

Professional Development for Virtual Environment: Designing Assistive-technology infused Inquiry-based learning experience for Online Teaching

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COVID-19 has presented new challenges for all teachers, especially teachers of students with special needs. Students have struggled with online learning environments with limited opportunities for social interaction and resources for these disruptive times. The study examined the effect of a professional development (PD) intervention, guided by the inquiry-based learning framework (IBL) to prepare special education teachers to engage students with disabilities for online teaching. This PD intervention used assistive technology (AT) as a catalyst for helping teachers to develop competencies in designing inquiry-based learning experience for online teaching. The research study utilized the sequential mixed methods approach to collect both quantitative and qualitative data. Findings showed that the structure and content of PD supported development of special education teachers' competency in designing AT-infused inquiry-based experience for students with disabilities. The study also indicated that development of AT competency was a non-linear process that was moderated by various contextual and personal factors.

Keywords: Inquiry-based Learning, Assistive Technology, Teacher Education, Online Teaching, Special Education, Professional Development

INTRODUCTION

Considering the challenges presented by the COVID-19 pandemic, there is an urgent need to prepare special education teachers to design high-quality practices that maximize support for students with disabilities. To accomplish this goal, joint efforts from teachers, school districts, and scholars have explored effective frameworks for encouraging educators to rethink the traditional teaching methods for online teaching environments. This article describes the use of a professional development (PD) intervention, guided by inquiry-based learning framework (IBL), to prepare special education teachers to engage students with disabilities for online teaching. Specifically, the PD intervention guided teachers to explore various K-12 curriculum, and design AT-infused, inquiry-based learning experiences for students with disabilities. The researchers believe the result of our study will inform special education teacher educators about the success and challenges for online teaching to enhance academic learning outcomes.

BACKGROUND

In the field of special education, teachers play a critical role in shaping students' learning and thinking in classrooms (Saloviita, 2018). However, over the past few decades, the field of special education schools has faced challenges in preparing teachers to support students with disabilities for online learning (Florian, 2019; Mason-Williams et al., 2019). Compared to general education classrooms, special education classrooms are more complex, with multiple stakeholders and educational entities. In this complex teaching environment, teaching is never routine; teachers must address students' abilities, diverse learning needs, challenges, questions, and parental concerns. Considering these challenges, it is important for schools and educational agencies to invest in preparing special education teachers to ensure high-quality practices and develop an inclusive culture for all student learners (Harry & Klingner, 2014). Research showed that professional development is a direct means to support individual teacher's knowledge and dispositions that increase students' learning outcomes (Fullan, 2015; Lynch et al., 2019).

Over the past twenty years, research has sparked progress to improve the teaching quality for online learning. Common practices and models for online learning have been widely used in the past two decades for preparing teachers to use technology to engage students' learning (Lyublinskaya, 2015; Niess, 2016). Additionally, assistive technology (AT) has been proven to support teaching and learning for online teaching (Siyam, 2019). Historically, AT has been an important component in understanding civil rights legislation for individuals with disabilities, therefore increasing their access to equitable education in schools. According to the Individuals with Disabilities Education Act (IDEA, 2004), AT refers to any technological equipment,

tool, or service that provides learning opportunities for students with special learning needs. Studies have investigated the role of AT, existing challenges, and school resources in supporting educators to meet the needs of diverse learners (Ortiz et al., 2020; Rice et al., 2018; Rice & Cun, 2021). Very few studies have identified factors that affected special education teachers' ability to design inquiry-based projects for online learning. Therefore, the purpose of the study investigated in what ways a professional development (PD) intervention, guided by inquiry-based learning framework (IBL), could prepare special education teachers to engage students with disabilities for online teaching.

LITERATURE REVIEW

Online Education Pedagogy

When the pandemic struck, special education teachers were required to teach online using video conferencing (e.g., Google Meet or Zoom). This posed numerous challenges as special education teachers lacked fluency in technology use, and very few had experience in designing for or engaging students for online learning (Meier & Mineo, 2021). To tackle ongoing challenges, today's K-12 educators, especially the special education teachers, need to develop effective pedagogical practices to engage students for online learning environments. This virtual environment does not naturally support student interaction and collaboration, therefore creating a learner-centered environment. Literature has identified several models for online learning that addressed this challenge.

