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Engaging Rural America in Computer Science: Understanding the Rural Context

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Abstract

In the United States, 1 in 5 people, approximately 66.3 million individuals, live in a rural area. To address the growing need for computing professionals and the need for a computationally literate populace, we need to engage rural learners effectively. A first step in this direction is understanding the learning context for students engaging in computer science, and how that differs for a rural population. In this paper, we draw upon the National Survey of Science and Mathematics Education, the High School Longitudinal Study of 2009, and the 2021 American Community Survey to underscore a lack of access to computer science learning contexts for students in these communities. We also explore how rural out-migration is compounding this challenge, and explore the roots of the rural out-migration trend.

We then examine how multiple strains of research and scholarship identify rurality as either a place-based identification (i.e., where a student is from) or a distinct social identity. While convenient, geographic-based definitions lack important nuance in understanding rural populations and tend to emphasize heterogeneity in rural populations, especially regarding economic factors (i.e., what the communities produce). In contrast, identity-based definitions often emphasize commonalities across rural populations including a set of shared values, a sense of belonging to a rural community, emphasis on social bonds, and a distrust of solutions offered by government, academia, and technology which are often seen as misguided and antithetical to those shared values. In certain kinds of decision-making, this rural identity has even been shown to overshadow intersectional racial and ethnic identities. This is an important consideration as 22% of the US rural population is composed of racial and ethnic minorities.

Finally, we discuss strategies to engage with rural populations authentically and meaningfully. We offer as an illustrative example our Cyber Pipeline program, an outreach effort including a Creative Commons licensed, customizable, modular curriculum; extensive teacher preparation program; and ongoing support for K-12 teachers working to bring computer science into rural schools. We also describe reasons why these rural-dwelling teachers seek to provide computer science education for their students. We highlight the specific challenges of this program, as well as our identified promising practices, in the hopes of fostering similar programs across the United States.

1 Introduction

Increasing participation in the field of computer science (CS) requires that we reach a broader audience of potential students. To date, efforts in broadening participation in CS within the United States have focused on a specific set of underrepresented groups: women, African

Americans, Hispanics, Native Americans, Alaska Natives, Native Hawaiians, Native Pacific Islanders, and persons with disabilities [1]. Simply walking into most undergraduate computer science classrooms in the United States will quickly confirm this underrepresentation.

However, gender, race, and ethnicity are not the only contributing factors to diversity. Our own university serves a primarily rural state, with nearly 60% of our population living in a rural area, yet when we examined our student body, only 24% of our CS undergraduates attended a rural high school. Clearly, this is problematic for a public university with a mission of supporting all students within the state, but it also led us to wonder if it was emblematic of a larger issue that had gone unnoticed. With one in five Americans living in a rural area [2] (compared to just over half living in suburban and one-third living in urban areas [3]) it would be a significant issue.

Indeed, a review of the literature suggests that failure to effectively engage with a rural audience is not limited to our university and state: **Maryland** - a 2013 study found 28.6% of rural high schools had no CS offerings, compared to 6.3% of urban and 2.1% of suburban schools [4]. **Virginia** - a 2018 study of reported that rural high schools were three times less likely to offer on-site CS courses than suburban counterparts [5]. **Texas** - a 2021 study in Texas found that rural students in the state had less opportunity and participation in CS than their suburban and urban peers [6]. These states have sizable proportions of their population in rural areas: Maryland 15%, Virginia 22.4%, and Texas 16.3% [7]. Clearly, more effort must be made to reach these populations.

A first step to designing successful interventions is understanding the population you seek to serve. Rural areas are a bastion of incredible diversity in natural and human resources, industries, and social and economic challenges [8]. Yet with this diversity, there are commonalities in social and cultural aspects, with research suggesting that these populations subscribe to a complex shared group identity referred to as *rural consciousness* [9]. While not yet adequately explored, there is also some evidence to support that, for intersectional identities, rural consciousness may play a larger role in decision making than gender, race, or ethnic identities.

In her landmark 2004 paper, Bridget Barron suggested that a learning ecology perspective was a useful mechanism for understanding how and why students engage in activities that develop an interest in technology careers. She identified five contexts that support students in developing fluency in an interest like a computer science — school, peers, home, community, and distributed resources — and argued that students need support across several contexts to help foster and grow their interest [10].

