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Assistive Technology Integration for Students with Speech and Language Impairments: A Mixed Method Study

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ABSTRACT

This study examines a large urban public school (UPS) district in the Midwest USA that has faced bankruptcy, state takeover of public education, and financial scams. As a result, UPS's capacity to integrate assistive technologies (AT) has been limited and is declining. This study investigates the UPS teachers' technological pedagogical content knowledge (TPACK) and how the UPS teachers integrate AT for students with speech and language impairments (SLI). This article details the UPS special education and general education teachers' TPACK across grade levels, content, and classroom settings. This article reports the UPS teachers' current integration of AT, instructional practices, implementation, and experiences integrating AT in the classroom for students with SLI. 94 UPS teachers participated in the online survey. The study found no significant differences in the UPS teachers' TPACK across classroom settings or grade levels. Results show no significant differences between the UPS teachers' TPACK in mathematics, social studies, science, or literacy content knowledge. The study revealed that UPS teachers utilize various AT tools, from basic tools like [calculators, audio/video recording devices, and voice amplifiers] to more advanced tools like [iPads, SmartBoards, and computers], for diagnostic, formative, and summative assessments. Results indicate that the UPS teachers utilize similar instructional methods across content and express mostly positive experiences integrating AT for SLI students

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INTRODUCTION

Students with Speech and Language Impairments (SLI) are the second largest group of students with disabilities receiving special education services in the United States, and the urban public schools (UPS) district investigated the most significant group receiving these services. Sadly, little attention has been paid to how students with disabilities use technology daily (Fernández-Batanero, 2022). It is unclear which specific Assistive Technology (AT) tools, such as speech-to-text software, communication boards, and text-to-speech applications, are utilized by students with disabilities based on age, grade, type of disability, and severity. AT is the technology used by individuals with disabilities to perform functions that may otherwise be difficult or impossible under the Individuals with Disability Act (IDEA, 2024). Students with disabilities require increased educational opportunities and encounter underrepresentation in research, use, and access to AT. Additionally, teachers of students with disabilities have limited access to, use of, and knowledge about AT as well (Edyburn, 2001; Alper & Raharinirina, 2006; Quinn et al., 2009; Alkahtani, 2013; Wu et al., 2018; Mohamed, 2018; Siyam, 2019; Fernández-Batanero, 2022). Moreover, teachers' perceptions and experiences of technology also impact AT use (Nam et al., 2013; Liu et al., 2017). As a result, students with disabilities experience achievement gaps due to the digital and pedagogical divide stemming from teachers' limited knowledge, experiences, attitudes, training, and access to AT (David, 2012; Flanagan et al., 2013; Nam et al., 2013; Connor & Beard, 2015; Liu et al., 2017; Mohamed, 2018). These barriers can negatively impact teachers' AT integration for SLI students. Hence, this study explored the UPS teachers' Technological Pedagogical Content Knowledge (TPACK). This framework examines the knowledge and skills teachers need to integrate technology effectively into their teaching and the variances in special and general education classrooms.

Technological Pedagogical Content Knowledge (TPACK)

The Technological Pedagogical Content Knowledge (TPACK) framework, a product of Shulman's (1987) pedagogical content knowledge (PCK), is not just a theoretical construct but also a practical tool for teachers. Mishra and Koehler (2006) expanded PCK by incorporating technological knowledge (TK) as an essential component of teachers' knowledge, as illustrated in Figure 1. Mishra and Koehler proposed the TPACK framework to identify how teachers combine technology, pedagogy, and content knowledge for teaching and learning (Kong et al., 2023). TPACK is not only a theoretical framework but also a critical one for examining technology integration (Wu, 2013; Engelbrecht et al., 2020; Saubern et al., 2020; Kholid et al., 2023; Su, 2023; Teichert et al., 2023). TPACK provides a structure to organize the development of work around pedagogy, content, and technology (Koehler & Mishra, 2009). The TPACK framework has been widely published in research on teacher education, teacher beliefs, and classroom practices (Saubern et al., 2020, p. 1). Cox and Graham's (2009) study confirmed the boundaries between TPACK and the combinations of its seven elements and suggested that TPACK is a "sliding" framework based on emerging technologies and the ongoing dialogue about the growing definition of technology.

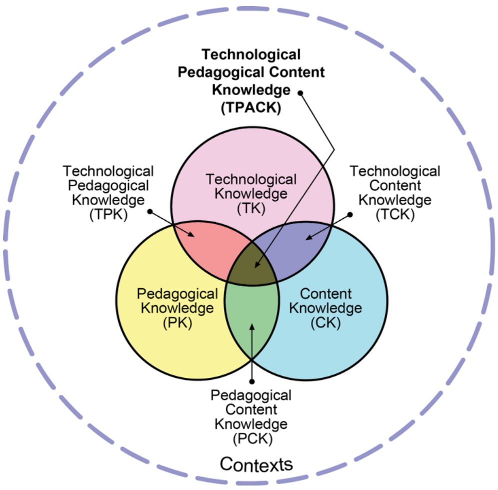

Figure 1. *TPACK (Koehler and Mishra, 2006, p. 1025)*

Over the last twenty years, various researchers have analyzed the TPACK model from many epistemological and methodological positions (Jimenez et al., 2023). Research has revealed that the use of technology in education is criticized for lacking theoretical foundations (Buckingham, 2013; Kholid et al., 2023). TPACK is criticized as weak in its theoretical use (Saubern et al., 2020). TPACK survey methods have commonly assessed teachers' technological knowledge (Baran et al., 2011; Willermark, 2018; Su, 2023). Most surveys have examined preservice teachers' self-assessment of TPACK and related knowledge domains (Schmidt et al., 2009; Willermark, 2018). Since existing surveys on TPACK have focused on teachers' self-assessment of technological knowledge, the challenges of creating and validating an instrument to measure teachers' TPACK application in multiple contexts, including different content areas, are complicated (Archambault & Barnett, 2010; Teichert et al., 2023). Former research on TPACK has distracted researchers from addressing the goal of TPACK and advancing the recognition of effective teaching with technology. A review of twenty-two TPACK studies indicates that researchers must address what teachers need to know to integrate technology effectively and how to develop their knowledge best (Saubern et al., 2020).

Research Questions

The study investigated how the UPS teachers integrate AT into their teaching and learning and their experiences integrating AT for students with SLI. More specifically, the following research questions guided the research inquiry:

1. What are the differences between the Pre-K-12 special education teachers and general education teachers in their use of TPACK in special education self-contained and general education non-self-contained classrooms for students with speech and language impairments (SLI)?

2. What are the differences in the Pre-K-12 special education teachers' and general education teachers' use of TPACK in elementary, middle, and high school grade levels for students with SLI?

3. What are the differences between the Pre-K-12 special education teachers' and general education teachers' use of TPACK during science, social studies, literacy, and math instruction for students with SLI?

In addition, the study explored teachers' experiences in integrating AT to support students with SLI, including:

- The AT commonly used in both general and special education settings for SLI learners,
- Teachers’ assessments of the effectiveness of the AT and content delivered and
- Teachers’ experiences integrating AT into classroom instruction for students with SLI.

The Context of the Study

The UPS district examined services for about 53,406 students. The UPS has about 7,116 employees, including 3,227 teachers, all 100% certified, and 50 or more hold National Board Certification. Seventy-eight percent of the students are eligible for free or reduced lunch. Eighty-two percent of the students are African American, and 14% of the students have a disability, with SLI students being the largest group receiving special education services. The COVID-19 pandemic hit the UPS district hard, revealing inadequate education for students in the USA and globally (Teichert et al., 2023). During the pandemic, the UPS district fed 2 million families; with COVID relief funding, the UPS expanded summer and after-school programming, provided mental health support for students, and developed a virtual school. The UPS district opened all its schools in 2020-21, allowing teachers and students to teach and learn in person or online. Twenty million dollars in additional funding provided all students with laptops and internet connections to learn from home. However, children with disabilities require more individualized instruction and support that they cannot access at home. Thus, COVID negatively impacted disabled learners' access to the programs and services critical for their educational development (Mete et al., 2022).