Specifically, the "Community of inquiry" (CoI) model has shown the effectiveness in online and MOOC (Massive Open Online Courses) space. Student learners could collaborate with each other to discuss questions, engage in group-based projects, and critically reflect on learning (Blayone et al., 2017). Teachers utilize technology to guide discussion to improve engagement, design video-based reflection, and incorporate multimedia-based instruction materials to support virtual learning environments (Kennedy et al., 2015). Another example is the 5E Instructional Model, which is designed to prepare special teachers to teach academic content to their students with disabilities (van Garderen et al., 2020). This model requires teachers to design learning activities and formative assessments to engage student learners by highlighting five phases. Specifically, these five phases include (i) the engagement phase that focuses on key pedagogical concepts, (ii) the exploration phase that discusses and collaborates with peers; (iii) explanation phase that clarifies misconceptions; (iv) elaboration phase that applies content into real-world contexts; and (v) evaluation phases that reflects on learning experience and misconceptions. Finally, Picciano (2018)

proposed a “Multimodal Model for Online Education” that highlights the importance of building an online learning community through interaction. The model utilizes technology to design content, develop questions, facilitate reflection, engage face-to-face teaching, prompt collaborative learning, conduct evaluation/assessment, and incorporate self-paced/independent instruction.

Special Education Pedagogy

Recent legislation has placed increased expectations on schools to effectively foster an inclusive learning environment in special education. Schools held accountable for student achievement, thus creating the necessity for urgent improvement in high-quality teacher education. The policy initiatives include, but are not limited to, Every Student Succeeds Act of 2015 and the No Child Left Behind Act of 2001. Numerous scholars have discussed the importance of rethinking the deficit thinking perspectives, which has exacerbated long-standing issues of equity and special education teacher shortages in special education (Tondeur et al., 2019). However, the deficit thinking model is still prevalent in the educational system, as evidenced by schools that categorize students based solely on their Individualized Education Program (IEP) identified disabilities further exacerbates implicit biases and stereotypes held by educators (Sebastian Cherng, 2017).

To address these challenges, special education pedagogy highlights the high-leverage practices that prepare teachers to deliver instructions and gives students the opportunity to solve problems with real-world connections in the classroom (McLeskey et al., 2019). This is consistent with the special education teacher preparation guidelines for Council for Exceptional Children (CEC), which is the largest professional organization dedicated to improving educational success for students with disabilities. The four aspects of practices for special education teachers include collaboration, assessment, social/emotional behaviors, and instruction to address the most critical practices that every K-12 special education teacher should master and be able to demonstrate in classroom teaching (McLeskey et al., 2019).

Finally, inquiry-based learning has proven to be a valuable approach that gives students the opportunity to solve problems with real-world connections in the classroom (Darling-Hammond & Hyler, 2020). Multiple studies have shown that this approach has a demonstrable effect on learning for students with visual challenges (Fast & Wild, 2018), students who are deaf or hard of hearing (Pedaste et al., 2020), and students with learning disabilities (McGrath & Hughes, 2018). The research study by McGrath and Hughes recruited seventeen middle-school students with learning disabilities to participate in inquiry-based science lessons. The results showed that most

participants acquired foundational science concepts and engaged in collaborative learning. The study exemplifies that inquiry-based projects could support students by addressing their common misconceptions about abstract scientific concepts and engaging them in hands-on practices.

Assistive Technology and Special Education

Research has shown that an effective technologically integrated curriculum can facilitate deep learning in the classroom (National Academies of Sciences, Engineering, and Medicine, 2018). Specifically, AT can support teachers in scaffolding the learning process, designing inquiry-driven practices, and developing high-level cognitive tasks and meta-cognitive skills in the classroom (Nordström et al., 2018). AT also provides new perspectives on curriculum development for students with a wide range of learning disabilities. Instead of simply technology for didactic purposes, teachers can use AT to encourage students to take an active role in the learning process (Harper et al., 2017). Students can also learn to design and propose innovative solutions to problems in their communities (Boger et al., 2017; Thaplial & Ahuja, 2021), and utilize AT to visualize their understanding of learning concepts across disciplines. These learning experiences help students develop the necessary skills to research, synthesize, analyze, and apply their exploration and research (Tondeur et al, 2019)

To disrupt the existing deficit thinking framework and reflect the best practices of learning sciences, technology must be used “wisely” to support emerging opportunities for students with learning disabilities (Wenglinsky, 2005). However, the majority of the research emphasizes the didactic use of AT to digitalize the status quo (Meier, 2018) without giving students agency to explore content knowledge and collaborate with peers (Atanga et al., 2020). Studies suggest that teachers need professional development to design inquiry-based projects to teach students with disabilities with the integration of AT to redefine impactful and effective opportunities (Levy et al., 2021; Murphy et al., 2020).

