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# Growing Computer Science and Information Technology Education in K-12: Industry Demand and Ecosystem Support

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## Abstract

Demand for IT skills has grown dramatically in the last decade. Companies have realized that they need more people to fill roles in their IT departments, and modern life increasingly relies on being able to navigate digital environments and use digital tools. Many school districts have responded to these demands by attempting to increase their offerings of computer science and information technology coursework. In this paper, we describe one region's effort to support K-12 schools in increasing digital skills for all students and the pipeline of IT professionals. We describe three approaches taken by three school districts to respond to these efforts in collaboration with local industry and other institutions. One school district partnered closely with local higher education institutions to offer early college classes, another focused on providing robust computer science courses of their own to high school students, and the third focused on developing broad digital skills especially at the grade school level (K-8). We argue that the collaboration maturation of efforts in the region allowed school districts to expand computer science offerings more easily and to use regional partnerships to increase the likelihood of being successful with their efforts.

**Keywords:** Collaboration, Alliance Maturity, Computer Science, Information Systems

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## 1. Introduction

Over the last decade, demand for information technology (IT) related skills has grown dramatically. In the workplace, employees are often more technical and work in jobs and careers that involve direct use of technology and digital skills. These organizations also have a specific need for IT and computer science (CS) skilled employees to work in technology-related careers. In our home and personal life, we rely on being able to navigate digital environments and use digital tools. Our interactions with others are often managed via digital platforms and social media. Society now requires us to be digital citizens. Students will need more technology-related skills to navigate these different realms.

Due to the high demand for their skills, computer science and information technology (CS/IT) professionals enjoy stable, high-income careers. According to the Bureau of Labor Statistics (2021), the median annual salary for CS/IT occupations was $91,250 in May 2020, about $45,000 greater than the median wage for all occupations in the U.S. The Bureau has also projected that the demand for CS/IT professionals will continue to grow at a 13% rate between 2020 and 2030 adding an additional 667,600 new jobs (U.S Bureaus of Labor Statistics, 2021). Despite these salary and job prospects, organizations have not been able to attract sufficient talent into their ranks (Vegas & Fowler, 2020).

Companies and higher education institutions in the Northeast Wisconsin region founded the Northeast Wisconsin Digital Alliance (NEW Digital Alliance) in 2015 to address the talent shortage in the region. This organization started as a loose affiliation of individuals, organizations, K-12 schools, universities, non-profits, and economic development organizations but has matured into a formal organization focused on building collaboration (Muraski, et al., 2021).

Spurred on by demands from local employers for CS/IT talent, parent interest, and societal trends, school districts across Northeast Wisconsin have begun to step up to service the need for CS. We describe three different approaches taken by three different school districts to respond to these efforts in collaboration with local industry and other institutions. One school district partnered closely with local higher education institutions to offer early college classes, another focused on providing robust computer science courses of their own to high school students, and the third focused on developing broad digital skills especially at the grade school level (K-8). We argue that the collaboration maturation of efforts in the region allows school districts to expand computer science offerings more easily and to use regional partnerships, including industry partners, to increase the likelihood of being successful with their efforts.

This paper is organized as follows. Section 2 addresses the case background, including collaboration networks and alliance maturity, as well as the state of computer science in the United States and Wisconsin. Section 3 describes the case study research methodology that was used as well as provides an overview of the case environment. Section 4 provides a case description and analysis. Section 5 provides a discussion of the findings. Finally, Section 6 includes the summary, limitations, and direction for further research.

## 2. Background

This section covers the recent history of collaboration networks and alliance maturing in Northeast Wisconsin and provides an overview of the state of computer science education in Wisconsin and across the United States.

### 2.1 Alliance Formation

After the dot-com collapse of 2000, enrollments in computer science and information systems degree programs dropped dramatically at regional colleges and universities and then slowly rose back to 2000 levels over nearly 15 years. See figure 1 for degrees conferred by University of Wisconsin institutions in Northeast Wisconsin. By 2015, with minimal interest among parents, companies, and students in pursuing these kinds of educational programs, school districts were not encouraged to offer more than the bare minimum of classes. Over time, however, this led to companies having difficulty finding qualified talent to fill an increasing number of IT job roles.

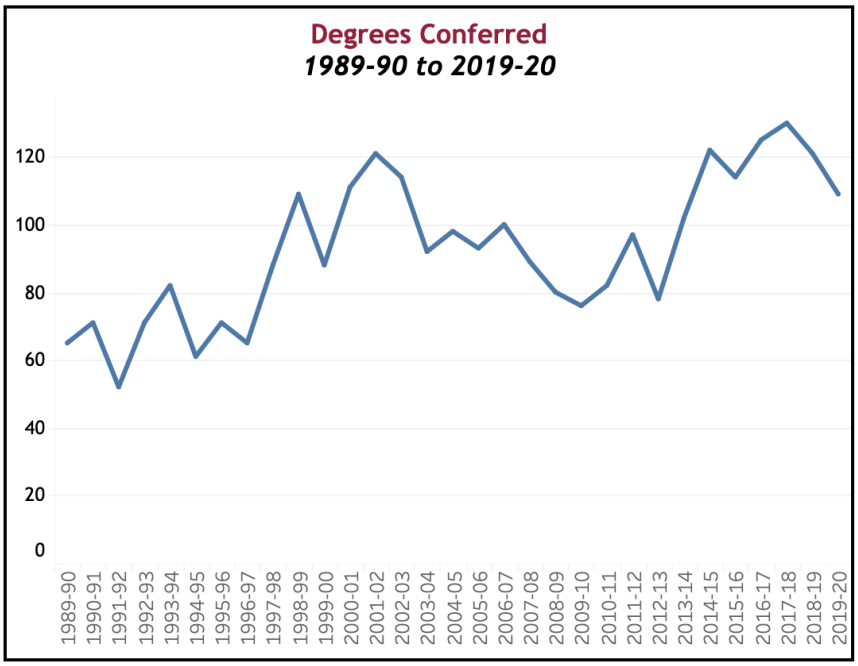


Figure1: Degrees conferred by University of Wisconsin Institutions in Northeast Wisconsin (UW-Green Bay, UW Oshkosh, and UW-Stevens Point) in Computer Science and Information Science (UW System, n.d.)

In 2015, several executives at regional companies worked to bring together a group of leaders from business, economic development, K-12, universities, and non-profits to discuss what could be done to increase the pipeline of people interested in filling the increasing number of IT jobs. While most businesses were simply interested in hiring graduates from 2- and 4-year university programs, they quickly realized that they also needed to focus on building greater interest among younger students.

However, school districts had few offerings and lacked teachers and other resources to dramatically increase their offerings. Several organizations tried to fill the void. Among them were the regional Cooperative Educational Service Agencies (CESAs), which were created in the 1970s to serve as a link across school districts and between school districts and the state. There are twelve CESAs across Wisconsin, three of which cover the NEW North region – CESAs 6, 7, and 8. Early on, they worked to identify model curricula, such as Project Lead the Way (PLTW) that could be purchased and implemented in school districts.

Several Chambers of Commerce in the region also hosted events aimed at attracting and retaining IT students to the region. This included the Fox Cities Chamber of Commerce hosting a 3-day event for IT college students from in and out of the region to convince them to live and work in the region post-graduation. Similarly, Amplify Oshkosh established an education committee connecting K-12 and higher education. Another organization that successfully launched during this period was Women in Technology Wisconsin, with a focus on providing support for women working and studying IT. One of the pillars of their work is WIT4Girls, which developed a curriculum for WIT4Girls Clubs, which ran as after-school activities at many school districts across the region.

