Where Research Meets Practice: A Living-Learning Community Model for Computing Education Equity

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Dr. Grace Caldara is the Director at the Center for STEM Diversity at Tufts University. The Center for STEM Diversity is committed to building an inclusive, equity-driven community that empowers STEM students of all backgrounds. Through intentional programming, we foster an environment where students can bring their whole selves to their academic journey. We design student-centered initiatives that provides comprehensive support tailored to the diverse needs of our community, creating opportunities for both personal and academic growth. By engaging in ongoing conversations and collaborations around diversity, equity, inclusion, justice and access with faculty, staff and students, we strive to create a more equitable and supportive STEM environment thereby ensuring that all students have the resources and support necessary to succeed. As the Director, Dr. Caldara drives the strategic vision of the Center by engaging faculty, staff, and the broader campus community to create points of access and opportunity for all students. Prior to joining Tufts, Dr. Caldara was the Senior Manager of Learning and Development at Supermajority, a non-profit organization working to advance gender equity through education, training, storytelling and activism. During her time at Supermajority she developed and facilitated a nationwide leadership program, run annually, in which she taught thousands of young women of color values-based leadership strategies. Additionally, she managed the 2.9-million-member Pantsuit Nation community focused on elevating personal stories and lived experiences from women from across the country. Prior to its merger with Supermajority, Dr. Caldara was the Director of Community Engagement for the Pantsuit Nation Foundation where she developed diversity, equity and inclusion training materials to more effectively support and guide her team of online moderators in facilitating difficult discussions around race, gender and other systematic marginalizations. She also authored content for the book Pantsuit Nation. Dr. Caldara holds a Master's and PhD in Chemistry from the University of California Irvine and a Bachelor's degree in Chemistry from Boston College.

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Background/Statement of the Problem:

This is a full, evidence-based practice paper for the MIND Division. The STEM Preparation Center (SPC) at North State University (pseudonyms) represents a strategic institutional commitment to addressing persistent disparities in STEM education and workforce preparation. Uniquely positioned at the intersection of student success outcomes, workforce development, and personal/professional identity formation, the Center serves all students while maintaining particular focus on those from disadvantaged backgrounds pursuing STEM degrees. Among its suite of summer bridge legacy programs, the Computing Science Summer Institute (CSSI) initiative exemplifies innovative approaches to early intervention in computing education. The CCSI is collaborative partnership between North State Universities' Computer Science Department and the SPC.

This paper examines CSSI, a distinctive program targeting students who have just completed their first year and are pursuing computing majors, co-majors, or minors. CSSI addresses a critical gap in computing education by providing early intervention precisely when students face foundational course challenges that often derail their academic trajectories. The program's comprehensive wraparound support model grounded by the Thrive Mosaic (™) Scholar Development Framework (Chapman, 2018; McGee & Robinson, 2020) explicitly unveils the "hidden curriculum"—those unwritten rules and insider knowledge that advantaged students often access through social capital and builds student community cultural wealth and academic capital. Through this intentional exposure, CSSI enables participants to master computing comprehension skills, discover their unique calling within computing industries, and ultimately "crack the code" to overcome underperformance patterns in early foundational computing courses.

Operating through private donor funding, CSSI will launch its fourth cohort in summer 2026. The fully funded program serves 12-15 carefully selected students annually, providing two foundational computer science courses during an intensive summer semester. Beyond academics, participants receive comprehensive support including meals, housing, small-setting classes with favorable student-faculty ratios, tutoring, peer mentoring, professional development sessions with industry partners, and technical interview skill development. This holistic approach creates

a living-learning community where students bond with like-minded peers who share similar struggles in computer science, fostering both academic growth and social belonging.

Program outcomes demonstrate remarkable success. Alumni have secured competitive internships at Microsoft, Adobe, Tesla and NASAs Jet Propulsion Lab after mastering technical interviews, participated in international study abroad experiences, and earned prestigious recognition including Hack. Diversity Fellowships, and NSF REU opportunities that smooths pathways toward graduate studies. The inaugural cohort, Class of 2025, have secured full time positions at Amazon and Microsoft or have gone on to pursue graduate degrees in Computer Science. These achievements reflect not merely academic skill development but fundamental transformation in students' capacity to advocate for themselves within highly competitive computing fields.

Following the inaugural cohort, program leadership recognized that CSSI's distinctive living-learning community model holds significant potential for broader replication. As computing industries face growing demands for socially and technically responsible professionals, universities nationwide could benefit from adapting this program/type of program. Consequently, the team has systematically collected data from cohort members through interviews and surveys, specifically tracking confidence development and professional identity formation in computer science. This evidence base documents program effectiveness while providing a replicable framework for other higher education institutions seeking to address equity gaps in computing education.

This research contributes to ongoing conversations about scaling high-impact practices in STEM education, demonstrating how intentionally designed summer bridge programs can transform student trajectories and ultimately diversify the computing workforce pipeline.

Overview of the Program and Major Components

North State University’s SPC was established in 2008 within the School of Engineering to support high financial need, first generation and systemically minoritized students. The first established program was the Students Succeed in Engineering (SSE) program which has grown into a full 4 year scholar program. In recent years, the center has expanded its outreach to include students from the School of Arts and Sciences and grown our program and academic offerings. The center offers a first year advising seminar for students (Reconstructing the Idea of Engineering and Sciences) an outreach and professional development program (STEM Buddies), and federal-funded undergraduate research opportunities. In addition to the established programs the center also offers academic and professional workshops, industry visits, drop-in hours with advising, scholar development and mental health counselor along with regular office hours for several courses. In addition to student support the SPC also provides departmental support for school of engineering departments through the Diversity and Inclusion Program Administrator (DIPA) position. This position works within the department on departmental goals of inclusion,

ethics, and community building. The holistic support and interconnectedness with all student support resources made the SPC an integral partner with the computer science department for not only the development of the CSSI program, but also uniquely situated to provide the student support needed for the success of the program.