INQUIRY-BASED LEARNING FRAMEWORK

Given the complexity of the special education and catalytic power of AT, the theoretical framework for the special education teacher PD in this study was developed around the central idea of teachers as designers based on three frameworks that studies show to be effective in special education: Understanding by Design (UBD), Universal Design for Learning (UDL) and Inquiry-based learning framework (IBL) (Du & Lyublinskaya, 2022).

Understanding by Design (UBD)

Understanding by Design (UBD) framework (Wiggins & McTighe, 2005) provides a guide for teachers in the development of inquiry-based learning curriculum, performance assessments, and classroom instruction that supports inquiry learning. UBD outlines a process of designing lesson plans starting with big ideas leading to development of performance tasks and assessments in authentic learning contexts. The three core stages of UBD include identifying desired results, determining assessment evidence, and planning learning experiences and instructions (Wiggins & McTighe, 2005). Therefore, UBD plays a critical role for special education teachers to uncover students' thinking by designing lessons based on big ideas and incorporating authentic tasks with the AT-infused curriculum.

Universal Design for Learning (UDL)

Initially developed by David Rose and Meyer (2006), Universal Design for Learning (UDL) provides a framework for teachers to use different means, access, and presentations to support learners from diverse backgrounds. The UDL framework consists of three core principles to provide multiple means i) for presenting information to overcome the physical, perceptual, and cognitive barriers in students' learning; ii) for actions and expression that considers the diversity that learners use to plan, strategize, and perform tasks; and iii) for engaging learners (Rose & Meyers, 2006). Therefore, the UDL could create pathways for teachers to use AT to support students with diverse learning needs.

Inquiry-based learning framework (IBL)

Inquiry-based learning (IBL) framework suggests that students gain a deeper understanding of material when they actively construct their understanding by working with and applying ideas and theories in real-world contexts (Levy et al., 2021). Specifically, it helps teachers to focus on concrete goals and give students agency in the open inquiry learning spaces. The inquiry-based approach provides opportunities for teachers to develop high-impact instructional strategies and design higher-order thinking experiences for students with disabilities (King & Smith, 2020). In the theoretical framework of the PD designed as part of this study, the AT-infused curriculum is in the intersection of the three core frameworks, UBD, UDL and IBL (Figure 1).

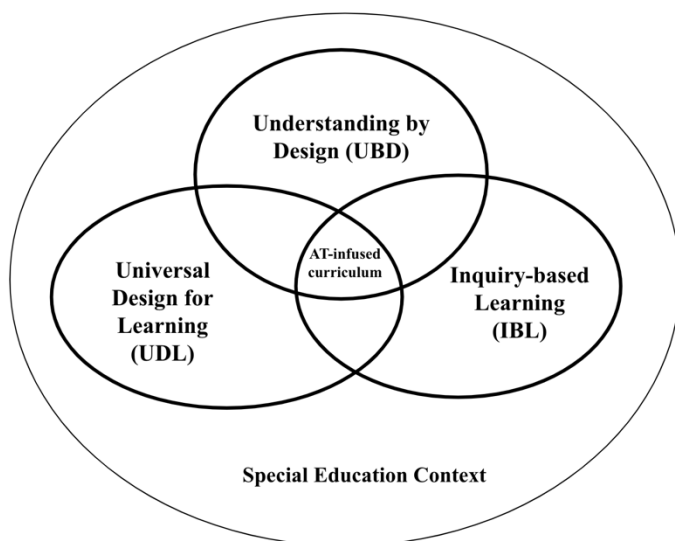


Figure 1. Theoretical framework for the special education teachers PD for design of AT-infused curriculum (Du & Lyublinskaya, 2022)

Therefore, this study investigated in what ways a research-based PD intervention, guided by inquiry-based learning framework (IBL) could prepare special education teachers to engage students with diverse learning needs for online teaching.

PROFESSIONAL DEVELOPMENT INTERVENTION

The goal of the 15-week blended PD program was to explore effective ways for special education teachers to use AT in self-contained classrooms by designing inquiry-based experiences to support learning of students with disabilities. The PD utilized a combination of in-person and remote sessions to accommodate for COVID-19 restrictions and to support teachers as they incorporated AT in their classrooms. During the PD program, one of the researchers met with the teachers weekly for a 90-minute session. In each session, teachers were introduced to a new AT through modeling and micro-teaching, then they designed their own lessons with that AT. Following each PD session, teachers implemented designed activities in their classrooms. Thus, starting week 2, each session also included reflection on the teaching of the lesson designed in the previous session.