This perspective provides a good framing mechanism for exploring disparities in computer science learning opportunities between rural and non-rural populations. A weakness in one context might not have a large impact, but issues across multiple learning contexts will likely have an outsized effect on students' opportunities and goals. Thus, if we find disparities in more than one learning context, we make a stronger case for recognizing rural populations as underserved. With this understanding, our research question becomes:

RQ1: Are rural US students provided fewer opportunities to engage with computer science through: a) the school context? b) the community context? c) the distributed resources context? d) the peer context? e) the home context?

2 Research Methodology

This study draws from existing national public-use data sets to determine if rural students are disadvantaged in specific learning contexts compared to their urban and suburban counterparts. The data sets were selected based on the appropriateness of addressing specific concerns aligned with student learning contexts and because they collected National Center for Educational Statistics' (NCES) locale classifications, allowing for aggregation by rural status.

2.1 Defining Rural

The challenge of studying rural populations is compounded by a lack of a singular definition for what constitutes as "rural" — existing definitions based on population can vary from less than 10,000 residents to less than 50,000 residents, and may or may not involve distances from urban centers [11].

For the purposes of this study we utilize the National Center for Educational Statistics' (NCES) locale classifications, which divides all locations within the US into four categories (**rural**, **town**, **suburban**, and **city**) that are further broken into three subtypes based on population density or proximity to urbanized areas [12]. NCES classifications are derived from the United States census, but offer a more detailed breakdown. The census defines an "urban area" as heavily developed and densely populated land used for residential, commercial, and other urban land uses with a population of at least 2,500 [13], encompassing the NCES **urban** and **suburban** classifications. The census defines all land falling outside of this **urban** categorization as "rural" [13], which encompasses the NCES **rural** and **town** designations.

For our analysis, we are collapsing the NCES-designated **rural** and **town** locale categories into a single category of "rural," corresponding to the census' definition, as it allows us to use the same population when we examine both census data and NCES-coded data. We also observe that NCES **rural** and **town** schools face similar challenges, and a visual observation of NCES locales confirm that (at least in our state) schools outside of urban areas serve a mix of town and rural populations. However, we will maintain the NCES **suburban** and **urban** designations for the analysis as there are important distinctions between these categories, and much of the prior K-12 computer science outreach efforts have focused on urban schools.

2.2 Data Sources

In this section, we will describe the data sources used, along with specific variables from those data sources used in the analysis to address concerns within specific learning contexts.

2.2.1 National Survey Of Science And Mathematics Education (NSSME+)

This research utilizes the public release datasets from the 2018 National Survey of Science and Mathematics Education (NSSME+). The data consists of responses from 7,600 teachers in computer science, mathematics and sciences, from 1,273 schools across the United States [14].

Sample Design The NSSME+ implements a complex sampling design which is a combination of stratification, clustering, and based on an unequal probabilities of selection. In order to ensure that the estimates are representative, we use the provided national survey weights, average weights, as well as 75 jackknife replicate weights. These are used to compute the mean responses and their respective standard error estimates. Each dataset has weighting variables, whose appropriate use is crucial to obtain accurate estimates [15].

Research Variables of Interest

- **Locale:** The survey variable `ccdUrban` codes NCES locale categories to distinguish rural schools from suburban and urban schools.
- **Lack of formal programming instruction**: Variable `scq22f` codes a yes/no response to the question "Grades 9-12 students in this school cannot take a computer science course that teaches programming or requires programming as a prerequisite."
- **Offered informal learning opportunities:** Variables `scq17a` through `scq17k` code yes/no responses to various informal computer science learning opportunities like after-school clubs and summer camps.

2.2.2 American Community Survey

This study also uses public data from the American Community Survey (ACS), an annual survey conducted by the United States Census Bureau. We draw from the 2022: ACS 1-Year Estimates Subject Tables which provide estimates presented as population counts and percentages on a variety of topics and aggregated by demographic and geographic factors [16].