In late 2015, a survey of local businesses was conducted that determined that by 2021, the region would have an additional 3,000 unfilled IT jobs given the rate of graduates at the time. This led many businesses to realize that the problems they had experienced with hiring IT workers for their companies were broader and not just something they would be able to resolve on their own. This led to the formal formation of the NEW IT Alliance, which would focus on attracting and retaining a robust IT workforce for the region. The Alliance was later renamed the NEW Digital Alliance, which is how we refer to it throughout this paper to avoid confusion. At the end of 2016, several local businesses and higher education institutions joined to formalize the organization further by hiring a director for the Alliance, which would allow for progress to be made consistently.

Schilling (2015) identified that shock and uncertainty lead to alliance formation and the establishment of a collaboration network that works to innovatively solve a challenge. In Northeast Wisconsin, Muraski et al. (2021) identified a regional CS technology talent demand challenge that resulted in the formation of an alliance (NEW Digital Alliance). The NEW

Digital Alliance facilitated the growth of a supportive collaboration network. Figure 2 illustrates this collaboration framework.

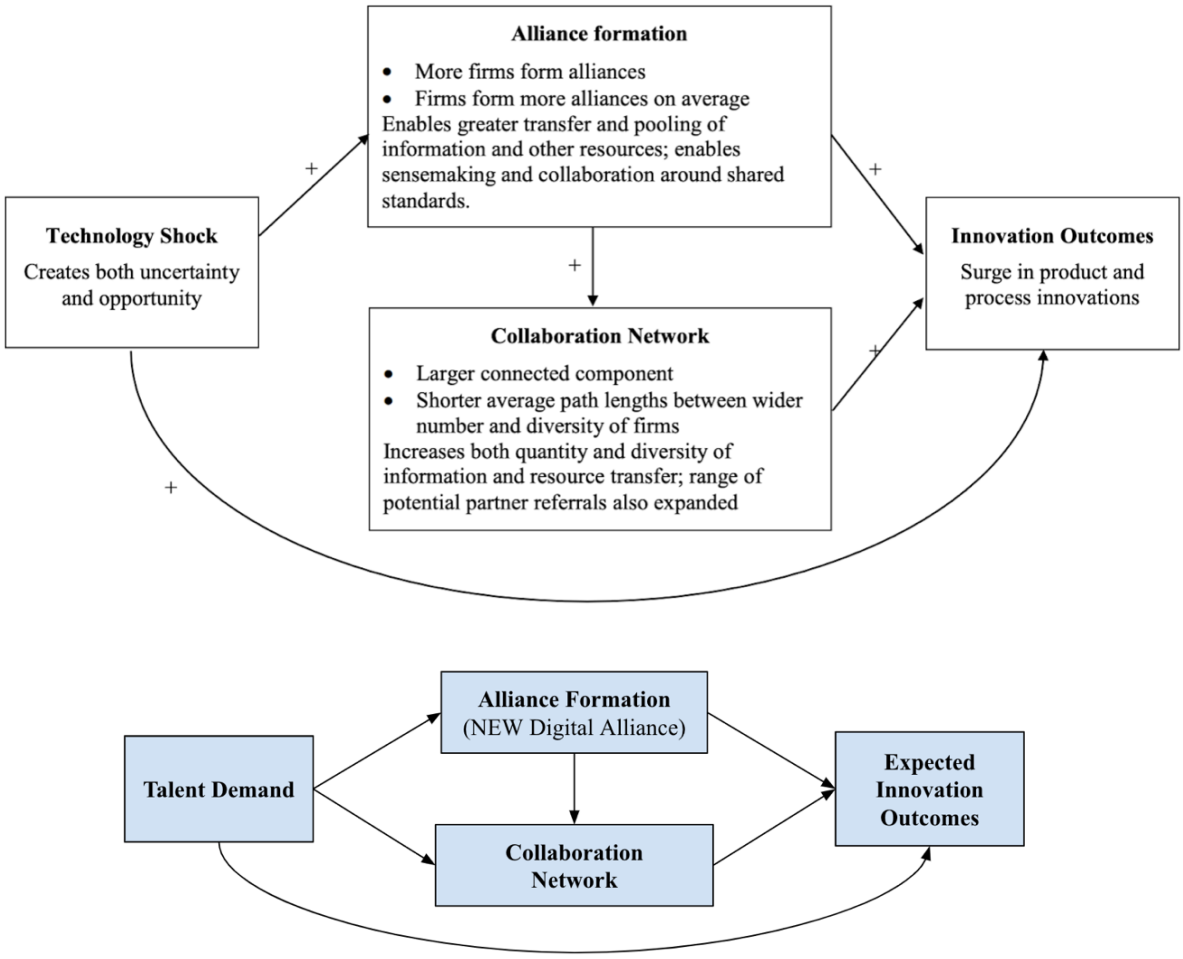


Figure 2: (Top) Original Schilling (2015) model and
(Bottom) NEW Digital Alliance Collaboration (Muraski et al., 2021)

### 2.2 Alliance and Collaboration Maturity

With a full-time director on board, the NEW Digital Alliance matured rapidly and became a central hub for all activities focused on the IT ecosystem in the region. The Alliance also launched several activities of their own, including NEW Connect IT, which is the only IT job and career fair focused on high school students in Wisconsin. This event has been held annually and attracted several hundred high school students to Lambeau field to learn about careers in IT and meet with universities and potential employers.

To support rural regions across the country in competing more effectively in the digital economy, Microsoft launched its TechSpark initiative and chose to focus on two counties (Brown and Outagamie) in Northeast Wisconsin. This became a key development that brought attention and energy to the region. One of the early goals set by TechSpark was to have every high school student take at least one computer science course before graduation.

One of the key programs Microsoft brought to the region was TEALS, which builds sustainable solutions by partnering high school teachers with industry volunteers and standardized curriculum in computer science. This allowed teachers to learn while teaching and eventually be able to teach the courses without having an IT professional in the classroom. The TEALS program has been successful and has grown from covering 32% of high schools in the region in 2017-18 to 75% in 2020-21 (M. Schuler, personal communication, June 1, 2021). The number of students has also grown – from 200 to 500 students during the period and the average number per school has increased by 34%. (M. Schuler, personal communication, June 1, 2021).

In 2018, Microsoft TechSpark and NEW Digital Alliance collaborated on a survey of school districts to determine the level of computer science offerings by school districts as well as what challenges they were facing. The presentation of the survey data was one of the first times that administrators and computer science teachers from school districts across the region had an opportunity to discuss together how to improve their offerings. This meeting formed the basis for the creation of the NEW CS Advisory Board.

The NEW CS Advisory Boards[1] composed of administrators and computer science teachers from regional K-12 school districts, higher education faculty, and local company representatives. The purpose is to enhance collaboration among school districts, higher education, and companies in the offering of computer science education in K-12 school districts. The advisory board was formed in 2018 as a collaboration between NEW Digital Alliance and Microsoft TechSpark but has since become an effort of the NEW Digital Alliance. The Advisory Board meets several times a year. The Advisory Board has served as a place where school leaders and teachers have been able to learn about trends and best practices in computer science education. Each meeting typically has a speaker that will present topics such as Diversity in the CS Classroom, Code.org Curriculum, and the CSforAll program. However, the advisory board has also allowed for information exchange between industry leaders, higher education partners, and schools on developing talent pipelines and pathways from K12 to professional IT jobs. A special focus of the CS Advisory Board has been on establishing local CS Advisory Boards in districts to support the efforts locally. And finally, the CS Advisory Board has allowed school districts to develop professional networks with other school districts.