Built on the success of the long running SSE program the CSSI program is a socially innovative program that addresses retention for low-income and first-generation students in computer science. The core of CSSI is a 12-week residential summer program for rising sophomores with participants taking two foundational courses in CS with intentional cohort-building programmatic activities. Recently, CSSI has grown to include wraparound support for participants for the rest of their undergraduate experience.

To date , the program has supported a total of 56 students over the course of four summers. The program is co-led with two Diversity & Inclusion Program Administrators (DIPA). The program offered courses to students including CS 11 (online), CS 61 (online), and CS 15 (in-person). A CS PhD student served as the CSSI Teaching Fellow for the program with additional support from peer mentors, both who participated in CSSI as undergraduates.

Overview

Each cohort of participants received on-campus housing, a meal plan, and stipends. During the summer, students enrolled in CS 11 (Introduction to Computer Science),or CS15 (Data Structures), and CS 61 (Discrete Math). Classes were taught either online by current PhD students in the CS department or in person. The in-person class has varied from year to year due to staffing availability. Year to year, there may be variation in the amount of students who are at the beginning of their CS journey– starting at CS 11. The remaining students enroll in CS 15. Generally, in-person courses are taught by a part-time lecturer, with a TA and an additional PhD student to assist students. The CSSI staff partnered with the Computer science department and students' academic advising team to ensure that the students were able to complete their courses.

On the co-curricular side, students participated in CS Enrichment with the PhD fellow and Life Lessons with Diversity and Inclusion Program Administrators (DIPAs[5]). DIPAs offer year-round STEM workforce, academic, and professional support to STEM faculty and students. We offered dedicated time to complete homework with support from PhD fellow and peer mentors. The course TAs provided office hours, and CSSI and individual one-on-one sessions with peer mentors. We offered Industry Chats with members of the CS faculty, the CS External Advisory Board and industry partners. Finally, we provided community building activities, including trips to Six Flags and Boda Borg.

Tackling the Hidden Curriculum

Based on information we had learned from the outcomes of the first two summer cohorts, we employed Life Lessons and CS Enrichment more intentionally to introduce the Hidden Curriculum. With Life Lessons, the goal was to highlight the assumptions that some faculty and institutions of higher learning often have about students' cultural knowledge. In addition, we wanted to introduce awareness about navigating the college culture so that they may overcome

challenges and gain greater access to opportunities and resources. The DIPAs restructured both components with learning activities and outputs, such as:

- Strategizing for the future by creating an Individual Development Plan (IDP).
- Building core competencies to achieve IDP goals and matching them with the competencies of actual computing positions listed professionally on LinkedIn.
- Introducing Thrive Mosaic Developmental Framework and identifying challenges and gaps of network support for each student.
- Promoting professional skills by practicing elevator pitches, creating or updating their LinkedIn pages, and writing practice with professional emails.
- Discussing ethics within the CS field, exploring the Social Identity Wheel, and exploring skills and values.
- Promoting mental health, wellness, and an overall sense of self via a Self-Care Plan.

CS Enrichment was first developed by the inaugural CSSI PhD fellow with the intention of addressing the technical skills of the Hidden Curriculum, (e.g., skills that are often expected of professionals in the industry but are not explicitly taught).The Phd fellows have collaborated since in the summer 2023 based in part on their experiences working with CS students. The summer of 2024, the PhD fellow introduced technical skills centered on challenging and growing student skills by focusing on the following components:

- Application of Bayesian Probabilistic Modeling
- Introduction to Research Processes
- Technical Skill Development
- Collaboration and Professional Presentation

The Bayesian Probabilistic Modeling served as the primary project students worked on this summer. It served as a platform for students to build technical proficiency in Python and navigate GitHub to upload their projects. While the students met most objectives, and the PhD fellow partnered with the CSD staff to adhere to ongoing student needs as needed.

In response to an increasing number of students expressing an interest in pursuing their own coding side project, but were running into barriers in pursuing their projects, we introduced Side Quest Time for the summer of 2025. Side Quest time is a student driven block of time with the PhD fellow as technical support. Sometimes students would use the time to independently work on their projects, other times the PhD fellow provided a brief lesson if students were running into similar problems. Students worked on a broad range of projects from building websites for their non-profit organizations to video game and app development. In addition to the PhD student providing feedback and technical advise the students would also help each other troubleshoot, provide advice and moral support.

Study Overview

Research Purpose

The primary purpose of this research is to evaluate the efficiency of the CSSI's computer science support program at North State University by examining students' academic and social experiences in Computer Science. The study aims to identify program practices that support student success in undergraduate computing education and understand the ways students navigate their computer science education.

Research Design and Methodology

Study Type

The research employs a mixed-methods longitudinal design combining (a) a pre-post survey design for program participants (i.e., both current students and alumni of the program), (b) survey data collection from a comparison group of students who are enrolled in similar coursework as program participants, (c) the analysis of administrative data, such as course taking patterns, grade point averages, and major changes, and (d) qualitative semi-structured interviews with both program participants, alumni, and members of the comparison group. In full, the study involves three distinct groups across multiple cohorts (2022, 2023, 2024, 2025).

The data collected from each cohort can be found in Table I below.

Group	Description	Data Collection
CSSI Participants	Current students enrolled in CSSI (Cohorts 2022-2025)	Summer surveys, Semester check-ins, Annual surveys, Interviews, Applications
CSSI Alumni	Graduates who participated in CSSI during their time at North State University	One-time Survey + One-time Interview, Historical summer/semester data
Comparison Group	CS students at North State University who did not participate in CSSI	One-time Survey + Annual Interview

Table I: Data Collected from Multiple Stakeholder Groups at Multiple Timepoints

Data Collection Timeline

For CSSI Participants

Summer Program (May - August):

- Pre-Summer Survey: Administered before program begins
- Mid-Summer Survey: Administered mid-way through summer program
- Post-Summer/Exit Survey: Administered at program conclusion

Academic Year:

- Fall Semester: Check-in survey + One interview (60 minutes)
- Spring Semester: Check-in survey (15 minutes)
- Continues throughout enrollment while study remains open
- Post-graduation (if study still open): One survey + One interview

For Comparison Group

- Fall Semester: One-time survey (15 minutes) + One interview (60 minutes)

For Alumni

- One-time participation: One survey (15 minutes) + One interview (60 minutes)
- Access to historical summer survey and semester check-in data from their cohort participation

CSSI Program Application and Selection

The research maintains comprehensive records of all CSSI applications, providing a baseline data about participants' backgrounds, motivations, and circumstances prior to program enrollment.