Sample Design Each year the census selects approximately 3.4 million independent housing unit addresses for inclusion in two sampling periods. A ratio estimation procedure resulting in two weights — one for person-level data and one for housing unit level data — that correct for over- and under-sampling within geographic regions is used [17].

The resulting estimates are provided with margins of error. We have used these to create derived estimates including aggregations across groups, percentages, and proportions, which requires calculating an associated margin of error, as well as testing for statistical significance [18].

- **School Age:** An estimate of the school age population derived by subtracting the population estimate of `Under 5 years` from `Under 18 years`.
- **Employed in a Computing Career:** A population estimate of the population 16 and older employed in a computing related career that is a relabeling of the `Computer and mathematical occupations` estimate, defined by Bureau of Labor Statistics occupation category of the same name.
- **Computing Career Percentage:** An estimate of the percentage of employed adults engaged in computing careers, derived by dividing the `Computing Career` population estimate by the `All employed populations 16 and over` population estimate.

- **School Child to Computing Professional Ratio:** A derived estimate ratio obtained by dividing the `School Age` population estimate by the `Computing Career` estimate.

2.2.3 High School Longitudinal Study Of 2009 (And Follow-Up Surveys)

This study also draws from data collected by the High School Longitudinal Study of 2009 (HSLS:09) conducted by the National Center for Educational Statistics (NCES). This comprehensive longitudinal quantitative study involves base and follow-up surveys throughout secondary and post-secondary years (the first follow-up was in 2012, the second in 2016, and post-secondary transcripts were collected in 2017-18) [19]. The longitudinal nature of this study allows us to address questions about students' transition to and persistence within their post-secondary studies — our variables of interest are derived from the 2016 second follow-up instrument.

Sampling Plan HSLS:09 utilizes two-stage sampling. In the first stage, public and private schools were selected with stratified random sampling, resulting in 1,889 schools, of which 944 (55.5%) chose to participate. In the second stage, a total of 25,206 students were randomly sampled with 21,444 respondents (approximately 27 per school). As this sampling plan involved stratified and clustered data, along with selective oversampling to address small populations of interest, sample weights are supplied with the HSLS:09 data and vary by instrument.

Research Variables of Interest

- **Locale:** The `X4LOCALE` categorical variable from the second follow-up student survey indicating the locale (based on NCES designation) of the student's last attended school.
- **Computing proficiency self-perception:** The `S4TPERSON1` variable is a four-point Likert scale from the second follow-up student survey indicating agreement (1=Strongly agree, 4=Strongly disagree) with the statement "You see yourself as someone who is good at solving problems using computers."
- **Others' computing proficiency perception:** The `S4TPERSON2` variable is a four-point Likert scale from the second follow-up student survey indicating agreement with the statement "Others see you as someone who is good at solving problems using computers."
- **Post-secondary enrollment level:** The `X4PS1LEVEL` variable indicates the level of the first post-secondary institution the student enrolled in (Four-year, Two-year, or Less than two-year).
- **Post-secondary dropout:** The `X4ATPRTFI` variable indicates student's attainment or perseverance towards their first post-secondary credential. We use the value "No degree at first institution, not enrolled at any institution" as an indicator of post-secondary dropout.

3 Analysis By Learning Context

In this next section, we discuss our analysis approach for each of the learning contexts, and provide the statistics from that analysis.

3.1 School

The school learning context is where many students are first introduced to the discipline of computer science through formal instruction — in a computer science course or embedded in other disciplinary learning — or through less formal opportunities like clubs, after-school programs, and the like. Rural schools often fall short on providing computer science education opportunities: for example, a 2013 survey of Maryland high schools showed that 28.6% of rural schools had no CS offerings, compared to 6.3% of urban and 2.1% of suburban schools [4]; a 2018 study of Virginia high schools reported that urban and suburban schools were three times more likely to offer on-site CS courses than rural schools [5]; and a 2021 study of counties in Texas concluded that all rural students in their state were disadvantaged in terms of both access to and participation with computer science educational opportunities [6]. While the disparities in this last study were highest for rural minorities, even rural white males faced a difference of more than three standard deviations in access to computer science education opportunities compared to their urban counterparts.