As collaboration continued to increase, the role of the NEW Digital Alliance became more prominent in the region. During this time, the state took notice and the Department of Public Instruction (DPI) requested that the Alliance lead the development of formal High School, College, and Career Pathways for IT. Based on the NEW Digital Alliance collaboration, DPI now has a standard template for use across all the different regions of Wisconsin. This pathway shows core IT fields (Business Analysis & Project Management, Cybersecurity, Data Technology, Network & Systems Infrastructure, and Software Development & Programming), the related high school courses, certifications, both technical diplomas and associate degrees from the Wisconsin Technical College System, as well as bachelor's degree programs in the region.

As collaboration networks mature over time, Morgan (2012) identified five stages of collaboration maturity including unaware, exploratory, defined, adoptive, and adaptive. Each of these states has related characteristics including goals and objectives, organizational culture, process, technology, and governance. Figure 3 shows the emergent collaboration maturity model.

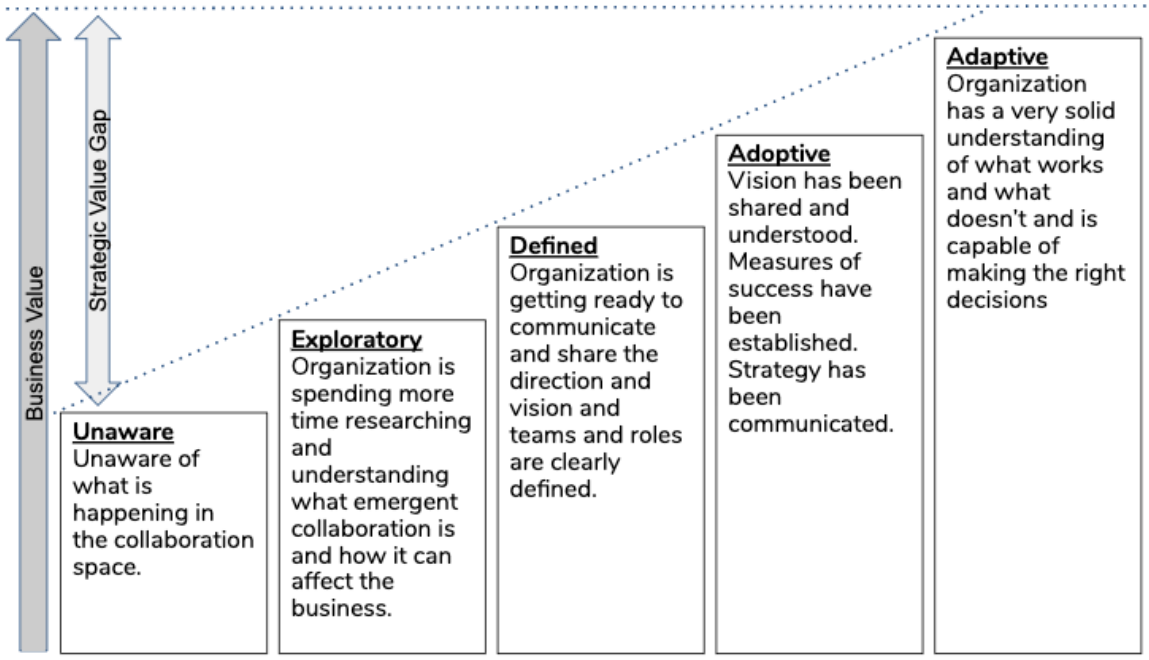


Figure 3: Emergent Collaboration Maturity Model. Adopted from Morgan, 2012.

[1] https://newdigitalalliance.org/new-cs-advisory-board/

In Northeast Wisconsin, the NEW Digital Alliance and the larger collaboration network achieved an adoptive level of maturity with plans to support an adaptive level in 2021 (Muraski et al., 2021). This maturing network and alliance are positioned to solve issues related to growing the IT talent shortage that could not be addressed with less mature networks and alliances (Muraski et al., 2021).

### 2.3 Partner Organizations in the Ecosystem

Throughout the region, several organizations have focused on the need to strengthen computer science education. This section includes brief descriptions of each of these organizations and their role in supporting computer science education. Table 1 shows the key collaboration partners in Northeast Wisconsin.

| Organization | Collaborative Role |
|---|---|
| Amplify Oshkosh | A local organization started by the Oshkosh Chamber of Commerce to promote the confluence and capabilities of technology in Oshkosh. This organization has an education committee that has helped support schools in the Oshkosh area. |
| Code.org | National nonprofit dedicated to expanding access to computer science in schools and increasing participation by women and underrepresented minorities. Offers standard curriculum to schools as well as materials for organizing Hour of Code events to introduce students to programming concepts. |
| Cooperative Education Service Agency (CESA) | Serve educational needs in all areas of Wisconsin by serving as a link between school districts, and between school districts and the state. Wisconsin is divided into 10 CESA districts. The Northeast Wisconsin area is covered by CESA 6, CESA 7, and CESA 8 (each of the CESA districts also cover areas outside of Northeast Wisconsin). CESA 7 has had strong collaboration with Microsoft and is organizing several activities through an initiative called CSTEY. |
| Computer Science Talent Ecosystem Youth (CSTEY) | A service of CESA 7, the goal of Computer Science Talent Ecosystem Youth (CSTEY) is to teach all K-12 students computer science prior to graduating from high school. |
| CSforAll | This national non-profit provides training and frameworks for school districts to help implement strong computer science programs. |
| CS Teachers Association Wisconsin DairyLand | Wisconsin chapter of organization focused on collaboration among computer science teachers. |
| Department of Public Instruction (DPI) | State organization that sets standards for public schools in Wisconsin and provides a regional Digital Technology Career Pathway that was developed by the NEW Digital Alliance. |
| Department of Workforce Development (DWD) | State organization, developing youth and adult apprenticeships in IT. One of their significant efforts has been to expand the offerings of Youth Apprenticeships to IT. |
| Inspire Wisconsin | Started as Inspire Sheboygan, this organization aims to help businesses build talent supply chains and connections with educators and students throughout Wisconsin. |
| Microsoft TechSpark | Microsoft TechSpark is focused on regional internet connectivity, digital skills development, career skills development, nonprofit support, and digital business transformation. Northeast Wisconsin was chosen as the second of six regions in the US (and one in Mexico) for TechSpark to focus on. |
| NEW Digital Alliance | Regional non-profit, funded by local employers, to help attract, develop & retain diverse IT talent in Northeastern Wisconsin to support economic growth. |
| NEW Manufacturing Alliance | Group of manufacturers, educators, workforce development, chambers of commerce and state organizations working to promote manufacturing in the Northeast WI region. |
| New North | Regional marketing and economic development organization representing the 18 counties of Northeast Wisconsin. |
| Northeast Wisconsin Education Alliance (NEW ERA) | Alliance that fosters regional collaboration among public colleges and universities in Northeast Wisconsin. |
| Technology Education and Literacy in Schools (TEALS) | TEALS is a Microsoft Philanthropic initiative whose mission is to get computer science in every high school, with a focus on AP (Advanced Placement) level CS classes. This program supports high school teachers by pairing them with IT professionals and ready-made curricula. |

| | |
|---|---|
| Women in Technology (WIT) Wisconsin | Regional non-profit focused on initiatives designed to attract, grow, and retain women and girls in technology related careers. They developed WIT4Girls Clubs, which could be offered as extra-curricular activities in schools throughout the region. |

