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Making Students STEM Ready: Building a Bridge Between 2-Year and 4-Year Institutions

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Introduction

Transferring from a 2-year college to a 4-year institution is an integral milestone for many students, and particularly for those from historically underserved groups (Karamarkovich et al., 2025). Individuals who obtain a bachelor's degree on average earn 35% more income than those who receive an associate's degree (National Center for Educational Statistics, 2024). Data show that transfers are on the rise: for instance, transfers from 2-year colleges to 4-year institutions have increased by 3.1% in 2024 compared to 2023 (Karamarkovich et al., 2025). These numbers were greater for STEM majors, where transfers increased by 8%.

Despite these growing numbers, students continue to report tuition cost as a barrier that prevents them from transferring, which disproportionately poses challenges for underserved students (Sandrin et al., 2025). Additional barriers include transfer credit issues and a lack of understanding about articulation agreements (Logue et al., 2023; Sandrin et al., 2025). Articulation agreements, which are formal partnerships between community colleges and four-year institutions, specify how courses and two-year degrees will transfer and apply toward a bachelor's degree. Contributing to these challenges are a lack of communication between 2-year colleges and 4-year institutions regarding transfer credit criteria and the subjective nature of transfer credit evaluation by 4-year faculty and administrators (Lougue et al., 2025; Sutcliffe et al., 2025). This can impact students' understanding of which courses might be eligible for transfer and deter students from transferring.

Although these barriers exist, there are several supportive elements that contribute to students successfully transferring from a 2-year college to a 4-year institution, many of which are attributed to federally funded grant-related support. Practices that foster a sense of belonging and identity, such as faculty mentored undergraduate research experiences (Gamage et al., 2022), and developing a cohort that receives advising (Sansing-Helton et al., 2021) and clear information about the transfer pathway (Sandrin et al., 2025) support students in making a vertical transfer in their STEM major. Additionally, students from both 2-year and 4-year institutions benefit from faculty mentored undergraduate research experiences.

Undergraduate research is a key determinant for persistence in STEM for students from both 4-year and 2-year institutions (Carpi et al., 2017; Gamage et al., 2022). Compared with 4-year institutions, there is a lack of research opportunities at 2-year colleges. Thus, not surprisingly, few community college students persist to doctoral degrees in science (just 2.1%) (National Students Clearinghouse Research Center, 2017, as cited in Goodwin et al., 2024). Undergraduate research experiences lead to robust outcomes such as increased retention in STEM disciplines, particularly for historically underserved students, which make up a large proportion of 2-year student populations (Estrada et al., 2016; Hensen et al., 2024). These experiences enhance knowledge and application of science, critical evaluation of data, and problem-solving skills, while also augmenting students' sense of belonging in STEM and their science identity, as seen for both 2-year and 4-year students (Hein et al., 2025; Vannier et al., 2023). The benefits of undergraduate research experiences for 2-year students are evidenced by increased transfer rates and more seamless transitions to 4-year colleges in STEM majors for students who participated in research programs (Gamage et al., 2022; Nguyen et al., 2024).

Critical to the undergraduate research experience is the mentorship relationship between faculty and students. Ten key practices for effective undergraduate research faculty mentorship include: i) anticipating student needs, ii) setting and scaffolding clear expectations, iii) technical training, iv) balance of rigor with emotional support, v) building community amongst undergraduates and research team, vi) one-on-one mentoring, vii) cultivating student ownership, viii) supporting professional development, ix) incorporating peer mentorship, and x) guidance for dissemination of scholarly work (Shanahan et al., 2015). The mentor-mentee relationship in undergraduate science research is particularly important for transfer students who face unique challenges and inequities once enrolled at a 4-year college (Zuckerman et al., 2024). Mentorship training that highlights transfer student experiences is an integral facet to inclusive mentorship practices (Zuckerman et al., 2024).