To examine the school context at the national level, we turn to the 2018 National Survey of Science and Mathematics Education (NSSME+). The study included a survey of school coordinators, which helped identify what computer science educational opportunities existed within their schools. Specifically, question 22f is a yes/no question with the prompt "Grades 9-12 students in this school cannot take a computer science course that teaches programming or requires programming as a prerequisite." A yes answer indicates the school offers no courses in programming. For rural schools, 29.7% (±5.5%) indicated a lack of available programming courses, compared to 15.1% (±5.3%) for urban schools and 8.1% (±2.8%) for suburban schools. Essentially, rural schools were twice as likely not to offer a programming course than urban schools, and more than three times less likely than suburban schools!

Similar results play out for informal school-based activities, as can be seen in Table 1. In nearly every category, rural schools offer fewer opportunities to engage in computer science than urban and suburban counterparts.

3.2 Community

The community learning context primarily deals with the availability of role models and mentors in the student's community, which can play a vital role in nurturing and guiding a students' interest in the field [10, 20, 21, 22]. Of especial importance to the impact of role models is the student's *perceived similarity* between the role model and themselves [23, 24, 25]. If we accept that rural students subscribe to a "rural" identity, then it follows that role models the students perceive as "rural like me" will have a much stronger impact on these students.

To assess the availability of these community mentors and role models, we turn to the 2022 American Community Survey. It collects occupation data for the employed population of age 16 and up. We will use the "Computer and mathematical occupations" category as representative of the subpopulation employed in a computing career. For rural areas, it reports 627,115 (±14,157) computing professionals, or 2.06% (±0.04%) of the employed rural population [26]. In contrast, the corresponding urban population is 5,547,093 (±52,213)

Table 1: NSSME+ School-based Computer Science Education Opportunities

Question	Rural+Town	Urban	Suburban
17a. Holds family computer science nights	8.5%±2.2%	16.4%±3.3%	14.5%±2.8%
17b. Offers after-school help in computer science	18.1%±2.6%	18.9%±2.7%	21.5%±2.5%
17c. Offers formal after-school programs for enrichment in computer science	13.9%±2.4%	23.5%±3.7%	24.6%±3.3%
17d. Offers one or more computer science clubs	18.6%±2.6%	33.2%±3.8%	28.6%±2.7%
17e. Participates in Hour of Code	29.6%±2.9%	35.4%±3.8%	46.6%±4.0%
17f. Participates in local or regional computer science fair	9.9%±2.0%	15.0%±2.9%	13.9%±2.9%
17g. Has one or more teams participating in computer science competitions	9.1%±1.6%	8.0%±1.5%	11.6%±2.3%
17h. Encourages students to participate in computer science summer programs or camps	36.2%±3.0%	48.2%±4.6%	47.2%±3.5%
17i. Coordinates visits to business, industry, and/or research sites related to computer science	16.5%±2.4%	24.2%±3.5%	18.4%±2.9%
17j. Coordinates meetings with adult mentors who work in computer science fields	12.5%±2.0%	18.9%±3.4%	19.3%±2.8%
17k. Coordinates internships in computer science fields	3.2%±0.7%	4.9%±0.9%	3.7%±0.7%

computing professionals, or 4.20% (±0.04%) of the employed urban population.

A difference of 2% may not seem like much, but when we consider the population of school-age children (ages 5-18) also reported by the ACS [16], the ratio of student to professional is 2:1 (with a 1% margin of error) for urban areas, but 18:1 (with a 2% margin of error) for rural areas. Thus, an urban student is *nine times more likely* to have a computing professional living within their community than a rural one.

Moreover, this disparity is further exacerbated by varying population density. Several rural counties in Kansas have an employed population density at or below 1 person per square mile [27], so students may have to travel long distances just to find a single computing professional in their area. This makes it even less likely that a student in these rural areas will have regular, meaningful interactions with a role model in the field.