The PD program was guided by the PD theoretical framework to develop inquiry-based student experiences. All technology tools were aligned with the unit topics and goals and were available to the teachers as either open access resources or tools provided by their schools. The PD program was divided into three units based on the purpose of instructional practices with technology: 1) pedagogical practices that utilized AT to engage principles of UDL (Rose & Meyer, 2006), 2) pedagogical practices that utilized AT to connect with special education pedagogy based on the guidance from Council for Exceptional Children, and 3) pedagogical practices that utilized AT to connect with online learning pedagogy. These practices were infused with technology to engage students in learning by inquiring, exploring, and discovering, instead of passively waiting for the delivery of information (see Table 1).

Table 1
PD Intervention

Weeks	Unit	PD focus	AT focus	AT tools
1-3	1	UBD	Identify desired results; determine assessment evidence, and plan learning experiences and instructions	Cognitive memory aids (e.g., Audacity) Stimuli control (AudioVisualizer) Speech recognition tool (Siri)
4-6	2	UDL	Provide diverse means access, and representation for learners	Digital Portfolios (SeeSaw) Infographics 3-D creation(s) (Canva) Graphic organizers (Coggle) Blog(s) and Co:Writer Universal
7-9	3	IBL	Introduce pedagogical practices across collaboration, assessment, social/emotional behaviors and instruction to facilitate inquiry-based learning	Tactile access (e.g., Braille system) Auditory access (e.g., ReaderPen) Visual access (screen readers) American Sign Language Hearing aids (e.g., SUBPAC)
10-12	4	Online Education Pedagogy	Introduce online pedagogical practices including content, delivery methods, and assessment	Aided or unaided communication/symbol system(s) (Boardmaker) Promoting system(s) (cues, auditory/tactile devices). Word processing tools (Notepad)
13-15	5	Inquiry-based Learning Experience	Introduce inquiry-based learning experience including structured, guided and open-inquiry.	Sensors (Arduino) Manipulatives (Didax, Toy Theater) Simulation (Scratch) Virtual/Augmented reality (AR Anatomy) Digital/board games (Civilization)

Unit 1 introduced pedagogical practices that utilize AT to engage principles of UBD, including three core stages of UBD include identifying desired results, determining assessment evidence, and planning learning experiences and instructions (Wiggins & McTighe, 2005). Also, the unit introduced the use of AT to design student-centered performance tasks in classroom learning. Unit 2 introduced pedagogical practices that utilize AT to engage principles of UDL, including utilizing AT to provide diverse means, access, and representation for the learners with diverse needs. Teachers utilized AT to reflect different methods to differentiate instructions to meet the needs of diverse learners. Unit 3 introduced pedagogical practices that utilize AT to connect with special education pedagogy. Specifically, the unit captured the professional knowledge base of special education teachers and highlighted the key four components, including (i) modified appropriate learning environments and interactions; (ii) designed appropriate curriculum content to individual with disabilities utilizing appropriate assessments; (iii) utilized collaboration to create inclusive learning environments and actively engage students; and (iv) considered individual capacities, interests, environment culture, and linguistic factors (Casserly & Padden, 2018). Unit 4 introduced the foundations of online education pedagogy to ensure learners to make informed educational decisions, diversify and recognize different forms of skills and knowledge, create diverse learning environments, and include learner-focused feedback and assessments. Unit 5 introduced different types of inquiry-based learning experience including structured-inquiry, guided-inquiry, and open-inquiry. Also, the unit provided core practices and examples by highlighting principles guided by UDL, UBD, special education pedagogy, and online education pedagogy.

METHODOLOGY

This study followed the sequential mixed method design that collected both quantitative and qualitative data to analyze the effectiveness of inquiry-based learning framework for online learning during a 15-week blended PD program in the United States. Two research questions were used to guide the research to analyze the effectiveness of the IBL for online learning.

Research Question 1: What is the influence of the PD intervention on development of special education teachers' competency in designing and teaching AT-infused inquiry-based experiences for students with disabilities for online teaching?

Research Question 2: What factors contributed to the variations for special education teachers to design and teach AT-infused inquiry-based experiences for students with disabilities for online teaching?

Context of the study

The study utilized the purposive sampling to select special education teachers working in schools for students with disabilities in metropolitan areas. Twenty teachers from six public urban schools in the northeastern region of the US agreed to participate in the study (Table 2).