Furthermore, teachers experienced challenges in online learning during the pandemic, making it difficult for them to do their jobs (Page, 2020, as cited in Teichert et al., 2023). Teachers' workloads increased as they transitioned to teaching online. Teachers encountered pedagogical challenges as they adapted familiar teaching methods to new media, forcing them to operate in virtual classrooms (Teichert et al., 2023). Teachers also reported difficulties meeting their students' needs online, needing more training to integrate technology effectively, and requiring help communicating between schools and homes. Some students needed access to reliable internet and digital devices.

Research Method

Mixed methods research, a comprehensive approach that has been in practice since the 1950s but was officially recognized in the late 1980s (McKim, 2017), combines qualitative and quantitative methods into a single study. This integration allows us to harness the benefits of both methods while minimizing their weaknesses (Fetters & Molina-Azorin, 2017). By linking qualitative and quantitative approaches, mixed methods research creates a more holistic understanding that cannot be achieved alone (Fetters & Molina-Azorin, 2017; McKim, 2017). In the context of our study, a mixed-methods approach was employed. A quantitative survey of 48 5-point Likert scale items collected teachers' self-reported Technological Pedagogical Content Knowledge (TPACK). The quantitative portion of the survey addressed the seven domains of TPACK. Qualitative data about the teachers' current practices, implementation, and experiences integrating AT were collected using three open-ended questions. Demographic and professional information, including email address, age, gender, degrees obtained, number of years teaching, number of years teaching SLI students, grade level currently being taught, and current classroom setting (i.e., special education self-contained or general education non-self-contained), was collected.

Context and Participants

The Urban Public School (UPS) district is one of the largest public school systems in the Midwest of the USA, serving 53,406 students. The UPS district currently employs around 3,227 teachers. Using the UPS student and employee database management system, a search of all special education teachers in the UPS district identified 594 special education teachers. However, 36 of these teachers were excluded from the study as transition center teachers who worked with adults aged 18 to 26, leaving 556 teachers as potential participants. From the UPS database management system, five special education program supervisors were identified and associated with these teachers and thus received correspondence from the researcher. A sample of 94 special education teachers from this target population provided data for the study. The adequacy of this sample was evaluated using a survey validation section on internal consistency analysis and the discriminant validity of the survey using the data collected from the sample.

Recruiting and Sampling Strategies

The UPS district teachers were recruited using the schoolwide database management system. The UPS database management system provides up-to-date district-wide student and staff information. The UPS district Regional Educational Service Agency maintains all the UPS student and staff data for the district. A search was conducted to identify all certified special educators who provide direct instructional support to Pre-K-12 self-contained and non-self-contained special education and general classrooms that have students receiving speech and language services. From this search of the UPS database system, an alpha report was generated identifying all the UPS district special education teachers by first and last name as potential participants, along with their school location number, program, and program supervisor, and entered into a Microsoft Excel spreadsheet. Teachers' email addresses were secured from the UPS database and district employee email system and linked to their names on the Microsoft Excel spreadsheet. Email addresses were used to send the TPACK survey and correspondence. All teachers' and supervisors' email addresses are public records secured from the UPS district website. Once all teachers' information was added to the Microsoft Excel spreadsheet, teachers' email addresses were added by linking the teachers' school location numbers to the program supervisor. It is important to note that all identifying information was kept strictly anonymous and destroyed at the study's end, ensuring confidentiality.

Data Collection Instrument

Qualtrics was used for the online survey. The survey gathered participants' demographic and professional data, including age, number of years teaching, number of years teaching students with SLI, gender, current grade level, classroom setting (e.g., special education/self-contained, general education/non-self-contained classroom, number of students with SLI), and degrees held. After carefully considering multiple instruments, the Survey of Preservice Teachers' Knowledge of Teaching and Technology (Schmidt et al., 2009, pp. 145-148) was modified for this study with permission from the publisher, as it closely aligns with the TPACK seven domains. One item was added to the TK subscale: "I have sufficient knowledge of assistive technology for speech and language instruction." The modified TPACK instrument consisted of 48 five-point Likert rating scales anchored as follows: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree. A small pilot study involving five teachers was used to pretest the survey, and the participants reported no difficulties understanding the survey instructions or the individual survey questions, which further validated the survey's effectiveness.

Validity & Reliability

Although Schmidt et al. (2009) have reported on their extensive efforts to construct a reliable and valid TPACK instrument, this instrument was slightly modified for use in the present study, necessitating a reexamination of its psychometric qualities. The 48 TPACK rating scale items were analyzed along with their Cronbach Alphas and Corrected Total-Item Correlation, which generally supported the hypothesized seven-subscale structure of the TPACK instrument. The internal consistency reliability of each subscale was evaluated using Cronbach's alpha coefficient. The values of Cronbach's alpha met DeVellis' (2012) and Nunally's (1978) standards for "good" to "excellent" reliability for all subscales. Some correlations among the constructs exceed 0.50, indicating low discriminant validity for the instrument. A TPACK score of 0.74 was indicated, which is relatively high. TPACK and TPK appear to measure the same knowledge construct observed in the findings. These two levels of knowledge may be combined to reflect one domain in future studies. TPACK and PCK scores of 0.70 were also relatively high. The Corrected Total-Item Correlation can be used to measure the convergent validity of a construct. If the correlation is high, above 0.50, between a given item and the construct, it possesses convergent validity. Most items possess high correlations, indicating a high convergent validity for the instrument. Therefore, the instrument is confidently said to have sufficient reliability and validity.

Discriminate Validity and TPACK

The TPACK instrument, a key focus of our study, has been extensively validated in numerous previous studies. However, some correlations among the constructs in our specific study exceeded 0.50, which could indicate low discriminant validity for the instrument. This is based on the data we collected from the UPS district teachers. A construct is considered valid if it is independent and not perfectly correlated with other constructs. Therefore, low correlations among the composed constructs below 0.50 are necessary to conclude that the instrument possesses discriminant validity (Campbell & Fiske, 1959). Table 1, for instance, reflects a TPACK score of 0.74, which is relatively high. This suggests that TPACK and TPK measure the same knowledge construct observed in our findings. These two knowledge levels could be combined to reflect one domain in future studies. Additionally, the TCK and PCK scores of 0.70 were relatively high, indicating that these two sub-domains may measure the same knowledge construct as observed in our findings. However, it is important to note that these findings could be influenced by the small size, social desirability bias, and acquiescence bias of the UPS district teachers' responses in our study.

One of the disadvantages of teacher self-reporting on TPACK is that research shows that accurately evaluating one's abilities is difficult (Lawless & Pellegrino, 2007; Willermark, 2018). Many individuals are unaware of their lack of knowledge, skills, or abilities. As a result, teachers' self-assessment or self-reporting of knowledge often reflects increased confidence rather than increased knowledge in practice, which raises questions about the validity of the approach. For example, some of the TPACK self-assessment questions are vague. For instance, the statement "I have sufficient knowledge about mathematics" involves uncertainty for the self-reporter; that is, what constitutes "sufficient"? In what situation? Also, what "technologies" are involved? These types of statements allow the self-reporter to interpret the questions and his or her abilities (Willermark, 2018).

Table 1 presents the inter-item correlations among the TPACK scales. Some correlations among the constructs exceed 0.50, indicating low discriminant validity for the instrument based on the data collected from the UPS district teachers.

Table 1. *Discriminant Validity Analysis*

	Mean	SD	TK	CK	PK	PCK	TCK	TPK	TPACK
TK	3.78	0.65	1.00						
CK	4.09	0.60	0.50	1.00					
PK	4.64	0.52	0.41	0.64	1.00				
PCK	3.95	0.87	0.39	0.54	0.46	1.00			
TCK	3.56	1.01	0.45	0.51	0.39	0.70	1.00		
TPK	4.23	0.70	0.60	0.45	0.56	0.37	0.50	1.00	
TPACK	4.17	0.68	0.60	0.52	0.59	0.47	0.51	0.74	1.00

Participants Profile

Survey responses were received from 94 respondents out of 556 teachers who participated in the study, resulting in a 17.0% response rate. A total of 94 cases remained for analysis. The data were downloaded from Qualtrics as an Excel file and then imported into IBM SPSS (Version 23.0). All data analysis was conducted using IBM SPSS (Version 23.0) statistical software. The majority of respondents were female, at 92.4% (n=85). Sixty-five percent (n=61) of respondents hold a master's degree, whereas 17% (n=16) possess a bachelor's degree. The current grade levels taught by teachers are more evenly distributed, with 40% (n=37) teaching in the Pre-K elementary setting, 25% (n=24) in middle schools, and 35% (n=32) in high schools. Seventy percent (n=66) of respondents indicated teaching in special education settings, and 30% (n=28) reported teaching in general education settings. About 75% (n=78) of the sample reported having ten or more years of teaching experience. Approximately 65% (n=69) of respondents indicated they have ten or more years of experience teaching SLI students.