3.3 Distributed Resources

The distributed resources learning context refers to the kinds of resources a student must actively seek out, such as libraries, internet sites, and online communities. Rural libraries face similar challenges to schools — with a smaller tax base, these libraries have limited

Table 2: Household Computer and Internet Access

Household Characteristic	Rural	Urban
One or more computer in house	93.8%±0.1%	96.2%±0.1%
Desktop or laptop	75.3%±0.1%	81.8%±0.1%
Broadband subscription	87.4%±02%	91.9%±0.1%
Without any internet	12.3%±0.2%	8.0%±0.1%

resources, and many towns lack even a basic library. Our state has over 1,890 cities, towns, and villages [28], but only 331 public libraries [29].

However, the majority of high-quality computing resources are distributed through the Internet, which makes broadband Internet access crucial to fostering a growing interest in computer science. Unfortunately, many rural areas still lack affordable access to the internet, or even access at all. The Federal Communications Commission (FCC) reports 22.3% of Americans in rural areas are lacking access to 25/3 Mbps or better terrestrial broadband coverage — compared to 1.5% in urban areas [30]. If we consider the new FCC definition of broadband as a minimum of 100/10 Mbps, the percentage of households lacking terrestrial access increases to 37.4% for rural populations and 2.6% for urban ones [30].

Access is, of course, only part of the picture; active participation requires a household both subscribe to high-speed internet and have a suitable computer available. Here we again turn to the American Community Survey, which collects household level data that reports on these necessary prerequisites, summarized in Table 2. On every measure, rural households lag behind their urban counterparts [16].

3.4 Peers

Peers are a valuable source of encouragement (or discouragement) for students developing an interest in computing, and peer-to-peer learning is a powerful mechanism [10, 21, 22, 20]. Peers can serve to introduce learning resources in other contexts, e.g., sharing distributed resources, introducing mentor figures, and providing opportunities to carpool to events. Moreover, a peer can be a source of computing hardware for economically disadvantaged students. A lack of perceived peers with a shared interest can greatly discourage students from pursing further learning in computing, especially for women and racial/ethnic minorities [21, 22]. Thus, the availability of peers with an interest in computing is likely a critical factor in nurturing a novice computer scientist.

Table 3: Student's perceived proficiency at problem solving with computers

	Rural+Town	Suburban	Urban
Self-perception	2.08±0.03 (SE=0.02)	2.02±0.03	2.03±0.04
Others' perception	2.09±0.03	2.05±0.04	2.06±0.04

To address the availability of computing-interested peers, we used two four-point Likert scale questions from the second follow-up survey conducted in High School Longitudinal Survey of 2009 project. The first of these (S4TPERSON1) asks the student's agreement with the statement "You see yourself as someone who is good at solving problems using computers." The second (S4TPERSON2) asks the students' agreement with the statement "Others see you as someone who is good at solving problems using computers." The mean reported values for these questions appear in Table 3. We found the reported values inconclusive, both due to the lack of variance, and also due to the open-ended interpretation of what "solving problems with computers" might mean to the student. Students who have had encounters with programming would likely consider using programming part of "solving problems with computers," while those with no programming exposure might focus more on using existing applications and searching the web when answering.

3.5 Home

The home learning context is one of the most powerful, as it is central to a student's life. One aspect is the availability of internet and computing hardware (see distributed resources above). It bears pointing out here that, while any internet-connected device can provide access to knowledge, a more powerful and keyboard-equipped computer (i.e. a laptop or desktop) is necessary for actually practicing many computing tasks, from programming to data science. As can be seen in Table 2, rural households are 6% less likely to have access to this kind of hardware.

Of course, parents are extremely powerful forces for encouraging (or discouraging) a student's interests [10, 21, 22, 20]. Returning to the concept of rural consciousness, researchers have encountered much concern from rural residents about sending their children to a four-year state university, which they felt would lead to one of two outcomes: 1) that successful students would leave their home communities to live in distant cities, leaving them largely cut off from their families [31]; and 2) unsuccessful students would return to their community saddled with crushing debt, no degree, and little opportunity. Moreover, the university represents a tremendous culture shock for rural students. As one of the study participants explained, "We lose kids when we send them [to a four-year university]. They self-destruct because the change is too traumatic [32, p. 115]."

