Retaining Vulnerable Students in CS Across School Transitions: The role of Cross-Sector Collaborations

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***Abstract*—The computer science (CS) for All movement has brought increasing opportunities in middle and high school, and there is a growing body of research on how to increase students' interest and knowledge. But little attention is paid to the structural factors that support or undermine student persistence in CS during the transition to college, which is where the most vulnerable students leave the pathway [1], [2]. In this paper we will describe how our researcher-practitioner partnership (RPP) has built a cross-sector collaboration to align structures and supports across a local school district, community college, and Latinx youth-serving non-profit organization. This work is guided by the following research question: *What factors help or hinder cross-sector collaborations from building structural supports for students to persist in Computer Information Systems (CIS)?* Data include interviews of teachers and counselors, and notes from monthly RPP meetings including key stakeholders and designers of the pathway. Data analysis was guided by the absorptive capacity framework, which describes readiness to "value new information, assimilate it, and apply it in novel ways as part of organizational routines, policies and practice" [3]. The findings highlight key strategies that others can use to foster cross-sector partnerships that build sustainable, structural supports for student persistence in CS, including having a broker help translate organizational tensions and identify points of opportunities to create authentic engagement opportunities.**

Keywords— equity, cybersecurity education, K-12, community college, research-practice partnerships, cross-sector collaborations

I. Introduction

The Computer Science for All movement was spearheaded in 2016 by then President Obama as an initiative to have every student learn computer science [4]. This movement has grown with support from the National Science Foundation, resulting in increased computer science (CS) and computational thinking opportunities in schools throughout the US. However, little attention has been paid to the transition from high school to college. While K-12 students might be introduced to CS, whether they launch into post-secondary opportunities or career exploration is left up to individual students with few formal connected pathways to colleges and universities. The most vulnerable students are less likely to successfully traverse complex institutional systems, and thus less likely to attend or persist in college [1] or CS.

While some programs support students in this transition [1], [2] they often focus on changing the individual student rather than on the structural factors that cause the disconnect. Many school districts are working in research-practice partnerships to offer CS courses or integrate it into core areas, with the aid of researchers to inform best practices [5], [6], but fewer are working with colleges and universities to help build the support systems students need to continue in CS beyond secondary school. Disconnects within and across schools can prevent student engagement and momentum. For example, studies show a lack of alignment in course content and standards from high school to community college in subjects like math [7]. Similarly, a lack of clarity about course sequence and how the content relates to careers leads many students to leave computing pathways [8]. Thus, creating continuity and clarity in what students learn across institutions can increase persistence, graduation, and college enrollment [9].

Cross-sector collaborations have experienced a re-emergence in education to combine resources to support students holistically [10]. One successful example is the Linked Learning guidebook which details how to build effective and equitable college and career pathways. Successful collaborations are strategic partnerships that have jointly negotiated expectations and goals; they are constantly evolving and require strong leadership, communication, and coordination to plan for the dynamic and unpredictable nature of the education landscape. Their success relies in part on knowledge brokers who understand the different organizational demands and assets and help to negotiate tensions and identify opportunities. They facilitate interactions, organize priorities and information, and help to build and maintain relationships [11].

II. The Role of Community Colleges

While national efforts like Linked Learning create pathways to community college, there are few examples of how to create equitable CS pathways that include these institutions. This is particularly important because community colleges serve large numbers of low income Latinx students; 46% of Latinx undergraduate students attend two-year institutions, compared to 34% of all undergraduates [12]. To broaden participation in CS, we need to create inclusive computing education pathways that include institutional supports for the transition to higher education. In the absence of these supports, students are left to negotiate the transition themselves, meaning first generation students and those who must work often do not persist beyond high school [13].

Student success requires coordinated, culturally responsive support structures. This is particularly important for students who are the first in their family to attend college [14], [15]. Support must go beyond academic guidance because economic and personal challenges, as well as confusion over

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course sequences, are common reasons that community college students leave CS [8].