Not all participants responded to every survey question. Thus, missing or incomplete responses to specific questions were excluded from the data analysis and not included in the results, either.

Data Analysis Methods

A range of selected statistical analyses were conducted to examine the relationships among the different variables, including descriptive statistics, the Mann-Whitney U test, the Kruskal-Wallis H test, and more, based on the distributional characteristics of the survey data and the research questions.

Table 2 presents the skewness and kurtosis values for each dimension of the TPACK instrument based on the collected data. These statistics reveal that the distributions of the constructs exhibit left skewness, suggesting that most responses tend to cluster around the "agree" and "strongly agree" categories. This distributional pattern informs the selection of hypothesis testing techniques to assess the statistical significance of differences between classroom settings, grade levels taught, and the means of the TPACK instrument. When the assumption of normality is violated, non-parametric tests are generally more suitable for testing mean differences. Consequently, the present analysis employs the Mann-Whitney U test to compare the means of two independent samples and the Kruskal-Wallis H test for comparing means across more than two independent samples.

Table 2. *Distribution of Constructs Analysis*

	n	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
TK	90	-.421	.254	-.338	.503
CK	91	-.823	.253	1.358	.500
PK	94	-1.896	.249	4.118	.493
PCK	94	-.995	.249	1.184	.493
TCK	92	-.510	.251	.012	.498
TPK	94	-.825	.249	.175	.493
TPACK	87	-.494	.258	-.092	.511

Data Analysis Results

The following summarizes the statistical analyses and presents the results by research question.

1. What are the differences between the UPS district Pre-K-12 special education teachers and general education teachers in their use of TPACK in special education self-contained and general education non-self-contained classrooms for students with SLI?

Table 3 displays the means of UPS district special education, general education, and classroom settings for their TPACK and indicates that both groups of teachers have no noticeable mean differences.

Table 3. *TPACK Means and Classroom Setting*

Current Classroom Setting		TK	CK	PK	PCK	TCK	TPK	TPACK
Special education	Mean	3.72	4.08	4.62	4.01	3.63	4.26	4.24
	n	63	64	66	66	65	66	62
	Std. Deviation	0.71	0.62	0.55	0.83	0.94	0.68	0.64
General education	Mean	3.80	4.16	4.72	3.84	3.33	4.07	4.00
	n	27	27	28	28	27	28	25
	Std. Deviation	0.60	0.48	0.33	0.91	1.16	0.75	0.73
Total	Mean	3.74	4.10	4.63	3.96	3.54	4.21	4.17
	n	90	91	94	94	92	94	87
	Std. Deviation	0.68	0.58	0.50	0.85	1.01	0.70	0.67

Table 4 displays the results of the Mann-Whitney U test, confirming that the data above, presented in a tabular format, indicates no statistical differences in TPACK dimensions based on the UPS district teacher and classroom setting at the 0.05 level.

Table 4. *Mann-Whitney U Test Results (Classroom Setting on TPACK)*

	TK	CK	PK	PCK	TCK	TPK	TPACK
Mann-Whitney U	803.500	813.500	906.500	828.000	751.000	795.500	613.000
Wilcoxon W	2819.500	2893.500	1312.500	1234.000	1129.000	1201.500	938.000
Z	-.415	-.441	-.153	-.825	-1.104	-1.075	-1.533
P-value	.678	.659	.879	.410	.270	.282	.125

2. What are the differences in the UPS district's Pre-K-12 special education teachers' and general education teachers' use of TPACK in elementary, middle, and high school grade levels for students with SLI?

Table 5 displays the means of the UPS district teachers' special education, general education, and current grade levels across the various domains of TPACK. The UPS teachers exhibit similar self-assessments on the TPACK instrument, regardless of their grade level or classroom setting.

Table 5. *Current Grade Level and TPACK Self-Assessment*

Current grade level teaching		TK	CK	PK	PCK	TCK	TPK	TPACK
Pre-K Elementary	Mean	3.69	4.08	4.57	3.97	3.60	4.18	4.20
	n	36	36	37	37	37	37	33
	Std. Deviation	0.68	0.56	0.53	0.88	0.80	0.66	0.70
Middle School	Mean	3.80	4.17	4.63	3.94	3.61	4.12	4.13
	n	22	24	24	24	22	24	23
	Std. Deviation	0.70	0.69	0.61	0.79	1.07	0.81	0.71
High School	Mean	3.76	4.08	4.75	3.97	3.42	4.30	4.17
	n	31	30	32	32	32	32	30
	Std. Deviation	0.70	0.53	0.34	0.90	1.21	0.68	0.64
Total	Mean	3.74	4.10	4.65	3.96	3.54	4.20	4.17
	n	89	90	93	93	91	93	86
	Std. Deviation	0.68	0.58	0.50	0.86	1.02	0.71	0.67

Table 6 presents the results from a Kruskal-Wallis H test statistic. There are no statistical differences in the TPACK dimensions based on grade level at the 0.05 level for the UPS district teachers and grade levels across TPACK.

Table 6. *Kruskal-Wallis H Test Results (Grade Level and TPACK)*

	TK	CK	PK	PCK	TCK	TPK	TPACK
Kruskal-Wallis H	.512	1.119	1.790	.090	.300	.925	.162
Df	2	2	2	2	2	2	2
P-value	.774	.571	.409	.956	.861	.630	.922

3. What are the differences between the UPS district Pre-K-12 special education teachers' and general education teachers' use of TPACK during science, social studies, literacy, and math instruction for students with SLI?

Table 7 indicates that the UPS district teachers' TPACK means across the four indicators of content knowledge in mathematics, social studies, science, and literacy did not display any significant mean differences.

Table 7. *TPACK and Content Knowledge (mathematics, social studies, science, and literacy)*

Descriptive Statistic	Mean	n	SD
Mathematics			
9. I have sufficient knowledge of mathematics.	4.18	94	.816
10. I can use a mathematical way of thinking.	4.14	94	.837
11. I have various ways and strategies for developing my understanding of mathematics.	4.16	94	.794
Social Studies			
12. I have various ways and strategies of developing my understanding of social studies.	4.18	94	.775
13. I have sufficient knowledge about social studies.	4.05	94	.896
14. I can use a historical way of thinking.	3.97	91	.809
Science			
15. I have various ways and strategies of developing my understanding of science.	3.98	94	.672
16. I can use a scientific way of thinking.	3.95	94	.753
17. I have sufficient knowledge of science.	3.82	94	.803
Literacy			
18. I have various ways and strategies for developing my understanding of literacy.	4.36	94	.701
19. I can use a literary way of thinking.	4.36	94	.701
20. I have sufficient knowledge about literacy.	4.29	94	.742

Note: The content knowledge question items above are numbered in the order in which they appear on the TPACK survey instrument.

Table 8 displays the results of the Mann-Whitney U test, finding no statistical relationship between any mathematics indicators and the classroom setting at the 0.05 observed significance level.

Table 8. *Mann-Whitney U Test Results (Mathematics and Classroom Setting)*

Test Statistics

	I have sufficient knowledge about mathematics.	I can use a mathematical way of thinking.	I have various ways and strategies of developing my understanding of mathematics.
Mann-Whitney U	889.500	863.500	859.500

Wilcoxon W	1295.500	1269.500	1265.500
Z	-.311	-.545	-.576
P-Value	.756	.586	.564

Table 9 displays the results of the Mann-Whitney U test, finding no statistical relationship between any social studies indicators and classroom settings at the 0.05 observed significance level.

Table 9. *Mann-Whitney U Test Results (Classroom Setting and Social Studies)*

Test Statistics

	I have various ways and strategies of developing my understanding of social studies.	I have sufficient knowledge about social studies.	I can use a historical way of thinking.
Mann-Whitney U	808.000	868.000	718.500
Wilcoxon W	3019.000	3079.000	2798.500
Z	-1.063	-.507	-1.415
P-value	.288	.612	.157

Table 10 displays the results of the Mann-Whitney U test, finding no statistical relationship between any science indicators and the classroom setting at the 0.05 observed significance level.