Table 4: Level of student's first post-secondary institution

	Rural+Town	Suburban	Urban
4-year	57.0%±3.0%	62.5%±3.6%	55.6%±4.4%
2-year	39.5%±4.5%	34.1%±3.3%	40.4%±4.4%
Less than 2-year	3.5%±1.0%	3.4%±1.2%	4.0%±1.4%

With this in mind, we examined what level of post-secondary institution students in the NSSME+ enrolled in as it could be seen as a reflection of this parental concern. The results can be seen in Table 4. These numbers do suggest that rural students show a stronger preference for two-year over four-year institutions. Moreover, we looked at the "burnout rate" of NSSME+ participants who had enrolled in a post-secondary institution but dropped out without a degree. For rural students, 17.6% (±1.5%) fell into this category, compared to 18.7% (±2.7%) for urban and 15.3% (±1.8%) for suburban participants.

4 Examining Rural Identity

In seeking to understand voting trends among rural populations, recent scholarship in political science has suggested that rural populations subscribe to a complex shared group identity identified as *rural consciousness* which [9]:

- is grounded in a sense of belonging to a *rural* location (a town, township, or rural area) even if the individual no longer lives there,
- incorporates concepts of the values and lifestyles adopted by rural people,
- espouses a belief of distributive social injustice against rural populations, suggesting the needs of urban and suburban populations are prioritized over those of rural populations.

This last point has important implications for any effort to reach a rural audience, as it often manifests as distrust of government and academia and the initiatives that arise from them.

To better understand this point of view, consider the recent example of the National Interest Electric Transmission Corridors (NIETCs), authorized under the Federal Power Act [33]. The purpose of these corridors is to streamline the process of building transmission infrastructure by making available federal funds and applying federal eminent domain processes within the geographic bounds. On the surface, this seems like an excellent benefit for rural areas hosting wind farms, bringing in lease money for wind turbines placed on farmland. Yet there are far more farms that do not host wind turbines that are also affected. Running east-west through Kansas, Missouri, Illinois, and Indiana, the proposed Midwest Plains corridor was 5 miles wide and 780 miles long [34]. Considering that the average farm size in America is 463 acres (0.72 square miles) [35], this corridor could potentially consume 5,390 farms! Moreover, given the number of farming families that could be displaced in a community, the likelihood of finding other farmland available for purchase nearby is very unlikely, essentially causing mass out-migration from the affected regions. It is hardly surprising that the plan led to mass outcries from affected farmers and communities, leading to the plan being scrapped [36].

An example more closely tied to schools is the changes to the National School Lunch program in 2010 championed by Michelle Obama. Specifically, the program mandated limited school lunches to 850 calories in an effort to curb obesity. Rural students and parents felt that this limit ignored the fact that most rural students maintain a highly active lifestyle (participating in athletics, working on the family farm, etc.) and needed more calories. This, too, caused a massive outcry among rural communities, even leading to the production of a protest music video by rural students [37, 38].

These examples underscore the challenge of crafting coherent policy affecting rural populations. As Castle observes [8]:

> There is a great propensity in this nation to identify problems as they occur in individual circumstances, compare them under varying conditions, and then refer

> them to Washington for a comprehensive solution. This has not and will not work in rural America. [...] rural problems are too diverse and too complex for a highly centralized approach unless it is combined with a capacity to reflect local conditions and circumstances.

Essentially, in crafting interventions for rural students, we need to engage with their communities to ensure that we understand and address rural concerns. This is not a new problem in education, and there are many existing frameworks that can be utilized in this effort, like culturally-relevant pedagogy [39], community-based learning [40], and possibly even critical pedagogy [41]. These approaches are participative in nature, mandating a collaborative process between the curriculum developers, the teachers, and the students – grounding learning activities in the concerns and interests of the students while providing the rigor needed to prepare students to effectively use CS [42]. Embracing such approaches helps avoid the sense of patronization that can come with curriculum crafted by higher education "experts" without meaningful engagement with the communities that curriculum is deployed in. A deeper exploration of rural identity and identity frameworks can be found in [43].

5 Strategies For Engaging With Rural Populations

While the data available to evaluate each learning context varied in availability and alignment to the question, we feel it is clear that disparities exist between rural and urban student populations. This is most clearly demonstrated in the school context. We see this as a critical area to address, as the school can serve as a gateway for introducing knowledge and skills not otherwise represented in a community.