III. Context

The work reported here is from a research-practice partnership (RPP) based in the central coast of California that consists of a K-12 district (82% Latinx, 78% eligible for free or reduced lunch), a community college (a Hispanic-serving institute with 45% Latinx student population), a non-profit organization that supports Latinx youth to pursue jobs in the tech sector, and a non-profit research organization [16]. The area is rural, agricultural and predominately Latinx. The RPP aims to build a robust Computer Information Systems (CIS) pathway that supports vulnerable, predominately Latinx youth, with cultural relevant supports. The focus is on CIS rather than CS because the focus is on preparing students with job skills in addition to preparing them for higher education. The work reported here is guided by the question: *What factors help or hinder cross-sector collaborations from building structural supports for students to persist in CIS?*

The first author of this paper is the knowledge broker for this RPP. She has a Masters in Applied Anthropology, and has taught science and technology classes to students throughout the county, including the district detailed here. She als works at the research non-profit. Using her knowledge of both practitioner and researcher realms, she guided the collaboration in unearthing tensions and negotiating solutions. Her anthropology training allowed her to be fully immersed in the project work, while taking detailed observation notes during partnership meetings [17]. The second author represents the research team in the RPP and has worked with all three of the practice organizations for over 15 years.

IV. Theoretical Framing

We use the absorptive capacity framework to understand the opportunities and challenges that face cross-sector collaborations trying to build systems that transect multiple institutions. Farrell and Coburn [3] define absorptive capacity "as the ability to recognize the value of new information, assimilate it, and apply it in novel ways as part of organizational routines, policies, and practice." This framework provides guidance around which conditions support or detract from development of the CIS pathway and how partnerships can leverage their individual strengths for the collaboration.

We applied this framework to help us understand what helped foster cross-sector collaboration, and the interactions that support absorptive capacity. Each organization's ability to learn from external partners requires the buy-in and involvement of key staff members, trust, strong communication pathways, and flexibility from those they are working with. This is particularly important, given the dynamic environment of school districts, colleges, and non-profit organizations.

We also use an RPP framework [5], [6] and utilization of a broker [11], [18] to understand how cross-sector collaborations can build an equitable CIS pathway that students can successfully traverse within and across institutions.

V. Methods

Interview data were collected by the research team from counselors, faculty, and teachers from both the community college and the school district. They were designed to understand what challenges they face and the strategies they employ in their efforts to increase CIS offerings and build a cross-institutional pathway. Interviews lasted between 30-45 minutes and questions included: "What are the resources or opportunities already in place for computing activities at your school or district?" and "How are you thinking about "equity" in CIS opportunities in college or K-12?"

Observational data were collected by the lead author over 2.5 years at cross-sector meetings that include a monthly leadership team (LT) meeting comprised of decision makers from all four organizations, as well as at subcommittee meetings focused on teacher professional development, marketing and communications, and student supports. The observations focus on the negotiations that take place to build and maintain these cross-sector collaborations in an RPP. Cross-sector pathway design and major decisions were negotiated at LT meetings, while implementation and direct services were undertaken by the counselors, faculty, and teachers.

Interview data were analyzed by first organizing them by question and then comparing across participants to identify themes. Responses were reviewed to identify issues brought up within and across institutions. The results were summarized and compiled into reports. The LT discussed the findings and negotiated action items that arose from the results. Meeting notes were analyzed using the absorptive capacity framework.

VI. Results

The data suggest that the collaboration has aligned structures and supports to build a CIS education pathway across institutions in several ways. These include: 1) dedicated high school teachers working together on course content and pedagogy; 2) classroom equipment and supplies to support hands-on learning; 3) connections between high school and college faculty on course content, online tools, assessments, and classroom setup; 4) college field trips for high school students; 5) articulation of two high school classes for college credit; 6) professional development for high school teachers; 7) connections between high school and college counselors to align outreach; 8) college teaching assistants in high school classes; and 9) pathway onramps that include summer camps and high school clubs.

The factors that help or hinder cross-sector collaborations from building structural supports for students to persist in CIS are situated in the four attributes that contribute to absorptive capacity [3]. The following section explores how these attributes can be expanded and applied directly to the cross-sector collaboration.

