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A Preliminary Analysis of Indiana Schools' Implementation of Virtual Instruction and CS Education in the 2020-2021 School Year

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Abstract

This study analyzed two datasets published by the Indiana Department of Education (IDOE) related to implementing virtual instruction and computer science (CS) education in Indiana schools during the 2020-2021 school year. The research explored schools' virtual instructional practices amidst unprecedented educational disruptions and the preparedness and execution of CS curricula. Using quantitative and qualitative methods, we first evaluated the distribution of different instructional modes, school districts' adoption of virtual instruction, their support mechanisms for students, successes, and challenges schools experienced, and their future plans for virtual learning. The findings reveal that hybrid and virtual instruction were prevalent, yet disparities in technology access and instructional quality persisted. Schools reported barriers related to technology resources, teacher preparedness, and student engagement. Additionally, this study highlights the inequities in implementing CS education, particularly at lower grade levels, underscoring the need for increased resources and teacher support. These insights aim to inform future educational strategies for multi-modality instruction and enhance the integration of CS education into K-12 curricula.

Keywords: *Virtual instruction, Computer science education, Indiana schools, Technology access, Teacher support*

Virtual Instruction

Due to the global pandemic, U.S. public schools transitioned to distant learning in March 2020. In Indiana, the Governor issued an order to close all public schools, initiating remote instruction on Mar 19. School buildings remained closed for the remainder of the Spring semester (Decker, Peele, & Riser-Kositsky, 2020; Herron, 2020). By the Fall of 2020, some in-person instruction resumed, but most Indiana schools adopted a hybrid model due to frequent school closings. A virtual option was offered for students who were sick or in quarantine. These patterns continued in the Spring semester of 2021.

Teaching with educational technology at the pre-college level has been prevalent since the 1990s (Means & Olson, 1997). With the development of technologies, various tools have been found to be effective in supporting K-12 students' learning. For example, visualizations make abstract phenomena and concepts visible, educational games promote student active engagement, and simulations make traditional labs more accessible (Chien, Hwang & Jong, 2020; Hao, Zhen, Wang & Jiang, 2021; Wang, Hodges & Lee (2022). Before 2020, most classroom technologies were integrated into in-person instruction, where students typically worked individually or in groups while interacting with these tools. However, due to the pandemic, more than two-thirds of school districts in the U.S. employed a hybrid model that included both in-person and virtual instruction (Herold, 2021). This abrupt shift highlighted the critical role of technology integration in shaping student learning outcomes.

While several studies have examined the learning experiences of college students during the year 2020-2021, few have investigated how K-12 schools accommodate the virtual, technology-rich learning environment during the pandemic (e.g., Barrot, Lienares, & Del Rosario, 2021; Muhammad & Srinivasan, 2021; Tan, 2021). This study seeks to address this gap by examining the virtual instructional practices Indiana K-12 public schools implemented during the pandemic in the 2020-2021 school year.

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K-12 Computer Science Education

There is a growing global awareness of the importance of computer science (CS) education. Integrating CS courses into the K-12 curriculum emphasized the need to prepare current students to transition from technology consumers to becoming technology creators (Yadav, Gretter, Hambrusch, & Sands, 2016). In Indiana, state requirements mandate that, after June 2021, all public schools include CS in the curriculum for K-12 students (IDOE, 2018). However, little is known about schools' readiness for CS implementation. Research has found that CS curriculum design is a complex task, as there is no single commonly accepted theory to guide the vision for the CS curricula (Pacheco, 2012; Webb et al., 2017). Therefore, understanding schools' current implementation of CS curriculum can provide valuable insights into the support needed for schools and teachers.

Research Objectives

This manuscript focuses on two primary objectives: 1) to examine the virtual and hybrid instructional practices implemented by Indiana K-12 schools during the 2020-2021 school year; and 2) to investigate schools' implementation of CS education at K-8 levels during the same period. The following research questions guided our study:

1. What modes of instruction did Indiana schools adopt during the 2020-2021 school year?
2. How did the public schools in Indiana support students' virtual learning during the pandemic?
3. What barriers and successes did schools experience with virtual instruction?
4. What were the schools' practices for implementing CS curricula at K-8 grade levels?