Table 1– Collaboration Partners

### 2.4 State of Computer Science Education in the US and Wisconsin

According to the 2021 State of Computer Science Education, nationwide, only 51% of high schools teach formal computer science classes (Code.org, et al., 2021). Only 30% of K-8 schools offer any type of computer science foundation course (Code.org, et al., 2021). Arkansas and South Carolina lead the nation with 93% of high schools offering computer science classes, while Minnesota lags with only 24% (Code.org, et al., 2021). These differences are exacerbated by existing socio-economic trends. Throughout lower-income and rural areas, computer science courses are only available in 46% of schools (Gallop & Amazon, 2021). Similarly, Black and Hispanic students in urban areas are less likely to say their school offers computer science courses (Gallop & Amazon, 2021). At the same time, interest in computer science courses is higher than actual participation in computer science courses. Nationwide, 62% of students indicate they would like to learn about computer science, and yet only 49% of these students completed a computer science course (Gallop & Amazon, 2021).

The Code.org Advocacy Coalition, the Computer Science Teachers Association (CSTA), and Expanding Computing Education Pathways (ECEP) have developed a set of core state policies that are designed to make computer science a fundamental part of high schools across a state. In Wisconsin, four of the nine recommended policies are met (Code.org, et al., 2021). Table 2 shows policies that are met in Wisconsin and those policies which remain unmet in Wisconsin.

| **Policies Met in Wisconsin:** | **Unmet Policies in Wisconsin:** |
|---|---|
| • Define computer science and establish K–12 CS standards<br>• Implement clear certification pathways for computer science teachers<br>• Create computer science preservice programs at post-secondary schools<br>• Allow computer science to satisfy a core graduation requirement | • Create a state plan for K–12 computer science (in progress)<br>• Allocate funding for CS teacher professional development<br>• Establish dedicated state computer science positions<br>• Require that all secondary schools offer computer science (in progress)<br>• Allow CS to satisfy admission requirements at post-secondary schools. |

Table 2 – Policies in Wisconsin (Code.org, et al., 2021)

In Wisconsin, the percentage of high schools that teach formal computer science classes has risen dramatically since 2017. During the 2017-2018 school year, only 34% of high schools offered a computer science course (Code.org, et al., 2021). That percentage grew to 62% during the 2020-21 school year (Code.org, et al., 2021). Access to computer science predicts interest in the topic and sustains interest in computer science as students leave high school. In Wisconsin, high school students participating in a computer science course are 6 times more likely to major in a computer science-related major and female students are 10 times more likely (Code.org, n.d.).

This research attempts to showcase three school districts in Northeast Wisconsin as they tackle these issues by documenting their approach and presenting key insights for other communities and school districts.

### 2.5 Research Questions

In considering collaboration networks, alliance maturity, and the state of computer science education in the US, we identified the following research questions:

1. What was the driving force for these school districts to increase their CS/IT course offerings?
2. How have individual school districts interacted with the existing collaboration network in building their CS/IT course offerings?
3. What challenges did school districts face as they sought to increase their CS/IT course offerings?

## 3. Research Methodology & Case Environment

Prior research has not explored the impact of external collaboration on the development of computer science and information technology-related offerings within a school district. In reviewing the success of three different school districts, we can provide insight and share our findings from these school districts.

### 3.1 Research Methodology

We explored collaboration across Northeast Wisconsin to understand three separate school districts and how they approached growing their computer science and information technology-related offerings.

#### 3.1.1 Case Selection

Following a critical case sample approach (Patton, 2014; Yin, 2017), we sought to identify school districts that exemplified computer science and information technology offerings for students. These cases would showcase the phenomenon we are seeking to research and have the potential to provide the most information (Patton, 2014). Finally, Patton (2014) notes that studying critical cases enable generalizations to be made from the gathered evidence. Based on our engagement in the region and initial interviews with regional non-profit leaders, we identified three school districts viewed as being very progressive in advancing computer science and information technology education. These districts include Howard-Suamico School District, The Hortonville Area School District, and The Sheboygan Area School District.

#### 3.1.2 Interviews

We created separate interview guides (Patton, 2014) for each category of participants: directors of regional non-profit organizations involved in growing STEM-related activities, high school administrators, information systems and computer science K-12 teachers, school district computer science advisory board members, and 2-year technical college administrators.

We conducted semi-structured interviews to guide conversations while focusing on the relevant issues (Patton, 2002). The co-authors jointly collected data via video conferencing technology (MS Teams), following standardized interview protocol, including (1) presenting the study to the interviewee, (2) asking the pre-defined questions, (3) probing for additional follow-up data, (4) recording answers, and (5) managing the interpersonal relations that transpire during an interview (Fowler, 2014). During each virtual interview, one of the authors acted as the primary interviewer while the other acted as a recorder. All interviews were recorded with video, audio, and transcription. In addition, the interviewers took detailed notes.

A total of 12 interviews were conducted. Interviews by category include directors of regional non-profit organizations (three interviews), high school administrators (two interviews), information systems and computer science K-12 teachers (three interviews), school district computer science advisory board members (three interviews), and 2-year technical college administrators (one interview). By school districts, we conducted four interviews relating to the Howard-Suamico School District, two interviews for the Hortonville Area School District, and three interviews relating to the Sheboygan Area School District.

#### 3.1.3 Qualitative Data Analysis

The survey design allowed for exploration of CS and IT education in each case as well as from regional perspectives. Interviews were summarized and analyzed. Key learnings and themes emerged that are included in the discussion. Similarly, district websites and course offerings were identified, analyzed, and presented in section 4.4.

### 3.2 Case Environment

This case explores computer science education within Northeast Wisconsin. Making up nearly a quarter of the state of Wisconsin, this region comprises 18 counties. Primary industries in the region include transportation equipment manufacturing, dairy foundries, product manufacturing, (pulp, paper, paperboard manufacturing, and converting), electrical equipment manufacturing, machinery manufacturing, and fabricated metal product manufacturing (New North, 2020). Manufacturing in the region has become increasingly reliant on technology and 25% of the workforce is estimated to work in advanced manufacturing industries (NEW North, 2020). This region can be seen in figure 4 along with the location of each of the school districts and higher education institutions involved in the case.