Building undergraduate research partnerships between 2-year and 4-year colleges with a focus on effective mentoring is an ideal strategy for bolstering the STEM pipeline to 4-year colleges. Many examples of these partnerships demonstrate successful outcomes for 2-year students (Gamage et al., 2022; Rosas Alquicira et al., 2022). While there are several community college research programs (Hensel & Cejda, 2014), community colleges report many barriers to providing wide access to research experiences (Rosas Alquicira et al., 2022). Further, partnerships between 2-year and 4-year institutions increase community college students' exposure to a 4-year college environment, increasing the ease of transition to bachelor's programs. These partnerships may also enhance research resources at a 2-year institution (Rosas Alquicira et al., 2022).

In addition to engaging in undergraduate research experiences, students at 2-year colleges who receive clear information about the transfer process through effective advising are more likely to successfully transfer to a 4-year institution (Community College Research Center, 2021). For instance, students who were part of a cohort program and received frequent advising throughout their time at their 2-year college had higher rates of transfer compared to students not part of the program (Sansing-Helton et al., 2021).

Program Description and Study

Mercy University is a private 4-year university federally designated as a Hispanic and Minority Serving Institution. It has three campuses to serve its students, making it accessible to students in and outside the metropolitan area of New York. Most of the students are non-traditional and 92% of the students commute to campus. Westchester Community College (WCC) is a public 2-year college also designated as a Hispanic and Minority Serving Institution, just outside the metropolitan area of New York and in close proximity to Mercy University's main campus, making the collaboration between

these two institutions ideal. Mercy and WCC have an articulation agreement to facilitate 4-year degree completion for WCC transfer students. The collaborative mentored research program between Mercy and WCC described herein aimed to inspire 2-year students to transfer to a 4-year Mercy STEM program while making the transfer process more fluid. With that goal in mind, Mercy received a Title III Hispanic Serving Institutions STEM and Articulation grant from the Department of Education. The program, referred to as STEM Ready, includes several initiatives to support student success. The focus of this study is on the STEM Ready Summer Research Institute (SRI) and the collaboration between the two institutions to support students from both Mercy and WCC in gaining successful outcomes from participating in the SRI and increasing WCC students' knowledge about the transfer process and transfer frequency to Mercy and other 4-year institutions. Additionally, the SRI was designed to cultivate a sense of belonging, science identity, and the development of research skills for all students in the program. To plan and organize each SRI, key personnel from both institutions met monthly, making the collaboration effective.

Students from both institutions engaged in a 4-week authentic faculty mentored research experience in a STEM field. Faculty research mentors consisted of both Mercy and WCC faculty. Each faculty had a group consisting of about 4-5 students, most of which had a mix of both Mercy and WCC students. Nearly all groups also had an undergraduate peer mentor who typically had prior experience in the faculty's area of research and, alongside the faculty mentor, would assist the student participants in their understanding of the research project and implementation of study protocols, along with guidance in analyzing and interpreting the study findings.

Student participants from both Mercy and WCC were primarily from the disciplines of biology, computer science, computer information systems, cybersecurity, mathematics and psychology. Unlike most research programs, students were welcomed to apply from all levels (freshmen through seniors) and with no GPA minimum. Faculty contributed to applicant selection and roughly 30% of student applicants ultimately participated in the SRI. A total of 191 students, including peer mentors, participated in the SRI during the summers of 2023 – 2025, 57% were from Mercy and 43% were from WCC. Most of the WCC SRI participants were part of a proactive advising program at WCC called Viking ROADS, an established opportunity program that helps motivated WCC students graduate with an Associate Degree in three years or less. Viking ROADS provides a range of supports including a one-on-one STEM counselor, who in part advises on the transfer process to 4-year institutions starting from a student's first year at WCC.

Faculty research mentors (range of 13 – 15 mentors per summer) had research or technology development expertise in biology, chemistry, computer science, computer information systems, cybersecurity, mathematics or psychology. The research projects were held at the faculty member's home campus (WCC's main campus in suburban NY for WCC faculty or Mercy's main suburban NY campus or two NYC campuses in Manhattan or Bronx). Structured faculty mentoring evolved throughout the SRI. As the program persisted, planning meetings among the faculty increased to three times prior to the start of the SRI with specific sessions focusing on faculty mentoring strategies, including specific training on engaging the 2-year students in meaningful dialogue about 4-year STEM major experiences. Faculty were also required to meet virtually with their SRI student mentees three times prior to the start of the SRI in the most recent year of the program (up from one pre-SRI meeting in previous years), to better help students get a jumpstart on their research projects. Faculty primarily used this time for ice breaking sessions, and to discuss the background of the projects and research protocols. Faculty mentors were also required to work with students following the SRI to prepare for conference presentations held during the academic year.