Methodology

Data Source

This study utilized two datasets obtained from the Indiana Department of Education (IDOE) website: Dataset #1, Modes of Instruction, and Dataset #2, Technology Plan. Both datasets were accessed in July 2022. Dataset #1 provides information on the percentages of weeks during which schools adopted virtual, hybrid, and in-person instruction as their primary modes. The IDOE collected this data on July 9, 2021. Dataset #2 contains responses from school districts regarding their use of technology and the implementation of CS instruction during the 2020-2021 school year. The dataset includes both multiple-choice questions (e.g. "Did your school/district upgrade its on-campus bandwidthin response to COVID?") and constructed response questions (e.g. "Describe any barriers you face when implementing virtual learning days and describe how they impact your decision to implement (or not implement) virtual learning days?").

Data Analysis

We used both quantitative and qualitative approaches to analyze the data. For the Modes of Instruction dataset (Dataset #1), we first grouped schools by county and calculated the average percentages of each instruction mode for every county. We then coded each county's primary instructional mode.

- In-person counties: counties where over 67% of schools conducted in-person instruction for more than 90% of the total weeks.
- Virtual counties: counties where more than 50% of the schools employed virtual instruction for over 50% of the whole week.
- Hybrid counties: counties not falling into the above two categories.

To address research questions 2, 3, and 4, we analyzed school districts' responses to 47 relevant questions from the Technology Plan dataset (Dataset #2). We present a summary of the analyzed questions, and the methods applied, in Table 1.

Table 1. Survey Questions and Data Analysis for Dataset#2

Topic	Questions	Analysis approaches
Virtual/hybrid instruction environment	1. 1:1 technology status 2. Amount of synchronous and asynchronous instruction 3. Percentage of purchased digital content in the curriculum	Quant analysis
Support for virtual learners	1. Percentages of students who do not have broadband internet access at home in each school district. 2. Ways that school districts support those who do not have internet access at home. 3. Staffing approaches for virtual learners.	Quant analysis
Barriers and successes	1. The barriers schools faced when implementing virtual and hybrid instruction. 2. The biggest successes schools experienced during the virtual and hybrid instruction and specific strategies they used to engage students	Qual analysis
Future plans	1. Advances made that will endure in the future 2. The top three PD goals identified in the next three years.	Qual analysis
*CS implementation	1. Do your students receive standards-based computer science (CS) instruction? 2. CS implementation strategy. 3. Where does the majority of CS instruction take place? 4. Who delivers the majority of CS instruction?	Quant analysis

Note: These same set of questions were asked for all grade levels.

Results

Modes of Instruction

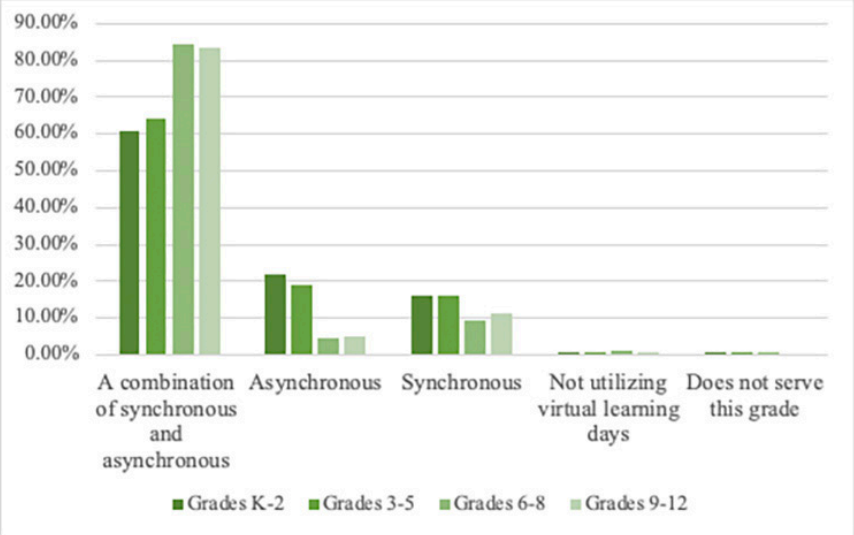
Table 2 summarizes the modes of instruction adopted by counties. The number of counties with in-person as the primary mode (48) is similar to those counties› employing hybrid as their primary mode (42). Only one county fell into the category of virtual. When mapping the locations of hybrid and in-person instruction across the state, we observed that schools in the northern region predominantly adopted in-person instruction, whereas more counties in the southern region implemented hybrid instruction.