A. Prior Knowledge and Expertise

The prior knowledge and expertise of individuals has helped the cross-sector collaboration build structural supports for students to persist in CIS. For example, prior knowledge of each other's institutions, such as an understanding of the

different priorities, played an important role in building the collaboration. For example, the knowledge broker had both taught at the school district and had done educational research at the non-profit using the district as a site. Researchers at the non-profit organization had previously implemented CS programs at the school district. Staff leaders at the community-based organization had previously worked at the research non-profit. And faculty from the community college had worked with all three organizations on different education initiatives. Therefore, individuals understood well the challenges that each organization faced in implementing the pathway and culturally relevant student supports.

In addition, individual members of the leadership team brought prior expertise that facilitated the ability to build structural supports for students to study CIS. College faculty and administrators brought expertise in CIS content and pedagogy which helped the high school teachers design curriculum and set up the physical classrooms to create a learning environment that prepared students for college CIS classes. This knowledge also helped to ensure that the high school classes went beyond a singular focus on CS to also introduce students to computer and information systems, a career-focused track that has particular appeal for students who do not plan to go directly to a 4-year college. Partners from the school district brought a range of previous experience, including serving in administrative roles at the high school level. This helped with communication about the CIS pathway with school principals, including how to brand the pathway and connect it to other school and district-level initiatives.

Staff from the community-based organization brought expertise in designing culturally-relevant, asset-based supports and leadership opportunities for Latinx youth from immigrant families. They used that expertise to question what was and was not happening in the development of the CIS pathway. This included advocating for classes that would address social justice issues rather than serving as a gatekeeper to weed out which students study computing. As a result, the CIS classes had a stronger focus on relevant job skills and career pathways. They also provided expertise on how to communicate about computing education and careers to Spanish-speaking families.

Finally, members of the research team brought expertise in research methods, working in RPPs, and the national CS for All movement. This helped with the collection of data to address practitioner questions about how to create an equitable and sustainable CIS pathway, and the sharing of data in graphical soundbites that could be used to refine approaches and assumptions about the pathway. The data showed what matters to students in their decision to engage or persist in the pathway, and what teachers need in order to provide equitable learning environments that have relevance across institutions. In addition, the research team provided relevant research on supporting young women and Latinx youth in computing, and examples of existing high school CIS classes and curriculum.

B. Communication Pathways

The data suggest that the success of cross-sector collaboration depends on how communication is shared and how joint problems are negotiated. In this collaboration, there were both formal and informal communication pathways. Formal paths of communication were available to all leadership stakeholders with equal voice and the ability to pushback within the partnership space; these decisions were made public within the leadership group. Informal paths of communication were non-public channels. They entail employing the broker individually to assert an agenda or express a viewpoint that might be seen as problematic and/or different from the original design of the project.

Leadership team meetings are considered formal in this framing. The decisions made in these meetings were discussed by all partners and support or dissent was vocalized freely; most decisions were shared with other members of the four organizations. This included the formation of ad hoc sub-committees or strategic design of research. Other decisions, however, were privately agreed upon and kept at the leadership level such as which staff members were the best fit for working across institutions. System-level changes that resulted from these meetings included the creation of a shared vision for a CIS pathway, increased support at each institution for the pathway, increased alignment of CIS teaching and learning across institutions, and the development of both formal and informal paths at all partner sites.

Informal communication paths included emails, texts, and phone calls that were not negotiated by the full partnership. These paths were used to negotiate decisions that were driven by a single institution for their needs, such as the shift from the initial focus on cybersecurity to a focus on software and systems development. Further, informal communication paths were employed when an organization was not having their needs met. Consultation with the broker allowed them space to unpack issues that formal paths either did not allow due to time or the sensitive nature of the information. This included conversations with teachers, faculty, and staff that wanted more clarity around decisions or to voice concerns they had but wanted to discuss prior to escalating to leadership.