The SRI consisted of an opening day team building exercise with all research groups participating together; students on different campuses were connected virtually on this first day. About midway

through the SRI, community building among all SRI participants was further cultivated through either a field trip or game day. During the majority of the SRI, student participants worked alongside their faculty research mentors and peer mentors to implement their authentic research projects in areas such as neuroscience, biochemistry, environmental science, big data analytics, cybersecurity ethical hacking, and psychological impacts of social media use. Along with the implementation of the study, students were also guided by their faculty and peer mentors through the process of analyzing and interpreting data and summarizing their findings for a final presentation. The SRI culminated with a rehearsal presentation day on the second to last day, where students received guidance on their presentation skills. On the final day of the program, students presented their findings to a large audience of peers, faculty, and administrators.

In week four of the SRI, WCC students were required to attend an information session focused on transferring to Mercy University. During this session, Mercy University and WCC admissions staff discussed the transfer process and articulation agreement between the two institutions. Furthermore, Mercy University Program Directors from each STEM major represented in the SRI: biology, computer information systems, computer science, cybersecurity, mathematics, and psychology, shared program highlights such as relevant coursework dedicated to research, internship opportunities, and clubs that students can participate in.

Study Aims

This study had two goals: 1) it aimed to demonstrate the benefits of faculty mentored undergraduate research experiences for students from both 2-year and 4-year institutions, specifically it examined the impact of the SRI on students' science identity, sense of belonging, and development of research skills, and 2) it examined WCC students' perceptions and understanding of the transfer process and the actual number of transfers to Mercy and other 4-year institutions after participation in the program. Below are the specific research questions addressed.

1. Do SRI participants self-reported science identity scores increase at posttest compared to retrospective pretest scores?
2. Do SRI participants self-reported sense of belonging scores increase at posttest compared to retrospective pretest scores?
3. Do SRI participants self-reported research skills increase at posttest compared to retrospective pretest scores?
4. Do WCC students understand the transfer process at posttest?
5. Do WCC students report that they frequently discussed the transfer process with other students in the SRI and their faculty mentor?
6. What are the vertical transfer rates for WCC students who participated in the SRI?

Method

This study used data collected from student surveys administered to SRI participants at the conclusion of each SRI session. Data were collected across three years (2023, 2024 and 2025), and each year included two SRI sessions each (Session 1 and Session 2), for a total of 6 periods of data collection. Participants were asked to rate both posttest ratings as well as retrospective pretest ratings at the conclusion of their SRI participation on measures related to science identity, sense of belonging, and research skills. Retrospective pretest ratings are preferable for those programs where participants will benefit from reflecting on their growth during the program and are potentially less likely to be biased in these situations (Hill & Betz, 2005). In addition to these scales, participants from WCC rated items related to understanding of the transfer process and transfer frequency of experience as posttest ratings only.

Institutional Review Board

The Institutional Review Boards at both Mercy University and WCC approved the survey data collection for SRI as part of the evaluation of the program, which ultimately was rated as Exempt.

Measures

Science Identity

Six questions from a published scale (Chemers et al., 2011) related to Science Identity were modified to replace “scientist” with each participant’s self-reported major/career aspiration, (e.g., Biology/Biologist). Participants were asked to rate each item at posttest (e.g., “Please think about how your identity as a [Biologist] changed *after completing the summer research* and indicate the extent to which you agree or disagree with the following statements: In general, being a [Biologist] is an important part of my self-image.” Participants rated each item on a five-point Likert-type scale: 1 = *Strongly disagree*; 2 = *Disagree*; 3 = *Neutral*; 4 = *Agree*; 5 = *Strongly agree*. After completion of all posttest scales, participants were then asked to rate corresponding items as a retrospective pretest (e.g., “Please think about your identity as a [Biologist] *before starting the summer research* and indicate the extent to which you agree or disagree with the following statements: In general, being a [Biologist] was an important part of my self-image.”) Participants then rated each item on the same five-point Likert-type scale. The internal consistency of the scale as measured by Cronbach’s α (.92) was closely aligned to the published α (.89).