It is important to note that counties were categorized as in-person if over 67% of the schools within them conducted in-person instruction for more than 90% of the weeks throughout the year. Additionally, within Dataset #1, schools were labeled as "in person" when their in-person attendance rate reached 75% on specific days. This classification means that even in counties coded as in-person, over 30% of schools may have implemented hybrid or virtual instruction, with up to 25% of their students attending virtually. As such, hybrid or virtual instruction was present in nearly every school in Indiana during the 2020-2021 school year. Understanding how schools managed these modes of instruction becomes essential. The findings related to hybrid and virtual instruction are discussed below.

Table 2. Mode of Instruction

Category	Category definitions	No. of Counties
In-person	Over 67% of schools in this county adopted in-person mode over 90% of the weeks.	48
Virtual	Over 50% of the schools in this county adopted virtual or hybrid mode for more than half of the total weeks.	1
Hybrid	Remaining schools	42

Figure 1. Amount of Synchronous and Asynchronous Instruction by Grades



Virtual/hybrid Instruction Environment

To understand the virtual and hybrid instruction environments, we analyzed school districts' responses to questions about their one-to-one (1:1) technology status, the amount of synchronous and asynchronous instruction during virtual learning days, and the percentages of purchased digital content in the curriculum.

A one-to-one technology district is defined as one that provides students with computing devices for learning at school. Among the 291 public school districts, 90.69% achieved 1:1 technology status across K-12. Approximately 2.4% did not provide devices, while the remaining school districts provided devices starting at a higher grade, such as 1:1 technology only for middle and high school students. Notably, of schools with 1: 1 technology, 23 (about 8.7% of them) did not allow students to take their devices home.

We also analyzed the amount of synchronous and asynchronous instruction during virtual learning days across grade levels (Figure 1). Most school districts implemented a combination of both synchronous and asynchronous approaches.

Instructional materials need to be adapted into digital formats to accommodate virtual learning. Our analysis revealed that 141 out of 291 school districts purchased less than 30% of their digital content, while sixty-five schools purchased over 50% of their digital content (Figure 2). However, this survey question only asked about the percentage of school-purchased digital content. Consequently, the exact total amount of digital content used remains unclear, as schoolteachers may also digitalize materials.

