17–53.

43. Powell SK, Barton LF. Undergraduate Research As a Catalyst for Career Competency Development. Scholarship and Practice of Undergraduate Research. 2026;9(3):6–16.

44. Baker VL, McCaffrey V, Manning CEN. Fostering professional development through undergraduate research: Supporting faculty mentors and student researchers. Mentoring & Tutoring: Partnership in Learning. 2022;30(2):216–34.

45. Morrison ME, Lom B, Buffalari D, Chase L, Fernandes JJ, McMurray MS, et al. Integrating Research into the Undergraduate Curriculum: 2. Scaffolding Research Skills and Transitioning toward Independent Research. J Undergrad Neurosci Educ. 2020;19(1):A64–a74.

46. Seifan M, Lal N, Berenjian A. Effect of undergraduate research on students' learning and engagement. International Journal of Mechanical Engineering Education. 2022;50(2):326–48.