Sense of Belonging

The sense of belonging measure consisted of eight items from Ingram (2012), including four items developed by Ingram and four items adapted from Freeman et al. (2007), all assessing Social Belonging. The items were further modified to include specific reference to either Mercy University or WCC, depending on the participant’s current enrollment. Participants were asked to rate each item at posttest (e.g., “Please think about your connection to [Mercy University] *after completing the summer research* and indicate the extent to which you agree or disagree with the following statements: I can really be myself at [Mercy University].”) Participants rated each item on a five-point Likert-type scale: 1 = *Strongly disagree*; 2 = *Somewhat disagree*; 3 = *Neither agree nor disagree*; 4 = *Somewhat agree*; 5 = *Strongly agree*. Participants were then asked to rate items as a retrospective pretest (e.g., “Please think about your connection to [Mercy University] *before completing the summer research* and indicate the extent to which you agree or disagree with the following statements: I could really be myself at [Mercy University].”) Participants rated each item on the same five-point Likert-type scale. The internal consistency of the scale as measured at posttest by Cronbach’s α (.87) was closely aligned to the published α (.91).

Research Skills

Participants then rated questions regarding research skills both before and after their research experience. All students were asked to rate nine of the original fourteen items published by Kardash (2000). In addition, depending on their major, students were asked to rate specific research skills associated with their major (e.g., For the items “Design an experiment or theoretical test of the hypothesis,” participants who were Computer Information Systems majors instead answered “Take a systematic approach to the engineering design process.”) Given the varied number of responses and small sample sizes associated with the five modified items, only those nine items in the original group were included in the current study. Participants were provided with instructions to think about their research skills before and after their research experience. Participants were asked to rate each item at posttest (e.g., After completing the summer research, to what extent do you feel you can... Understand Contemporary Concepts in your field.”) Participants rated each item on a five-point Likert-type scale: 1 = *Not at all*; 2; 3; 4; 5 = *A great deal*. Participants were then asked to rate items as a retrospective pretest (e.g., Before starting the summer research, to what extent did you feel you

can...Understand Contemporary Concepts in your field.”) Participants rated each item on the same five-point Likert-type scale.

Transfer Preparedness

Students from WCC rated items related to the transfer experience at SRI as posttest items only. Participants rated their understanding of the transfer process on one item and three questions related to the frequency of their experiences during SRI related to transfer, created by the evaluation team. The transfer process item was “How well do you understand the general process of transferring from WCC to any four-year college or university to study a program in biology, psychology, computer science, cybersecurity, computer information systems, or mathematics?” Participants rated the item on a five-point Likert-type scale: 1 = *Not at all*; 2 = *A little*; 3 = *Somewhat*; 4 = *Very*; 5 = *Extremely*. The items related to frequency of experience related to how participants spoke with other Mercy students, their research faculty mentor, or any students enrolled at WCC about the transfer process on a five-point Likert-type scale: 1 = *Never*; 2 = *Rarely*; 3 = *Sometimes*; 4 = *Often*; 5 = *Always*.

Procedure

The survey questions were programmed into an online survey software platform (i.e., Alchemer) by the project’s external evaluation team. A member of the evaluation team sent the survey link to the project’s Data Analyst to be forwarded to students via email. In addition, students were encouraged to complete the survey towards the end of the program via communication in person by a faculty member and the Data Analyst. All participating SRI students were provided with an opportunity to complete the survey. Peer mentors were also asked to complete the survey; however, their responses are not included in the current analysis.

Data Cleaning

Survey responses from all participating sessions were combined into one data file for analysis. All peer mentor responses were removed from the dataset. Composite variables were calculated by combining questions for each construct of interest (e.g., sense of belonging) for both pretest and posttest scores.

