Science Learning with *Hero Elementary*: Accessible Blended Learning Resources to Reach All Students

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Introduction

As digital and blended learning resources become more prevalent in formal (regular school day) and informal (afterschool, summer programs) learning environments, there is a growing imperative to design learning resources that allow a diverse range of students access to their instructional content. In particular, there is a need for digital and blended resources that are accessible and engaging for three groups of students: those with disabilities, English learners, and socioeconomically disadvantaged students. These groups are represented at notably high levels in today's classrooms. Approximately 7.1 million, or 14 percent, of all public school students in the U.S. have Individualized Education Programs (IEPs) and are receiving special education services, and about two-thirds of these students spend 80 percent or more of their school time in a general education classroom (U.S. Department of Education, 2020). In addition, approximately 5 million, or about 10 percent, of public school students in the U.S. are English learners who are currently gaining proficiency in English. It is estimated that about 15 percent of children in the U.S. live in poverty (U.S. Census Bureau, 2019).The percentage of students in a school who are eligible for free or reduced-price lunch under the National School Lunch Program (NSLP) has been used as a proxy measure for the concentration of low-income students. About 24 percent of schools in the U.S. are designated as high-poverty, that is, they have more than 75 percent of students eligible for free or reduced-price lunch (U.S. Department of Education, 2020). This suggests that a high percentage (about 18%) of socioeconomically disadvantaged students are present in today's public school classrooms. At the same time, research suggests that as the Next Generation Science Standards (NGSS) become more widely adopted, the need for NGSS-aligned learning resources for diverse groups of learners is particularly acute (Dalton, 2017; Heinrich et al., 2020; Kyei-Blankson et al., 2019; Sturgis et al., 2018). To address the need to reach diverse populations of student learners, designers of digital and blended science learning resources are recognizing the value of (a) incorporating design features into their products that support equitable access to instructional content, and (b) enabling educators to adapt resources to provide maximum access to the learning content for their students.

Hero Elementary, produced by Twin Cities PBS (TPT), is a multiplatform educational media initiative that includes an animated PBS Kids television series and a suite of digital and non-digital learning resources designed to support science and literacy learning for children in grades K–2 in formal and informal learning environments. The *Hero Elementary* project is funded by the Ready to Learn Initiative, a grant program administered by the U.S. Department of Education to promote the development and distribution of educational media programming and multiplatform resources to promote school readiness for preschool and elementary age children, particularly in low-income communities. The overarching goal of the *Hero Elementary* project is "to build the science and literacy skills of diverse students ages 5 to 8 and promote equity for historically underrepresented children in science (race-ethnic minorities, children in low-income households, children with disabilities, English learners)" (Ellington et al., 2021).

This report describes a case study that examines the design and use of *Hero Elementary* science resources with K–2 elementary students representing a broad diversity of abilities and cultural identities, including students identified as having moderate cognitive disabilities, English learners, and socioeconomically disadvantaged students. The report examines how these digital and blended resources, designed with equity and accessibility in mind, can support science and literacy learning for students representing a range of backgrounds and identities.

Hero Elementary Learning Resources

Hero Elementary includes television episodes, digital and analog games, nonfiction e-Readers (e-books and e-articles), hands-on activities and scientific investigations, and a digital science notebook, as well as educator professional development and resources. Television episodes and resources are currently available through PBS

television stations, apps, websites, and streaming services. The engaging *Hero Elementary* narrative involves a school for young superheroes, where kids learn to master their superpowers — like flying and teleportation — while exploring science. The diverse group of characters includes Lucita Sky, AJ Gadgets, Sara Snap, and Benny Bubbles, along with their enthusiastic teacher, Mr. Sparks. The team often uses the "Superpowers of Science" to help them investigate, observe, make predictions, and figure out solutions to problems that occur in their community. Figure 1 shows *Hero Elementary*'s main characters, or the "Sparks' Crew."

Figure 1.* Hero Elementary*'s cast of characters.

For use in informal and formal learning settings, *Hero Elementary* learning resources are bundled into "playlists," with each playlist focused on a specific science topic aligned to grade-level standards. Resources in each playlist include a television episode, two hands-on science-focused activities, two tablet-based Science Power Notebook activities, a digital or analog game, and an e-reader activity. Playlists can be implemented by educators in classrooms or virtually. Educators guide students through the digital and non-digital activities in the playlists, all designed to engage students in science exploration and learning. Students access *Hero Elementary* resources by logging into their *Hero Elementary* account via a tablet or other digital device. Educators can monitor students' progress by viewing an educator dashboard. Table 1 shows the contents of a typical playlist — this one

is focused on life science and titled *Animal Parents and Their Young*.

***TABLE 1.* Learning resources included in a typical *Hero Elementary* playlist, *Animal Parents and Their Young*.**

TITLE	TYPE	TIME	DESCRIPTION
Who Belongs Together?	Hands-on Activity	20 minutes	Children observe picture sets of animal parents and babies to identify the body features that show they are the same type of animal.
Animal Family	Science Power Notebook	10 minutes	Children describe how an animal parent and baby are alike. (Ties to Who Belongs Together?)
Compare	Song	5 minutes or less	Children hear a song about a Superpower of Science: comparing. May play this song more than once during a playlist.
Hatching a Plan	Video	20 minutes, including discussion	When an egg cracks and a baby bird emerges, Sparks' Crew tries to find the baby's parents! They use evidence of ways that parents and offspring are alike and different to identify the baby bird's parents. They figure out that the baby is... a swan!
Alike, Not Alike	Science Power Notebook	10 minutes	Children compare an adult swan and a baby swan to identify similarities and differences. (Ties to *Hatching a Plan*.)
Baby Grows Up	Hands-on Activity	30 minutes	Children observe, describe, and compare picture sets of animals to identify ways that a baby animal changes as it grows up.
Critter Collectors	Digital Game	20 minutes	Players match baby animals to their parents and observe their behaviors! Match all the babies, and record all the animal behaviors for your collection!
PebbleGo	E-articles	15 minutes	These articles provide factual information about how animal parents and offspring look alike and look different.
Choice Time		15–30 minutes	Children may use the playlist content any way they wish. May have Choice Time more than once during a playlist.

Educators implementing *Hero Elementary* participate in *Hero Elementary* educator professional development programming and access educator resources through a *Hero Elementary* educator website. While engaged in this professional development, educators learn how to implement *Hero Elementary* in person and/or virtually. In addition, they learn how *Hero Elementary* resources are designed to reach a broad variety of learners, and how they can adapt their use of *Hero Elementary* to provide greater access to science content for their students.

Early in the design process, the TPT *Hero Elementary* design team created a document that became an important part of the *Hero Elementary* narrative and resources. The document, "Superpowers of Science," represents the NGSS Science and Engineering Practices (SEP), described in terms that students and educators can easily interpret and adopt. Television episodes and other learning resources frequently reference the "Superpowers of Science," and *Hero Elementary* characters model their use in their everyday lives. In every television episode, there is a moment when the characters encounter a problem or mystery, and they realize they can use the "Superpowers of Science" to help them find a solution. The "Superpowers of Science," as presented to students and educators, are shown in Table 2.