Table 2
School Demographics

School	% Students with Special Needs	% English Language Learners	Staff Experience: % of teachers with 3 or more experience	% Student Attendance	School Size	Student Background in %
School A	19	17	43	92	394	Asian: 9 Black: 21 Hispanic: 60 White: 9
School B	35	7	80	89	309	Asian: 0 Black: 59 Hispanic: 37 White: 2
School C	19	9	66	94	565	Asian: 3 Black: 11 Hispanic: 42 White: 39
School D	21	4	81	94	772	Asian: 6 Black: 28 Hispanic: 21 White: 40
School E	15	15	78	98	962	Asian: 88 Black: 1 Hispanic: 5 White: 3
School F	19	18	56	93	799	Asian: 3 Black: 5 Hispanic: 65 White: 24

Participating teachers' classrooms had at least two different AT devices, including low-level AT (e.g., pencil grids and clay), medium-level AT (e.g., interactive whiteboards and digital-storying tools), and/or high-level AT devices (e.g., hearing aids, Augmentative and alternative communication, and GPS systems).

Participants

A total of twenty special education in-service teachers participated in the study from special education classrooms. Researchers worked with teachers and spent between 10 and 47 hours per school, with an average of 27 hours per school (See Table 3). Descriptive information about the teachers is available in Table 3.

Table 3
Teacher Information

School	Teacher Participants	Student IEP
School A	4 Total: 2 Special Education (ELA & Science); 2 ICT classrooms	Students with learning disabilities students with ELL
School B	4 total: 2 Special Education (Social Studies, ELA, and Science); 2 ICT classrooms	Students with speech or language impairment, students with visual impairment, students with ELL
School C	3 total: 1 Special Education (Social Studies); 1 Special Education (Technology); 1 Special Education (Science & Social Studies)	Students with learning disabilities students with ELL
School D	3 total: 1 Special Education (ELA); 2 ICT classrooms	Students with learning disabilities students with ELL
School E	3 total: 1 Special Education (ELA); 2 ICT classrooms	Students with autism, students with ELL, students with multiple disabilities
School F	3 total: 3 ICT classrooms	Students with visual impairments; students with ELL

Instruments

This study employed a Special Education Teachers Competency for AT (SETCAT) classroom observation protocol that was previously piloted and validated to examine teachers' level of AT competency in three distinct domains: instruction, differentiation, and environment in the special education classrooms (Du, 2021). The domains of instruction and differentiation each include five core indicators. The domain of environment includes four core indicators. The core indicators are assessed independently based on the evidence of specific performances, which are categorized according to the following levels of competencies with AT: Level 1 (Incompetent) - teacher does not meet any performance attributes in each core indicator, Level

2 (Basic) - teacher meets at least one performance attribute in each core indicator, Level 3 (Capable) - teacher meets at least two performance attributes in each core indicator, Level 4 (Advanced) - teacher meets at least three performance attributes in each core indicator, and Level 5 (Expert) - teacher meets at least four performance attributes in each core indicator. The average content validity index (CVI) for the match of the content was 0.95, demonstrating that 95% of the content accurately matched the instrument proposed domains. The CVI of relevancy was 0.89, thus indicating that 89% of the considered factors were relevant to the proposed measurement goals. The values of Cronbach's α ranged from .87 to .9 for three domains of the classroom observation protocol, including *instruction*, *differentiation*, and *inclusive learning environment*.

Data collection and analysis

Both quantitative and qualitative data were collected to accurately capture how special education teachers designed curriculum with the integration of AT. To address RQ1, the classroom observation protocol was used to quantitatively evaluate the performance of teacher participants who integrated AT to design inquiry-based learning experience. The scores were compared and discussed during the meeting with senior research experts to ensure the agreement in the interpretation of the rubric criteria as well as performance indicators. A one-way repeated-measures analysis of variance (ANOVA) was conducted to analyze the shift of teacher change. Qualitatively, the researchers conducted a case study based on the weekly lesson plans developed by the teachers during each week of PD and field notes of classroom observations of these lessons. Researchers analyzed qualitatively using thematic analysis that identified the evidence of specific performances related to the following three themes: i) teacher's competency in using AT for content delivery with explicit, planned information to promote discussion (shortly Instruction), ii) teacher's competency in using AT for adapting instruction to meet the needs of students with diverse needs (shortly Differentiation), and iii) practices with AT of creating environment that support development of students' social and emotional skills (shortly Environment). In order to address RQ2, pre- and post-PD teacher interviews were conducted and analyzed using thematic analysis that included the following themes: teachers' ideas about their students' abilities to learn and teacher's thinking about the role of AT in special education.