Participants

A total of 132 out of 153 eligible students responded to the survey at the completion of their SRI session, representing a response rate of 86%. Participants were students enrolled at either Mercy University or WCC at the time of their participation in SRI. Participation in the survey was confidential. Student demographic data were requested from Mercy SRI program staff and linked to survey responses. All participant responses were included in the final sample.

Students self-reported demographic data on their application to SRI. The program also determined the institution that each student was enrolled at the time in addition to their self-reported major. About half (51.5%) of students were enrolled at Mercy University at the time of the SRI. The most frequently represented major was biology (39.4%). Most students were either freshman (37.9%) or sophomores (30.3%) at the time of their participation in SRI.

To determine whether students increased their self-ratings for each of the constructs (i.e., science identity, sense of belonging, research skills) from retrospective pretest to posttest, we employed a series of paired-samples t-tests to compare the ratings on each of the composite variables. Self-reported ratings for Science Identity items were excluded for the 11 students in “Other” majors.

Table 1. *Final Sample Demographic Characteristics*

		n	Percent
Institution	Mercy University	68	51.5%
	Westchester Community College	64	48.5%
Discipline	Biology	52	39.4%
	Psychology	29	22.0%
	Computer Science	16	12.1%
	Cybersecurity	14	10.6%
	Other*	11	8.3%
	Computer Information Systems	5	3.8%
	Mathematics	3	2.3%
	Chemistry	2	1.5%
Academic Level at the Time of Participation in SRI	Freshman	50	37.9%
	Sophomore	40	30.3%
	Junior	27	20.5%
	Senior	15	11.4%

Note: $N = 132$. *Other* includes: Criminal Justice, Environmental Science, Health Science, Human Resources, Liberal Arts, Neuroscience, Nursing, Pre-Physical Therapy, and Social Work

Results

To answer research questions 1, 2, and 3, we assessed students' self-ratings at pretest and posttest. The results of the paired sample t-tests comparing students' science identity, sense of belonging, and research skills indicate that students had significant increases from pretest to posttest in each of these areas (see Table 2).

Table 2. *Pretest and Posttest Descriptive Statistics and Paired-Samples t-Test Results*

Construct	Sample Size	Pretest Mean (SD)	Posttest Mean (SD)	Significance Level	Effect Size
Science Identity	120	3.58 (0.68)	3.83 (0.71)	$p < .001$	0.41
Sense of Belonging	132	3.82 (0.73)	3.99 (0.64)	$p < .001$	0.30
Research Skills	129	3.51 (0.83)	4.25 (0.56)	$p < .001$	0.90

Transfer Preparedness

For research questions 4 and 5, we assessed posttest ratings only for understanding the transfer process and students' frequency of experience (see Table 3).

Understanding the Transfer Process

Students rated their understanding of the transfer process item moderately high at posttest ($M = 3.63$, $SD = .96$) suggesting that most students had a good understanding of the transfer process by the end of their participation in SRI.

Transfer Frequency of Experience

The three items related to students' frequency of discussion regarding transfer with other students and their SRI faculty mentor were combined as one composite variable ($\alpha = .66$). Mean ratings for frequency of experience were slightly lower than knowledge of understanding the transfer process, but were moderate overall ($M = 3.32$, $SD = .79$).

Table 3. *Transfer Preparedness Posttest Ratings (n = 63)*

Construct	Number of Items	alpha	Mean	SD
Understanding of Transfer Process	1	-	3.63	0.96
Transfer Frequency of Experience	3	.66	3.32	0.79

Transfer Frequency

For research question 6, we calculated the vertical transfer rates for WCC students who participated in the SRI. The number of students who transferred to Mercy from WCC's Viking Roads program was 25, and of those, 14 participated in the SRI. Additionally, 33 WCC students in the SRI transferred to another 4-year institution. The transfer rate to Mercy for WCC SRI participants was 17% (14 out of 82) while the transfer rate for WCC ROADS scholars in matched majors who did not participate in the SRI was 5% (11 out of 220), the non-SRI ROADS data spanning 5 cohorts.

Discussion

To recall, the three primary aims of the SRI are: one, to provide an opportunity for Mercy and WCC students to improve research skills in a mentored environment. Two, to foster a sense of belonging within the student participants to encourage greater collaboration with their peers, but also to develop and strengthen their self-identification as a researcher and to their current major. Three, to support and encourage potential WCC transfers to Mercy within STEM majors.