Application Components

The application collects comprehensive information across multiple domains:

1. Demographics:
    - Name, email, class year, GPA
    - Race/ethnicity
    - First-generation student status
    - Pell Grant recipient status
    - Accommodation needs (class, workshops, outings, living arrangements)

2. Academic Background and Motivations:

- What they want to get out of the program (100-word response)
- How acceptance would help their CS journey
- Pre-college computing experience
- Motivations for CS major
- CS classes already completed
- Obstacles experienced in pursuing computer science

3. Financial Circumstances:

- How program might lessen financial hardships
- How they financially support themselves
- Whether basic needs (housing, food, textbooks) are being met at
- How they would utilize the stipend ($5,135 - $6,078)

4. Commitment and Awareness:

- Ability to commit to spending majority of summer at North State University
- How they learned about the program

Program Benefits

- Financial aid for two CS classes
- Financial stipend of $5,500 (amounts vary slightly by year)
- Summer residential opportunity at North State University
- Smaller class sizes
- Cohort-based learning community
- Professional networking opportunities
- Research exposure opportunities
- Specialized instruction (CS Enrichment, Life Lessons)

CSSI Summer Program Surveys: Detailed Analysis

CSSI participants complete three surveys during the summer program. These surveys track participants' experiences, development, and perceptions throughout the intensive 12 week residential program. Data has been collected across multiple cohorts (2023, 2024, 2025), enabling longitudinal and cross-cohort analysis.

Pre-Summer Survey

Administration: Before summer program begins

Purpose: Establish baseline expectations, motivations, and self-perceptions before program participation

Key Content Areas:

1. Opportunity Cost Assessment
Participants rate the importance of various program benefits on a 5-point scale (Very Unimportant to Very Important):

- Financial aid for two CS classes
- Financial stipend of $5,500
- Opportunity to stay at North State University for summer
- Opportunity to network with professionals
- Opportunity to learn about research
- Opportunity to be part of a cohort
- Opportunity for smaller class sizes
- Opportunity to partake in CS Enrichment
- Opportunity to partake in Life Lessons

2. Alternative Opportunities

- Whether they forwent internship opportunities to attend CSSI
- Current preparedness to secure internship for next year (5-point scale)

3. Cohort Expectations

- Number of fellow CSSI students known prior to program (0, 1-2, 3-4, 5-6, 7-9, 10-12)
- Hope that program will help make meaningful peer connections
    - Anticipated continued contact with CSSI students throughout North State University (5-point scale)

4. Baseline Self-Efficacy

- Feeling capable of being a computer scientist (5-point scale)

Mid-Summer Survey

Administration: Approximately halfway through the summer program

Purpose: Check-in on program effectiveness, identify areas for mid-course adjustment, assess developing confidence and community

Key Content Areas:

1. Skill Development Assessment

- Confidence in CS skills (0-5 scale)
- Effectiveness of class instruction in developing CS skills (0-5 scale)

2. Program Component Evaluation

- Open-ended: Most helpful aspects of CSSI program so far
- Open-ended: Least helpful aspects of CSSI program

3. Career Preparation Progress

- Open-ended: Confidence in ability to get internship for following summer

4. Community Building

- Open-ended: Ways CSSI has (or has not) helped create community within CS

5. Program Improvement Suggestions

- Open-ended: Things CSSI can do to help students get closer to academic and professional goals

6. Mid-Program Self-Efficacy

- Feeling capable of becoming a computer scientist (4-point scale: Definitely not, No, Yes, Definitely yes)

Post-Summer/Exit Survey

Administration: End of summer program

Purpose: Comprehensive program evaluation, satisfaction assessment, and collection of improvement recommendations for future cohorts

Key Content Areas:

1. Satisfaction Ratings (0-100 scale)

Participants rate satisfaction with each program component:

- Programming Course (CS 11 or 15)
- Discrete Math Course (CS 61)
- Student Success Classes (Life Lessons)
- Technical Skills of CS (CS Enrichment)
- Social Events (bowling, entertainment venues, social activities)
- In-person Industry Talks
- Office hours/study hall

2. Component-Specific Evaluation (Open-ended responses)
For each major component, participants provide detailed feedback on:

- What went well with programming instruction (CS 11 or 15)
- What could have gone better with discrete math instruction (CS 61)
- What went well with in-person instruction
- What could have gone better with in-person instruction
- What went well with online instruction
- What could have gone better with online instruction
- What went well in Life Lessons and CS Enrichment
- What could have been better about Life Lessons and CS Enrichment
- What went well with external speakers (Colloquia and Industry Talks)
- What could have been better about external speakers
- What went well about social events
- What could have been better about social events

3. Additional Open Response Areas
Space for any additional feedback, suggestions, or reflections about the program experience

CSSI Semester Check-In Surveys

Following the summer program, CSSI participants complete semester check-in surveys during the academic year. These surveys track participants' continued progress, persistence in CS, maintenance of community connections, and ongoing impact of the summer program. Check-in surveys have been administered in Fall 2023, Spring 2024, and Spring 2025.

Survey Structure and Content

1. Cohort Identification
    - Identification of which cohort the participant was part of (Summer 2022, Summer 2023, etc.)

