ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #38028

Secure and Upgrade Computer Science in Classrooms through an Ecosystem with Scalability & Sustainability (SUCCESS)

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Dr. Afrin Naz is an associate professor in the West Virginia University Institute of Technology Computer Science and Information Systems department. She is an ABET Ideal Scholar and has been active in research on promoting Computer Science education in K-12 schools, for which she has been awarded one NSF grant and 15 non-NSF grants. In the past seven years, she organized 25 workshops/camps for West Virginia K-12 teachers and students. She and Co-PI Mingyu Lu have been the directors of the after-school STEM program in Raleigh County Schools and Fayette County Schools since 2018. Results from her research have been presented at the American Association of Engineering Education conference, ABET national symposium, and Frontiers in Education conferences. In the last six years Dr. Naz and her team launched more than 20 workshops for high school and middle school teachers.

Dr. Mingyu Lu received the B.S. and M.S. degrees in electrical engineering from Tsinghua University, Beijing, China, in 1995 and 1997 respectively, and the Ph.D. degree in electrical engineering from the University of Illinois at Urbana-Champaign in 2002. From 1997 to 2002, he was a research assistant at the Department of Electrical and Computer Engineering in the University of Illinois at Urbana-Champaign. From 2002 to 2005, he was a postdoctoral research associate at the Electromagnetics Laboratory in the University of Illinois at Urbana-Champaign. He was an Assistant Professor with the Department of Electrical Engineering, the University of Texas at Arlington from 2005 to 2012. He joined the Department of Electrical and Computer Engineering, West Virginia University Institute of Technology in 2012, and he is currently a Professor. His current research interests include wireless power transmission, radar systems, microwave remote sensing, antenna design, and computational electromagnetics. He was the recipient of the first prize award in the student paper competition of the IEEE International Antennas and Propagation Symposium, Boston, MA in 2001. He served as the chair of Antennas and Propagation Chapter of IEEE Fort Worth Section from 2006 to 2011.

Dr. Lynnette Michaluk is a social sciences researcher at the West Virginia University Center for Excellence in STEM Education. Her research interests include broadening participation in STEM. She is Co-PI of the National Science Foundation KY-WV Louis Stokes Alliance for Minority Participation and Research Scientist for Secure and Upgrade Computer Science in Classrooms through an Ecosystem with Scalability & Sustainability. She is evaluator for the National Science Foundation GP-IMPACT: Improving Geoscience Education for Rural and First-Generation College Students, RII Track 2 FEC: Enabling Factory to Factory (F2F) Networking for Future Manufacturing, and Department of Education Title III Strengthening Potomac State College.

Dr. Gay Stewart, professor of physics and Eberly Professor of STEM Education in the West Virginia University Department of Physics and Astronomy, is director of the WVU Center for Excellence in STEM Education. She is a former president of the American Association of Physics Teachers (AAPT). In addition to her leadership role in the SUCCESS RPP, she has played an important role in several NSF-funded programs which generate and support highly-trained high school physics teachers, college teaching assistants, and K-12 STEM teachers who are competent in inquiry-based teaching methods. She has also served on the board of directors of the American Physical Society (APS), AAPT, and the American Institute of Physics, and co-chaired the redesign of the Advanced Placement (AP) Physics course sequence for the College Board. Stewart was named Fellow of the APS in 2009, after a nomination from the APS Forum on Education for her work preparing teachers at the University of Arkansas, leadership in the Physics Teacher Education Coalition and College Board AP Physics Test Development Committee and Physics Redesign Commission, and fellow of the AAPT in 2015. The University of Arkansas Alumni Association named her as their 2007 teacher of the year. She was the 2019 winner of the Oersted Medal of the AAPT, for her

outstanding, widespread, and lasting impact on the teaching of physics through her pioneering national leadership in physics education, her exceptional service to AAPT, and her mentoring of students and in-service teachers.