***Table 2. Hero Elementary* "Superpowers of Science," along with child-friendly language.**

Superpowers of Science	Child-Friendly Language
Ask questions	Ask • wonder
Collect information	Collect information • find evidence • get data
Compare	Compare • what's the same and what's different?
Explain	Explain • figure out what happened • use evidence to explain
Figure it out	Create a way to fix it • figure out a way to solve it • fix the problem • solve • what are your ideas?
Investigate	Find out • investigate
Keep track of data	Keep track • keep track of data • write it down
Learn more information	Learn something new • check it out • read about it • check with someone who knows
Look for patterns	Find patterns • I've noticed that before… • it keeps happening • look for patterns
Make sense of information	Make sense of data • make sense of information • what does that tell you?
Name the problem	Know the problem • understand the problem • what do we need to fix? • what's the problem?
Observe	Notice • observe

Plan an investigation	Make a plan
Predict	Predict • tell what you think happens next
Share what you know	Share your ideas • share information • talk about what you found out
Test	See what happens • test your idea • try it

Like the NGSS SEP, the "Superpowers of Science" are inherently equity focused. These practices, or superpowers, are something that everyone has access to and that everyone can use. This idea is incorporated into the television episodes and in the educator professional development. The "Superpowers of Science" encourage children to think and work like scientists, to approach problems the way scientists do, and to use science to benefit their community. This approach is meant to make science meaningful and accessible to children from communities that have been historically underrepresented in science fields. Also, the "Superpowers of Science" are the "connection point" between science and literacy. All of the NGSS SEP involve communication. Accordingly, the approach to literacy is based on supporting children to use speaking, listening, writing, and reading to engage with science content.

Designing and Using Resources with Equity and Access in Mind

The TPT design team created summary and planning documents for each science topic, detailing key aspects of the science topics and literacy connections. Content creators, including television script writers and digital game designers used this information to understand the science and literacy concepts and incorporate the content meaningfully into each playlist and each media resource. In addition, TPT provided developers with specific information about designing equitable and accessible science and literacy content using an integrated equity-centered approach to transmedia programming (Ellington et al., 2021). At the same time, the TPT design team developed guidelines for the use of *Hero Elementary* resources by educators. Guidelines for resource developers and for those developing educator professional development included strategies for creating and using content for young learners that promote equity, providing access to learning content for the diverse groups of students. Strategies that promote equity focus on eliminating barriers for young learners who are underrepresented in STEM-related fields. For instance, one strategy involves helping young learners develop a 'STEM identity,' in which they feel confident and excited to learn and use science throughout their lives. Strategies to promote accessibility focus on supporting access and eliminating barriers to engaging in learning content for learners with varying abilities and learning styles.

Guidelines for the Design of *Hero Elementary* Resources

Early in the project's development process, TPT's resource design team conducted an extensive review of research to identify best practices in designing science learning resources for students from groups that are historically underrepresented in STEM. Subsequently, the team developed design specifications and guidelines for the developers of *Hero Elementary* learning resources, including those developing television episodes, digital and analog games, hands-on activities, and digital Science Power Notebook activities. The TPT design team created a key document that informed the design of new resources for teaching and learning: the *Transformative Transmedia Framework for Early STEM Learners* (Ellington et al., 2021). This design specification document summarizes and operationalizes research on equity and access in education, particularly in science (Ellington, 2018; Gay, 2010; Lee et al., 2015).

Collections of research that informed TPT's design documents included the NGSS, research on STEM identity development (Cook, 2014; Kane, 2012; Martin, 2012; McGee, 2015; Wilson, 2016), literacy for English learners (National Academies of Sciences, Engineering, and Medicine, 2017), and Universal Design for Learning (CAST, 2011). Universal Design for Learning (UDL) emphasizes flexible learning environments and multiple modes for learning to ensure that individual learning differences are accommodated during instruction. UDL frameworks identify design features and instructional practices that maximize accessibility and remove barriers for learners at each stage of the learning process, including affordances that provide for multiple means of engagement, representation, expression, and action (CAST, 2011).

Figure 2 shows the guiding principles for the design and implementation of *Hero Elementary* resources presented in the *Transformative Transmedia Framework for Early STEM Learners* (Ellington et al., 2021, p. 11). A description of each guiding principle, and examples of the types of guidance provided to *Hero Elementary* content creators, including television script writers and producers, can be found in Appendix A. The framework illustrates how transmedia content creators can use an asset-based approach to support early STEM learners in exploring and affirming their multiple identities while connecting STEM and literacy learning to their communities and lived experience.

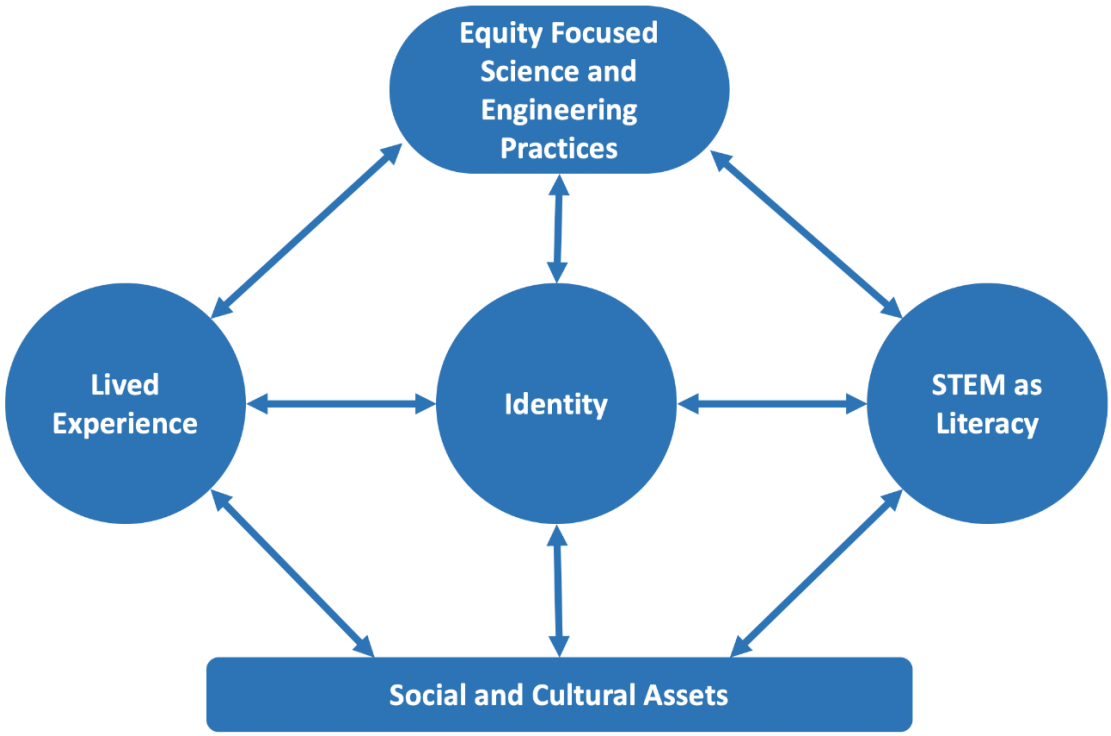

Figure 2. Transformative Transmedia Framework for Early STEM Learners. (Ellington et al., 2021, p. 11)

Guidelines for Educators' Use of *Hero Elementary* Resources

In addition to creating comprehensive design guidelines related to equity and accessibility to guide the developers in creating *Hero Elementary* content, the TPT design team created a document that summarizes research-based strategies for educators' use of science resources to foster an equitable learning experience for all learners. The *Effective Strategies for Engaging All Young Learners in Science* (or "*Equity Strategies*"), summarized below in Figure 3, provides practical guidance for educators as they plan and use *Hero Elementary* with students that represent a range of backgrounds and identities. *Hero Elementary* educator professional development (described below) includes training around the *Equity Strategies*, including examples of how to

implement equity-focused learning, such as presenting content in multiple representations, providing opportunities for hands-on exploration, vocabulary support, and facilitated discussion and reflection about science. Educators learn how using the *Equity Strategies* can support their students to persist in learning, develop science and literacy competencies, and cultivate a STEM identity.