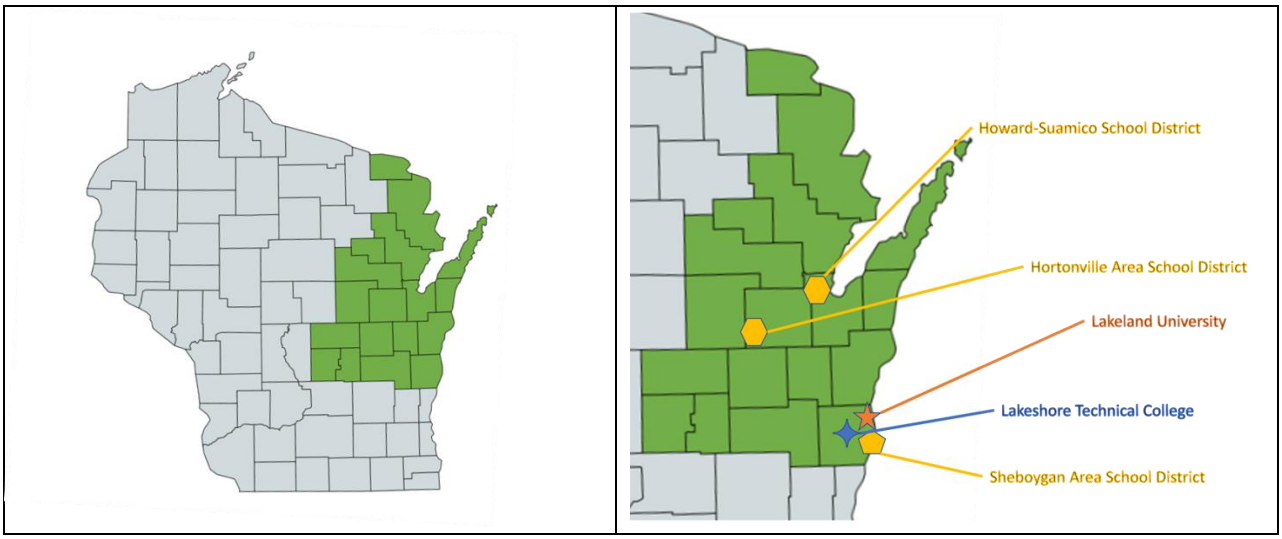


Figure 4: Map of the 18 counties that make up Northeast Wisconsin as well as the location of the schools and higher education institutions involved in the case.

This 18-county region has 91 school districts, servicing approximately 186,235 students (National Center for Education Statistics, n.d.). In addition, the region is serviced by the Wisconsin Technical College System. The Wisconsin Technical College System overlaps this economic region with four separate 2-year colleges: Fox Valley Technical College, Lakeshore Technical College, Moraine Park Technical College, and Northeast Wisconsin Technical College. Additionally, the region is home to several universities with degree programs in information systems and computer science, including the University of Wisconsin-Green Bay, University of Wisconsin Oshkosh, and Lakeland University.

The authors have been active in both education and industry across the region for several decades. One of the authors has consulting, strategic planning, and IT project management experience across several companies and organizations in the region before joining UW Oshkosh as a faculty member. He has since been involved in several NEW Digital Alliance committees and initiatives, including the regional computer science advisory board as well as the Howard-Suamico computer science advisory board. The other author was involved from the very early days of the NEW Digital Alliance in 2014 when it was just a loose affiliation of companies, universities, K12 schools, and interest groups, and was able to follow the early stages of the formation of the collaboration. He is also involved in the regional computer science advisory board.

## 4. Case Description & Analysis

In this section, we describe the efforts over time that have led to school districts increasing their support for expanding computer science and IT offerings, as well as case descriptions of the very different approaches taken by three separate school districts in expanding their computer science course offerings.

### 4.1 Howard-Suamico School District Computer Science Approach

The Howard-Suamico School District (HSSD) encompasses the Village of Howard and the Village of Suamico northwest of Green Bay, WI. Serving 6,000 students, the district is the 25th largest in the state of Wisconsin and includes five elementary schools (K-4), an intermediate school (5-6), a middle school (7-8), and one high school (9-12). In 2018, School administrators attended a chamber of commerce event showcasing school district successes across Brown County, including those school districts that were offering computer science (CS) courses. HSSD's Bay Port High School was not listed. At the same time, the district began hearing from parents seeking courses that would prepare their children to work with computers and technology, including programming and computer science. As they looked at program offerings across schools, administrators realized there was no coordinated or consistent approach to offering digital skills. Similarly, parents, business organizations, and post-secondary schools were clearly signaling that they were not getting enough students with interest or experience with digital skills. The motivation quickly crystallized around a goal of

integrating digital literacy across the curriculum at all ages and increasing awareness and enrollment in new technology-focused electives at the high school.

#### 4.1.1 Implementation

Early in the process, HSSD attended a Regional CS Advisory Board meeting hosted by Microsoft and the NEW Digital Alliance. Based on learnings and best practices shared during the regional meeting, HSSD established a local CS Advisory Board comprised of 40 community members. One of the authors serves on HSSD CS Advisory Board as a parent and regional college professor of information systems. The CS Advisory Board stands as one of the only community advisory boards within the school district. This board has contributed to the overall vision and strategy as well as specifics on K-12 pathways and digital immersion programs across the district.

Throughout this early collaboration with Microsoft and the NEW Digital Alliance, HSSD drafted an initial written strategy covering both 3-year goals and 5-year goals. As the strategy matured, HSSD formulated 3-6-12 month tactical plans that are updated each year and align to the 3-year and 5-year strategic plans. State of Wisconsin Computer Science standards for K-8 as well as recommended CS electives for high school were implemented.

Another valuable early collaboration partner was CSforAll. CSforAll provides both a network of school districts and other educational-related organizations across the country working on growing, advancing, and implementing CS programs. CSforAll also provides content and curriculum to assist school districts in establishing and growing CS programs. The HSSD CS team attended a CSforAll workshop as well as virtual conferences since joining. Similarly, HSSD partnered with Microsoft TEALS. Girls who Code also partnered with HSSD to host a Girls who Code Event for girls in grades 5-8. Before the event was canceled because of COVID-19, over 100 girls had signed up for the event.

Finally, HSSD established the role of Digital Integrators. In each elementary school, digital integrators work with and train teachers on innovative technology, integrating technology into the curriculum and developing formative assessments. These digital integrators also meet regularly and are part of the strategic planning for the districts and included in HSSD CS Advisory Board meetings.

#### 4.1.2 Challenges

While the community, administration, and most individual teachers supported the movement toward integrating CS into the curriculum and increasing CS-related courses at the high school, several challenges remained. Specifically, at the elementary school level, the immersion of CS into all content areas proved to be challenging. Elementary school teachers face many challenges and requirements, including managing increasingly complex and growing classrooms, parents, increasing state and district requirements, and recently COVID-related challenges. While technology integrators were added to the staff across the schools, arranging ongoing training to improve digital literacy and develop immersive experiences in all content areas provided a challenge. In addition, some teachers believed that specific content areas should not be adapted for two outcomes (content and digital immersion). While there are specific CS courses in all other grade levels, gaining immersion of the technology into the actual academic curriculum at the elementary level is a longer-term goal.

#### 4.1.3 Outcomes

Several outcomes have been identified. The CS-related strategic plan has matured throughout the process. HSSD has developed a CS-related 3-year and 5-year plan with related 3-month, 6-month, and 12-month operations plans. Teachers at all levels are included in both the operational plans as well as the strategic plans. A strategic planning committee now includes an Assistant Superintendent, Director of Technology, several Technology Integrators, and teachers from elementary, intermediate, middle, and high school.

At the high-school level, HSSD is measuring student enrollment in various CS-focused courses. Anecdotally, they are seeing students encouraging other students to enroll in classes, so they meet the required 13-student minimum. All courses that have been offered have run and the number of courses is increasing, especially at the high school level. Administrators can also track the progression of courses as students advance through the offerings. The data is too new to draw any conclusions. It is hoped that the increase in required digitally focused courses at the elementary, middle, and intermediate schools will drive interest and enrollment in high school courses. Similarly, as new high school courses are developed, HSSD is working closely with regional 2-year and 4-year colleges and universities to ensure the courses are aligned with offerings at the post-secondary level and offer students either dual credit or advanced standing. The goal is to ensure students have a pathway to continue their education. Many courses aligned with the Wisconsin DPI Digital Technology Career Pathways.