Table 10. *Mann-Whitney U test Results (Science and Classroom Setting)*

Test Statistics

	I have various ways and strategies of developing my understanding of science.	I can use a scientific way of thinking.	I have sufficient knowledge about science.
Mann-Whitney U	862.000	895.000	859.000
Wilcoxon W	3073.000	1301.000	1265.000
Z	-.605	-.271	-.602
P-value	*.545*	*.787*	*.547*

Table 11 displays the results of the Mann-Whitney U test, finding no statistical relationship between literacy indicators and the classroom setting at the 0.05 observed significance level.

Table 11. *Mann-Whitney U Test Results (Literacy and Classroom Setting)*

Test Statistics

	I have various ways and strategies of developing my understanding of literacy.	I can use a literary way of thinking.	I have sufficient knowledge about literacy.
Mann-Whitney U	721.000	788.000	795.500
Wilcoxon W	2932.000	2999.000	3006.500
Z	-1.867	-1.251	-1.173
P-value	*.062*	*.211*	*.241*

Qualitative Data Analysis Results

Qualitative data were collected and analyzed to build a deeper understanding of teachers' practice of AT integration in the classroom for students with SLI. Open-ended questions were used to gather data about teachers' use of AT in their educational practices. The qualitative analyses focus on the UPS teachers' implementation of assistive technology in their classrooms, the tools they use, their assessments of effectiveness, and their experiences with integration. Specific analysis was conducted to identify and compare their practices across content areas at various grade levels in either special education or general education classroom settings. The following were explored in detail through qualitative analyses:

- The assistive technology tools commonly used in both general and special education settings for SLI learners,
- Teachers' assessments of the effectiveness of the assistive technology and content delivered and
- Teachers' experiences integrating assistive technology into classroom instruction for students with SLI.

Qualitative responses to the open-ended questions were recorded, coded, categorized, and then analyzed. The types of assistive technology tools used by both general education and special education teachers for students with SLI were compiled into a Word document. Next, the teachers' assessments of the effectiveness of the assistive technology and the content delivered were also documented. Finally, the experiences of teachers integrating AT into the classroom for SLI learners were collected. After initial data coding and categorization, themes and patterns were identified. Further analysis was conducted as guided by the research questions.

The following sections report the key findings.

Teachers' use of AT

Table 12 displays the AT commonly utilized in general and special education classrooms by UPS district teachers.

Table 12. *Assistive Technology in the Classrooms*

Type	Frequency
Computers	25
Audio/Video Recordings (Elmo, Voice Output Device, Voice Amplifier and Camera, Projector and Radio)	10
Calculators	2

iPad	15
Smart boards (Communication and Neo Boards)	16
Computer Programs, Software and Online Applications for SLI	4
Educational Games (Leapfrog and Others)	4
Voice to text (text to speech)	5

Only 40% (n=37) of the participants responded to the question. However, using AT devices in UPS classrooms for SLI students is significant. Computers, laptops, and desktops are the most utilized AT devices, demonstrating their crucial role in facilitating learning. Many UPS teachers also show a high rate of using smart boards, another important AT tool. Smart boards are the second most used AT tool in the classroom to increase SLI students' communication and participation in class. iPads for reading and other activities are cited as UPS's most utilized AT tool. UPS teachers also use audio/video recording devices such as cameras, projectors, YouTube, and voice-activated devices. A small percentage of teachers indicated their use of educational games and educational websites in their instruction in UPS district classrooms.

The UPS teachers reported using special computer programs and software during instruction and assessment. 40% (n=37) of teachers reported Math, Science, English/Language Arts, and Social Studies as the most commonly shared content taught. The state mandated the content taught utilizing AT for SLI students identified by the UPS teachers (e.g., Math, Science, and Language Arts). The most frequently used instructional strategies by teachers for SLI students using AT occurred during direct instruction, individual instruction, group instruction, and mini-lessons. They evaluated SLI student learning through diagnostic, formative, and summative assessments. The teachers expressed that these instructional methods help SLI students communicate, practice, and master new skills.

Teachers were asked to describe how they assessed the effectiveness of the content using AT and the teaching methods utilized in the classroom during a lesson. Thus, teachers include the content, the AT tool(s) used, and the instructional approaches implemented. Teachers in the UPS district identified common types of low-tech to high-tech AT tools when instructing students with SLI. Teachers also identified similar types of AT tools as part of their daily instructional program. The UPS teachers identify commonly used standard AT technologies across core content and on state tests. The UPS utilizes AT during content—direct, group, and mini-lessons. Few teachers identify educational games and educational websites as aids to their instruction. The UPS identified diagnostic formative and summative assessments to evaluate mastery of content material when instructing learners with SLI.

Teachers' Assessment of AT and Content Effectiveness

Table 13 summarizes the methods UPS teachers use to assess the effectiveness of the content delivered through AT-facilitated instruction.

Table 13 reports the three types of assessment used by the UPS teachers to evaluate the effectiveness of content delivered through assistive technology-facilitated instruction: formative, summative, and diagnostic assessments.

Table 13. *Assessment of Assistive Technology and Content Effectiveness*

Assessment Type	**Description**	**Examples**	**Frequency**

Formative	Formal and informal testing by teachers during the learning process to collect baseline data in order to modify instructions for learners.	Removing the iPad to test students' recall ability for words, pictures, songs and colors (2). Using how many times a student activates a voice-output device to measure their achievement (3). 15 minutes of math activities while the teacher walks around the classroom evaluating students' progress (3). Daily living assessments using hands' movement instruction (2). Utilize daily living skills' assessment like sweeping, mopping or organizing through observation (2). Use of the internet to research independent projects (2).	14
Diagnostic	Baseline data that allows teachers to identify a learner's prior knowledge and to identify misconceptions the learner may have before formal instruction begin.	Use of iPad to assess students' ability before the test (1). Use of Kahoot app for assessing students' prior knowledge on apples before the apple orchard annual trip (2). Use of students' attentiveness to assistive technology as a measure of assistive technology effectiveness (1). Use of computers to pre-test students' ability in various topics and subjects (3).	7

Summative	Used to evaluate what a student has learned at the end of the learning period.	Use of iPad to assess students' ability at the end of intended to be covered course material (2). Subjective created scales were used based on final examinations to assess students' performance during a class (2). Students' performance was assessed through teachers' observations of students' achievement during class (1). Listening to students' verbal answers and observing their progress throughout the class (3).	8

Note that the numbers above in parentheses represent the number of teachers utilizing the method mentioned.

Only 47% (n=44) of the sample responded to this question. Three main types of assessment were identified across the teachers' answers: formative, summative, and diagnostic. Teachers' observations of students' progress were among the most common methods emerging from the responses. Furthermore, AT, such as an iPad, the internet, and voice recorders, were all used to deliver class assessments. Students spent out-of-class time on their computers searching the internet for relevant material to perform assigned assessments. In-class reading assignments were also delivered through the iPad. Many teachers also mentioned using applications to teach students new topics or to test their abilities on covered material. The UPS teachers were finally asked to provide information about their experiences integrating assistive technology for SLI students. The UPS utilized formative assessment to test student recall, responses, performance, fine motor skills, and independent living skills as indicators of success or mastery using AT. The UPS utilizes diagnostic assessment techniques to assess prior knowledge, measure the SLI students' current level of mastery, and listen to and observe students' verbal responses. The UPS utilized summative assessment to assess abilities, evaluate student performance, and listen to verbal responses by answering questions to evaluate SLI students' overall learning using AT.

Teachers' experiences integrating AT for students with SLI in the classroom

42% (n=39) of special education teachers responded to the question, and 11% (n=10) of general education teachers responded. The use of AT, computers, Picture Exchange Communication Systems, Text-to-Speech, and various applications and software for SLI education were reported to have a positive impact on students. It helped them better understand the material, increased their motivation to learn, and encouraged their class participation. Teachers identified participation in daily lessons, curriculum, and daily activities as the most commonly recognized teacher experiences with integrating AT for students with SLI. A few teachers mentioned that AT improves SLI students' self-esteem, is beneficial, enhances overall morale, and allows SLI students to participate in lessons and actively communicate with others with whom they would otherwise be unable to engage. One of the most prominent challenges facing the UPS teachers was that many respondents lacked formal training and experience in instructing students with SLIs using AT. Some teachers expressed learning how to use AT through trial and error. Furthermore, the available training, funding, and assistive technology in many schools, along with teachers' awareness, do not provide sufficient support for delivering adequate education for SLI in the UPS district.