2. Current Academic Status
    - Declared major
    - If major is not CS: Open-ended questions about what prompted the change and barriers preventing continuation in CS

3. Academic Performance (Optional Disclosure)
Participants can choose to share their grades in core CS courses:
    - CS 11 grade (A, B, C, D, Fail, Pass, Did not take, Prefer not to disclose)

- CS 15 grade (same options)
- CS 61 grade (same options)

4. Career Preparedness
    - Current preparedness to secure internship for next year
    - Option to indicate if internship has already been secured since CSSI

5. Self-Efficacy and Belonging
    - Feeling capable of being a computer scientist (4-point scale)

6. Program Impact Assessment (Open-ended)
    - Ways CSSI has (or has not) helped create community within CS
    - Ways the structure of CSSI supported growth and development in CS

7. Cohort Connection Maintenance
    - Degree of remaining in contact with CSSI peers (5-point scale from Definitely not to Definitely yes)

Participant Tracking and Contact Lists

The research maintains comprehensive contact lists for all CSSI participants across all cohorts (2022, 2023, 2024, 2025). These lists enable:

- Longitudinal Follow-up: Ability to track participants throughout their undergraduate career and post-graduation
- Cohort Comparisons: Analysis of outcomes and experiences across different program years
- Response Rate Monitoring: Tracking participation in surveys and interviews over time
- Targeted Recruitment: Ability to invite specific cohorts or subgroups for particular research activities
- Alumni Engagement: Connection with program graduates for retrospective evaluation
- Program Scale Documentation: Evidence of program reach and participant demographics across years

Annual Research Evaluation Surveys: Detailed Analysis

In addition to the program-specific summer surveys and semester check-ins, all three participant groups' complete comprehensive annual evaluation surveys. All survey instruments share a

common core structure with specific modifications for each participant group. The surveys are administered via an electronic platform and take approximately 15 minutes to complete.

Survey Structure and Content Domains

The annual surveys are organized into the following major domains:

1. Demographics and Background Characteristics

Race and Ethnicity

Comprehensive racial and ethnic identification with follow-up questions for specific ancestry:

- African American/Black: Additional questions about ancestral origins (U.S. multigenerational, specific African countries, Caribbean nations)
- Asian American/Asian: Detailed ethnicity options (Chinese, Taiwanese, Indian, Korean, Filipino, Vietnamese, Japanese, Pakistani, Thai, Iranian, Bangladeshi, Laotian, Cambodian)
- Hispanic/Latino/a/x: Country of origin tracking (Argentina, Bolivia, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, Uruguay, Venezuela, Spain)

International Student Status

- U.S. Domestic Student, U.S. Permanent Resident, U.S. Citizen, Non-U.S. International Student

Gender Identity

Inclusive options: Agender, Genderqueer, Gender fluid, Man, Non-binary, Questioning or Unsure, Transgender, Trans Man, Trans Woman, Woman, Prefer to self-describe

First-Generation College Student Status

Defined as students whose parents did not graduate from a four-year private college or university with a bachelor's degree or equivalent

Financial Aid and Support

Comprehensive tracking of funding sources including family support/savings, Perkins Loan, Pell Grant, University Scholarship, State Merit Scholarship, Private Scholarship, Private Loan, Federal Subsidized/Unsubsidized Loans, College Work Study, On/Off-Campus employment

2. Pre-College Computer Science Experiences

High School Coursework

- Non-AP computer science courses, AP computer science courses, Online self-driven learning, CS outreach programs

Co-Curricular Activities

- Robotics clubs, Hackathons, CS-related internships, CS-related summer camps

3. Academic Plans and Motivations

Current class rank, major declaration and plans, motivations for major choice, anticipated graduation date

4. Career Aspirations and Graduate School Plans

Interest in graduate studies with field specification and likelihood of career plan changes during college

5. Co-Curricular Involvement at North State University

CS-related activities (clubs, internships, volunteer activities, outreach programs, research experiences) and general campus involvement

6. Preparedness for Professional Development

Self-assessment of preparedness to secure CS internships and pursue undergraduate research within the next year

7. Psychosocial and Academic Integration Measures

Validated scales measuring: Intent to persist/major change plans, Local sense of belonging in CS, CS self-efficacy, College adjustment, CS major adjustment, Opportunities to learn about CS job market

8. Program-Specific Components (CSSI Participants Only)

Additional survey questions evaluating specific program components: CS Enrichment sessions, Life Lessons, Homework Launch, Bi-Weekly Staff Check-Ins, Side Quest Time, Industry Chats, DIAMOND Colloquia, and course withdrawal patterns

Interview Protocol: Detailed Analysis

The qualitative component consists of semi-structured interviews conducted by graduate research assistant and PI. Interviews last approximately 60 minutes and are audio/video recorded (only audio retained). All interviews require re-consent at the beginning of each session.

Interview Structure for Current Students

The interview protocol for current students (both CSSI participants and comparison group) explores: (1) Background and pre-college experiences, (2) Motivations for pursuing CS, (3) Experiences in CS at North State University (academic and social), (4) Experiences in CSSI (participants only), (5) Socio-academic goals and preparedness, and (6) Future plans.

Interview Protocol for Alumni

The alumni interview protocol is adapted to focus on retrospective reflection, covering: (1) Post-graduation update, (2) Motivations post-graduation, (3) Retrospective North State University CS experiences, (4) Retrospective CSSI evaluation (alumni participants only), and (5) Post-graduation plans and reflections.

Additional Data Sources

Beyond surveys and interviews, the research incorporates:

Institutional Records

- North State University transcripts (courses and grades)
- High school records (GPA and pre-matriculation credits)
- CSSI program evaluations (for program participants)

All records are accessed through the School of Engineering's Dean's Office and handled exclusively by IRB-approved research team members.

Research Ethics and Participant Protections

Informed Consent Process

- Initial consent obtained before survey participation, Re-consent required at beginning of each interview, Participants explicitly consent to records access, Age verification (18+ required)

Voluntary Participation and Withdrawal Rights

- Completely voluntary participation, Right to skip questions or take breaks, Right to withdraw at any time without penalty, No impact on relationship with North State University, Option to request data destruction upon withdrawal

Risk Mitigation

Identified risks include potential discomfort during reflection, possible identification despite pseudonyms, and potential unauthorized data access. Protection measures include use of pseudonyms, name blinding, North State University's-approved secure storage platforms, separation of identifying information from research data, and audio-only retention from recordings.