### 4.2 The Hortonville Area School District Approach

Hortonville Area School District is a small but growing school district located in Northeast Wisconsin and primarily serving the communities of Hortonville and Greenville. In 2019-20 the district had a total enrollment of 4,135 students. The district has three elementary schools (K-4), two middle schools (5-8), and a single high school with 1,150 students.

In 2016, one of the math and computer science high school teachers in the district retired, opening a position for the current computer science teacher, who had realized that very few schools were doing STEM education well, so she decided to go through Code.org training to become certified to teach computer science and put some of her ideas into practice. Hortonville was one of the first districts in the region to join the TEALS program after two Microsoft leaders (Michelle Schuler, Manager of TechSpark Wisconsin, and Brad Smith, President), met with district administrators to introduce the program. By having IT professionals as volunteers in the classroom, the district was able to start offering AP Computer Science A to students without having a CS qualified teacher.

#### 4.2.1 Implementation

The district strategy has revolved around strong industry collaboration and input in developing their own robust computer science courses that address industry needs. Hortonville has implemented a robust local CS Advisory Board with strong representation from industry as well as participation from teachers, district administrators, and the district's curriculum director. One unique aspect of the board is that the board is co-chaired by a student and the high school principal with the student facilitating the meeting. In recent years, the district has had a number of students in the CS program both strong technical and leadership skills who have had an impact throughout the region. Student Sam Schiedermayer presented at regional CS Advisory Board and was featured in IoT (Insight on Technology) Magazine (Thiel, 2019). Similarly, student Grace Vandenheuvel interned with NEW Digital Alliance and facilitated large panels at the annual NEW Connect IT event.

The CS Advisory Board plays a significant role in determining strategy and direction for CS offerings. The district looks to industry for input on which classes to offer. One example of this industry-focused mindset was to move the introductory programming class from C++ to Python. The district has worked with a local insurance company to establish a youth apprenticeship program where students will work in the IT department of the company while still going to school. Through this program, students gain valuable real-world skills, including writing code to be deployed to the production environment.

At the middle school level, the district has implemented a digital literacy requirement that is integrated into required courses like English, social science, and math. This is supported by a Technology Coordinator, who works with teachers to integrate concepts and technologies into their classes. In addition, they offer a few IT-related clubs, including WIT4Girls and Girls Who Code.

#### 4.2.2 Challenges

Some of the challenges faced by Hortonville included:

- Getting enough student enrollment, especially girls.
- Teacher availability
- Teacher training
- Lacking a ready-made curriculum for data analytics
- Avoiding classes being cancelled for low enrollment – making sure CS classes are not competing against each other for the same students.

#### 4.2.3 Outcomes

Industry involvement in the form of the CS Advisory Board had a significant influence on class offerings in the district. The board helped the district develop a pathway from Middle School through high school, introducing the right classes in high school, establishing a Youth Apprenticeship program for IT, and establishing coding clubs in the middle schools.

### 4.3 The Sheboygan Area School District Approach

Sheboygan Area School District is located in Eastern Wisconsin about an hour north of Milwaukee and an hour east of Fond Du Lac. The area is home to several large companies, including Kohler Company, Acuity Insurance, and Johnsonville Sausage. Due to its relatively isolated location, companies have had to rely on local talent development and have had a tradition of supporting the local workforce development efforts.

The district is the largest of the three we looked at with approximately 10,000 students and two high schools, Sheboygan

North (1,489 students) and Sheboygan South (1,040 students). In addition, they have three middle schools and ten elementary schools. The district also offers eight charter school options at various levels.

The Sheboygan area is home to two institutions of higher education, Lakeshore Technical College (LTC), which is part of the state's public Technical College System, and the private 4-year institution, Lakeland University (Lakeland). Both institutions have had a history of collaboration with local businesses and other educational institutions.

Prior to the 2019-20 academic year, the CS offerings in the district had been similar to many other school districts: a hodgepodge of offerings with no clear direction or reason for including courses. They did have a very popular district-wide coding club for elementary students and had done some work to establish an E-sports team, but were not able to get it all put together.

#### 4.3.1 External Collaboration

When Acuity Insurance had difficulty attracting the necessary IT talent, they approached the school district for help. The district quickly realized they did not have the resources to support the needs, so they brought in LTC and Lakeland University. During the initial discussions, the partners decided to develop a larger program that would go beyond the needs of Acuity. They designed a program called College Here and Now[2] here students would be able to take an associate degree in web and software development while in high school through courses offered by LTC. After high school, students would be able to either find employment immediately based on their associate degree or continue their education at Lakeland University and complete a bachelor's degree in Management Information Systems in two years.

The LTC courses were offered at both high schools in classrooms that were furnished by LTC and branded to look like college classrooms to give students a strong sense that they were participating in a college program. LTC is expanding the College Here and Now initiative to other smaller school districts in the area through online and remote class delivery allowing students in smaller and rural districts to access the courses.

Outside of collaborations with LTC and Lakeland, the Sheboygan Area School District has participated in the NEW Digital Alliance regional CS Advisory Board as well as in that organization's NEW Connect IT job and career fair aimed at high school students. Outside of this, they have not collaborated strongly with other partners. Prior to College Here and Now, Sheboygan South had a well-functioning advisory board working on a computer science pathway. However, this was abandoned after College Here and Now was launched.

#### 4.3.2 Implementation

College Here and Now was launched in Fall 2019 with a lot of excitement and much stronger demand than initially envisioned. While having a goal of 10 students at each of the two high schools, a total of 103 students signed up for the program initially. In the first year, those students received three courses in programming, databases, and web development. Two courses were taught by LTC instructors and one by a high school instructor.

At the middle and elementary school levels, no IT or CS coursework was offered – neither as standalone courses nor through structured integration into existing courses. Several schools did have clubs and extra-curricular activities where students learned and gained experience outside of formal classroom settings.

#### 4.3.3 Challenges

The program encountered several challenges along the way. These fall into three categories:

##### 4.3.3.1 Expectations of College-Level Courses

There was a mismatch between student preparation/maturation and the college-level expectations of the courses.

- The entry-level LTC course was seen as not appropriate for high school students. Work is currently underway on developing a better entry-level course.
- The maturity level of some of the students – especially among those in their first year – was not high enough to handle the college-level coursework.
- The school district did not have offerings in elementary and middle school leading to students not having much exposure to IT and CS concepts before going into college-level courses.
- The college-level classes had fewer formative assessments, which led to high failure rates among students.
- Some examples and assignments in the college-level classes assumed life experiences and interests of the typical

[2] https://www.sheboygan.k12.wi.us/programs/college-here-now

30-year-old technical college student. This made it hard for younger students to sometimes understand and care. This was especially true for female students.

LTC tries to alleviate this mismatch by allowing students to switch from college grade to transcript audit about two thirds of the way through each class.

4.3.3.2 Teacher Preparation

Finding teachers qualified to teach computer science courses is challenging for any school. Since this program relies on dual credit courses that are taught in high schools and provide college credit, the instructors must follow the same qualification standards as would be expected of the college instructors, including having a master's degree in the field they are teaching. LTC worked with the district to help qualify some high school teachers to teach the college courses.

In Fall 2020, the school district hired a computer science teacher with extensive industry experience. He has worked to revise several courses and provide better introductory experiences for the students before moving into the College Here and Now courses.