C. Strategic Knowledge Leadership

Strategic knowledge leadership refers to how well members of the collaboration can identify and leverage resources at their organization to build and strengthen a cross-sector CIS pathway. Examples of this include a cross-institution subcommittee that built on institutional communications tools to create marketing materials that illustrate the pathway components and how they intersect. Another subcommittee included school and college counselors who built on existing efforts to strengthen wrap-around services for matriculating seniors and formalize their cross-institution outreach to students.

Individuals have also leveraged their organizational capacity to strengthen the engagement and persistence of students throughout the pathway. This work is not possible without key leaders delegating tasks and building on existing initiatives and expertise. For example, the school district administrator leveraged knowledge and relationships at the middle schools to create a 7th/8th CIS class sequence to better prepare students for the introductory high school class. They built on external resources, such as with the college and local tech industry to offer field trips and guest speakers. Knowing who and how to work with is a critical part of creating an

equitable, cross-institutional pathway. But relying on the same person or persons repeatedly, particularly if they do not have the requisite relationships or expertise, can hinder this process.

Other examples of strategic knowledge leadership include knowing how to leverage resources and personnel to continue supporting students, even during distance learning in the COVID-19 pandemic. For example, the school district identified a counselor-in-training, who was hired by the community-based organization to make phone calls to students in the introductory CIS class. The research team used the data the counselor collected to describe students' challenges in maintaining focus during class time. The school district also leveraged other funding sources to purchase kits so students could do the hands-on portion of the class from home; a critical step since the research data show that the hands-on experience was what students most enjoyed about that class.

D. Resources for Partnering

Resources for partnering are distinct from resources to support the implementation and work. There is a lot of time, staffing, and materials needed to partner effectively and we are fortunate to have a grant from the National Science Foundation's CS For All initiative, which requires an RPP and allows resources to be directed towards the collaborative effort and not just the direct services.

The use of the grant resources for partnering was seen at all levels of the RPP. Leadership team meetings gave space to discuss strategic implementation and big picture ideas. At the implementation level, it was essential to provide resources for faculty and teachers to collaborate on curriculum, pedagogy, and classroom set-up. Further, staff were supported to help set-up and refine classrooms to meet teacher needs. The broker mediated these relationships and served as a consultant to ensure that the right people were meeting to discuss the pressing issues identified at leadership team meetings.

Further, these resources allowed researchers to negotiate, refine, and disseminate knowledge to stakeholders often not involved in these dialogues. Dedicated staff employed for this project helped researchers refine strategies to recruit participants. With the onset of remote learning, staff's role was redefined to share responsibilities needed by all partners. This included using a counselor from the school district to help recruit for expedient research and to bring in relevant resources for students and families during insecure, transitory times following the onset of the pandemic.

VII. Discussion

To achieve CS for All, we need effective cross-sector collaborations that can build sustainable infrastructure to support students to persist within and across institutions. While there exists a lot of guidance on the benefits of collaborative efforts such as cross-institutional collaborations [10], research-practice partnerships [5] and absorptive capacity, there is little guidance about how these frameworks transect one another and how to apply the specific principles to achieving equity in computer science education [3]. This study is a first step in describing the efforts of one cross-sector collaborative.

Next steps in this research will cultivate a deeper understanding of how these principles play out in real time. This will entail studying how the collaborative leverages power and resources to maximize benefits to students who have been further disenfranchised by unequal resources as a result of remote learning. It is clear is that these cross-sector collaborations require a lot of time and dedication across all partner sites. But simply putting in time does not create equitable results. Favorable results must be negotiated through organizational tension and facilitated by a knowledge broker.

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References

[1] K. Fabian, E. Taylor-Smith, D. Meharg, and A. Varey, "Facilitating computing students' transition to higher education," in *Proceedings of the 1st UK & Ireland Computing Education Research Conference on - UKICER*, Canterbury, United Kingdom, 2019, pp. 1–7, doi: 10.1145/3351287.3351298.

[2] A. Joshi, G. Bruno, X. Apedoe, S. Engle, S. Rollins, and M. Malensek, "Engendering community to computer science freshmen through an early arrival program," in *2020 ASEE Virtual Annual Conference Content Access Proceedings*, Virtual On line, Jun. 2020, p. 34545, doi: 10.18260/1-2--34545.