Rachel Pauley, Director of Technology, Raleigh County West Virginia Schools, is a leader in bringing CS education to West Virginia's students and integrating technology into their classrooms. In addition to her role as senior personnel for the Secure and Upgrade Computer Science in Classrooms through an Ecosystem with Scalability & Sustainability, she previously served as Digital learning Coordinator, Principal, and Assistant Principal as well as Technology Integration Specialist and Teacher for Raleigh County Schools.

Abstract Secure and Upgrade Computer Science in Classrooms through an Ecosystem with Scalability & Sustainability is an NSF-funded Computer Science (CS) educational Research-Practice Partnership whose shared goal is to provide high quality CS educational opportunities to all middle school students in rural Raleigh County West Virginia (WV) before expanding to additional districts. The project will help districts meet recent WV requirements that all K-12 students be exposed to a variety of CS experiences throughout their careers. Specifically, SUCCESS is creating a "Design Research Partnership", made up of CS experts and Raleigh County teachers, counselors, and principals, who are adapting and implementing the Code.org curriculum in middle school classes, and creating (and later providing) middle school teacher CS PD and counselor and administrator workshops in years 2 and 3. SUCCESS is also creating a Video Library with local CS and STEM professionals, providing technical support, and conducting a research study of the impact of the implementation on Raleigh District teachers, counselors, principals, and their students. These results are shared with partners to iteratively improve all aspects of the project and are also disseminated to WV state, district, and other partners. We discuss progress to date, as well as results of analyses of pre-implementation survey responses from participating teachers and their students.

Keywords: Research Practice Partnership; Computer Science Education; Rural Participation in Computer Science

Secure and Upgrade Computer Science in Classrooms through an Ecosystem with Scalability & Sustainability (SUCCESS) is an NSF-funded (#2031355) Computer Science (CS) educational Research-Practice Partnership (RPP) whose shared goal is to provide high quality CS educational opportunities to all middle school students in a rural area. SUCCESS brings together people, programs, knowledge, and resources to provide CS education and career counseling to students in these middle schools. Core RPP members are West Virginia University (WVU) Center for Excellence in STEM Education (CE-STEM), West Virginia University (WVU) Beckley campus (WVU-B), WV Raleigh County School District, West Virginia Department of Education (WVDE), and Code.org. The SUCCESS RPP partnership convened initially at a workshop in summer 2021, where a Design Research Partnership (DRP) was formed and middle school-level "design teams" including teachers, principals and counselors were created, and senior personnel worked with them to understand how the DRP would use data obtained from partners and students of participating teachers to provide and iteratively improve professional development (PD) and other supports to additional West Virginia (WV) rural districts in summer 2022 and 2023 and to modify the most widely used CS curriculum in the world (Code.org). The SUCCESS RPP also creates a CS course sequence that satisfies a state middle school career exploration requirement and supports districts in implementing CS education in their schools, thereby expanding CS opportunities for rural students.

The problems of practice to be addressed by the SUCCESS RPP are important nationally: In 2008, the National Science Foundation proposed the CS10K Project, an effort to place CS curricula in 10,000 schools by 10,000 well-qualified teachers by 2017, [1] highlighting the need to prepare students for a world heavily influenced by computing [2] and move them from being technology consumers to producers. [3] But by 2020, only 19 states had policies giving all high school students access to CS courses, and only 8 offer CS access to all K-12 students. [4] Schools in urban and rural areas are less likely to offer CS than those in suburban

areas, contributing to the access divide and disparities in CS participation and achievement by socioeconomic status, race, and gender. [5], [6] Over 20% of public-school students in the US attend schools in rural districts. [7] Integration of CS into the K-12 curriculum remains elusive for many rural districts because they lack educators with CS expertise. [8] Rural schools face other challenges to implementing CS, including lack of principal and counselor awareness of the importance of CS to all careers, and community ambivalence about subjects that could lead students to seek careers outside of the community. [9]

Teaching and career counseling for rural students requires unique understanding of these challenges and the local characteristics that shape community life and family dynamics. The SUCESS RPP is working with these local uniquely qualified teachers and counselors to increase their knowledge of CS and awareness of the importance of CS to virtually every career at every level of education and provide the necessary support for their success in the form of resources, opportunities, and much needed place-based innovations. [9]