RESULTS

RQ1. The Influence of PD intervention on teachers' competency to use AT to design inquiry-based learning experience

Quantitative Analysis

A one-way repeated-measures analysis of variance (ANOVA) was conducted to evaluate the potential hypothesis that there was no change in participants' use of AT when measured before, during, and after participation in the 15-week blended PD program session ($N = 20$). Descriptive statistics demonstrate that, in general, participants achieved a capable level of using AT ($M = 3.84$, $SD = 0.22$) in week fifteen. Participants began with a basic level of using AT ($M = 2.07$, $SD = 0.12$) from week one to week six ($M = 2.95$, $SD = 0.23$). Participants' performance scores steadily increased and fell between the basic and capable level from weeks eight ($M = 3.08$, $SD = 0.25$) through fourteen ($M = 3.55$, $SD = 0.22$). Finally, by the end of the program (week fifteen), scores were getting close to the advanced level as defined on the Classroom Observation Rubric, with most participants reaching this level ($M = 3.84$, $SD = 0.1$). These ratings and evaluations were consistently measured by the core domain, as well as indicators pre-evaluated by the researcher.

The results of the ANOVA indicated a significant time effect from Week 1 (unit 1) to Week 6 (unit 3), and Week 15 (unit 5). $F(2, 38) = 169.01$, $p < .001$, with large effect size ($\omega^2 = .62$). Post hoc tests using the Bonferroni correction revealed the observational rating of the classroom practices in three main categories: instruction, differentiation, and environment. A paired T-test indicated that classroom observation score increased significantly from the unit 1 (week 1 to week 3) to unit 3 (week 7 to week 9) ($t(19) = -5.73$, $p < .001$), from unit 3 (week 7 to week 9) to unit 5 (week 13 to week 15) ($t(19) = -11.627$, $p < .001$), and from unit 1 (week 1 to week 3) to unit 5 (week 13 to week 15) ($t(19) = -24.957$, $p < .0011$).

Single Case Study

Pre-PD interview with Katherine showed that she had prior experience of integrating technology into teaching and was very motivated to learn more about using technology to support students with disabilities for online learning. She indicated that "combining drama with technologies was a fun way to make STEM projects and develop students' creativity", and she wanted to "try new technology ... when implementing new projects". Katherine also demonstrated positive attitudes and determination indicating even negative experience and challenges will not stop her from learning different ways to use AT in her teaching.

From the very beginning of the intervention, Katherina demonstrated her understanding of the UBD framework discussed during Unit 1 of PD for online teaching. For example, during the first six weeks of the study she planned a series of lessons around the big idea of fairness that connected these lessons in a virtual environment. However, analysis of AT-infused tasks in her lessons showed that consistently through the first six weeks her primary approach was the teacher-centered instruction, specifically delivery of information with the help of technology. Her use of AT also did not support building an inclusive environment for her students. On the contrary, her ability to adapt technology for the needs of her students improved over this period. While during week 1 of PD she used a YouTube video for a whole class content delivery which led to passive learning for students and lack of differentiation, by the end of unit 1 of PD she started to adapt AT to the needs of her students. For example, during week 6 Kathrine used the application Chrome Music Lab for individual student use as they develop understanding of music creation. The application is a web-based that makes learning music more accessible through online learning environments. Also, students without music instruments at home can utilize the online platform to make songs and explore the core concepts of rhythm, strings, and melody (see Figure 2). These changes in AT-based student tasks represent Katherine's growing understanding of the role of AT in differentiation of instruction. Overall, by the end of unit 1 of PD, Katherine remained at the Basic level of AT competency in the domains of Instruction and Environment but reached the Capable level of AT competency in the domain of Differentiation.

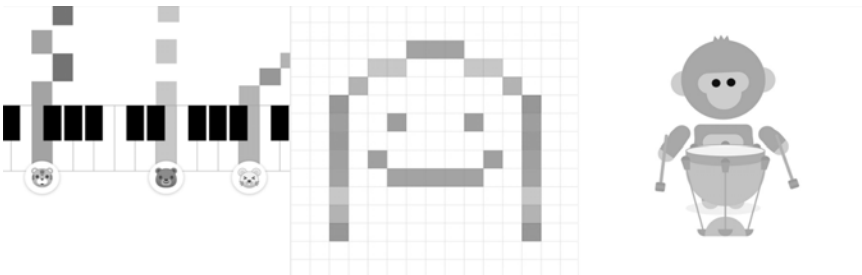


Figure 2. Music Lab Interface.

Analysis of AT-infused tasks that Katherine designed for her lessons during unit 2 of PD showed that her levels of AT competency in the domains of Instruction and Differentiation did not change over this period. On the contrary, she was able to incorporate AT to manage classroom procedures, and to establish an environment of respect and rapport. Katherine utilized the

diverse AT tools to facilitate the students' collaboration and conversational discourse. For instance, during week 8, she incorporated timers and created classroom rules for students to listen to each other, take turns to respond to questions, and voice individual ideas in the virtual learning environment. During week 9, Katherine designed the lessons to introduce the concepts of fraction. The lesson started with interactive review of the concepts of denominator using PhET followed by a matching activity and multiple-choice quiz to check student understanding of definitions. The next part of the lesson was a revised PhET activity from the previous assignment. At the beginning of the activity students were asked to make a prediction about the relationship between the denominator and numerators. They were then instructed on how to construct a fraction. Students were to develop their own procedure to determine the relationship between these two measurements and record their work in the group's Google Document. Therefore, by the end of unit 2 of PD, Katherine reached the Capable level of AT competency in the domain of Environment.