1. Connect science to children's "sense of place": the physical, historical, and socio-cultural aspects of their local community.
   Early science learning helps children understand the world around them. In the primary years, this is best accomplished when children engage in their immediate surroundings and investigate everyday natural phenomena. Providing opportunities for developmentally appropriate exploration of their surroundings helps children understand how things work and offers an important foundation for future science learning.

2. Empower children to be doers of science by connecting to the cultural knowledge and experiences of their families and communities.
   Children come from different cultural and linguistic backgrounds and have a rich knowledge of their cultural and linguistic practices. When children are given opportunities to leverage these practices in developing scientific knowledge and practice, they engage in scientific reasoning. Provide opportunities to incorporate children's cultural and linguistic experiences into science learning.

3. Engage children's curiosity through real-world, hands-on experiences.
   Science learning for young children needs to be concrete and tangible. When engaging with scientific content, children learn better through physical interactions with the concepts. Providing hands-on experiences in realistic contexts supports children's understanding and expands their knowledge of a scientific idea by applying it in their lives. Real-world science is creative and fun!

4. Provide flexible learning experiences with multiple representations to engage all children.
   All children learn differently from one another. Provide different means of interaction for students to understand the content. Include resources such as science related literature, hands-on activities, realia (real objects or events), Venn diagrams, and concept maps. Depending on children's background knowledge, provide resources to bridge their understanding of new ideas. For example, provide vocabulary support for English learners and adaptive materials for children with learning differences.

5. Facilitate discussion and reflection about science experiences.
   Encourage children to develop science language and terms. Set high expectations for them about the importance and value of science knowledge. Offer opportunities for children to practice science language to describe, explain, and predict science phenomena.

6. Support science learning by connecting to home and community partnerships.
   Partner with home and community resources in meaningful ways. Have families participate in classroom events. Include role models from students' communities, especially those who use STEM in everyday life. Engage community knowledge and resources to support children's science learning.

Figure 3. Effective Strategies for Engaging All Young Learners in Science (Equity Strategies).

An important source for the development of both the *Equity Strategies*, as well as for the *Transformative Transmedia Framework for Early STEM Learners,* was the seminal book *NGSS for All Students* (Lee et al., 2015). *NGSS for All Students* identifies specific research-based instructional strategies that can promote access to science learning for particular groups of learners, including students with disabilities, English learners, and students who are socioeconomically disadvantaged. These strategies, closely associated with TPT's design documents and educator professional development, are shown in Table 3.

TABLE 3
Research-based instructional strategies to promote access to science learning for students with disabilities, English learners, and students who are socioeconomically disadvantaged (Lee et al., 2015).

Group of Learners	Instructional Strategies
Students with Disabilities	• Provide accommodations and modifications • Include differentiated instruction to meet individual needs using UDL and response to intervention • Include family outreach
English Learners	• Include discourse practices • Provide language and literacy support • Include home language support • Address home culture connections
Socioeconomically Disadvantaged Students	• Address students' sense of place • Include project-based learning • Provide access to students' funds of knowledge

Training and Support for Educators Implementing Hero Elementary

All programs taking part in the study participated in *Hero Elementary* educator training in 2019 or 2020. Educators who were unable to participate in an onsite training facilitated by a *Hero Elementary* trainer had the option of completing *Hero Elementary* training virtually. In addition, TPT provided support to educators during implementation through the *Hero Elementary* educator website, webinars, and direct one-on-one support. TPT anticipated the move of some sites to distance learning during the COVID-19 pandemic, and therefore developed a virtual training in summer 2020 that included an orientation to using the program materials virtually. These revised materials were used for all training sessions in fall 2020 and winter 2021. A 2019 WestEd evaluation (McCarthy et al.) indicated that *Hero Elementary* professional development activities were effective in building educators' capacity to deliver the program in their informal learning environments. All educators taking part in the case study completed TPT's *Hero Elementary* professional development, either in person, virtually, or by using TPT's online professional development course, and a majority mentioned they found the training to be useful.

Study Design

The equity and accessibility features of *Hero Elementary* resources, representative of the research-based *Transformative Transmedia Framework for Early STEM Learners* and the *Equity Strategies*, are specifically designed to support learners on their distinct learning paths and allow them to engage meaningfully with science and literacy content. The equity and accessibility features also provide educators with information and support for adapting *Hero Elementary* activities to meet the needs of learners. The current case study focuses on these two aspects of the resources (design and use). In addition, the case study examines similarities and differences in how *Hero Elementary* is used and adapted in in-person settings, compared to virtual settings.

The study's guiding questions include:

1. Do the design features of *Hero Elementary* support access to science learning for K–2 students, including those identified to have moderate cognitive disabilities, those who are English learners, and those that are socioeconomically disadvantaged?
2. What adaptations do educators make to *Hero Elementary* that are intended to provide greater access to the content for their students? How do adaptations differ for different types of student populations, specifically those with moderate cognitive disabilities, English learners, and those that are socioeconomically disadvantaged?
3. What are the similarities and differences in how *Hero Elementary* is implemented in person and virtually?

The study examines the ways that students representing a range of backgrounds and identities access *Hero Elementary*'s science content and the ways that educators use and adapt the resources to facilitate student learning. In particular, the study explores how principles, strategies, and phenomena related to the *Transformative Transmedia Framework for Early STEM Learners* and the *Equity Strategies* are reflected during *Hero Elementary* implementation at the afterschool programs taking part in the study.

Methods

The descriptive case study described in this report took place as part of a larger quantitative and qualitative evaluation of the *Hero Elementary* program. Case studies employ a research approach that provides an in-depth understanding of complex phenomena in authentic settings. They are particularly useful in gaining insights into "who, what, how" questions related to a program or intervention (Yin, 2018). Descriptive case studies "describe a phenomenon in its real-world context" (Yin, 2003, p. 286), and are "especially good for … getting a rich picture and gaining analytical insights from it" (Thomas, 2011, p. 23). The study employed a holistic design (Yin, 2018), meaning researchers used a single unit of analysis, the *Hero Elementary* program, to examine existing theories regarding the design and use of blended science learning resources.

Participants and Data Collection

The study was conducted in four large afterschool programs serving a range of student populations that have been historically underrepresented in STEM, including students identified as having moderate cognitive disabilities, English learners, and socioeconomically disadvantaged students. The programs are located in different regions of the U.S., including the nation's Southwest, West Coast, South, and Southeast regions. Thirty administrators and educators across the four programs participated in the study (n=30). Data collection included administrator and educator interviews, written communication with educators, observations of educator planning meetings, and observations of classroom implementation of *Hero Elementary*. Interview and observation protocols aligned to the study's guiding questions were developed to gather data on how programs implemented *Hero Elementary*, how the design features facilitated students' access to the content, adaptations made by educators to maximize student learning, and successes and challenges reported by educators.