While 86.39% of West Virginia's population completes 12th grade, only 20.6% complete a Bachelor's degree and the percentage of the state's population living below the poverty level is among the highest in the nation at 15.8%. [10] Graduating high school with 21st century and coding skills could greatly change the socioeconomic outlook for these students, many of whom believe their only career opportunities are in the coal industry. [11] There are currently 1,553 open computing jobs in the state; the average salary for all jobs here is $42,370 while the average salary for a computing occupation in the state is significantly higher at $75,109. [12] Yet these jobs are out of reach for most: in 2017, only 190 of the state's students graduated with a degree in CS and only 405 high school students took an Advanced Placement CS exam in 2020. Thus, the benefits of providing CS PD and curriculum support [13] to K-12 teachers has potentially far-reaching effects. Local barriers to students' CS participation align with the findings from the CS literature:

- Counselors and teachers are unaware of the importance of CS education [14]
- Teachers are not equipped with CS content knowledge [15]
- Counselors lack awareness of CS job prospects necessary to advise students [9]
- Principals don't actively support initiatives to increase CS participation because they do not understand CS [16]

The SUCCESS RPP addresses recent state requirements, and while some of WV's districts had made a CS course available in some high schools prior to the project's onset, many schools lacked teachers with the experience necessary to teach the class, and the situation was even more dire at the middle school level. For example, there was no common CS curriculum. There had also been a lack of administrative support for having teachers attend CS PD. In addition, counselors had not encouraged students entering high schools offering the CS course to take it for the reasons mentioned above.

Then, Senate Bill 267 charged the WV Department of Education with creating a plan to make CS available to all K-12 students. Bill 267 makes WV one of the first states to require all students be exposed to a variety of CS experiences throughout their K-12 career. The WV Board of Education had previously mandated College and Career Readiness Standards for Student Success for grades K-12 to prepare students for seamless and successful entry into college or career. The standards are based on 16 Career Clusters, groups of occupations and broad industries based on commonalities identified by empirical evidence (with input from workforce and post-secondary leaders, the WV Board of Education and teachers) for the success of every student. [17] *Virtually every career in all clusters, regardless of education level, requires CS.*

The RPP approach was implemented to meet CS education goals in the state. RPPs are collaborative, long-term partnerships whose goal is to improve persistent problems of practice, often in a local context, in education. In the RPP model, research is incorporated into decision-making processes, and the problems addressed are meaningful to practitioners in schools and districts. [18] RPP partners iteratively define and refine common goals, research questions, metrics, and implementation. RPPs bring practitioners into the research process, thus research questions are more relevant to them and the results from RPP research are more likely to be implemented in real-world contexts. [19]

The SUCCESS RPP leverages its partnerships to customize the Code.org middle school curriculum for local rural contexts and prepares and supports middle school teachers to deliver the curriculum, and principals and counselors to support CS education through knowledge of its importance to careers using data-driven decisions to continuously improve. RPP activities, a summary of related progress to date, and future plans include:

- **Creating a Design Research Partnership (DRP)** The DRP has been rapidly established through workshops, meetings, video chats, and follow up visits with RPP senior personnel and WVU Information Technology (WVUIT) students. It will continue to evolve as new teachers, counselors, and principals become involved as the project expands to additional districts.

- **Adapting the Code.org curriculum** The DRP team includes CS experts Drs. Afrin Naz and Mingyu Lu, 11 teachers, and 5 counselors in Raleigh County, among others. This DRP team revised the curriculum with input; the revised curriculum has since been implemented in CS classes in 5 of the district's middle schools, impacting ≈ 651 students to date. The DRP team will continue to obtain input and revise the curriculum as needed for the duration of the project.

- **Providing Middle School Teacher CS PD** DRP team teachers and counselors provided input to Drs. Naz and Lu at the summer 2021 workshop and subsequent meetings and their input was shared with the evaluator. PD will be created for additional teachers, counselors and principals in other districts based on the work of the DRP, and will be provided in summers 2022 and 2023.