Participant Compensation

$25 Amazon gift card per survey completion, $25 Amazon gift card per interview completion, payment delivered via email approximately 72 hours after completion

IRB Oversight

Study approved and monitored by North State University Social Behavioral & Educational Research Institutional Review Board (SBER IRB)

Key Research Questions Addressed

Based on the comprehensive instrumentation, the research is designed to answer questions about: (1) Program effectiveness, (2) Persistence and retention, (3) Social integration, (4) Career preparation, and (5) Equity and access.

Comprehensive Data Summary Timeline

The CSSI program evaluation encompasses an exceptionally comprehensive data collection strategy:

Data Source	Timepoint	Purpose
Application	Pre-program	Baseline characteristics, motivations, financial circumstances

Pre-Summer Survey	Start of summer	Expectations, opportunity costs, baseline efficacy
Mid-Summer Survey	Mid-program	Progress check, component evaluation, mid-course adjustments
Post-Summer Survey	End of summer	Satisfaction, comprehensive evaluation, improvement suggestions
Semester Check-ins	Fall and Spring	Persistence, performance, continued impact, community maintenance
Annual Evaluation Surveys	Fall and Spring	Comprehensive academic/social/career assessment
Annual Interviews	Yearly	In-depth qualitative exploration of experiences
Administrative Records	Continuous	Objective academic outcomes, verification
Alumni Survey/Interview	Post-graduation	Long-term outcomes, retrospective evaluation

This comprehensive research study employs exceptionally rigorous methodology to evaluate the CSSI program's effectiveness in supporting computer science students at North State University. The integration of:

- Application data providing baseline characteristics
- Three-phase summer surveys (pre, mid, post) tracking real-time program experiences
- Semester check-ins monitoring continued progress and persistence
- Annual comprehensive evaluation surveys and in-depth interviews
- Administrative records for objective verification
- Contact lists enabling robust longitudinal follow-up across four cohorts
- Alumni retrospective evaluation

- Comparison group data

positions this study to provide unprecedented insights into the academic and social factors that contribute to CS student success, the specific program components that most effectively support student persistence and achievement, the pathways through which students navigate undergraduate computing education, the long-term impact of support programs on career trajectories, and best practices for supporting diverse students in computing fields.

The multi-year, multi-method design with multiple data collection points throughout each academic cycle, careful attention to ethical protections, and comprehensive participant tracking reflects a commitment to producing high-quality evidence that can inform both CSSI program improvements and broader efforts to support success in undergraduate computing education. The inclusion of comparison groups, validated measures, administrative data, application materials, multiple cohorts, and both current student and alumni perspectives positions this study to make significant contributions to understanding effective practices in CS education support programs.

The granular evaluation of individual program components at multiple timepoints, combined with comprehensive assessment of academic outcomes, social integration, career preparedness, and equity considerations, provides a model for rigorous program evaluation in STEM education. The findings from this research have the potential to inform evidence-based practices for supporting student success, particularly for populations historically underrepresented in computing fields. The multi-phase data collection strategy enables both summative evaluation of overall program impact and formative evaluation supporting continuous program improvement.

Comprehensive Analysis of non-CSSI Computer Science Student Experiences at North State University

Non-CSSI students who lacked prior programming experience faced significant challenges navigating introductory computer science courses at North State University, often resulting in traumatic experiences that led to withdrawal from the major. One non-CSSI participant described attending extensive 12-hour office hours sessions and utilizing all available tutoring resources while taking CS 11, yet consistently feeling lost and unable to find lab partners willing to work with someone who was "way too lost."
The emotional toll of these struggles culminated in an incident where a teaching assistant became visibly frustrated while attempting to explain recursion and walked away mid-explanation, stating "I just can't do this" and never returning. This student recalled walking home "at one or two in the morning after office hours feeling awful and terrible," questioning whether they were "such a burden to the TAs." The isolation extended beyond academic struggles, as this non-CSSI participant—despite being "a very social person"—was repeatedly rejected as a lab partner in sessions designed for collaborative work, creating a sense of not belonging in the computer

science community. These experiences ultimately led to complete withdrawal from the course and the decision to leave computer science entirely, with the student stating "I don't ever want to be in a CS space ever again."

The institutional support available to non-CSSI students proved inadequate or actively discouraging for those seeking guidance in pursuing computer science. One non-CSSI participant called a CS department administrator freshman fall inquiring about pursuing CS despite having no prior coding experience, and received only warnings about the competitive nature of the field and the fact that "most incoming CS students arrived with substantial programming backgrounds," with no constructive pathway, resources, or encouragement offered. Faculty interactions ranged from unhelpful to problematic, with one non-CSSI participant witnessing their best friend being "ignored out of everybody else" during a professor's office hours, amid pre-existing "rumors of this professor being racist." The physical environment of CS office hours—described as a large room with windows creating a semi-public space—amplified feelings of embarrassment when struggles became visible to other students, and the queue-based system meant long waits during crowded periods, adding social pressure to the academic challenges. Without structured peer support networks or dedicated mentorship, non-CSSI students who struggled were left to navigate these barriers independently, often interpreting their difficulties as evidence of personal inadequacy rather than as gaps that could be addressed with appropriate support.

The long-term consequences of these early negative experiences manifested in altered academic trajectories and lasting psychological impacts. The non-CSSI participant who withdrew from CS 11 ultimately switched to engineering psychology, completely disengaging from computer science spaces despite initially having interest in the field. This student later reflected that CS "might have been manageable now that I'm older and now that I've picked up better study habits," acknowledging that metacognitive skills developed through perseverance in other engineering fields could have transferred to CS had the early experience included adequate support rather than isolation and discouragement. Another non-CSSI participant described feeling "pretty burnt out" from navigating academic demands without structured support, cobbling together help from various sources with varying degrees of success. The contrast was particularly stark for non-CSSI students from underrepresented backgrounds, who faced not only academic challenges but also cultural isolation in predominantly white spaces, without the benefit of cohort-based communities or mentors who understood their specific experiences.

These students often found themselves needing to advocate for themselves in environments where their presence was questioned and their struggles were met with frustration rather than pedagogical problem-solving, creating barriers that transformed potentially surmountable academic challenges into reasons to abandon computer science entirely.