Figure 2. Percentages of Purchased Digital Content

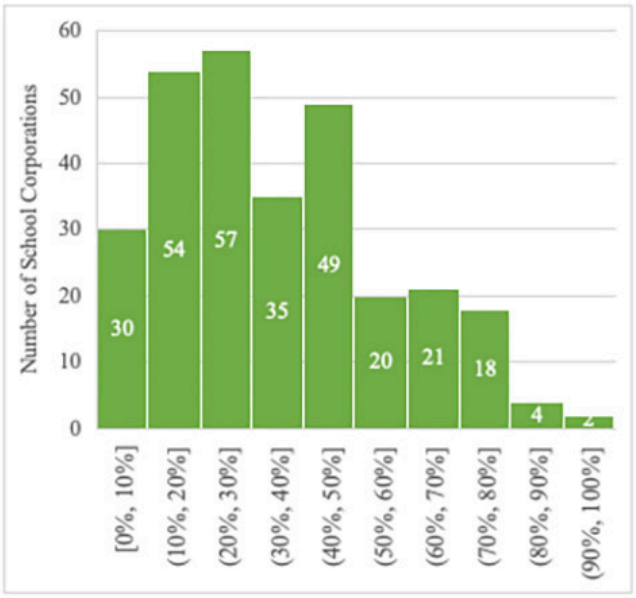
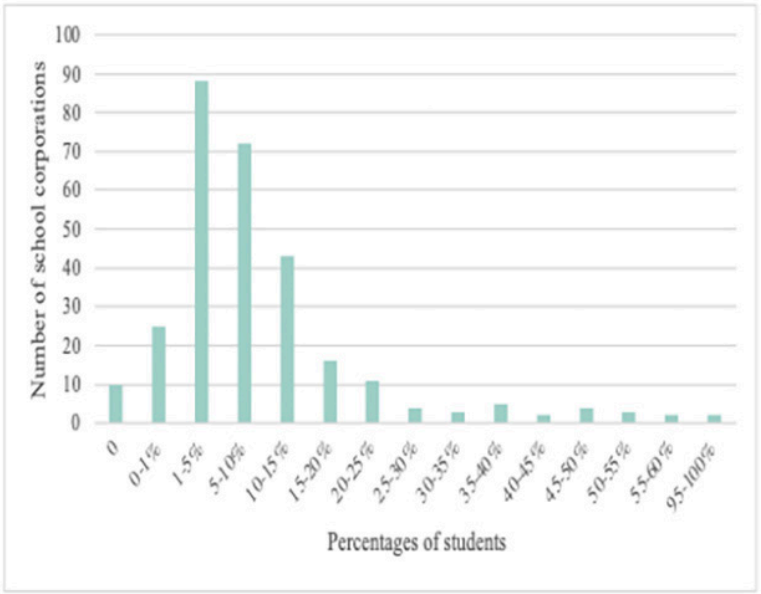


Figure 3. Students Who Don't Have Broadband at Home



Support for Virtual Learners

We investigated how schools supported students during virtual learning days by examining ways schools provided internet support for those who did not have access to broadband services at home and the staffing approaches used for virtual learners.

To contextualize these efforts, we first analyzed the percentages of students lacking broadband access at home (Figure 3). 203 school districts had 1-15% of students without broadband access at home. Only two school districts reported that over 95% of students had broadband access at home. These findings highlight the widespread need for schools to facilitate internet access during virtual learning days.

Table 3 summarizes how schools supported students without internet access at home. Schools employed three main strategies: providing internet access, distributing physical materials, or combining the two approaches. To make the internet available, school districts distributed hotspots, directed students to public internet locations (e.g., connecting to public internet at libraries), and extended school Wi-Fi availability after hours. For students in areas with limited internet services, schools supplemented these efforts by distributing physical materials.

We also examined how schools staffed virtual instruction (Table 4). Half of the school districts required classroom teachers to simultaneously teach both virtual and in-person students, synchronously or asynchronously, with no dedicated virtual teachers. Some schools compensated their classroom teachers for checking in with asynchronous students after school hours. A small number of schools hired instructional assistants or virtual coordinators to provide additional support for classroom teachers. Among the 156 school districts with dedicated virtual teachers, responsibilities varied. Some school districts assigned dedicated virtual teachers to deliver synchronous virtual lessons, leaving classroom teachers to manage asynchronous and in-person learners. Others relied on dedicated virtual teachers to conduct daily check-ins with asynchronous students.

Table 3. Ways to Support Students Who Do Not Have Home Internet Access

Category	No. of school districts
Provide internet accessibility support by distributing hotspots, providing a list of public Wi-Fi, extending school Wi-Fi use hours, etc.	70
In addition to internet support, distribute physical materials or make materials offline available	213
Only distribute physical materials	4

Table 4. Staffing Approaches for Virtual Learners

Staffing approaches	No. of school districts
Dedicated teacher only	42
Classroom teacher only	121
Both dedicated and classroom teachers are available	114
Some grades with vendors	8
Only vendor	2
No virtual	3

Barriers and Successes

We conducted thematic analyses of school districts' responses to three constructed response questions: the barriers they faced when implementing virtual instruction, their biggest successes, and how they were successful in engaging students in virtual learning days.