Discussion

The COVID-19 pandemic revealed inadequate education for students in the USA and globally (Teichert et al., 2023). Over 1.38 billion students were deprived of in-person learning due to social mandates and requirements (Su, 2023). Social isolation, the economic downturn, and lockdowns had a deleterious impact on children with special needs (Mete et al., 2022). Preliminary data suggested that teachers faced various challenges with online learning during the pandemic. One report indicated that 83% of 505 educators surveyed across the US had difficulty doing their jobs (Page, 2020, cited in Teichert et al., 2023). Teachers' workloads intensified as they transitioned to teaching content and materials online. They encountered pedagogical challenges as they adapted familiar teaching methods to new media, forcing them to operate in virtual classrooms (Teichert et al., 2023). Teichert et al.'s (2023) study of 389 Midwest teachers unveiled that they reported difficulties in meeting their students' needs as they transitioned to online learning. A lack of training hindered teachers' ability to integrate technology effectively, and communication between schools and homes needed improvement. Students required access to reliable internet and digital devices, even when access was not a problem. Students' limited digital literacy skills in navigating online platforms were identified as a challenge. Teachers recognized student engagement, communication, and the shift to online pedagogy as significant challenges during the pandemic. The pandemic pushed teachers to learn new technologies and expand their technological knowledge to meet learners' needs (Teichert et al., 2023). Technological knowledge, training, and access to digital devices and assistive technology tools to support learners with disabilities online became crucial for students during times of crisis.

The COVID-19 pandemic school closures impacted the daily lives of families and children (Mete et al., 2022). The pandemic affected the emotional and mental health of young children in general (Jiao et al., 2020). Children's mental health suffers during times of disaster, and they often exhibit high levels of stress, anxiety, and emotional and behavioral difficulties as their special education programs and services cannot be adequately supported during school closures (Mete et al., 2022). One study examined 116 families of students in Turkey receiving special education programs and services and the effects of COVID-19 infection on their family life (Mete et al., 2022). It was found that the pandemic adversely affected 94.6% of families (Mete et al., 2022). Students' daily routines worsened; time with their parents, reading, and playtime activities decreased. Screen time increased from 1 to 3 hours, indicating an overall regression in child development. Certain special education practices in the home ceased.

Children with special needs require more individualized instruction that they cannot access at home. COVID-19 adversely impacted their ability to obtain these programs and services that are critical for their educational development (Mete et al., 2022). Losing access to educational services and AT may negatively affect students' learning outcomes. Maintaining a daily routine is essential for students with disabilities during disasters (Mete et al., 2022). A routine is vital because it prevents children with disabilities from experiencing additional emotional and behavioral difficulties, making access to special educational services and AT crucial. More studies addressing the impact of COVID-19 on students with disabilities are needed. The pandemic disrupted education during and after its occurrence and has become a new normal in education that will most likely continue (Mete et al., 2022). The pandemic may have significant implications for these learners in the future.

Recent decades have seen an explosion in educational development due to advancements in digital technology. Teachers' digital literacy increased because of COVID-19, and obstacles for both teachers and students also grew (Shuqiong & Di, 2022; Su, 2023). The pandemic's impact allowed teachers to utilize their technological knowledge and skills. Due to social distancing requirements, the pandemic influenced and accelerated the development of online educational platforms and digital technologies for teaching and learning (Shuqiong & Di, 2022; Su, 2023). There are concerns that the requirements for technology integration, prompted by the pandemic, may have further implications for education (Engelbrecht et al., 2020; Kholid et al., 2023). These critical changes impacted how students with disabilities were educated using technology, negatively affecting their access to technology and support services. Research examining the impact of teachers' technological knowledge during the COVID-19 pandemic should be considered in future scholarship.

Urban Public School (UPS) TPACK Study

This timely study explored an Urban Public School (UPS) district's teachers' TPACK and the current integration of AT for students with SLI. Teachers were asked about the types of AT tools, the effectiveness of these tools, and the extent to which such technologies are integrated into their classrooms. Teachers are expected to have adequate knowledge of integrating technology, yet special education teachers are expected to possess more technological knowledge (Demirok & Baglama, 2018). Special education teachers receive various technology training in their special education programs that address the needs of students with disabilities, which general education teachers do not. Regardless of the classroom setting, TPACK scores do not differ; special education and general education teachers are prepared to integrate technology in the classroom for teaching students with SLI. General education teachers have sufficient TPACK knowledge to support students with SLI in general education settings. One study by McGregor and Pachuski (2009) reported that the use of AT by experienced general education teachers could be more satisfactory due to their ability to utilize AT in the classroom and the fact that they require additional technology training to use technology across content in their education programs.

The TPACK survey questions reported teachers' self-assessment during science, social studies, literacy, and math instruction for students with SLI. UPS teachers' TPACK knowledge is consistent regardless of the grade level taught. Both special and general education teachers demonstrate the same level of TPACK knowledge. Both special education and general teachers possess sufficient TPACK knowledge to support students with SLI and disabilities at all grade levels. Regardless of their content, teachers are comparable; they have adequate TPACK knowledge to teach across content areas. Teachers reported similar technology knowledge, content knowledge, pedagogy content knowledge, technology content knowledge, and technological and pedagogical content knowledge among UPS teachers. This research has found no differences between teachers in special or general education classrooms concerning technology knowledge (TK). This result is inconsistent with the expected outcome, where special education teachers are believed to have a higher command of technology use, alteration, and incorporation into classroom instruction. The findings of this study may be explained by the nature of the items presented on the TPACK instrument. The language of the eight items comprising technology knowledge is general, so any teacher, regardless of their classroom setting, is expected to exhibit high self-reported agreement with all items. If another survey instrument featured specific types of technology used by students with disabilities, such as particular software or applications widely utilized by students with SLI, the results might differ. General education teachers are rarely exposed to specialized programs, devices, computer software, and applications that assist students with disabilities in their educational journey. Therefore, they are expected to score low on items featuring information regarding specific classroom technologies for learners with disabilities.

This research found that special and general education teachers have the same content knowledge (CK). This finding is consistent with the expected outcome that teachers, regardless of their classroom setting, should exhibit the same content knowledge in their specific areas and the general education requirements in their completed programs of study. Nevertheless, the items on the instrument are generic, and teachers are likely to agree with the presented statements. Results might have differed if each area featured specific items from its domain. For instance, if the area devoted to mathematics included an item like “I utilize concepts of calculus, matrix algebra, and discrete mathematics in my instructional materials," teachers of social studies and literacy would be expected to answer "strongly disagree” or "disagree." This research found no pedagogical knowledge (PK) differences between special and general education teachers. This finding is expected to be the outcome of the research since both groups of teachers are anticipated to master a certain standard of classroom pedagogy. More importantly, the TPACK instrument lacks specific items featuring pedagogical approaches in special education settings. General education teachers are expected to exhibit a lower understanding and utilization of special education pedagogy.

Nevertheless, this research did not investigate any specific instructional or assessment design pertinent to special education students. Since both groups of teachers take courses in similar domains covering concepts and practices of pedagogy, they are expected to exhibit similar trends regarding the construct. While the TPACK construct of pedagogical content knowledge (PCK) aimed to measure specific pedagogical approaches for SLI students, the wording of items was vague and generic, lacking specific markers where general education teachers could pinpoint and disagree with the statements. Items of PCK did not inquire about specific practices, behaviors, or actions teachers took in or outside the classroom to guide SLI students in learning. They asked whether teachers applied promising pedagogical approaches for SLI students in various subjects. Indeed, teachers are likely to agree with the statements presented. This research found no difference between special and general education teachers' technology content knowledge (TCK). This result is inconsistent with the expected outcome, where special education teachers are held to a higher standard, and their specific knowledge of the technology used for SLI students is greater than that of general education teachers. The primary driver for this result is the poor operationalization of the construct provided by the TPACK instrument, which is one of the criticisms identified in the literature (Willermark, 2018). No specific technology or technical skill type was mentioned in the four items measuring TCK. Therefore, it took considerable effort for general education teachers to disagree with any of the statements presented to them.