CSSI Student's PROGRAM EVALUATION Analysis:
SENSE OF BELONGING AND COMPUTING IDENTITY DEVELOPMENT

The CSSI program at North State University has demonstrated substantial impact on students' sense of belonging and computing identity development across multiple cohorts from 2022-2025. Drawing from longitudinal survey data and program documentation, the evidence reveals how intentional programmatic design centered on community building and holistic student support effectively fosters both psychological and professional development among historically underrepresented students in computer science.

PROGRAMMATIC FRAMEWORK AND THEORETICAL FOUNDATION

The CSSI program's approach to identity development and belonging is grounded in the recognition that students who have been historically excluded from STEM spaces require more than technical skill building alone. The program embraces a holistic student development model that addresses both the visible curriculum and the "hidden curriculum"—the unspoken norms, values, and expectations that create barriers to access and success in computing fields. This framework manifests through three interconnected programmatic pillars: structured mentorship and wrap-around support, targeted programming that explicitly addresses systemic gaps, and intentional community building those positions peers as resources.

The wrap-around support system, mirrored through CSSI Graduate Fellows and bi-weekly staff check-ins, creates accountability structures while building the mutual trust necessary for students to feel their social and emotional needs are being met. These relationships proved especially vital during the academic year when students transitioned back to traditional coursework, as they provided consistent touchpoints for seeking support and practicing professional communication skills. This aligns with research demonstrating how students acquire cultural capital to better navigate university environments through sustained mentorship relationships.

COMPUTING IDENTITY DEVELOPMENT: QUANTITATIVE EVIDENCE

Survey data across the 2024 and 2025 cohorts reveals substantial growth in students' computing identity, measured through their self-perception as capable computer scientists. In the 2024 cohort, 71.4% of students entered the program feeling capable of becoming computer scientists (responding "definitely yes" or "probably yes"), while at program exit, this proportion increased to 75%. More significantly, the distribution shifted dramatically toward stronger conviction, with 41.7% responding "definitely yes" at exit compared to just 21.4% at entry. Among those who

expressed uncertainty or doubt at entry (28.6% responding "probably not" or "might or might not"), most showed marked improvement by program completion.

The 2025 cohort demonstrated even more pronounced gains. Students entered with 78.6% feeling capable of becoming computer scientists, which increased to 92.3% by mid-summer and remained at that level through program completion. By the exit survey, 61.5% reported "definitely yes" to feeling capable of declaring or continuing with Computer Science as a major, with an additional 30.8% responding "probably yes." This represents near-universal confidence in their trajectory, with only 7.7% expressing uncertainty. The data suggests that the refinements made to the program structure between cohorts, including the addition of CSSI Peer Mentors and enhanced professional development programming, contributed to accelerated identity development.

The program's impact on students' perception of themselves as computer scientists was not merely incremental but transformative for many participants. In the 2025 cohort, 69.2% of students indicated the program "significantly increased" their feelings that they are computer scientists, with an additional 15.4% reporting "somewhat increased." Only 15.4% felt the program had no impact on these feelings, and notably, no students reported a decrease. This stands in contrast to the 2024 cohort, where 58.3% reported "somewhat increased" feelings and only 16.7% "significantly increased," suggesting that programmatic enhancements in the second iteration created conditions for deeper identity transformation.

The mid-summer checkpoint in the 2025 cohort provides particularly valuable insight into the temporal dynamics of identity development. By mid-program, 84.6% of students already felt capable of becoming computer scientists, with one student expressing doubt and another expressing strong conviction ("definitely yes"). This suggests that the intensive early programming—combining coursework with Life Lessons, CS Enrichment, and professional development—creates rapid shifts in self-perception within the first 3-4 weeks of the program.

SENSE OF BELONGING: BUILDING COMMUNITY IN COMPUTING

Pre-program surveys consistently revealed that students entered CSSI with limited sense of community within the Computer Science department. In the 2024 cohort, 50% of students reported "probably not" feeling a sense of community in CS, with only 35.7% expressing any degree of belonging ("probably yes" or "definitely yes"). The 2025 cohort showed similar patterns, with 42.9% reporting "probably not" or "definitely not," and only 35.7% feeling they belonged. This baseline data underscores the isolation many underrepresented students experience in computing environments, even after completing their first year of coursework.

The program's impact on peer connection was striking and consistent across cohorts. In the 2024 exit survey, 91.7% of students responded "yes" to having made meaningful connections with their peers, with only one student expressing uncertainty ("maybe"). The 2025 cohort showed identical results, with 92.3% confirming meaningful peer connections at both mid-summer and program exit. These near-universal positive responses suggest that the cohort model, supplemented by structured community-building activities and shared academic experiences, effectively creates the conditions for relationship formation.

The qualitative responses illuminate how students experienced community building beyond simple friendship formation. Students described CSSI as creating "a close-knit community space" and "the safest safe space for me on campus yet." One student reflected: "You guys have taught me that I truly do belong in CS and the fields that I hope to explore more and that North State University and the SPI will be a resource for me all throughout my undergraduate career." This articulation of belonging extends beyond peer connections to encompass institutional belonging—feeling that one has a rightful place within the computer science community and can claim institutional resources.

The importance of peer community manifested in students' ability to utilize their cohort as a resource. Mid-summer responses revealed students actively leveraging their community: "The smaller and supportive community has helped me a lot" and "the flexibility of CS15 and the community of peers" were cited as most helpful aspects. Students also demonstrated sophisticated understanding of their community's value, with one noting: "Having everyone collaborating and struggling together as well as helping one another" and another describing it as "having a community to talk about insecurities about my future in terms of career, especially as a low-income student." These responses suggest students developed what scholars term "peer cultural capital"—the ability to draw on peer networks for both emotional and practical support in navigating academic and professional challenges.