Katherine designed for her lessons during unit 3 and 4 of PD showed that her levels of AT competency in the domains of Differentiation and Environment did not change. On the contrary, she reached the Advanced level of AT competency in the domains of Instruction. Specifically, she showed a growing understanding of the special education pedagogy based on high-leverage practices and online education pedagogy. For example, in week 8, she designed writing projects for students and kept a journal while exploring the changes that happened to the agricultural industry. Considering students with ELL and autism, Katherine purposefully model social and emotional protocol that allowed students to work with each other by overcoming the social communication and language barriers. Similarly, in week 10, Katherine encouraged students to act as engineers to redesign the school cafeteria. She provided direct instructions to develop students' essential academic skills in measurement, then created a collaborative space for students to communicate online then completed the group project. In week 12, Katherine designed tasks for students to develop a map illustrating the formation of climate change. She provided students with incomplete map that had four nodes – Intergovernmental Panel on Climate Change (IPCC), the Kyoto Protocol, Conference of the Parties to the Convention on Biological Diversity (COP15), and UN Climate Change Conference (COP27) -- each linked to an internet source. Students were expected to provide Internet resources to explore the properties of different historical periods with key characteristics to establish their hierarchy and complete the concept map. However, her instructions were very prescriptive and did not provide students with opportunities to explore their own questions about climate change in the historical period and differentiate instructions. Therefore, by the end of unit 4 of PD,

Katherine reached the Advanced level of AT competency in the domains but remained at the Capable level of AT competency in the domain of Differentiation and Environment.

During unit 5 of PD, Katherine improved the quality of AT-based tasks, and created guided-inquiry tasks for online learning. Katherine also demonstrated improvement in her competency to use AT to differentiate instruction. For instance, during week 11, she incorporated simulations for students to develop conceptual understanding of artificial intelligence through guided expiration. During week 12, students utilized the MIT App inventor platform through guided expiration and instructions for online instructions. In this lesson she provided students with multiple AT tools, such as text-to-speech processing software that allowed the system to recognize the voice comments from the users. Students also used image recognizing software to classify different objects and prepare them to build the final projects. During week 14, students conducted user interviews and conducted research based on identified problems that they would like to solve. She encouraged students to utilize the App inventors to create mobile applications in tackling challenges. During week 15, she designed the lesson about the ethical discussion of autonomous agents. The lesson started with an interactive Kahoot game simulation to formatively assess learners' prior knowledge in robotics, followed by a virtual reality simulation that provided an immersive social experience to check their understanding. The next part of the lesson provided a simulated video and matching activities to introduce new concepts on revolution followed by open-ended questions to invite students to critically think about the implications of ethics of artificial intelligence. After the introduction, students were assigned to work with the team to complete a concept map based on the incomplete map to conduct research and explore the impact of the technology on societal impacts. The lesson concluded with a Time to Climb as summative assessment to assess students' understanding of core concepts and terminology. However, during this period her AT competency level in the domain of Environment did not change. Therefore, by the end of unit 5 of PD, Katherine reached the Advanced level of AT competency in the domains of Instruction and Differentiation but remained at the Capable level of AT competency in the domain of Environment.

RQ2. Teachers' mindset about abilities of students with disabilities

Based on the analysis of a pre-PD interview with teachers, initially, majority teachers' decision-making process in selecting AT was based on students' academic learning limitations. Taking teacher Katherine as an example, she explained at the very beginning that "students could not do this [web-based] tasks, they struggle with image and sound recognition". Also, the teachers' deficit-thinking mindset could be seen from her judgment of

her student prior knowledge and skills, as can be seen from the following statement: “some of my students did not have any literacy and communication skills prior to joining my class”. Even though Katherine viewed AT as a useful classroom resource, based on her prior experience with AT she didn’t think that AT could enhance her students’ learning: “the AT was not helpful, and we did not have much AT in classrooms ...my low students were never able to read [independently] regardless of the use of AT”. After completing the PD, her perceptions of the role of AT in supporting students with disabilities started to change. Based on the analysis of the post-PD interviews, Katherine recognized that she had a deficit-thinking mindset about abilities of her students with disabilities, as she explained that “I could not imagine our students could conduct individual observation, establish, and test hypotheses [for the use of AT] ... I never imagined [my low students] could make a thermometer”. As a result of her experiences in the PD program, Katherine became aware of her students’ abilities when supported by AT in an effective way. This represents shifts in her mindset towards asset-based thinking about students with disabilities.