This analysis found no difference between teachers' self-assessments of technology pedagogical knowledge (TPK). Such a result is inconsistent with the expected outcome that special education teachers should possess higher levels of TPK compared to general education teachers due to the specialized training and work expectations regarding instruction, assessment, and lesson delivery that special education teachers receive for preparing SLI students compared to the general population of students. One potential explanation for this finding is the inadequate specificity provided by the TPACK framework for measuring the intended constructs. There has been no mention of any specific application or software used by SLI students in the instrument. Teachers recognize the complex interplay between CK, PK, and TK when teaching content using appropriate methods and technology. Finally, teachers' self-assessment of TPACK was similar to their classroom settings. However, one study shows that special education teachers have higher levels of TPACK than general education teachers (Demirok & Baglama, 2018). Therefore, general education teachers' TPACK scores are expected to be lower than those of special education teachers. This finding is contrary to expected results, where special education teachers are anticipated to exhibit higher abilities and use of TPACK compared to general education teachers due to their specialized knowledge and expertise in differentiated instruction for the non-traditional student population, SLI students, and because special education teachers are certified to teach all populations of learners.

In contrast, general education teachers are not trained to deliver educational services to special education learners or required to modify or differentiate instruction for these learners. The unexpected result is explained by the inadequate information on TPACK provided by the questionnaire. None of the items featured a specific technology, pedagogical approach, or combined method for students with disabilities. This led to the expected outcome that all teachers reported high agreement rates with all presented items, regardless of their field. The qualitative finding indicated that UPS teachers utilized various common low-to-high-tech Assistive Technology (AT) tools in the classroom. For example, computers, iPads, Smartboards, audiobooks, video recording devices, calculators, and iPads were standard teaching tools across grade levels and subject content. Computers and audiobooks improve the lives of students with disabilities (Erdem, 2017; Demirok & Baglama, 2018). The UPS teachers use AT tools to assess the effectiveness of instruction during group instruction, direct instruction, and many other lessons. Teachers also utilize AT for SLI learners in diagnostic, formative, and summative assessments. They use AT to check for prior knowledge, recall, student responses, and observations during diagnostic assessments. For informal assessments, UPS teachers utilize AT to evaluate the effectiveness of instruction through recall, performance, and verbal responses from SLI learners.

Moreover, summative effectiveness assessment using AT focuses on student mastery of content, performance indicators, scales, and verbal responses on assessments. For example, two teachers identified using iPads to conduct formative assessments to test students' recall of words or pictures. Three teachers reported using iPads and observing how often students activated voice-output options to measure achievement. UPS teachers use formative assessments to gather baseline information about a student to modify or differentiate instruction. Regarding summative assessments, two teachers used iPads to assess students' abilities at the end of covered course materials, and two teachers used teacher-made scales on a final examination. Formative and summative assessments are two tools that UPS teachers utilize to ensure that students with SLI achieve. UPS teachers utilize AT tools for diagnostic purposes as well. Diagnostic data allow teachers to identify students' prior knowledge and any misconceptions the students may have before formal instruction begins. Three teachers reported using computers to pre-test SLI students on content, and two assessed students' attention spans using AT to measure AT effectiveness on instruction. Often, UPS teachers utilize AT devices and observe SLI students' attention spans, responsiveness to the tools, and non-verbal gestures (e.g., clapping, smiling, singing, and pointing) to determine academic growth and student engagement as a diagnostic measure. It was shown that UPS teachers' experiences with implementing AT in the classroom revealed many similarities and some complexities. All UPS teacher respondents were familiar with the AT tools and used some form of AT in the classroom. However, only some general education teachers responded to this question, which may suggest that general education teachers require more opportunities and training to integrate AT.

UPS teachers said they were integrating assistive technology in the classroom for SLI learners. UPS teachers expressed mostly positive experiences integrating AT for SLI students. Teachers reported that their experiences were beneficial for motivating students with disabilities and improving learning outcomes. UPS teachers reported that AT tools allow students to collaborate with others, boost student morale, and build students' self-esteem. UPS teachers reported that AT tools improve students' participation in daily lessons and activities, enhance communication skills, and allow students to interact with technology. UPS teachers expressed the need for more AT training and financial resources in the school to support and encourage the use of AT. Furthermore, with the development of AI and the impact of the pandemic on students with disabilities, the need for technology integration in the classroom is essential. Teachers are critical to technology integration for students with speech and language impairments and are vital to all learners' success and learning outcomes. Providing resources and training to teachers can directly impact student achievement. Unfortunately, many technology tools are not designed for educational purposes, which requires teachers to adjust or modify tools for teaching and learning, making teaching with technology difficult. Thus, technology developers should address student needs and abilities when developing technologies for students with disabilities, as these learners are the most vulnerable and require the most help and support in school.

Additionally, this study provides a unique contribution to the field by examining the integration of AT in a large UPS district that has experienced significant challenges, including bankruptcy, state takeover, and financial mismanagement. These challenges have hindered the district's ability to effectively incorporate AT into educational practices. By focusing on the TPACK of teachers in a context of resource scarcity and organizational instability, the study offers new insights into how teachers adapt and utilize available technologies for students with SLI. A key contribution of this study is its focus on the specific integration of AT for students with SLI, a population that often faces unique barriers to learning. The study's findings provide a detailed understanding of the instructional practices, tools, and experiences of both general and special education teachers in the integration of AT across grade levels and content areas. Despite the absence of significant differences in teachers' TPACK across various classroom settings and content knowledge areas, the study reveals the widespread use of a diverse range of AT tools, from basic assistive devices to more advanced technologies, indicating a broad, albeit varied, approach to supporting students with SLI.

This research is significant because it fills a gap in the literature regarding how teachers in financially and administratively strained districts implement AT, particularly for students with disabilities. The study also sheds light on the realities of technology integration in classrooms where resources are limited, offering valuable insights for policymakers, administrators, and educators who are seeking to enhance AT integration in similar contexts. The findings suggest that, even in challenging circumstances, teachers demonstrate adaptability and positive engagement with AT, highlighting the potential for AT to support student learning even in resource-constrained environments. In sum, this study contributes to the field by providing empirical evidence on the state of AT integration in a struggling district, offering important implications for both the practice and future research related to technology integration in special education. This approach emphasizes the study's unique context (a district facing financial instability and state takeover) and its contribution to understanding the integration of AT in such settings. It also positions your findings as offering new insights into how teachers in challenging circumstances manage to implement AT for students with speech and language impairments despite limited resources.

Artificial Intelligence (AI) and Emerging Learning Technologies in K-12

Although this study did not address any research questions related to AI, it is apparent that AI in education and emerging technology has transformed teaching and learning (Zhang & Aslan, 2021; Casal-Otero et al., 2023; Gillani et al., 2023; Hopcan et al., 2023; Marino et al., 2023; Su et al., 2023). AI is an ambiguous term that references a collection of methods, capabilities, and limitations that may not be explicitly articulated by researchers, educational technology companies, or AI developers (Gillani et al., 2023). Coined in 1956, various disciplines (e.g., computer science, psychology, mathematics) have contributed to AI development (Casal-Otero et al., 2023). AI is a system of computers or machines working in unison to emulate or reproduce human cognition (Tai, 2020, as cited in Marino, 2023; Gillani et al., 2023; Hopcan et al., 2023). AI tools and systems are designed to deal with complex human actions: learning, analyzing, synthesizing, and adapting. AI machines imitate human behavior. AI is used for work that requires human intelligence to be performed by a computer. AI is oriented to comprehend, model, and replicate human intelligence, encouraging machine learning, perception, natural language processing, knowledge representation, reasoning, and more.

Scholars have studied AI in education (AIEd) and claim that AIEd techniques may personalize learning, increase the efficiency of the learning environment, guide teachers and students through the teaching and learning process, and enhance interactive experiences at school and in the classroom. Studies suggest that AIEd fosters creativity and critical thinking in students, enabling the monitoring and evaluation of complex skills. AI may support learners in their representation, expression, engagement, and learning activities (Hopcan et al., 2023). AI may also help humans understand instructional approaches to teaching and learning in various contexts. Although AI technology cannot work anonymously, it is excellent for routine and repetitive tasks, which is especially important for students with cognitive impairments. However, more methodological proposals for introducing AI in K-12 education are needed (Casal-Otero et al., 2023). Many educational professionals and researchers tend to think of technology exclusively as machines; however, Finn (1960) notes, "In addition to machinery, technology includes processes, systems, management, and control mechanisms, both human and non-human, and a way of looking at problems as to their interest and difficulty, the feasibility of the technical solution, and the economic values considered of those solutions" (Finn, 1960, p. 10). Over the past several years, AI has raised many questions about machines' roles in promoting humanity (Casal-Otero et al., 2023; Gillani et al., 2023; Su et al., 2023).