- **Providing Counselor and Administrator Workshops** The summer workshop mentioned above included counselors and principals (who are also part of the DRP) for the last two days. They also engaged in the subsequent in person and virtual meetings. Following these experiences, the district-level design team is designing workshops to be offered to additional counselors and principals in 2022 and 2023.

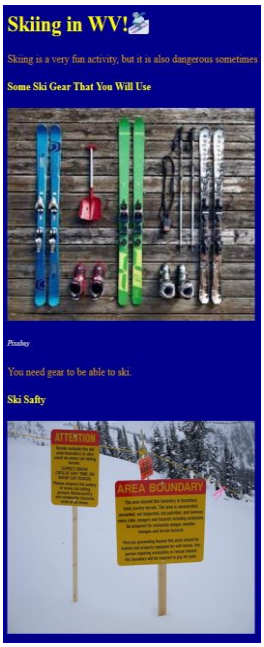
- **Creating a Video Library with Local Professionals** Two pilot videos were filmed, and input obtained from RPP members; middle school student input will also be obtained on these videos before more are produced. The goal is to produce 3 videos featuring local STEM employees to represent each of the 16 career clusters by the end of the project.

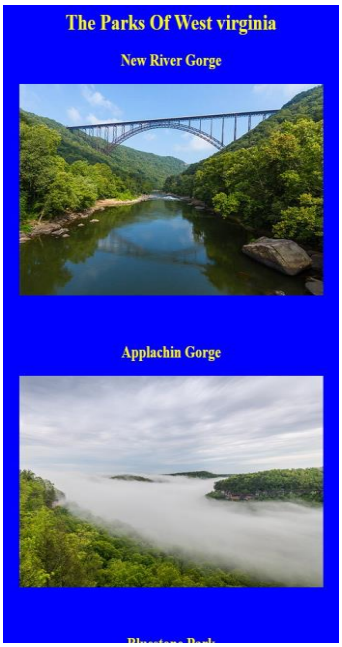
- **Providing Technical Support** Technical support has been coordinated and provided by Rachel Pauley, Raleigh District's Director of Technology. Undergraduate CS students from the WVU IT program have also been providing in-class and virtual support and all will continue to do so. Rachel Pauley also coordinates data collection between academic and middles school partners.

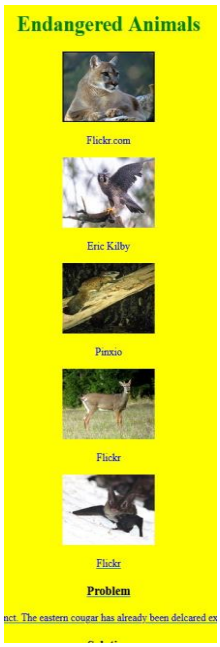
- **Studying the Impact of the Implementation** on Raleigh District teachers, counselors, principals, and their students. Dr. Lynn Michaluk, social sciences researcher, is conducting SUCCESS RPP research and has been working with senior personnel to create surveys, and collect survey responses, notes from meetings, interviews, etc. since summer 2021.

Providing Data Collected to State, District and Other Partners, and the broader community through research presentations and publications, etc. Anonymous data collected from teachers, counselors, principals, and students has been analyzed and shared with partners and the external evaluator and used to iteratively improve the project implementation, which is a continuous process for the duration of the project. This fall, for example, data collected indicated that several changes had to be made to the curricular materials to accommodate different course lengths, and teacher training had to be provided at the last minute due to school staffing changes.

SAMPLE SUCCESS RPP Student Webpages.







The RPP research study is funded by NSF to assess increases in students in CS interest and enrollment in CS courses, not to assess student content knowledge gains. However, teachers are assessing learning as they would any other subject using available Code.org assessments and RPP revisions and will then provide feedback to DRP personnel for curriculum and PD revisions at the end of the academic year.