Moreover, in a post-COVID world, remote work is a common aspect of computing careers, meaning students who develop computational skills can return to their communities with solid employment prospects. Studies of rural student aspirations have shown that rural students retain strong attachment to their home communities, and would prefer to return to those communities given the opportunity [44]. In doing so, they can both enrich the community learning context as role models and mentors to the next generation, as well as providing a robust home context for their own families.

Rural schools have the potential to be drivers of economic development by fueling this process through fostering computational skills, knowledge, and identity in their students. Computer science, with its lack of representation among rural populations and its association with big tech, is often seen as antithetical to rural values. Thus, in designing interventions, it is not enough to be aware of the challenges facing rural students and their communities, but also necessary to understand the unique strengths arising from rural lifeways and how computing can be integrated into rural identities. More research — especially research embracing participatory approaches — is needed.

To support that research effort requires not just targeted funding, but a shift in perspectives. Rural school populations are small; the average student population (including both elementary and secondary students) of a rural fringe schools is 553, rural distant 282, and rural remote 163, with a lot of variation around those averages [45]. Of our state's 353 public high schools, half serve fewer than 182 students, and a quarter less than 88 [46]. Accordingly, interventions will need to target more than one school to achieve statistical power, bringing increased costs and challenges. Moreover, planning and budgets must account for travel time between research centers and rural schools. While this may appear to be a setback, it also means findings will be more generalizable as working with multiple schools reduces threats to validity emerging from working with a single school population.

Likewise, rural students would benefit from additional support at the post-secondary level. Rural areas suffer from persistent poverty that directly impacts students and also results in lower funding for public schools, and are often located farther from post-secondary institutions than urban and suburban areas, limiting opportunities to engage with university outreach programs [47]. Culture shock at a large institution can also impact rural students' well-being; finding themselves surrounded by thousands of strangers who do not share a rural identity can lead to a sense of isolation [32]. While universities have developed excellent support systems for marginalized students, rural students are not often included in these programs or even considered an important demographic. In fact, our own institution fails to track the rural status of students, so we had to hand-code students' status based on the high school they attended for our earlier analysis. We believe a greater recognition of rural student populations within higher education institutions would be beneficial to improving their educational outcomes.

5.1 Our Approach: The Cyber Pipeline Program

Our department recently took up the challenge of bringing quality computer science instruction to our state, with a strong focus on rural schools. The Cyber Pipeline Program was the genesis of this effort, providing no-cost curriculum and professional development to K-12 schools across our state. In the past four years, we have reached 105 of our state's 287 school districts, with 60 of those schools classified as rural and 28 as town by the NCES. A detailed discussion of the program can be found in [48], but we will discuss what we believe made our program most successful briefly here.

First, our initiative joined in on a university-wide drive to refocus on our land-grant mission. Thus, our effort to bring CS to a K-12 audience had support at multiple levels in the university. Our department head was able to leverage this initiative to join a statewide "listening tour" where university faculty and administrators visited the state's K-12 and two-year institutions to better grasp the challenges faced. This helped us start with a clear picture of what challenges our partners in K-12 faced in adopting CS instruction in their institutions.

This tour identified several key concerns - the cost of adding computer science to a school's offerings, the challenge of identifying and recruiting qualified teachers to carry out that offering, and the diverse range of computing hardware and lack of strong IT support. To address these concerns, the Cyber Pipeline curriculum was developed as a turn-key packaged curriculum that only required a licensed teacher in a "facilitator" role. It was delivered through Codio, an online platform that provided access to cloud-based virtual machines to the students at a negotiated low cost, which we were able to cover with private donations. The curriculum itself was developed in-house, including creative commons licensed textbooks and hundreds of short instructional videos recorded by faculty and hosted on YouTube. Two of the courses in the curriculum are aligned with the AP Computer Science Principles and AP Computer Science A courses, allowing schools to offer the corresponding AP exam for portable college credit.