Program 1: Southwest Border Education Center

Program 1 is situated in one of the poorest communities along the U.S.-Mexico border. The program includes three sites serving learners birth to 12 years — an early childhood development center and two afterschool programs. The program serves predominantly Latinx students, many of whom reside in Mexico and spend the week in the U.S. with family in order to attend school in the U.S. Educators described students as coming from highly socioeconomically disadvantaged households, including many single-parent households, where Spanish is spoken as the first language. Administrators reported that 90 percent of students are English learners with varying degrees of English proficiency and levels of comfort using English. Becoming proficient in English while maintaining or developing Spanish proficiency is a goal of the program for its students. The program also emphasizes STEM learning. Educators reported that there were one or two students with moderate cognitive disabilities in the program. Program 1 implemented *Hero Elementary* during in-person afterschool classes during fall through spring 2019–20, and, due to the COVID-19 pandemic conditions, also conducted one class using

hybrid methods, and one class virtually via distance learning during spring and summer 2020.

Data collection in Program 1 occurred in fall 2019 and in spring and summer 2020. Data collected includes interviews with an administrator, a site coordinator, and five educators, including one distance educator. The distance educator was interviewed twice, as was one of the in-person educators, in summer 2020 and again in fall 2020. The administrator was interviewed in winter 2020 and again in summer 2020. In-person observations were not possible due to the ongoing pandemic.

Program 2: West Coast Urban School District

Program 2 is located in a large urban center and partners with public schools with the highest population of underserved youth in the school district. Serving elementary schools throughout the district, the program aims to provide high-quality out-of-school-time programming to low-income families, including African American and Latinx students, English learners (approximately 45%) and students who are socioeconomically disadvantaged (over 80%). The program aims to use public school spaces for afterschool academic support, enrichment, and youth development activities. The program also supports parents to effectively communicate with their child's school. Staff are dedicated to supporting children's connection to their communities and to ensuring their neighborhood is a healthy place in which to grow up. Program 2 implemented *Hero Elementary* during in-person afterschool classes in fall 2019 and winter 2020.

Data collection at Program 2 occurred in fall 2019 and late spring 2020. Data collected includes three administrator interviews, observation data from an educators' planning meeting, and interviews with six educators at three afterschool sites. Researchers observed an in-person professional development meeting, but were not able to observe classroom implementation due to the ongoing pandemic. Program 2 did not implement *Hero Elementary* virtually.

Program 3: Non-Profit Organization Serving a Southern Urban School District

Program 3 serves a population of K–12 predominantly African American urban students, more than 95 percent of whom are socioeconomically disadvantaged, with most raised by single parents or grandparents in impoverished neighborhoods of an urban center. Four percent of students served were identified as having disabilities and 2 percent are English learners. In the school district served by the program, only 27 percent of students are considered academically "on track" for the next grade level. The afterschool program provides academic enrichment and homework help, as well as a meal and a safe place for students to spend their time after school and over the summer.

Program 3 implemented *Hero Elementary* during in-person afterschool classes and virtually via distance learning. In fall 2019, *Hero Elementary* was implemented in person at all afterschool sites in the program. In winter 2020, all but one of the sites pivoted to implement distance learning. This site, supporting families of essential workers, implemented a hybrid model, using both in-person and virtual methods to implement *Hero Elementary*.

Data collection at this program occurred in fall 2020 and winter 2021 and included interviews with one administrator and four educators who implemented *Hero Elementary* in person and virtually. In-person observations were not possible due to the ongoing pandemic.

Program 4: Southeastern Education Center for Students with Disabilities

Program 4 serves students who qualify for special education and related services under the Individuals with Disabilities Education Act and have IEPs that outline the accommodations and modifications each child needs to be able to access educational content. Program 4 receives referrals from public and private schools and provides afterschool individualized learning opportunities to students with disabilities across a large metropolitan area. All of the students participating in the program have a developmental, learning, and/or physical disability, such as autism, Down syndrome, or cerebral palsy. While *Hero Elementary*'s target age group is 5–8, this program also implements *Hero Elementary* with older children who function developmentally at the target age level. Though older, the majority of students attending the afterschool program access academic content at the kindergarten level. Approximately 90 percent of the students are socioeconomically disadvantaged. Twelve percent of students are from families where two languages are spoken. Enrollment in this

program has dropped by about two-thirds due to the COVID-19 pandemic, as a number of students have medical conditions that make it too risky for them to attend school in person. Unfortunately, for many students with disabilities, distance learning is not a viable option, as it often does not allow for sufficient one-on-one support. Program 4 implemented *Hero Elementary* during in-person afterschool classes in fall 2019 and winter 2020, and again in the 2020–2021 school year.

Data collection at Program 4 occurred during two separate site visits, one in winter 2020 and one in late fall 2020. The first round of data collection involved a two-day visit to the school. The first site visit included observations over a two-day period of three students with varying abilities and preferences for using *Hero Elementary*, and interviews with their educator. One administrator interview and two pre-observation interviews were conducted with the afterschool educator prior to the classroom visits to gain an understanding of the role of the educator in implementing *Hero Elementary*, the student participants, activities to date, and plans for implementation during the observations. Researchers used a running record of observations of the educator and of student behavior. Educator post-observation interviews occurred immediately following the observation sessions. The second round of data collection was implemented virtually. Two new staff were responsible for the administration of the program during the 2020–2021 school year. They were interviewed in fall 2020. A program coordinator and an educator, both new to *Hero Elementary* during the second year of implementation, were also interviewed in late fall 2020. A virtual classroom observation was conducted via two Zoom sessions, one with an older group of 12 students (aged 15–22), and one with a younger group of three students (aged 5–10). A follow-up interview was conducted with the educator, immediately after the virtual classroom observations.

Data Analysis

Qualitative analytic methods were used to analyze the data (Charmaz, 2007). The data, comprised of transcribed interviews and observation notes, were analyzed deductively using a set of external codes developed at the onset of the study based on the research questions, as well as a set of internal codes, that is, codes that emerged during analysis (Miles & Huberman, 1994).

A code book was created based on related literature, TPT's design frameworks, and the study's guiding questions. Transcripts and other data were coded with the tags created in the code book using NVivo software (QSR International) to facilitate analyses. Based on the initial code tagging, the code book was then refined and used to code the remaining interview transcripts and observation data. The software was used to help categorize and classify the data, and to sort sentiment, themes, and attributes from the data. Three researchers working independently were involved in coding the data. Each document was coded by at least two researchers. The agreement rate between coders was approximately 80 percent. Using peer debriefing, pairs of coders came together and discussed the items causing disparities and then came to an agreement on each item.

Using a process described by Yin (2018), researchers conducted a data reduction process whereby key findings from the coding process were documented in analytic memos. One researcher would summarize the findings from data coding for one round of data collection, that is, all data related to an in-person or virtual site visit, to create a draft analytic memo that describes the site visit and findings from the data related to the site visit. The second researcher would review the original coded documents related to that particular site visit, then review the related draft analytic memo. Using peer debriefing, the two researchers would meet once again to discuss any discrepancies in their interpretation of the data analysis and come to consensus on wording included in the analytic memo. Six analytic memos were generated during data analysis. The final step in the data analysis involved researchers reviewing each analytic memo, synthesizing findings across memos, and writing draft language for the key findings they identified. Draft language written by individual researchers describing study findings was reviewed by at least one other researcher, and if there were disparities in their interpretations of the data, researchers again discussed the disparities and used peer debriefing methods to agree on the language to be used.

The analyses allowed for researchers to discern findings related to the study's guiding questions, including those related to *Hero Elementary*'s design features, adaptations made by educators, and similarities and differences in how *Hero Elementary* is implemented in person and virtually.

Findings

Data analysis resulted in findings related to implementation, the case study's guiding questions, and additional findings related to the study's guiding questions.