SIGNIFICANCE

The study seeks a new way to explore the effectiveness of IBL for online learning. The results revealed a shift in terms of teachers’ ability to design inquiry-based learning experiences that integrated AT over the period of PD intervention. The professional development for special education teachers shows promise and begins to re-conceptualize special education to focus on teaching practices in creating an inquiry-based learning environment for on-line learning.

AT provides schools with the potential to leverage greater opportunities for teachers and students in special education. When AT was introduced into schools, it was introduced with the expectation that it would provide a more equitable learning system. More recently, major technological changes and improvements have provided educators with new ways to support and encourage teachers to make pedagogical shifts to focus on problem-solving, critical thinking, exploration and analytical research, communication, and collaborative skills. To facilitate the interaction among the teachers and students, AT has the potential to redefine the professional relationship between teachers and students, which creates the potential for students to act as “knowledge-builders” and teachers as designers in culturally and linguistically diverse communities.

However, these promises have not been fully realized (Cuban, 2018). The main challenge lies in properly leveraging the power of AT and preparing teachers to acquire professional competency in the use of AT and

build meaningful learning opportunities (Frenzel et al., 2021). The process for adopting AT will require time and consistent efforts. To create balanced, culturally, and linguistically diverse learning communities, existing school equitable resources are limited to facilitate the teacher shifts in special education.

To tackle the ongoing challenges, special education teachers need greater preparation to build knowledge and skills for inquiry-based teaching practices (Ainscow, 2020). Teachers need assistance to integrate AT to curriculum planning to connect students with deeper modes of inquiry, understand students' cultural experiences, value choices and voices, and construct an inquiry-based learning environment. More emphasis should be placed on inclusive education that fosters a truly inquiry-based learning environment to support students with learning disabilities and close the gap between general and special education students. Most importantly, the need to prepare special education teachers for teaching with AT became even more critical in 2020 when the world suddenly relied on virtual learning due to the COVID-19 pandemic.

Finally, the dominance of deficit thinking in the special education field limits teachers' ability to design around students' assets in classroom teaching (Amor et al., 2021). In the field of special education, it is important to reflect on the practices and emerging research in general education and re-conceptualize teacher education to shift away from behavior-driven, deficit-thinking teaching models. To create a systematic design process to improve teaching practices, this research suggested an ongoing need to create a common societal understanding of inclusive education to move beyond "inclusion" and the cultural, institutional, and educational boundaries of the school system. Research institutions, schools, and government agencies have conducted research to study the relationships between inclusive education and teacher/student learning outcomes. Ongoing study could engage more teacher participants to increase statistical power of the research study. Future studies should continue to scale the professional development guided by the IBL framework to the local classrooms and engage educators in special education to create an inclusive learning environment to meet the needs of diverse learners.

IMPLICATIONS

The study has demonstrated how the IBL learning framework could be used to prepare educators to design inquiry-based curriculum with the integration of AT with online learning environments. In practice, it is critical to motivate educators who participate in the PD program as designers to integrate AT for online learning. Guided by IBL, teachers could design inquiry-based lessons and integrate AT effectively to help students develop complex

knowledge base to solve problems. Teachers also had opportunities to collaboratively share knowledge, expertise, and techniques that help educators equalize instructions for students with diverse learning needs. Additionally, when modeling the usage for AT, the PD should situate the content to teachers' existing knowledge structure and content to facilitate the discussion, as well as encourage teachers to explore diverse AT tools to design inquiry-driven projects to ensure learners' outcomes. Finally, at the policy level, ongoing policies should continue to develop credible and equitable systems for diverse student learners through enhancing professional development for educators, which is not limited to English language learners, students with learning disabilities, and broader scope learning communities. An accountable and equitable assessment system should guide researchers to seek effective strategies to support learners with diverse needs and capture nuances of inclusive practices.

CONCLUSION

The fifteen-week professional development intervention based on the IBL learning framework seeks a new way to prepare teachers to use AT strategically to design curriculum around the specific needs of their students and engage them in inquiry-based classroom practices for online learning. Shifting from the "separate but equal" policy that has been traditionally implemented for students with disabilities, this IBL offers an opportunity for collaboration between researchers and special education professionals to redefine the high-quality, high-impact opportunities for teachers for online learning.

DECLARATIONS

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