Barriers

School districts shared three major barriers to virtual instruction. 1. Availability of technology resources, including limited broadband internet access at home and a lack of devices for students. Many variables contributed to students' lack of broadband internet access at home, such as low-income families being unable to afford the service, inadequate infrastructure in rural areas, and family resistance to internet use for religious reasons. Additionally, in households with multiple children, insufficient bandwidth often hindered simultaneous access to synchronous online learning. 2. Teacher struggles. Teachers were not adequately prepared to teach across multiple modalities. Teachers experienced difficulties promoting students' engagement, tracking learning progress, and communicating with students and parents via technology. 3. Students' learning. Students frequently submitted incomplete or low-quality work, experienced declining grades, and struggled with time and task management. Younger students, in particular, faced additional difficulties due to lack of academic support from parents and childcare at home.

Successes

When answering the biggest successes over the past year with virtual/hybrid learning, the school districts shared the following successes: 1. Teachers' continuous growth in their competence and confidence in delivering virtual lessons. 2. Students' improvements in their technology literacy. 3. More eLearning resources implemented, such as learning management systems and new digital teaching tools.

When sharing their strategies for engaging students during virtual and hybrid learning, many school districts candidly admitted that it was challenging to maintain high levels of engagement and expressed uncertainty about their success in this area. Nonetheless, summaries of schools' specific strategies to encourage student participation and involvement during virtual learning days are listed in Table 5.

Future Plans for Virtual Learning

We conducted a thematic analysis of school districts' responses to questions regarding the advances they made during the 2020-2021 school year that they plan to sustain in the future, as well as their top three professional development (PD) goals for the next three years. The advances that school districts identified as enduring include continuous PD for teachers and staff, the ongoing offering of virtual and hybrid learning models, the consistent technology integration in the in-person model, and the integration of K-5 computer science curriculum. When asked whether they would continue to offer a fully virtual option, 26% of school districts responded affirmatively, while 46% indicated they were considering it. In addition, 81% of school districts expressed plans to continue to utilize virtual learning days beyond the 2020-2021 school year, with 14% of them considering.

Table 6 lists the top three PD goals school districts identified in the next three years. Notably, school districts emphasized digital literacy. Many school districts listed specific goals related to digital literacy, such as virtual learning frameworks and digital assessments. These findings underscore the pivotal role that technology will continue to play in shaping instructional strategies and professional growth in the coming years.

Table 5. Strategies to Engage Students in Virtual/Hybrid Learning

1.	Consistency between virtual and in-person instruction.
2.	Create instructional videos.
3.	The standardized layout of LMS.
4.	Synchronous video check-ins.
5.	Allowing flexibility
6.	Designated staff to communicate with students and parents.
7.	Daily small group and one-to-one tutoring sessions.
8.	Diversify the ways of presenting information.

Table 6. Professional Development Goals in the Next Three Years

1.	Digital literacy, including the use of technology tools, cybersecurity awareness, and digital curriculum.
2.	STEM and project- and problem-based learning.
3.	Virtual learning framework SAMR, UDL
4.	Social-emotional learning
5.	Practices to improve student engagement in virtual learning
6.	Computer science standards implementation
7.	Data-driven instruction
8.	DEI training
9.	Authentic digital assessments
10.	PBL

CS Instruction

We analyzed school districts' responses to four questions regarding their implementation of CS instruction: whether students received standard-based CS instruction, school districts' implementation strategies, where CS instruction took place, and who delivered the CS instruction. The findings, detailed in Figures 4,5,6 &7, revealed notable patterns.

We noted that Standards-based CS instruction was more commonly offered at higher grade levels than lower ones. For example, about 52% of schools provided CS instruction for kindergarteners, 61% for 4th graders, and above 64% for 8th graders. About 80% of K-8 schools provided CS instruction or were developing plans to implement it. This widespread commitment indicates a growing emphasis on equipping students with foundational CS skills.