Student participants appear to generally benefit from participating in the SRI, as shown by the statistically significant increases in the three assessed self-reported constructs of science identity, sense of belonging, and research skills. These results suggest that participation in the SRI resulted in students generally identifying more strongly as researchers or scientists, fostering belonging with their peers in the SRI, while also developing and improving research skills. Finally, with the transfer-related findings, the reported mean values for both transfer preparedness and transfer frequency of experience suggest that WCC students who participated in the SRI not only had a good understanding about the transfer process but also took the opportunity to discuss the topic with others during the SRI, potentially setting up an environment where WCC SRI student participants may be more likely to consider transferring to Mercy or another institution after their time at WCC. The data showed that there was a higher transfer rate to Mercy for WCC students who participated in the SRI than those in a cohort advising model alone.

Faculty participants, although not part of the target population for the data analysis, were able to provide feedback on their SRI experience at the conclusion of each session. Some of the feedback supported the findings from the survey, such as improvement in research skills (Cobblestone Inc., Mercy STEM Ready 2025 SRI Summary, p. 9) or observing stronger peer connections within groups indicative of belonging (Cobblestone Inc., 2024 SRI Summary, p. 8).

Faculty Benefits of SRI Participation

The survey findings support the notion that students benefit from participation in the SRI, but what about the faculty participants? Some faculty noted in their feedback that the SRI was a mutually beneficial experience, finding the SRI experience to be an opportunity to directly watch growth in their supervised students and work with already motivated students (Cobblestone Inc., Mercy STEM Ready 2023 SRI Summary, p. 14). One benefit that should not be overlooked is research and mentoring opportunity: although the SRI is a Mercy-led program, it is open to both Mercy and WCC faculty and students. One WCC faculty mentor remarked that their participation in the SRI fostered a

long-term mentorship with a student in their group, even well after the conclusion of the SRI session (Cobblestone Inc., Mercy STEM Ready 2024 SRI Summary, p. 13).

Strengths, Limitations, and Future Directions

This study has several noteworthy strengths, for instance planning for the SRI included a close collaboration between the two institutions allowing for the diverse needs of students and faculty from both 2-year and 4-year institutions to be met. For example, accommodating WCC and Mercy faculty to conduct research at their home institutions made it easier for them to use resources with which they were already familiar. Typically, when 2-year and 4-year institutions collaborate toward the goal of faculty mentored research experiences, the research is usually conducted by faculty from and at the 4-year institution, oftentimes due to available resources (Gamage et al., 2022). Furthermore, offering research opportunities at both institutions provided students a choice to participate in research at their home institution or at the other institution, in close proximity.

Another key strength was the mix of both WCC and Mercy students in most faculty mentored research groups, which created opportunities for meaningful interactions. Much of the published faculty mentored research models either consist of just 2-year or 4-year institution students rather than both working side-by-side (e.g., Carpi et al., 2017; Gamage et al., 2022; Nguyen et al., 2024). Furthermore, many undergraduate research experiences require a minimum GPA for student participation. The SRI did not, making it inclusive for a group of individuals who may have never been selected had there been a GPA cutoff.

Although most measures lacked a true control group for comparison, the within-subject design allowed the authors to track change over time, making it an efficient design for identifying perceived growth in the areas of sense of belonging, science identity, and research skills for all student scholars. Another limitation is that questions related to the transfer preparedness and transfer knowledge of WCC students were posttest only. Hence, we lack a comparison of students' knowledge of the transfer process prior to their participation in SRI. Future studies should compare these ratings in a true pre-posttest comparison. While the current study focused on the outcomes for both 2-year and 4-year students combined, it would be valuable to explore potential differences in outcomes between 2-year and 4-year students in a future study.

Conclusions

Overall, this study demonstrates the importance of faculty mentored undergraduate research experiences for both 2-year and 4-year institution students. Our program showed that students' perceptions of sense of belonging, science identity, and research skills increased as a result of engaging in hands-on research experiences. Additionally, for the 2-year students, the SRI supported their knowledge about transferring.

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