The research study employs a quasi-experimental cross-sectional mixed methods approach to examine the impact of experiences on DRP teachers, principals, and counselors and how the CS education implementation impacts student interest in CS and intent to enroll in CS courses for all grades. For the period discussed, baseline data are being collected to answer the following research questions:

RQ1 What is the impact of SUCCESS implementation on interest in CS and intent to enroll in CS courses for 6th, the, and 8th grade students? Do responses for treatment group students differ in any way by gender?

RQ2 How does participating in, and serving as a partner for, the DRP impact participating teachers' perceptions of their abilities to effectively teach CS? Do teachers feel that their efforts to teach CS are supported by administration? Do responses differ between women and men teachers?

Data Sources used to answer RQs 1 and 2 include:

Students: Interest in CS: pre- and post-instruction survey instruments from the Barriers and Supports to Implementing Computer Science (BASICS) project. [20] [21], [22] **Teachers (and Counselors):** perceptions of CS pre- and post-RPP participation survey instruments developed for the same BASICS project. All surveys contain Likert-type multiple choice items and short answer items. The survey scales ranged from 1 – 7; scores from 1 – 3 indicate agreement with the item, 4 indicate neither agree nor disagree, and 5 – 7 indicate disagreement with the item.

Baseline survey data of interest in CS and intent to take additional CS courses was collected from 191 students of DRP teachers in the first month of the Fall 2021 academic year. We had intended to collect data only during the first week, but that was not possible due to COVID quarantines at several sites. The information obtained was necessary to both A) provide baseline data to examine changes in interest and intent to take more CS courses after taking CS classes from DRP teachers and 2) to provide DRP teachers, counselors, and principals with actual data regarding student CS interest obtained from their students, since their pre-survey responses indicated that many believed their students were NOT interested in CS.

Student responses indicated that their students are interested in CS; see Table 1 for average scores and standard deviations for each gender group. Results of multivariate analysis of variance indicated that there were no significant differences between any gender group for either CS interest item (all p's > .05).

Table 1. **Results of Comparisons Between Gender Groups for Average Student Survey Scores.**

Survey Item	Girls (n = 72)	Boys (n = 100)	Other (n = 6)	Prefer not to Answer (n = 13)
1. I am interested in learning more CS	3.86 (2.13)	4.00 (2.64)	4.50 (2.16)	4.92 (2.43)
2. I am interested in taking more CS courses	3.38 (1.82)	3.72 (2.06)	3.33 (2.16)	4.69 (1.88)

Students were also asked whether they would consider taking another CS course. Results from the 189 students who responded indicated that 22% (42) definitely would take another course, 61% (117) were open to taking more courses, and only 16% (30) said they would not take another CS course. A chi-square test of association showed that there was no significant association between gender and response category, X^2 (6, N = 189) = 7.86, p = .24. Students were also asked to provide a reason for their responses to this item, whether positive or negative.

Most positive responses fell into one or more of 3 categories listed below with samples (*indicates pseudonym):

- **CS is fun and/or interesting:** "Because working with computers can be fun and turn into a career. Also making websites and/or games is fun." Russell*

- **CS is important for connecting with friends, communication and/or teamwork:** "You get to learn new things, like new languages. You also may meet someone that has the same thoughts/opinions." Beth*

- **CS can help you in your future job and/or be successful (money):** "I think coding is very fun. If you choose this career you will be paid quite a bit." Billy*

Conversely, a single reason was provided for students' negative responses: they did not enjoy coding. All written responses to this item contained some version of "No. I don't like to code." Thus, it appears that coding is currently the primary barrier to increased participation of these students. It is important to note that all students in the sample are not in agreement on coding; some said they love it, some said they hate it, and several said that they do not like it, but think it is important.

Anonymous student survey responses were shared with DRP teachers at the November Workshop. Some expressed surprise, but all agreed that the data helped them feel more knowledgeable about their students' interests and needs, which would inform their classroom practices.