In-Person Implementation of *Hero Elementary*

Observations and participant interviews showed some variation in the ways that the different afterschool programs implemented *Hero Elementary,* relating to their schedules, resources, and populations. This section provides an overview of how participating programs typically implemented *Hero Elementary* with students in person at their afterschool sites.

As described by educators and administrators in interviews and observations, *Hero Elementary* was typically implemented in afterschool programs during students' free time, after they had completed their homework. Generally, a small number of students worked on *Hero Elementary* for around 30–40 minutes each session. With the exception of Program 4, serving students with disabilities, students usually worked independently, asking each other for help, as needed, or letting educators know if they needed assistance. Educators supported other students with homework completion, as well as those who needed support with *Hero Elementary* activities. Less frequently, educators reported that students used *Hero Elementary* in pairs or small groups, such as when the tablets needed to be shared or when it was convenient to group older students with younger students to assist them with completing *Hero Elementary* activities. Educators reported that at times, they also facilitated whole-group *Hero Elementary* activities with students, such as watching videos and reading e-readers together or doing Science Power Notebook activities together.

For Program 4, with few exceptions, students were unable to work independently on *Hero Elementary* activities. For this program, multiple aides were needed to assist students, to allow the educator to lead discussions and activities as a group. This program also made strategic use of an interactive whiteboard to allow students to watch the videos and play digital games as a whole-group activity, with students taking turns playing the game on the interactive whiteboard as other students watched. In addition, to maintain engagement, educators in Program 4 kept sessions to 30 minutes and scheduled sessions throughout the week to permit the students time to reflect upon the information. Shorter sessions and use of repetition and reinforcement helped students to process the lessons; as a result, it took about double the time for Program 4 students to complete a playlist, compared to the other programs.

Educators at all four programs shared that they made efforts to tie *Hero Elementary* topics to other work the students were engaged in at the afterschool program, such as choosing *Hero Elementary* playlists to coincide with a "theme of the week" and connecting direct instruction and hands-on science activities to *Hero Elementary* content. Based on their self-reports, educators spent considerable time planning the curriculum, as well as researching additional activities to expand and accompany the content in the playlists to ensure that students would have consistently rich STEM content to engage with throughout the week. These activities were always tied to the theme of the playlist, and sometimes reinforced themes from the school day, as well.

One site reported using *Hero Elementary* more as a focal point of the curriculum, weaving playlist activities into planned STEM lessons throughout the week. For example, Mondays would be "tablet day," when the students would watch an episode, work in the Science Power Notebook, and be introduced to the theme of the playlist. Tuesdays were devoted to either a scientific investigation or other hands-on activity. On Wednesdays, students were given a worksheet created by educators that was related to the theme of the playlist. On Fridays, students had the opportunity to catch up on any *Hero Elementary* work from earlier that week, including playing the digital game.

For most of the sites, two sessions a week were devoted to *Hero Elementary* playlists, although two educators routinely incorporated *Hero Elementary* lessons three to four times a week, often supplementing the playlists with additional worksheets, books, and science investigations that expanded on the theme of the playlist. Playlists were typically completed within a two-week period. Some educators reported spreading out the sessions during the week to accommodate the other afterschool activities.

For the sites where English learner students had noticeable language difficulty understanding the content of the playlist activities, in particular for Programs 1 and 2, bilingual staff ensured that students were able to follow along and participate in the activities. This took multiple forms, including having an English learner student pair up with a student with higher English proficiency to explain and discuss the content, having the staff check in with and help students ensure they were following the activity, and having the staff translate portions of the activity to the class.

Virtual Implementation of *Hero Elementary*

Two participating programs included sites that implemented *Hero Elementary* with students both in person as well as through distance learning during the COVID-19 pandemic. The sites in the programs that implemented *Hero Elementary* virtually used similar strategies to engage their students in using *Hero Elementary* online. Educators at both programs would log on to Zoom one, two, or three times a week and spend 30–40 minutes implementing *Hero Elementary* with their students. During their time on Zoom, educators would share their screen with students and focus on one of two activities: the television episode or the science investigation (either showing the video of the investigation, or, less commonly, having children view and participate in the investigation). Although educators encouraged students to complete other playlist activities, including the digital games, Science Power Notebook, and e-readers at home on their own time, educators reported that at least half of the students were not able to log in to their *Hero Elementary* account successfully on their home tablet or other device. Some of the barriers to *Hero Elementary* access at home reported by educators included lack of internet access, difficulty logging in to the student's account, lack of adult support, and lack of a tablet or other home device. Educators asked students to report on their progress during Zoom sessions or via phone calls. Educators reported sending reminders to students encouraging them to complete playlist activities, called "homework" by some educators. Educators also invited parents to use *Hero Elementary* resources for parents, including a parent playlist, and they sent reminders to parents about activities their students were expected to complete at home.

Because it supported families of essential workers during the pandemic, one afterschool site in Program 1 and one site in Program 3 implemented a hybrid program, implementing *Hero Elementary* virtually *and* in person in the classroom. In this case, instead of having students implement the digital games, Science Power Notebook, and e-reader activities on their own at home, educators were able to support students in implementing them in the classroom.

Successes and Challenges Related to *Hero Elementary* Implementation

Educators and administrators were very positive overall about implementing *Hero Elementary*. Successes reported coalesced around student engagement in the content, ability to relate to the characters and themes, and science and literacy learning. Challenges of *Hero Elementary* implementation reported by educators related to internet connectivity issues, ensuring that English learners could understand the functions of the playlists, and ensuring that students of different ages and abilities understood the content and remained engaged in all of the activities.

A few educators shared concerns that their knowledge of science might not be sufficient for them to teach some playlist activities, although this did not seem to be a widespread sentiment among the implementers. Other educators were reassured by *Hero Elementary*'s presentation of science concepts in everyday, non-threatening ways that facilitated connections between science and students' lives.

> *…it doesn't feel like science… but once you get down to it and you get into the details, you realize it is science. But when you're going through it, it's just like, "Oh, I'm doing what I normally do." It doesn't feel like science when we're teaching them about how things balance… or how things freeze that we're eating.*
>
> *I guess "fun" is the word. Because normally when people think about science, they're like, "Oh, numbers and chemicals and all these things," But it's really, it's the simplicity of science, but it's still technically complex topics.*

Implementation Successes: Student Engagement and Educator Satisfaction

All educators reported that students enjoyed the *Hero Elementary* program and were engaged in science learning. They agreed that students were learning and demonstrating usage of new vocabulary and new science ideas, as well as gaining experience using technology.

> *I love how it makes the children just explore a little bit more in technology and for them to know that this is the future. I'm glad that the kids have this opportunity to be exposed to the media and to know how to use the tablet and everything. I think it's very beneficial for the kids.*

Several educators noted as successes the value of "real-life" depictions of nature and science in the e-readers and that children playing at recess would exhibit transfer of concepts they learned in *Hero Elementary* to other contexts (e.g., applying pushes and pulls in their play).

> *The positive part is how they use educational vocabulary. It was also very neat to see how they compare what they are doing to what they are learning in the [*Hero Elementary*] application and use those new vocabulary words — and actually funny to see how they use some of the fancy words to express something. Like the vocabulary learned on that part of the [*Hero Elementary*] application and then connecting it to what they were doing at school.*

> *We've found it very successful. They were working in groups and asking other classmates about how they were doing it and sharing different opinions. And that's very important, student interaction, to talk about a certain theme, for example. And it was very, very interesting to see how they were sharing their own ways of moving the figures and how each one had different strategies. And it was very fun and interesting to watch.*

Many students with disabilities were also observed using science vocabulary when communicating. One educator mentioned that she had observed some of her students transfer *Hero Elementary*'s science knowledge to other situations. In addition, the educator helped students relate *Hero Elementary* topics and scenarios to their lives. For example, when one of the *Hero Elementary* characters learned to calm down by taking deep breaths, the educator had the students practice this behavior, helping them to maintain engagement and to learn a useful skill.