4.3.3.3 Technology-Related Challenges

The LTC courses were based on development using PCs whereas the school district provided Chromebooks to students. While LTC had computers in the classrooms, it became a challenge for many students whose families did not have their own computers. The school district was able to resolve this by providing PCs to students in this situation. The program also faced issues with lack of broadband access for many families - similar to what many schools have faced during the COVID-19 pandemic.

Internet access in high schools is severely limited by filtering which sites students have access to. It became necessary to create allowed lists of websites that students would be able to access from the LTC classrooms to support working on assignments and looking up reference materials.

4.3.4 Outcomes

Because of the College Here and Now program, the school district was able to provide a robust course offering to students without needing to hire additional teachers. LTC gained significant brand recognition among students and parents and saw significant publicity around the initiative. While the program is too new to have produced students who have earned an associate degree while in high school, many students have earned some college credits through the program and earned valuable IT/CS skills. The first associates degree graduates are expected in spring 2022. Because of the success of the program at Sheboygan, the program is being expanded to other nearby school districts.

**4.4 Assessment of High School Courses**

During our research, we identified many CS/IT-related courses offered across the three school districts. We used the five career pathways identified by the Wisconsin Department of Public Instruction (DPI) to categorize the course offerings. These pathways include:

- Business Analysis and Project Management
- Software Development and Programming
- Network and Systems Infrastructure
- Cybersecurity
- Data Technology

Table 3 lists all the courses offered in the three districts by the DPI Career Pathways with a more detailed breakdown of Software Development and Programming to identify clusters of courses in this area. Several digital technology courses offered in the districts do not match with any of the DPI pathways, so we listed those separately in Table 4.

The analysis shows that programming and software development courses are the most commonly available across all districts with 23 out of the 32 courses offered. All three districts have robust offerings in this area – and it's the only category where all districts have offerings. We did not find any courses offered in Business Analysis and Project Management, though it is possible that some aspects of these areas are covered in programming courses. The remaining three categories have a few offerings in some of the districts.

As the largest district, and with support from LTC and Lakeland, Sheboygan has the widest set of offerings with the other two districts having fewer offerings in a narrower set of areas. It should be noted that we did not evaluate how frequently courses run or the number of students enrolled.

| DPI Pathway | Category | HSSD | Hortonville | Sheboygan | Category Count | DPI Count |
|---|---|---|---|---|---|---|
| **Business Analysis & Project Management** | | | | | 0 | 0 |
| **Software Development and Programming** | **Programming** | • Coding<br>• Advanced Placement Computer Science Principles<br>• AP Computer Science A | • Computer Programming I<br>• Computer Programming II<br>• AP Computer Science A - TEALS<br>• AP Computer Science Principles - TEALS | • PLTW Computer Science Principles 1 & 2<br>• Programming Introduction – LTC (taught by SASD)<br>• Object Oriented Programming 1 – LTC Course<br>• Object Oriented Programming 2 – LTC Course | 11 | 23 |
| | **Web Development** | None Identified | • Multi-Media & Web Design<br>• Advanced Multi-Media Web Design | • Advancements in Web Design & Development<br>• Digital Web Design<br>• Web Development 1 – LTC Course (taught by SASD)<br>• Web Development 2 – LTC Course<br>• Web Development 3 – LTC Course | 7 | |
| | **Mobile App development** | • Mobile Application Design and Development | None Identified | • Mobile Device Development 1 – LTC Course<br>• Mobile Device Development 2 – LTC Course | 3 | |
| | **Video Game Development** | None Identified | • Computer Animation and Game Design | • Advanced Programming & Game Development | 2 | |
| **Network & Systems Infrastructure** | | None Identified | • Cisco Networking I<br>• Cisco Networking II | • Cisco IT Essentials | 3 | 3 |
| **Cybersecurity** | | • Cybersecurity and Ethical Hacking | None Identified | • Web Security (South HS only) - Lakeland University | 2 | 2 |
| **Data Technology** | | • Artificial Intelligence<br>• Solving Big Problems with Big Data | None Identified | • Introduction to Database Design & Development – LTC Course<br>• Database Basics - Lakeland University online | 4 | 4 |
| | **Total:** | **7** | **9** | **16** | **32** | **32** |

Table 3. Course offerings at the three school districts categorized by DPI Career Pathways

Several of the digital technology courses offered did not fit into any of the DPI Career Pathways. Those courses are listed in Table 4, and include course work on general office technology, such as Microsoft Office. We also identified courses that were computer science introductions as well as applications of digital technologies in areas such as robotics and digital marketing. Howard-Suamico also offered several courses in video game design that did not appear to have a software development component to them.

| Category | HSSD | Hortonville | Sheboygan | Category Count |
|---|---|---|---|---|
| **General Office Technology** | Business Communications | • Keyboarding<br>• Office for the 21st Century - FVTC<br>• Microsoft Information Management<br>• Advanced Microsoft Office - FVTC | • Microsoft Office Specialist 1<br>• Microsoft Office Specialist 2 | 8 |

| | | | | |
|---|---|---|---|---|
| | | • Computer Applications | | |
| **CS Intro** | Keys to Computer Science | None | Intro to Computer Science | 2 |
| **Digital Applications** | • Digital Marketing<br>• E-Sports<br>• Introduction to Robotics<br>• Robotics I | None | • Exploring Robotics and Automation (North HS only)<br>• Computer Modeling for Robotics | 6 |
| **Video Game Design and Graphics** | • Video Game Design and Development 1<br>• Video Game Design and Development 2<br>• 3D Character Creation and Animation<br>• Intro to Digital Media/Graphics | None | None | 4 |
| **Total:** | **10** | **5** | **5** | **20** |

Table 4. Digital Technology Course offerings that do not fall under any of the DPI Career Pathways

## 5. Discussion

In this case study, we explored the adoption of computer science and information technology coursework across three school districts in Northeast Wisconsin. Many of these collaboration opportunities originated from the founding and maturation of the NEW Digital Alliance as a central hub for collaborative solutions for the CS talent shortage across Northeast Wisconsin (Muraski, et al., 2021).

### 5.1 Drivers

RQ1: What was the driving force for these school districts to increase their CS/IT course offerings?

First, all three school districts identified the engagement of local and regional businesses. In the Howard-Suamico School District, these industry partners communicated expectations to administrators for all students to graduate with a wide range of digital skills. The Computer Science Advisory Board includes many parents representing many large employers from around Green Bay who highlighted the ongoing need for more digital and technical skills from all graduates. In the Hortonville Area School District, the CS advisory board had strong participation from local companies. This board provided input to drive the offering of courses that would be valuable to industry and instrumental in adding required digital literacy elements in core middle school courses like English, social science, and math supported by technology integrators. At the high school level, progress was driven in large part by a dedicated and qualified computer science teacher. In Sheboygan Area School District, the need for skilled IT workers was felt acutely by one of their largest employers in the region. Across all three school districts, the driving force for increasing CS/IT course offerings and additional digital skills came from local business and industry encouragement.

Second, all three school districts faced a push from outside groups to offer more CS.IT course offerings. These groups included Teals (Microsoft), NEW Digital Alliance, local Chambers of Commerce, and the Wisconsin Department of Public Instruction (DPI). Third, two of the school districts highlighted the role of specific teachers and their interests in growing CS/IT courses. These two teachers were actively recruited and asked to spearhead new CS/IT course development. Surprisingly, we did not identify additional funding as a significant reason for school districts to provide additional coursework in CS/IT. In other words, money was not a direct source of motivation for the school districts. We also did not find that parents and students were significant drivers of additional courses. While a few parents with a background in IT did engage in the advisory boards at Hortonville and Howard-Suamico, we did not see a broad push from parents and students. In fact, both Howard-Suamico and Hortonville struggled to get enough enrollment in their classes.