[3] C. C. Farrell and C. E. Coburn, "Absorptive capacity: A conceptual framework for understanding district central office learning," *J Educ Change*, vol. 18, no. 2, pp. 135–159, May 2017, doi: 10.1007/s10833-016-9291-7.

[4] M. Smith, "Computer Science For All," *The White House (President Barack Obama)*, Jan. 30, 2016. https://obamawhitehouse.archives.gov/blog/2016/01/30/computer-science-all#:~:text=Computer%20Science%20for%20All%20is,be%20active%20citizens%20in%20our.

[5] E. C. Henrick, P. Cobb, W. R. Penuel, K. Jackson, and T. Clark, "Assessing research-practice partnerships: Five dimensions of effectiveness," William T. Grant Foundation, New York, NY, 2017. [Online]. Available: https://wtgrantfoundation.org/library/uploads/2017/10/Assessing-Research-Practice-Partnerships.pdf.

[6] W. R. Penuel *et al.*, "A comparative, descriptive study of three research–practice partnerships," National Center for Research in Policy and Practice, 4, 2020.

[7] T. Melguizo and F. Ngo, "Mis/Alignment between high school and community college standards," *Educational Researcher*, vol. 49, no. 2, pp. 130–133, Mar. 2020, doi: 10.3102/0013189X19898697.

[8] L. A. Lyon and J. Denner, *Chutes and Ladders: Institutional Setbacks on the Computer Science Community College Transfer Pathway*, vol. 19. 2019.

[9] T. Domina and E. Ruzek, "Paving the Way: K-16 Partnerships for higher education diversity and high school reform," *Educational Policy*, vol. 26, no. 2, pp. 243–267, Mar. 2012, doi: 10.1177/0895904810386586.

[10] C. J. Riehl, J. R. Henig, J. R. Wolff, and M. A. Rebell, "Building impact: A closer look at local cross-sector collaborations for education," Teachers College, Columbia University, New York, NY, 2019. [Online]. Available: https://www.wallacefoundation.org/knowledge-center/Documents/Building-Impact-Executive-Summary.pdf.

[11] C. Conaway, E. O'Hara, and J. Vasan, "Spotlight: The role of brokers in research-practice partnerships," *NNERPP Extra*, vol. 1, no. 1, pp. 10–11, 2019.

[12] Hispanic Association of Colleges and Universities, "2019 Fact Sheet: Hispanic higher education and HSIs.," 2020. [Online]. Available: 2019 Fact Sheet: Hispanic higher education and HSIs.

[13] "Integrated supports for college & career readiness in a Linked Learning approach," *John W. Gardner Center for Youth and Their Communities*. https://gardnercenter.stanford.edu/projects/integrated-supports-college-career-readiness-linked-learning-approach.

[14] A. Johnston, M. Castellano, and S. Darche, "Aligning systems for equity in college and career pathways: Report to the field," UC Berkeley Graduate School of Education, College and Career Academy Support Network (CCASN), Berkeley, CA, 2019. [Online]. Available: https://casn.berkeley.edu/wp-content/uploads/2019/07/Symposium-4-report.pdf.

[15] L. Hubbard and M. McDonald, "The viability of combining academic and career pathways: A study of Linked Learning," *null*, vol. 19, no. 1, pp. 1–19, Jan. 2014, doi: 10.1080/10824669.2014.943759.

[16] "Current term enrollment estimates," National Student Clearinghouse Research Center, Fall 2020. [Online]. Available: https://nscresearchcenter.org/wp-content/uploads/CTEE_Report_Fall_2020.pdf.

[17] J. J. Schensul and M. D. LeCompte, *Essential ethnographic methods: a mixed methods approach*, 2nd ed. Lanham, MD: AltaMira Press, 2012.

[18] J. Malin, Ed., *The role of knowledge brokers in education: connecting the dots between research and practice*. Abingdon, Oxon ; New York, NY: Routledge, 2019.