Regarding implementation strategies, schools were more likely to mandate a set of lessons across the districts for lower grades, but higher grades often had more flexibility, leaving instructional decisions to individual school buildings. As for the location of CS instruction, the most common options across K-8 grades were required special rotations or standalone classes. However, for grades 6-8, elective CS courses were offered more frequently than required classes.

Finally, the personnel for CS instruction varied by grade level. School districts may have licensed teachers, media specialists, or TAs/paraprofessionals teaching the CS lessons. Licensed teachers were the primary instructors across K-8, but their prevalence increased with grade level. For example, while nearly 70% of kindergartens had licensed CS teachers, this figure rose to over 96% by 8th grade. Media specialists and teaching assistants (TAs) or paraprofessionals were also employed but to a lesser extent than licensed teachers.

Figure 4. Availability of Standard-Based CS Instruction

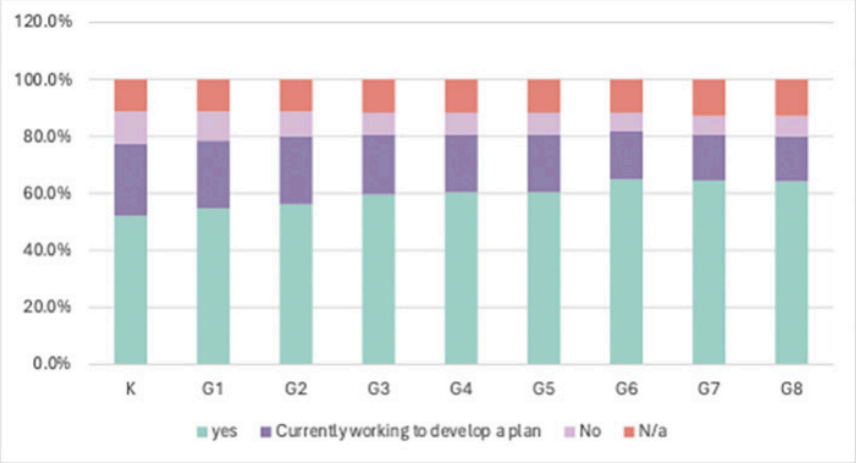


Figure 5. Schools' CS Implementation Strategies

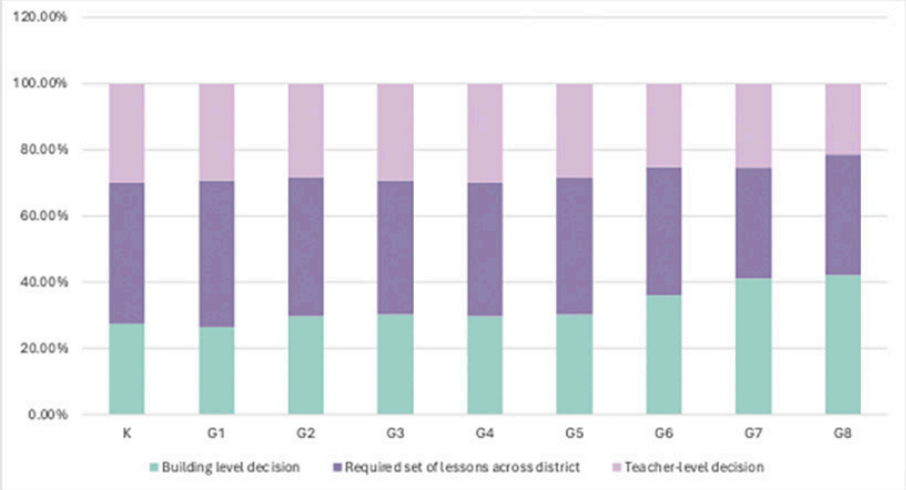


Figure 6. Where CS Instruction Takes Place

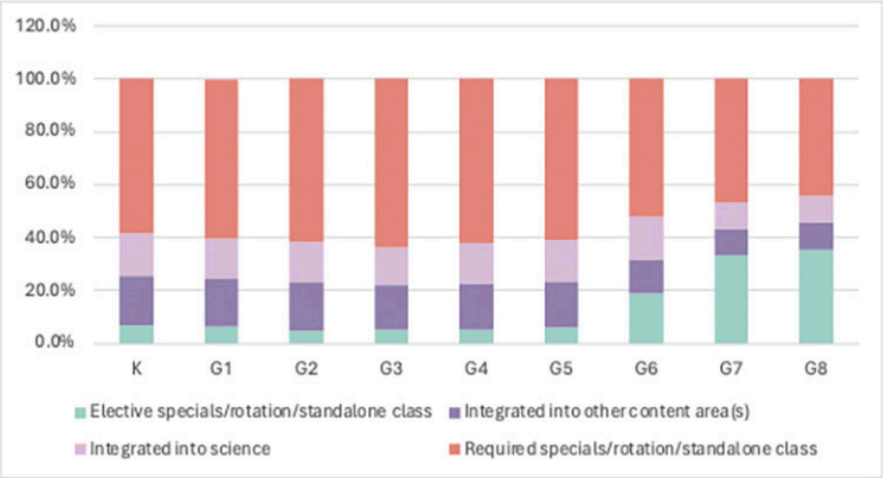
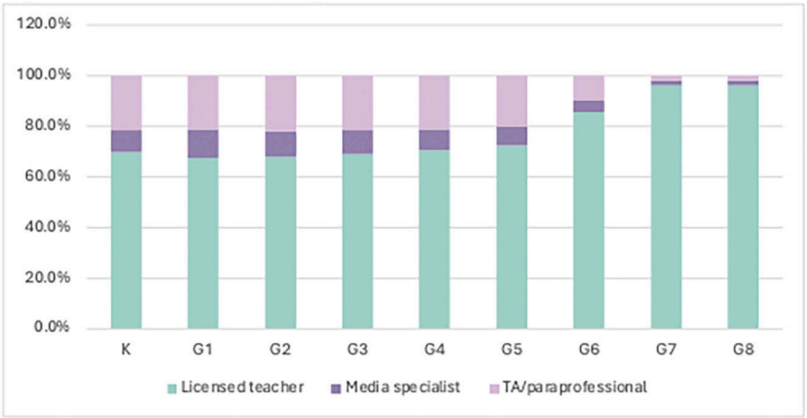


Figure 7. CS Instruction Staffing



Conclusion

This study analyzed two datasets published on the IDOE website, focusing on virtual/hybrid instruction and the implementation of CS education during the 2020-2021 school year. The findings suggest the popularity and complexity of virtual and CS instruction, leading to three key conclusions related to teacher education. First, almost all schools implemented some form of virtual and/or hybrid instruction, requiring classroom teachers to manage both in-person and virtual learners. This dual responsibility underscores the need for