### 5.2 Collaboration Networks

RQ2: How have individual school districts interacted with the existing collaboration network in building their CS/IT course offerings?

Considerable interaction occurred between the school districts in the existing collaboration as they built their CS/IT course offerings. The Howard-Suamico School District collaborated with the Regional CS Advisory Board to learn about options, partners, and pathways across Northeast Wisconsin and beyond. HSSD then established its own CS Advisory Board to increase engagement with the community, including parents, industry partners, large employers, and post-

secondary schools. Initial collaboration with the NEW Digital Alliance and Microsoft TEALS led to the integration of CSforAll and TEALS into the schools. HSSD also utilized technology integrators in the K-8 grades to build digital skills into the curriculum and grew student interest in enrolling in more CS-related courses in high school. The Hortonville Area School District has been influenced strongly by external collaborations. They were early adopters of Microsoft TEALS and established Youth Apprenticeships with local companies. They also participated strongly in the Regional CS

Advisory Board. They took advantage of several collaborative opportunities throughout the region, including TEALS meetups with other teachers and industry volunteers, DairyLand Computer Science Teachers' Association, and Code.org training at Marquette University. The Sheboygan Area School District experienced collaboration between the school district, the technical college, and the university to develop an accelerated pathway from high school through an associate degree in web development to a bachelor's degree in management information systems. The effort relied heavily on dual-credit coursework offered by the technical college in the high schools and strong articulation agreements between the institutions, allowing students to efficiently bring all their credits from high school. All three school districts benefited from a mature collaboration network across Northeast Wisconsin. Collaboration network maturation results in improved collaboration and increased innovative outcomes (Muraski, et al., 2021).

### 5.3 Challenges

RQ3: What challenges did school districts face as they sought to increase their CS/IT course offerings?

Each school district faced challenges as they sought to increase their CS/IT course offerings. In the Howard-Suamico School District, integrating CS/IT into the elementary curriculum faced several challenges. In addition, both Howard-Suamico and Hortonville faced challenges in getting enough enrollments in high school courses, especially female students. Hortonville and Sheboygan were challenged by the lack of teacher availability and concerns about teacher training and qualifications. The Sheboygan Area School District experienced strong interest among high school students, but soon realized the courses were challenging and not all high school students were prepared for the rigor of college coursework. The school district and the technical college are now working on developing more appropriate introductory coursework to prepare students better. Finally, the school district was also challenged by technology availability since students needed PCs for the classes, but the school district was based on Chromebooks. This was overcome by the district making PCs available to students who needed them.

## 6. Conclusion

Growing technology-related skills in our K-12 schools will benefit students in many areas of society, home, and personal life. Industry demand for information technology-related skills continues to soar. Despite the personal and societal benefits, high job demand, and high salary, high school students are not pursuing CS/IT-related majors or careers at a rate that can meet demand. We describe three different approaches taken by three different school districts to respond to these efforts in collaboration with local industry and other institutions.

The Howard-Suamico School District responded to parents and regional businesses in growing their offerings of technology and programming courses. Working through the Regional CS Advisory Board, HSSD established a local CS Advisory Board to provide input on curriculum structure. HSSD utilized the CSforAll framework and TEALS volunteers in building technology into the entire K-12 curriculum.

The Hortonville Area School District relied heavily on input from local industry in shaping their offerings. As an early adopter of the TEALS program, they leveraged industry professionals to support classroom teachers in offering coursework that would otherwise not have been possible to put up. They used their local CS Advisory Board to provide input on class content and curriculum structure, including integration of a digital literacy requirement in middle school. The CS Advisory Board was also notable for its inclusion of students in co-leading the board. The district had a qualified CS teacher with strong ideas on how to organize a CS program for high school students, which also contributed to their success.

The Sheboygan Area School District has long-standing connections with local industry and a tradition of collaborating on talent development issues in the local area. When local companies were facing problems finding IT talent they reached out and established a collaboration with the school district and two local higher education institutions to establish a new program called College Here and Now. Through this program, Lakeshore Technical College offered an associate degree in web development at the high schools, and Lakeland University allowed students who completed the associate degree to transfer all credits and complete a bachelor’s degree in Management Information Systems in two years. In effect, this allowed students to earn a bachelor’s degree in two years following high school. The technical school set up two

classrooms inside the high schools dedicated to the program that were furnished and branded as college classrooms.

There are two key limitations to this study. First, this paper focused on only three school districts. It could be insightful to explore additional school districts in the same geographic area or school districts in different geographical areas to increase generalizability. Second, this study did not include all perspectives. While we attempted to include regional leaders, administrators, industry leaders, parents, and teachers, we acknowledge that we only captured limited perspectives. Wider interviews and surveys could yield richer results and greater insight into the approaches and collaboration these school districts underwent.

There are several paths for future research. First, issues of diversity, including racial and gender, have not been addressed in this research. Efforts to recruit women and racially diverse students deserve added attention. Second, the role of technology integrators should be explored. Digital integrators are those that help teachers incorporate technology and digital skills directly into the curriculum. Schools may not have time or educators to offer specific technology-related courses at all grade levels. By embedding technology and digital skills into the curriculum, schools can ensure students are able to apply these 21st century skills while focusing on core curriculum learning. Finally, research including a broad survey of stakeholders in K-12 education could shed additional light on this issue. Stakeholders would include parents, students, teachers, administrators, local organizations, industry leaders, as well as former students.

This study argues that collaboration maturation throughout the Northeast Wisconsin region facilitated the expansion of computer science offerings within school districts. Similarly, the use of regional partnerships, collaboration, and industry partners increased the likelihood of school districts being successful with their efforts. While the IT/CS talent shortage remains, these school districts have taken steps to address the need.

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## Author Biographies

**John Michael Muraski** is an assistant professor of information systems in the College of Business at the University of Wisconsin – Oshkosh. After 20 years of working and consulting in industry, he transitioned into higher education and earned his DBA at the University of Wisconsin – Whitewater. Over the last 10 years, he has taught at both the undergraduate and graduate level and led the development of several new programs, include the ERP and Business Analysis programs at UW Oshkosh. Dr. Muraski conducts research into two main areas: (a) new technology characteristics that enhance infusion between a software and an employee in an organizational context and (b) challenges and opportunities relating to high school and college student reluctance to explore technology-related educational pathways.

**Jakob Holden Iversen** is a Professor of Information Systems with 20+ years of experience in higher education teaching, research, and administration. He currently serves as Associate Dean for the College of Business at University of Wisconsin Oshkosh. He earned his Ph.D. at Aalborg University in Denmark with a focus on Software Process Improvement. He has been at UW Oshkosh since 2000 where he has taught a range of courses at both the undergraduate and graduate level in Information Systems. Throughout his time at the University of Wisconsin – Oshkosh he has worked on creating new degree programs in collaboration with other departments as well as other universities in the University of Wisconsin System. This included leading the development of the Interactive Web Development Management major, the Information Systems minor, and participation in the creation and redesign of a number of other degree programs. As a scholar he has published in leading academic journals including MIS Quarterly, and is the co-author of two textbooks on Mobile app development and C# programming. A recent focus for his research and teaching has been in the area of mobile app development and usage.

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