AI is changing education and the traditional role of a teacher. AI education is becoming necessary in K-12 classrooms to prepare learners early for the social and technological changes it will bring. AI innovations remain experimental in education, and new collaborations with educational institutions are forming in related interventions, such as AI-enabling adaptive systems. Understanding AI to develop AI-related teaching methods is essential for both teaching and learning. AI applications will require future generations of learners to have the skills to utilize technologies effectively in society (Casal-Otero et al., 2023; Su et al., 2023). AI literacy competencies are essential to communicate, work, and live with others and machines (Su et al., 2023). Zhang and Aslan's (2021) review of selected studies on artificial intelligence in education, published between 1993 and 2020, indicated that some AI technology applications benefit education. For example, chatbots, expert systems, intelligent tutors or agents, machine learning, personalized learning systems or environments, and visualizations offer various AI tools that may enhance teaching and learning in K-12 education. AI has limitations, such as failing to generalize and identify causal relationships. More research is needed to detail how AI should be taught. Uncovering this knowledge may inform the design and development of curricula for emerging AI technologies (Su et al., 2023). There needs to be more clarity between what AI technologies can do and how they are implemented in authentic educational learning environments (Zhang & Aslan, 2021; Gillani et al., 2023; Hopcan et al., 2023). Emerging AI technology has sparked debates about these technologies' political, pedagogical, and practical implications in an educational context. AI is critical for machines to serve humanity better (Gillani et al., 2023).

Students with disabilities may significantly benefit from AI technology due to its various applications, such as learner profiling, performance prediction, assessment, evaluation, personalization, and adapting learning to meet the student's needs. Machine learning may support students with disabilities and at-risk students by providing feedback to measure student learning early on (Hopcan et al., 2023). Hence, more AI technology and its implementation in education are essential (Zhang & Aslan, 2021; Marino et al., 2023; Gillani et al., 2023; Hopcan et al., 2023). These emerging technologies may have significant implications for students with disabilities as AI brings a wide range of technologies, features, and functions to provide exciting opportunities to learners with disabilities. Bridging the gaps between AI technology development and educational applications in K-12 and special education classrooms is critical. AI has facilitated varied instruction, increased learner engagement, generated adaptive learning materials, provided enriching learning environments, and improved learning outcomes. AI technologies are also capable of addressing learners' effective and emotional needs, which is essential for students who are emotionally impaired or have disabilities. AI may offer exclusive design technology to address students' needs. Unfortunately, there is a lack of educational perspective in AI development and implementation (Zhang & Aslan, 2021; Gillani et al., 2023; Hopcan et al., 2023). AI is expected to proliferate (Zhang & Aslan, 2021; Casal-Otero et al., 2023; Gillani et al., 2023; Hopcan et al., 2023; Su et al., 2023). The implications of AI in special education remain unclear (Marino et al., 2023; Gillani et al., 2023; Hopcan et al., 2023). Therefore, AI policy considerations and future research are necessary (Marino et al., 2023).

Teachers recognize that technology is critical to instruction; however, most technologies have limited designs for educational purposes. Teachers are often required to transform technology tools into educational tools by redesigning or modifying them from their original use (Koehler et al., 2011). This can negatively impact the learning outcomes of students with disabilities, which is why AI tools are vital due to their functionality and capabilities in supporting these learners. AI may provide students with disabilities access to assistive technology (AT) tools with enhanced features and applications, helping them access the curriculum, improve their mobility, and assist students who are visually impaired and have speech and language deficits. New developments in AT (e.g., eye-gazing AI tools, digital tutors, digital alarms, remind-me, supervised learning, and reinforcement learning) may be essential in supporting students with specific language impairment (SLI) and other disabilities, enabling them to function, adapt to their learning environments, and access curricula. AI applications are crucial for these learners, as many ATs use features that are technology-enhanced devices interacting with their environment (Hopcan et al., 2023; Marino, 2023).

AI may support these learners’ representation, expression, engagement, and learning activities (Rao, 2021; Hopcan et al., 2023). AT tools may also be utilized to promote universal learning design (UDL), supporting learners with disabilities and students in K-12 (Rao, 2021; Hopcan et al., 2023). UDL is a framework that accommodates individuals with disabilities by eliminating unnecessary barriers in the learning process and environment. Mainstream and special education students benefit from UDL, for which AI digital tools provide individualized and personalized support for students with disabilities (Hopcan et al., 2023). Digital tools (e.g., vocabulary look-up, text-to-speech, digital portfolios) have instructional and assistive features that aid learners with disabilities and others. AI tools like chatbots can facilitate personalized learning (e.g., Happy Numbers) and support students with special needs in the learning environment. AI can also streamline administrative tasks, and AI applications in education have led to new web-based systems such as educational data mining and learning analytics. Teachers can use digital technology in alignment with the principles of UDL, AT, and AI technology to reduce barriers and support learners in achieving their learning goals. AI has rapidly developed and made life more accessible for people in many areas; thus, adopting new technologies that benefit both teachers and students is essential.

As mentioned earlier, AI, AIEd, and AT in special education can provide personalized learning tailored to meet the needs of individuals with disabilities by offering personal learning and individual knowledge at their level and interests. Students with disabilities can explore content more deeply based on their learning needs. Personalized learning environments can guide and support these students. AI tools allow individuals to contribute significantly to the educational environment and provide immediate and constructive feedback (Hopcan et al., 2023). For instance, a game-based approach to AI for teaching and learning in K-12 offers fun learning and enjoyable lessons that may be effective in the context of AI in education (Su et al., 2023). Other important uses of AI and AIEd in education include facilitating administrative tasks like managing office-related database systems, tracking attendance, predicting student dropout rates, identifying students at risk for special education, and finding solutions for those who may drop out early or have been identified as needing special education services, all of which are critical applications of these emerging technologies. These tools can also facilitate assessments, provide embedded evaluations, monitor student skill acquisition in real-time, determine whether students have learned a subject through moment-by-moment assessments, evaluate how students think and react during learning, and provide summative and formative evaluation measures using game-based assessments—all capabilities of AI and emerging technologies (Hopcan et al., 2023). AI literacy must be considered at the K-12 grade levels as a set of skills that enable learners to recognize AI by learning about how it works and learning to live with AI. Hence, it is vital to incorporate AT teaching at the early stages of education (Casal-Otero et al., 2023). AI at the K-12 level is not prevalent in formal educational settings, which presents a challenge.

Traditionally, teaching AI has occurred at the university level in disciplines closely related to computer science. Research may integrate machine learning into subjects beyond computer science. Additionally, acquiring knowledge in AI poses a significant pedagogical challenge for researchers and teachers and a cognitive challenge for students (Casal-Otero et al., 2023). With the rapid growth of AI, there needs to be a better understanding of how teachers can leverage AI methodology for teaching and learning, so educators and AI experts must collaborate to bridge the gaps in techniques and pedagogy (Casal-Otero et al., 2023).

Recommendations

The findings provide critical information to support education policymakers, stakeholders, the State Departments of Education, special educators, technology supervisors, universities, colleges, and state, county, and district officials. Teachers are essential to the successful use of AT for teaching and learning. They are the critical factor in technology integration and students' success. Most educators in this study mainly reported positive experiences with integrating AT; however, a few teachers expressed that they still do not have adequate access to AT at their current jobs. Teachers reported that they use a variety of low- to high-tech AT tools; however, more specialized AT tools for SLI learners need to be developed. While teachers expressed that they understand AT, most still need clarification about what AT is. For example, most teachers reported all technology as AT. According to the definition, AT is any device that students use to increase, maintain, and develop their ability to access the curriculum. However, in many cases, teachers identified technology tools not specified for SLI as AT. While research shows that AAC devices are the most commonly used type of AT by students with SLI, few teachers in this study have selected augmentative and alternative communication (AAC) tools to support these learners. Therefore, an intensive evaluation process should be implemented to assist with the evaluation and selection of AT tools for students.