Results from 11 DRP teachers' baseline survey data of perceptions of their abilities to effectively teach CS and support from administration for their efforts to teach CS was also collected. Teachers had from 2-22 years teaching experience, 0-5 years CS teaching experience.

Teacher's average scores and standard deviations for each gender are shown in Table 2. In general, DRP teachers reported positive perceptions of their abilities to teach CS (Items 1- 4). Most also reported having positive perceptions of support for CS at their school (Items 5, 6, and 8), and were not sure whether they should have more input into CS education at their schools (Item 10). Two-tailed *t*-tests were run due to the number of dependent variables (items), despite the small sample size, because these tests are considered robust to violations of assumptions of normality. Levene's test of homogeneity of variance indicated heterogeneity of variances between groups for items 5, 7, and 8, therefore the *p*-value for non-normality is reported. Results indicated that there were no statistically significant differences for any items between women and men teachers.

We also asked DRP teachers to provide short answers describing the biggest barriers to teaching CS in their schools at the Summer 2021 Workshop, prior to implementation of the revised CS curriculum. Most responses involved technical issues or lack of CS teacher knowledge, with many teachers mentioning that their knowledge was growing because of their participation in the DRP. Several teachers also mentioned potential cultural barriers. **The most frequently mentioned barriers were:**

- Difficulty rolling out devices at the beginning of the year within the allotted time frame
- Teachers do not have Chromebooks but students do, so they cannot see the same OS
- Lack of ability to schedule time and space needed [Hence curriculum adjustments for different class schedules at different schools in the district]
- Lack of CS content knowledge, however that is growing with DRP participation
- Getting parents to help students at home. Parents won't know CS material and it will upset some of them.
- Lack of student interest [note that students' survey responses indicated that they are interested in CS, which was discussed with DRP members at a later workshop].

Table 2. Results of Comparisons Between Women and Men for Average DRP Teacher Survey Scores.

Survey Item	Women (n = 5)	Men (n = 6)	p value
1. I understand CS concepts well enough to be a very effective teacher of Intro CS.	2.50 (1.22)	1.60 (.54)	.16
2. I have nearly every skill I need to teach Intro CS well.	2.67 (1.21)	1.40 (.54)	.06
3. I will be really good at teaching Intro CS.	2.17 (.75)	1.40 (.54)	.08
4. What I learned at this workshop will help me feel comfortable teaching Intro CS over time.	1.50 (.54)	1.40 (.54)	.77

5. Learning CS can help prepare students for most careers.	1.17 (.54)	1.00 (0)	.38
6. My school leaders recognize the benefits of offering Intro CS for students.	1.50 (.54)	1.20 (.44)	.35
7. I am confident in my abilities to use Code.org materials in the classroom.	2.50 (1.37)	1.80 (.83)	.34
8. The principal allocates resources and personnel necessary to provide CS classes for our students.	2.30 (1.50)	1.60 (.89)	.36
9. I am involved in school decisions about CS education.	2.16 (1.32)	1.00 (0)	.08
10. I should have more input about CS education in my school.	3.66 (1.50)	3.20 (2.16)	.34

SUCCESS RPP has made substantial progress in establishing and maintaining a Design Research Partnership to bring CS education to Raleigh County WV middle schools, despite preexisting challenges discussed in the introduction as well as new challenges, including staff changes and shifting quickly to online instruction temporarily because of the pandemic. Data from DRP teachers, counselors, and their students has been used to improve curricular materials, classroom practices, and plan the next PD offering for additional WV districts in summer 2022; the same process will occur the following year. Through these future PD offerings, SUCCESS RPP will help more districts in the state make CS available to all students as outlined in Senate Bill 267, making WV one of the first U.S. states to require all students be exposed to a variety of CS experiences throughout their K-12 careers.

Data obtained to date indicates that DRP teachers are effectively overcoming challenges they face to providing high quality CS education in their schools and that they feel that their voices are valued in the work of the DRP. It also shows that contrary to their prior beliefs, most of their students are interested in learning CS; furthermore, both teachers and their students recognize the importance of CS education to their future careers.

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