PROFESSIONAL IDENTITY AND SELF-EFFICACY DEVELOPMENT

The program's impact on self-efficacy—students' confidence in their ability to succeed in computing—emerged through both structured skill-building and exposure to professional networks. Mid-summer data from the 2025 cohort showed confidence in CS skills averaging 3.0 on a 5-point scale, with 46.2% rating themselves at a 3, suggesting moderate confidence. While this might appear modest, students' growth trajectory and their articulation of development suggest this reflects realistic self-assessment rather than imposter syndrome. Students rated the effectiveness of class instruction at developing CS skills slightly higher (averaging 3.4), with 53.9% rating it at 4 or 5, indicating they perceived their learning environment as supportive of skill development.

Critical to self-efficacy development was the program's professional development component, which students consistently identified as transformative. One student articulated: "1:1 time with Mason has been crucial in helping me develop my professional confidence to reach out to professionals and schedule informational meetings with them. I think I've become a much more assertive and self-confident individual who's made peace with uncertainty in the future but now possess the tools to go after my goals and interests." This statement reveals how professional development programming fostered not just technical confidence but agency—the belief that one can actively shape their trajectory in computing.

The emphasis on professional development also helped students develop what Godwin et al. (2016) term "critical agency"—the capacity to recognize and navigate systemic barriers while maintaining commitment to the field. Students articulated learning "the real expectations of a CS degree" and gaining "insight towards the workplace for computer science," suggesting they developed more sophisticated understanding of the field beyond coursework. One student noted feeling "inspired to take meaningful steps towards my future such as practice interviews, setting up my LinkedIn, and getting closer to professors," demonstrating how exposure to professionals and explicit skill-building translated into concrete action.

NETWORK DEVELOPMENT AND SOCIAL CAPITAL

The program's success in helping students build professional networks represents a critical dimension of belonging and identity development. Using the framework of Connectors (individuals who provide access to networks) and Coaches (individuals who support cognitive and emotional growth), the program helped students identify and cultivate relationships with key supporters. The 2025 cohort, 69.2% of students identified having a Connector, with program staff. Students also identified the CSD more broadly, individual faculty members, and professionals they met through the program.

The quality of these connections extended beyond transactional networking. Students described relationships characterized by genuine support: "Mason has been so helpful in offering insight and also knows so many different people" and “John also knows a lot of people in the department that he tells us about." The identification of multiple potential Connectors suggests students developed understanding of network building as ongoing practice rather than one-time encounters. By program exit, 69.2% maintained their Connector identifications, suggesting these relationships endured beyond initial formation.

Coach identification proved more complex, with students less certain about these relationships at both mid-summer (38.5% identifying a Coach) and exit (46.2%). The qualitative responses suggest this may reflect students' developing understanding of different types of support relationships rather than absence of mentorship. Students who did identify Coaches described

relationships involving "establishing a more clear line of reasoning" and helping "align my emotional and cognitive state to what I had envisioned to occur in my career." This suggests students who successfully identified Coaches had experienced deeper developmental conversations that fostered self-reflection and goal alignment.

PROGRAMMATIC ELEMENTS SUPPORTING BELONGING AND IDENTITY

Students' qualitative responses reveal which programmatic elements most effectively supported belonging and identity development. Professional development emerged as the most consistently valued component, with students citing it as most helpful across both cohorts. The specificity of students' appreciation—noting opportunities to "network with professionals," attend "professional development and research colloquiums," and receive "tips" on professional communication—suggests this programming successfully demystified professional pathways and provided concrete tools for navigation.

The Life Lessons component, explicitly designed to address hidden curriculum, proved effective in supporting students' professional confidence and sense of belonging. Students valued learning "life lessons" and "navigating college and the professional world," with one noting it helped develop "soft skills related to communication, collaboration, and problem-solving, as well as offer space for students' own identity development." This direct instruction in implicit norms appears to reduce the burden of navigating unfamiliar cultural terrain independently.

CS Enrichment showed more mixed reception, with some students finding it transformative and others finding it unfocused. One student enthusiastically described: "CS enrichment. I love Kasey, and she is very patient with all student and was always willing to repeat instructions to me :) She made it fun to want to create a website," while another requested "more focus for cs enrichment...giving the class a clearer purpose rather than switching between different topics a lot." This variation suggests the value of exploratory technical learning may vary based on students' prior exposure and learning preferences, pointing to potential areas for refinement.

The smaller class sizes and cohort structure enabled relationship building both with peers and instructors. Students repeatedly mentioned instructors by name ("John is so helpful with CS15!" and "I love Kasey"), suggesting the program's scale allowed for personalized attention that fostered belonging. The integrated nature of the program—having the same cohort across courses, enrichment activities, and professional development—created multiple contexts for relationship formation and mutual support.

SUSTAINED IMPACT AND LONGITUDINAL CONNECTIONS

The program's design included mechanisms for sustaining belonging beyond the summer intensive. Students anticipated staying connected with their CSSI peers, with 100% of 2024 pre-survey respondents and 92.9% of 2025 pre-survey respondents answering "definitely yes" to anticipating continued contact throughout their time at North State University. The creation of CSSI alumni networks, Discord servers with embedded alumni channels, and ongoing SPC engagement provided infrastructure for sustained connection.

Students' identification of CSSI and SPC staff as ongoing resources suggests they developed understanding of institutional support as accessible and legitimate. Comments like "the fact that Will Tomlinson came to give us a talk and responded to my email has been very much helped by the fact that Kasey had invited him" reveal students learned how institutional advocates can facilitate access to opportunities. This understanding represents a form of navigational capital that extends beyond the summer program.

The relationships formed during CSSI appeared to create ripple effects into students' broader academic experience. Students described feeling more comfortable "getting closer to professors" and utilizing campus resources like the STARR center and Career Center. This suggests the program successfully addressed what Jack (2016) describes as differential comfort with institutional resources, helping students develop what he terms "acquired cultural capital" through explicit coaching and supported practice.

ADDRESSING CHALLENGES AND AREAS FOR GROWTH

While outcomes were overwhelmingly positive, student feedback identified areas where the program could further strengthen belonging and identity development. Several students expressed desire for more explicit industry exposure through company visits: "One of the main reasons I wanted to join CSSI was because of the large focus on diverse industry exposure through company visits and other speakers." This suggests students hunger for tangible connection between their identity development work and professional possibilities.