> *Actually today, … we were eating lunch, … and someone had poured the water out and he was like, 'Oh, you got liquid all over the table.' And I was like, 'Why didn't you just say water?' And he was like, 'We learned liquid yesterday.'*

> *[I asked the students] 'Well, can I hold a liquid in my hand?' They were like, 'You can't hold water.' And so, I was pretty proud of that.*

> *Oh, do you see what he's doing to calm down? He's taking deep breaths. That's what we need to do if we need to calm down.*

There was some divergence across groups of educators in terms of which parts of the playlist students enjoyed most (e.g., at Program 4, the students loved the e-readers and did not prefer the videos; at another site, it was the opposite). Some sites reported that students particularly enjoyed "free drawing" in the Science Power Notebook. Students also appreciated the ability to move from one activity to another independently.

> *They love the Science [Power] Notebook, when they can record, and they have different colors, and they can do many things there. In general, kids love to draw and scribble and use all colors. It was fun and they also connected it with science — for example, animals and different habitats and the vocabulary that goes along with that.*

> *They enjoy the e-books [e-readers]. I love sitting two children together to read the books. It talks about science and gives them real pictures. Not just the cartoons. Real images.*

> Hero Elementary *is very accessible so they can go from one playlist, activity to another. They love that, because they want to go back and complete later — to not always be working in one specific activity or area, to make it more fun. In the beginning, we tried all the kids working at the same pace, but some were*

ahead and some behind, so we gave them a break and then started with a new assignment [playlist].

Challenges Related to Hero Elementary *Implementation*

High-speed internet connectivity was noted as an ongoing challenge at some sites. In addition, while students generally loved using the Science Power Notebook, as noted above, educators sometimes found it difficult to keep students engaged in a meaningful learning activity while using the Science Power Notebook. Educators also shared that some of the games were confusing for some students to learn how to play. On the other hand, educators mentioned that occasionally children on the older end of the recommended age range needed more of a challenge.

> *They love the camera and video — I have to keep them on track to type and write, not just take pictures — they have to learn something about science.*

> *Sometimes the games are confusing. It is easy to watch videos and take notes, use camera, but they need help with the games, and I have to go back and get my tablet and play a little bit so I can explain to them how to do it.*

Depending on the size and composition of the class, educators reported it could be very difficult to implement certain activities with the sound of the tablets playing simultaneously. Some sites circumvented this issue by ordering inexpensive headphones for the students to use. For Program 4, students had successful experiences when educators decided to use the interactive whiteboard for activities like the *Critter Collectors* game and the Science Power Notebook. The class could observe a fellow student successfully navigate the game or task on the interactive whiteboard. This helped all students better understand the functionality of the tablet as well as how to approach the *Hero Elementary* activity. Educators described these students with disabilities as being eager to play other *Hero Elementary* games on the interactive whiteboard and tablets after that initial positive experience.

One of the educators for Program 4 shared that it was sometimes challenging for students with disabilities to grasp implied messages in the videos.

> *So, the use of subliminal messages may not be the best way of teaching these students. For example, when the characters walked into the movie theater during one video, they were like, 'Oh my gosh, everything looks silly.' If they directly said like, 'Oh, it all looks melted,' that might be beneficial.*

Educators of English learners mentioned that it would be helpful to have bilingual access for students to use the playlists. They shared that while it is helpful that the program is in English to support second language learning, it would be helpful if at least some of the features were available in Spanish.

> *When they have the option to choose Spanish [in other applications], they will go back and forth, just for them to get that knowledge in both languages. Or maybe when you press on the animals or the characters, just to have it in Spanish, as well, and not for them to be asking [the meaning of words in English], because sometimes they're embarrassed because maybe younger kids know more English than they do.*

During virtual implementation, up to half of participating students were not able to log in to their *Hero Elementary* accounts on their tablets due to lack of support. Additionally, during virtual Zoom sessions with their class, students had to use their tablets to access Zoom, so could not access *Hero Elementary* from home during class time.

Impact of *Hero Elementary* on Student Learning and Engagement in Science

Educators overwhelmingly agreed that *Hero Elementary* educator materials, along with the engaging playlist activities, support science learning for their students. In interviews, educators described examples of student learning and mentioned possible mechanisms for *Hero Elementary*'s success.

> Hero Elementary *is [effective], because they've broken it down for the teacher to be able to explain, "Hey, you say this here." And the kid is going to say this here. It tells them what to say. Even if they have to like, explain it further. I think the kids are understanding, but they understand because it's easy.*

> *For [the playlist] "Parents and Their Young," just being able to show them different animals, bringing in*

> *stuffed animals or toy animals, and hiding them, having to go out and find those animals that have those [characteristics]. We discussed the characteristics of the parent and the child. How do you differentiate between the two? And how do you know that child belongs to their parent? And just going out bringing those toys out and them having to go find that parent that goes with their child. I think it brought a more balanced [understanding] to those, even though the animal may not look like it, but 'Hey, this is that parent to that child.' So, they were able to grasp that concept of it.*

> *When you're asking them questions about, like the hot and cold, what's going to melt or what do they think.... They give good answers. They get it.*

A majority of educators mentioned seeing evidence of science learning with their students.

> *I think they are learning new things and I think it gives them the opportunity to apply what they already know and still learn new things.*

> *Mine are [learning].... I think when they get in the older grades, they might think back, "Oh, I remember seeing that in* Hero Elementary*."*

> *As far as the educational aspect of it, they are responding because they not only see it, they're getting an opportunity to get involved with it.*

> *They're getting involved with it to try to build up a vocabulary of science. We're still in the initial stages of it. But I have heard a little bit of the scientific language trying to evolve.*

> *That kind of language, I try to keep going the whole time. Because it's a lot easier if it's a normal way of speaking. It's how we speak to one another.... It could become a part of the daily conversation. We're in story time. I can still use those words, observation, conclusion, determination. It's just become a norm ... and they don't realize they're actually in it.*

One educator described a discussion she had with her students related to the "Parents and Their Young" playlist.

> *We were talking about the characteristics, I heard her [a student] talking about the "characteristics." I said, "I know what your parents look like. So, [what's] one of those characteristics?" And for her to say, "Well, my mom, she has my ears. She looks like me." Okay. So, I think they understand. They can put things together.*

One educator said that students are bringing science knowledge they acquired from *Hero Elementary* back to their classroom. An administrator mentioned, "At some of the school sites, teachers can even tell you more, how it's entering into the environment of the school curriculum." Three educators specifically mentioned their students use vocabulary words they learned from *Hero Elementary*. One educator mentioned she is using *Hero Elementary* vocabulary in other interactions with her students and that "students are using the vocabulary."

Hero Elementary *Support for Science Learning in Early Grades*

Our analyses also showed that for many students who have little or no science instruction at school, *Hero Elementary* can help prepare them for later science learning. Several educators mentioned that science was not taught in the early grades at their school. They were appreciative that their students were engaging in *Hero Elementary*, mentioning that the science they were learning now, in an engaging and grade-appropriate format, would facilitate learning when they encountered science content in later grades.