Teachers require training in the selection, evaluation, and implementation of AT for it to benefit end users. They must learn to use and integrate AT across content areas, as many subjects require in-depth knowledge and integration of AT. One teacher expressed that she enjoys using AT but finds it tricky to teach across subjects since you have to instruct students on how to use the AT while also covering the content area. With a basic understanding of AT and how to utilize it in various content areas (PCK and TCK), most teachers can effectively apply AT for its intended purposes. 21st-century educators must be aware of the variety of specialized AT tools available for students with SLI and other disabilities. Teachers should be allowed to practice using AT to demonstrate self-efficacy and confidence when integrating it across content. At the state and district levels, stakeholders must provide educators with essential opportunities to explore AT during professional development and collaborative networking to improve its use in schools for students with disabilities. Teaching preparation programs should develop coursework designed to educate teachers on effective integration. Future teachers must be flexible and willing to utilize AT for teaching and learning. Teachers should be willing to be lifelong AT and technology users. A thorough review of AI and AIEd technologies in schools must be conducted. The types of tools teachers use in the classroom need to be identified. Additionally, research and authentic settings of teachers using emerging technologies must be examined to ascertain what teachers are using for teaching and learning with students with disabilities and precisely how these AI tools are being utilized. More intense research in data mining and learning analytics is needed regarding disabilities. With all the benefits of AI, we understand how to effectively integrate AI and emerging technologies in the classroom based on empirical research and studies. of this study, I included some recommendations on how teachers can enhance their awareness and improve technology integration. Six recommendations were included to provide clarity to the reader. Scholarships need to tease out all of the tenets of AI in educational research to provide support for teachers, students, and special education classrooms.

The study provides a valuable baseline for understanding how teachers in a large urban public school district integrate AT for students with SLI. To enhance teachers' awareness and improve the integration of AT in their classrooms, several strategies could be considered.

1. Professional Development and Training: One of the key ways to improve teachers' awareness and effective use of AT is through targeted, ongoing professional development. While the study indicates that teachers are utilizing various AT tools, there may be gaps in their understanding of how to optimize these tools for specific student needs. Offering specialized workshops on the range of AT tools available—ranging from basic devices to more complex technologies like iPads and SmartBoards—could increase teachers' confidence and competence in using these tools effectively. This training could be differentiated based on the teachers' familiarity with technology and specific subject areas, helping them better tailor AT to students with SLI across different content areas (e.g., literacy, mathematics, social studies, etc.).

2. Collaborative Learning Communities: Encouraging collaboration between special education and general education teachers could improve the collective knowledge of AT usage. Forming learning communities or collaborative teams where teachers can share strategies, successes, and challenges when using AT tools would foster an environment of continuous improvement. Teachers could benefit from discussing how they have adapted AT for specific classroom settings, grade levels, and content areas, and this could lead to more effective and personalized instruction for students with SLI.

3. Increasing Awareness of Specialized AT for SLI: While the study suggests that UPS teachers use a variety of AT tools, it would be helpful to emphasize more specialized technologies specifically designed for students with speech and language impairments. For instance, speech-to-text software, communication boards, or advanced text-to-speech programs may be underutilized or underappreciated by teachers who are not fully aware of their potential benefits. Regular training on such specialized tools, as well as case studies or demonstrations of their successful integration in the classroom, could increase teachers' awareness and understanding of how these technologies can support the individual needs of SLI students.

4. Clear Guidelines for AT Integration: Teachers may benefit from more structured guidelines or best practice frameworks for integrating AT into their teaching. While the study found that teachers across grade levels and content areas reported using similar instructional methods, more concrete, evidence-based strategies for using AT could help bridge any gaps in knowledge. For example, creating simple checklists or resource kits that outline how specific AT tools can be used for various assessment purposes (diagnostic, formative, or summative) would help teachers feel more equipped to implement AT effectively.

5. Teacher Feedback and Reflection: Teachers' awareness and understanding of AT could also be enhanced by establishing a system for regular feedback and reflection on how AT is supporting students with SLI. Structured opportunities for teachers to reflect on their experiences and the effectiveness of the AT tools they are using could lead to greater self-awareness and refinement of instructional practices. These reflections could be shared in professional learning communities or one-on-one meetings with support staff to create a culture of improvement and innovation.

6. Leveraging Peer Mentoring: Pairing more experienced or tech-savvy teachers with those less familiar with AT could create mentorship opportunities that build teachers' capacity for integrating technology in the classroom. This peer mentoring model would allow less-experienced teachers to learn from their colleagues' successful strategies and gain more confidence in utilizing AT tools.

In conclusion, improving teachers' awareness of assistive technologies requires not only providing access to a variety of tools but also offering clear, ongoing support through training, collaboration, reflection, and mentorship. These steps would ensure that teachers have the necessary knowledge and resources to use AT effectively to support the learning needs of students with speech and language impairments.

Conclusion

This study investigated UPS teachers' technological pedagogical content knowledge (TPACK) and how they integrate assistive technology (AT) in the classroom. This article details UPS special education and general education teachers' TPACK across grade levels, content, and classroom settings. It reports UPS teachers' current integration of AT, instructional practices, implementation, and experiences integrating AT in the classroom for students with speech and language impairments (SLI). 94 UPS teachers participated in the online survey. This study found no significant differences in teachers' TPACK across classroom settings or grade levels. Results show no significant differences between teachers' TPACK in mathematics, social studies, science, or literacy content knowledge. The study revealed that UPS teachers utilize low- to high-tech AT tools for diagnostic, formative, and summative assessments. Results indicate that UPS teachers employ similar instructional methods across content areas and express mostly positive experiences integrating AT for SLI students. Teachers are essential to technology integration. They require training in integrating AT, utilizing various AT technologies, and fostering positive experiences teaching students with disabilities. Teacher training and assistive technology should adapt as technologies emerge and AI applications increase. Educational policymakers play a critical role in supporting school districts, while district leaders provide teachers of students with disabilities access to training on emerging technology tools to improve these learners' educational outcomes.

The COVID-19 pandemic revealed inadequate education for students in Michigan, the U.S., and globally. Teachers face many challenges adapting teaching methods to new online mediums. Meeting students' needs as they transitioned to online learning was the biggest challenge during the pandemic. The lack of training and teachers' inability to integrate technology effectively online must be addressed. Digital literacy skills in navigating online platforms were identified as challenging. The pandemic pushed teachers to learn new technologies and expand their technological knowledge. Access to digital devices and AI and AT tools for learners with disabilities online became crucial during times of crisis. Teachers need to be open to using AI and AT together. AI has been shown to benefit learners in education (Zhang & Aslan, 2021; Hopcan et al., 2023; Su et al., 2023). Teachers must develop their technological knowledge by integrating AI into the classroom (Hopcan et al., 2023; Marino et al., 2023). More research is necessary to ensure these emerging technologies are available to learners with disabilities. Applying AI and emerging technologies in education, specifically for students with disabilities, is essential for enhancing their functional, adaptive, and academic skills. Research must be conducted on AI technologies in educational settings for learners with disabilities who use AT. AI and educational researchers must work collaboratively to actively answer questions and better understand the theory and practice of AI and emerging technologies in education (Gillani et al., 2023).

We are at the infancy level of AI in K-12 education, not to mention the limitations of AI in special education classrooms. Some efforts are being made to design models that frame AI literacy proposals in education. However, limited AI learning experiences exist in education. Guidelines on what students are expected to know and learn about AI in K-12 settings are needed. Developing a conceptual framework of didactic proposals for AI literacy is a critical benchmark that describes competency areas for AI and K-12. Ethics and legal norms, along with social and security issues linked to AI and technology, are also crucial. AI technologies must address and collaborate with other AI experts to understand pedagogical and problem-solving strategies to improve teaching and learning. AI literacy should be based on an interdisciplinary, competency-based approach and integrated into the school curriculum (Casal-Otero et al., 2023). Building on the competency and content of disciplinary subjects, it should be integrated with AI literacy into those subjects. AI literacy must support teachers and their active participation in designing didactic proposals alongside pedagogy and AI experts. (Casal-Otero et al., 2023). Finally, teachers must be digitally competent in integrating technology into the classroom for learners with disabilities.

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NA

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