However, we did not want the program to become another online course – we wanted the local teachers to engage with us, the content, and their students and grow into a coach/mentor role. To aid in this, we created a professional development program that consisted of six courses leading to a graduate certificate in Computer Science Education. Recognizing the constraints on our teachers' time, these courses are delivered asynchronously and allow teachers to move at their own pace. We were able to leverage a state grant to provide the first ten credit hours to our teachers at no cost, and we secured private donor support for the remainder. Our college also funded a "help desk" of graduate and undergraduate teaching assistants to both help teachers in the PD courses and in setting up and delivering their own courses. Finally, recognizing that many of our teachers would be the only computer science teacher in their district, we host a four-day workshop culminating in a statewide CSTA chapter conference that teachers in our program attend, providing rich opportunities for networking.

A second contributing factor was that three of the faculty involved in creating and running the program are from rural communities in the state. This background gave us both familiarity with the culture of rural Kansas and also a degree of legitimacy in the eyes of the K-12 teachers and administrators we work with. This is a passion project for us, and it shows. We have shouldered the responsibility of teaching the professional development content courses overload as the program was launching, and have taken the reins of the state CSTA chapter when the current president re-entered industry. We have also leveraged the undergraduate clubs we mentor to create a state-wide computer science student community, inviting our high school students to participate in an annual Hackathon, Game Jam, and Programming Contest, and are working towards an agricultural robotics competition.

Third, we have engaged the teachers in our professional development program as co-creators of our curriculum. This began with encouraging our teachers to offer feedback on the curriculum as they worked through it (we have teachers complete the same learning tasks found in our K-12 curriculum) and using that feedback as part of our continuous improvement process. This led to a complete overhaul of our CS0-equivalent curriculum while our first group of teachers were still completing it. Seeing that we were listening and attempting to address their concerns in near-real time helped develop a substantial amount of trust, and opened the feedback floodgates. The teachers gave us invaluable critiques, even exposing pain points that had gone unnoticed in our undergraduate courses for years.

We are in the process of expanding upon this collaboration to create rural-focused curriculum units that can be "plugged" into offerings of the course. Some of the lessons ideas emerging from this effort can be seen in [42]. By bringing K-12 teachers, disciplinary experts, and our own CS content knowledge and pedagogy we are working to create a modular, interdisciplinary curriculum that engages our rural constituents in exciting and holistic ways.

Fourth, in engaging with teachers, students, and communities through the Cyber Pipeline program, we have emphasized the availability of remote work within computer science and interdisciplinary computing. Helping students and teachers understand that there are wellpaying career options in these fields that will allow the students to remain within their community is important. For students, simply understanding that a a computing career is possible and does not require relocating can help stimulate interest. For teachers and counselors, it is important that they recognize the opportunity, as they often serve as gatekeepers directing students towards future career options. To assist in this education effort, we have produced several videos featuring alumni from our department who came from rural areas of the state and are engaged in remote work. We will be sharing these in school-wide assemblies with our Cyber Pipeline program schools, and report the impacts of this approach in a future paper.

6 Conclusion

By examining national survey data from a learning ecologies perspective, we have shown clear disparities in the school, community, and access to distributed resources contexts for rural students when compared to their urban and suburban peers, and suggested the need for a more nuanced exploration of the peer and home contexts. Any such effort would benefit from examining the impact rural consciousness plays on how rural students and their families engage with computing as a career option.

In this exploration, we also build a case for identifying rural populations as a distinct underrepresented group in computer science. Being officially designated as such by organizations like the National Science Foundation can lead to increased funding opportunities for both research and interventions, leading to better outcomes for rural students with an interest in computing fields. We also argue that in this effort, it must be recognized that research focused on rural schools faces many unique challenges not encountered in urban and suburban-centered educational research including small student populations and schools located at significant distances from the researchers' institutions.

We firmly believe that this outreach and research effort is worthwhile. Meeting the computational needs of our country requires broadening participation in computing, and rural students account for nearly 20% of the population. Rural areas also boast low housing and cost-of-living and often serve as sites for renewable power generation. Combine that with the relatively low infrastructure requirements of many computing-centric industries (essentially office space, computers, and an internet connection), rural communities are ideal sites for remote work in computing fields and could prove ideal incubators for tech startups. Thus, better preparing these rural populations can lead to economic revitalization of their communities.

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