Students also requested more structured follow-up mechanisms, including "more check ins or accountability regarding the side quest" and potential "CSSI alumna Zoom meeting near the middle or end of the cohort to hear from the alumna." These requests reveal students' recognition of the value of peer learning and accountability structures in sustaining development.

The variation in responses about CS Enrichment effectiveness points to the challenge of meeting diverse learning needs within a cohort model. Some students found the exploratory nature valuable while others sought more focused skill-building, suggesting potential value in offering multiple tracks or allowing for more student choice in enrichment topics.

IMPLICATIONS AND CONCLUSIONS

The CSSI program demonstrates that intentional program design centered on community building, explicit skill instruction, and holistic support can substantially impact both sense of belonging and computing identity development among underrepresented students. The nearly universal formation of meaningful peer connections (92% across cohorts) and the dramatic increases in students' self-perception as computer scientists (from 71-79% at entry to 92-93% at completion in recent cohorts) provide compelling evidence of the program's effectiveness.

Several programmatic features appear particularly critical to these outcomes. First, the cohort model creates built-in peer support and shared experience that counters the isolation many underrepresented students experience. Second, explicit instruction in professional norms and hidden curriculum reduces the burden of independent navigation and builds concrete skills alongside confidence. Third, structured mentorship that combines emotional support with professional guidance helps students develop both sense of belonging and self-efficacy. Fourth, sustained engagement throughout the academic year through check-ins, alumni networks, and CSD connection provides scaffolding for continued development.

The program's evolution across cohorts—with improvements in outcomes between 2024 and 2025—suggests that responsive refinement based on student feedback strengthens impact. The addition of peer mentors enhanced professional development, and explicit attention to network building (Connectors and Coaches framework) appear to have accelerated identity development and deepened sense of belonging.

Looking forward, the success of CSSI provides a model for supporting underrepresented students in computing that extends beyond summer bridge programs. The proposal's vision for a Living-Learning Community model that extends programmatic elements throughout the academic year represents a promising direction for sustaining and amplifying the identity development and belonging cultivated during the intensive summer experience. The evidence suggests that when institutions invest in creating supportive communities, explicitly teaching navigational skills, and fostering meaningful relationships, students develop both the confidence to see themselves as computer scientists and the sense that they rightfully belong in computing spaces.

Future Direction: Reproducibility

Based on interviews with CSSI participants across multiple cohorts, participants consistently identified key structural elements that contributed to the program's success in building academic and social support networks. The intimate cohort structure of approximately 12 students emerged as a foundational component, with participants noting how the small group size facilitated deeper connections and made it easier to seek help from peers. As one participant explained, working within this smaller group meant "it was just easier to like, text the [other participants] to do homework together. Hey, I'm stuck on this can we work this problem out together," highlighting how the small cohort size directly enabled the collaborative learning environment essential to a living learning community. Students particularly valued being grouped with peers who shared similar backgrounds and experiences, including financial aid recipients and first-generation college students, which created an immediate foundation of mutual understanding and reduced feelings of isolation that often accompany being underrepresented in technical fields.

The program's effectiveness as a living learning community stem from its integration of academic acceleration with comprehensive support structures. The summer intensive format, combined with financial stipends that eliminated the pressure to work, allowed students to focus entirely on skill development while simultaneously building community bonds. Participants reported that this dedicated time helped them feel less "behind" compared to peers and provided crucial exposure to computer science concepts in a supportive environment. The mentorship component proved particularly valuable, with faculty and staff providing guidance that extended beyond technical skills to include professional development and networking strategies. Multiple participants noted how mentors helped demystify professional networking, with one student describing how a mentor emphasized that professionals "are also just people" and taught them how to "strike up a conversation" confidently. This holistic approach to student development—addressing both technical competencies and professional soft skills—created a comprehensive support system that extended well beyond traditional academic programming.

The sustainability and long-term impact of community building emerged as a critical indicator of the program's success and replicability. Participants consistently reported that friendships formed during the summer program lasted throughout their undergraduate careers, with cohort members continuing to study together, share job opportunities, and provide mutual support. As one graduate reflected, "these friendships sort of lasted throughout college... we were able to just like, keep in contact, in touch, and also hang out beyond the program," demonstrating how the initial investment in community building created enduring support networks. The program also successfully connected students to broader institutional resources and professional networks through industry chats and alumni panels, with students reporting that these connections directly contributed to internship and job opportunities. This sustained engagement suggests that the living learning community model can create multiplier effects that extend far beyond the initial program period.

For institutions considering replication of this model, several critical success factors emerge from participant experiences. First, maintaining small cohort sizes (10-15 students) appears essential for creating the intimate environment that facilitates peer bonding and collaborative learning. Second, providing financial support through stipends removes a significant barrier and allows students to fully engage with the program without competing work obligations. Third, intentional recruitment of students with shared identity markers—such as financial aid recipients or students from underrepresented backgrounds—creates immediate common ground while addressing equity gaps in computer science education. Fourth, the program must balance structured academic components with opportunities for informal social interaction, as participants valued both the technical skill development, and the casual connections formed during group activities. Finally, dedicating adequate staff and faculty resources for mentorship and individual student monitoring helps ensure that struggling students receive timely intervention, addressing one area where early cohorts identified room for improvement.

The CSSI model demonstrates that effective living learning communities in technical fields require more than simply housing students together or offering supplementary coursework. Instead, successful replication depends on creating an ecosystem that addresses the multiple dimensions of student success: academic preparation, peer community, professional development, financial security, and ongoing mentorship. The program's success in helping students feel they belong in computer science—as evidenced by participants' continued engagement with the field and their maintenance of community connections—suggests that this model offers a viable blueprint for other institutions seeking to support underrepresented students in STEM disciplines. By prioritizing small cohort sizes, comprehensive support structures, and intentional community building, universities can create living learning communities that not only improve individual student outcomes but also contribute to diversifying and strengthening the broader computer science community.

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