> *Math and reading are great, but science is ... important as well. And I think that the STEM piece is [important].*

> *[The teachers] are focusing on reading and math. [*Hero Elementary*] gives [students] a hands-on experience with the science, and more of the science activities.*

> *I think [science] needs to be given to the younger children even though they might not be catching it in class, because we're not, to me, emphasizing it that much in the school, because they're not giving grades for stuff.... I know they need to know it when they get older....*

One educator, who was also a classroom teacher, mentioned that *Hero Elementary* has prompted her to incorporate science vocabulary introduced in the *Hero Elementary* program and teach more science in her formal classroom.

> *I try to bring in some of the scientific aspects of what we're doing in* Hero Elementary. *So, the kids are gradually learning the language. Things like "observation." When I'm working with math or English, I use the word observation. What do you observe? What do you see? Okay, we're in this math scenario. What do you think would possibly be the result of it? Observe it, think about it, put it into action. When the answer's not correct, it's okay, let's just go back and experiment a little bit more. Those kinds of little things that they can be touched with.*

Hero Elementary *Alignment with NGSS and Classroom Science Instruction*

For students who do receive science instruction during the regular school day, *Hero Elementary* often reinforces the science they are encountering in their school classroom. Several educators mentioned that their students reported that the science they were learning in *Hero Elementary* was similar to topics in science they encountered in their school curriculum. These educators saw this as a strength of the *Hero Elementary* program.

> *[In discussions] they start to come up with their own ideas too and they relate it to school and things that are going on in their classrooms … might [be] similar.*

> *For them to see [the academic content] again, in a different perspective, kind of sets them up for success. Like, "Oh I know about that." The one that we're on now is "Plant Parts." Well, currently in Kindergarten, I know for a fact that they're on plant parts.*

Another educator mentioned that she was able to have students recall science knowledge they had learned at school while engaging with *Hero Elementary* playlists.

> *I was trying to kind of make the first ones [playlists] easy, I don't want to use the word easy, but just set them up for success, something that would activate prior knowledge where we could have a discussion. They could tell me something that they already knew, and also if they discovered something new.*

Impact of *Hero Elementary* Design Features on Student Access to Science Learning

This section describes findings related to the study's questions 1 and 2, below.

1. Do the design features of *Hero Elementary* support access to science learning for K–2 students, including those identified to have moderate cognitive disabilities, English learners, and those that are socioeconomically disadvantaged?
2. What adaptations do educators make to *Hero Elementary* that are intended to provide greater access to the content for their students? How do adaptations differ for different types of student populations, specifically those with moderate cognitive disabilities, English learners, and those that are socioeconomically disadvantaged?

As detailed below, results of the data analysis suggest that the equity- and accessibility-focused design features of *Hero Elementary* resources facilitated students' access to academic content and to engage in science learning. The evidence suggests that when implementing *Hero Elementary* in person or virtually, educators used and made adaptations to *Hero Elementary* learning resources in ways that provided greater access to science content for their students.

Reported below are results around a) how *Hero Elementary* design features support students' access to the science content, related to the *Transformative Transmedia Framework for Early STEM Learners*, and b) educator use and adaptation of the resources related to the *Equity Strategies*. Findings related to the following *Hero Elementary* design features are discussed.

- Connecting science to children's "sense of place"
- Building STEM identities and connecting to cultural knowledge and experiences

- Incorporating real-world, hands-on experiences
- Providing flexible learning experiences with multiple representations
- Facilitating discussions about science
- Supporting science learning by connecting to home and community

Connecting Science to Children's "Sense of Place"

The majority of educators interviewed mentioned that they appreciated that the structure of *Hero Elementary* allowed them to connect science learning to their surroundings. The design of the activities in the playlists allows for the use of objects in students' surroundings that they will find familiar, while affording them the opportunity to explore common natural phenomena. One educator provided a description of how the design of *Hero Elementary* activities allowed for a rich classroom discussion of the behaviors of local wildlife. The discussion referenced a *Hero Elementary* episode in which *Hero Elementary* characters encountered wild animals in their environment.

> *They talk about the babies, the animals and their babies, you have to think about how their mom takes care of them and protects them. And then some of them talked about their pets and someone brought up about … the video with the possums — if you leave things out, feeding the animals and they come around, you might be afraid of them. But you know, if you leave things like that out, they might come around, but they're not trying to harm you. They're just trying to eat just like when [the kids are] hungry.*

The majority of educators interviewed and observed in the study mentioned that, while implementing *Hero Elementary*, they purposefully connected their science learning activities to students' communities and neighborhoods. A typical comment from one educator describes how *Hero Elementary* content is tied to students' local environments: "We talk about the community, our neighborhoods we live in. We do that when I talk about science, how this is the area we live in, this is our neighborhood."

Educators reported that when they implemented *Hero Elementary* in person, they often visited locales important to their community, such as community gardens and parks. Educators also mentioned that they strove to integrate their activities with students' lives, including, according to one educator, "… their social, their emotional, their historical, their environmental, their physical … every aspect and every environmental circle of the child."

Another educator mentioned that she realized how important their community garden was in connecting the students' science learning to the community and students' families. While implementing *Hero Elementary*'s "Plant Parts" playlist, this educator referenced their community garden. When the program moved to distance learning, she continued to reference the garden, sharing photos with the students and discussing the plants currently growing there and how the garden benefitted the community.

> *[We talk] about things in the community that will help [them]. Such as gardens because we have a garden here. And so we talked about things like that, things in the community that will help sustain the community. When they were face-to-face, they helped to grow the vegetables outside, but now they can't. But we try to still show them the garden and what's growing out there and keep them engaged and let the parents know that they can come back and get vegetables and things.*

Educators sometimes took local context into consideration when choosing *Hero Elementary* resources to implement. For example, an educator chose to implement the "Heating and Cooling" playlist, thinking that the kids would relate to the content since their locale is generally quite warm.

One educator shared that *Hero Elementary* makes science more relatable for students with disabilities. She said that being able to watch the videos and see relatable characters making sense of science phenomena in familiar contexts supports learning for students with disabilities.

> *Like [AJ, the* Hero Elementary *character], he has autism and it's very well known in the show that he has autism like, "Oh, I don't like loud things. I don't like when things are a certain way," or stuff like that. And so being able to watch that and see, and them getting over their fears and us acknowledging it, I think it*

> *just overall, it makes science easier for us to teach to them just because it's adaptable to their needs.*

This educator also discussed how *Hero Elementary* supports making connections to their community.

> *And when we're talking about building buildings and using the blocks that they play with every other day, like, "Oh, this is something that I play with every other day. And I'm in a building now, this is how it was built." And so being able to adapt these lessons into using, connecting it to the community, as well as connecting it to what they do here with us, makes it easier for them to connect that it's science. Small group was also learning in school about community helpers, it's like building police stations and things like that. When we did the five senses we talked about, "Oh, what are you doing at home? What are you feeling? What are you touching?" And things like that.*

Building STEM Identities and Connecting to Cultural Knowledge and Experiences

A culturally competent, asset-based approach to science learning enables students to gain confidence as doers of science, while embracing their other diverse identities. All educators mentioned how the *Hero Elementary* characters' personalities, strengths, and challenges allowed for their students to deeply connect with the characters, enhancing students' motivation to engage in science learning activities. Several educators described how their students became interested in *Hero Elementary*'s narrative, and how it motivated them to engage in science and talk about their observations.