teacher preparation programs to include training in multi-modality instruction. Additionally, the study suggests that employing more dedicated virtual teachers could enhance student support, as teaching both in-person and virtual lessons simultaneously poses significant challenges for educators. Second, the effectiveness of virtual learning environments depends on several interconnected factors: the availability of technology resources, teachers' readiness to deliver virtual instruction, and students' preparedness for e-learning. Finally, while Indiana school districts were making strides in implementing CS instruction, significant disparities were observed between grade levels. Lower grades received fewer resources, including a smaller proportion of licensed CS teachers and fewer opportunities for standards-based CS instruction, compared to grades 6-8. This uneven distribution of resources points to an inequity in CS instruction across K-8 that should be addressed to ensure all students have access to foundational CS education.

The 2020-2021 school year was unique in that schools had to go through a rapid transition to virtual or hybrid instruction in response to the global pandemic. This study analyzed school districts' modes of instruction, their implementation of virtual/hybrid instruction, and CS education during this unprecedented time. We acknowledge that the datasets used in this study did not specify the roles of school personnel who answered the surveys, leaving questions about teachers' direct, first-hand experiences with simultaneous in-person and

virtual instruction. Future research related to how teachers navigate virtual and in-person teaching in their everyday classrooms may better inform the design of PDs and teacher preparation curricula to better equip educators for both in-person and virtual instruction.

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