> *I think it is because when I first began the program with my kids, we made a character connection. Well, I made a character connection with the kids, and that, "Who would you like to be?" or "Who touches you the most, and why?" So, each time the kids are looking forward to whoever they chose while watching the others. So they're involved with, "Wow, Sarah did this," or "Danny Bubble did this." And I keep the kids connected with that character so they [notice] the response of each of them.*

Nearly all educators mentioned that *Hero Elementary*'s characters, as well as their activities and environments, were relatable to their students because the students could see themselves in the characters and the settings.

> *I like that it has the different characters, and they feel like, "Oh, that looks like me, or, that acts like me."*

> *I really like the characters that they put in [*Hero Elementary*] — very age-appropriate and they look like little kids, too. So maybe that's why the kids love them, too, because they can relate to them.*

> *You have a diverse group of characters that you can talk about within the lessons and they can see, and it talks about [their world]. They can see themselves in the characters … they acknowledge it and see it.*

> *I think they like seeing the* Hero Elementary *[characters] who look like them. I think they like the fact that they're kids [the* Hero Elementary *characters] and they're at school. Because they are the Sparks' Crew [*Hero Elementary *cast] and they're in school like them and they're little kids like them and they're still learning how to do stuff just like them.*

Educators shared that the relatability and resilience of *Hero Elementary* characters was particularly important for students with disabilities.

> *I would say one of the good things that I noticed they liked, they like the diversity of the characters, I know sometimes. Like how [AJ, the* Hero Elementary *character] has autism, they see that, and they recognize, "Oh, he doesn't like the leaf blower, I don't like the leaf blower either." And so things like that they're familiar with and they enjoy.*

> *And seeing the characters overcome things that they're afraid of or things that they're not comfortable with is great for our kids. So anytime they can see that and see an example of somebody like they see this guy [AJ], and [Lucita Sky], she can fly but she's afraid of heights. And then there's several different instances where you see her overcoming that fear. So for them to see that, that's a great thing.*

In addition, educators frequently reported connecting *Hero Elementary* hands-on science investigations to students' lived experiences at home, in order to support development of STEM identities by showing students that they participate in science daily.

> *We ask them about their day. We asked them, "What did you do today?" "So, we helped our mom." They love to help their mom. "We helped our mom cook today." "Really. So what involvement, what was the procedure, what did you use, what did you find out about it? What was the result?" Those kinds of things that are keeping their consciousness. What they don't realize is* Hero Elementary*, along with their environment, [is occurring] at the same time.*

Incorporating Real-World, Hands-On Experiences

Providing authentic and hands-on science experiences is also an important part of building students' STEM identities. References to and opportunities for such experiences are strongly incorporated into *Hero Elementary* playlists, which may facilitate student engagement in science learning. A majority of educators shared that the program prompted students to think about real-world examples of science phenomena that they had experienced in their lives. One educator provided an example of how *Hero Elementary* facilitated rich discussions with students around local phenomena they could observe locally, such as the behavior of wild animals.

> *Just showing them the different animals and how they have to fend for themselves and all that. They wouldn't normally get that in an [afterschool] setting with what we [usually] teach them. It's giving us that way to show them that "Hey, this is what these animals go through."*

Several educators mentioned that the design of *Hero Elementary* allowed for afterschool educators in their program, who often do not have the resources to implement experiences requiring extensive set-up and equipment, to implement real-world and hands-on activities. For example, one educator mentioned the ease of conducting an investigation on temperature and states of matter when implementing the "Heating and Cooling" playlist.

> *How we're doing "Heating and Cooling." [*Hero Elementary*] is another way to do it here. Because I'm not going to go in and [conduct an investigation], bring that into the program. But just the way they [the* Hero Elementary *resources] present it, it's different. And it's reachable for those students.*

Educators also mentioned that the real-world, hands-on activities made science learning particularly accessible to their students. One recounted a *Hero Elementary* activity from the "Plant Parts" playlist she implemented with her students.

> *… we had the kids going out, looking for the different plants and identifying the different parts of a tree or whatnot …We planted a flower garden in our center. So, they actually got a chance to look at the different parts of it, observe it and plant it. And then they started seeing how it was growing. "Hey, I need to add the water to it." "The sunlight is helping the stem get the nutrients for the flowers to bloom." So I think that it's reachable [for students] because of the activities that are presented.*

The program coordinator working with students with disabilities related a relevant insightful anecdote about the value of hands-on experiences:

> *We did the one that was the wiggle wobble balance. And so that one, it was an activity where you're racing to build a tall tower right after we watched the video. And so in the video, it says, the ice cream that had the wider bottom was able to stay standing and stay stable versus the ice cream cone that's a triangle. And so having them go against each other, one student, he was very focused. He's very excited, like, "Oh, yeah, we're building. I'm going to build the highest tower." The other student she was, "Yeah, we're building a tall tower, but it has to be stable." And so, she understood that, "Yes, I want to be the tallest but I also want to be the sturdiest."*

Providing Flexible Learning Experiences with Multiple Representations

Flexibility in learning environments and approaches, and providing multiple modes of delivering content, are key to ensuring that all learners are engaged, and their individual learning styles accommodated. Although the developers of the *Hero Elementary* resources designed them with a suggested order within a playlist in mind, they recognized that they could be sequenced with flexibility by the educator, depending on classroom circumstances and student needs. All educators interviewed expressed appreciation that the *Hero Elementary* resources were adaptable and accessible to engage a broad range of students, either through the direct use of

the resources, or by allowing educators to adapt the resources for the needs of particular children.

> *I really believe that it hits them all. It hits all levels because if one, say, like my [student who is autistic], he's a high-functioning autistic but autistic in general. I think he understands what they're doing.... He's second grade. He enjoys the hands-on and the games. So, I mean, it reaches each kid at their level.*
>
> *The lesson plan is all planned out, even down to the time, the minute, the second that you can do it. And it's flexible [so] that you can put this on one day, then change it up.*
>
> *Everything's there, you don't have to add. Of course, like I said, with the scavenger hunt and all those things, you can add things, but you don't really have to.*

Educators emphasized how the range of different activities and multiple representations of key concepts engaged students with different learning preferences and abilities.

> *It was particularly great for them to have five different types of activities, each that appeared to be helpful for different students, like those who are ELL, have IEPs, or are visual learners and kinesthetic learners, the ones that really like the hands-on activities. They can see the content in different ways, in different modalities.*
>
> *I liked the organization of it and the flexibility of it.*

Educators of students with disabilities noted that hands-on activities are particularly important for this group. For example, the playlist activities related to touching materials after state changes have occurred (e.g., ice to water) engage these students in the lessons. In addition, educators reported that *Hero Elementary*'s flexible and scaffolded design allowed them to involve students of different ages and abilities in different ways, providing access to science content at many levels simultaneously. This feature is particularly important in nonformal education settings that often serve multiple age and ability groups in less-structured environments. An educator mentioned that the older and higher-achieving K–2 students were deeply involved in science investigations and other hands-on activities, while younger students sometimes needed more support.

> *My [high achieving] kids, they enjoyed the more hands-on things. And then we have my middle kids. They want to do the hands-on, but they get frustrated, and they want someone to sit down next to them and, "Hey, help me with this here." They all enjoy working in the program. But yes, there are different, like, levels to it.... It has that range and is understandable.*
>
> *I wouldn't say it's too challenging, more of the ones with the attention problems [can be challenged]. It hasn't been too challenging. I think the program is so engaging for them that they like it.*

Another educator mentioned that the professional development provided by TPT allowed her to plan adaptations, including accommodations and modifications, to best present the learning materials to her broad range of students.

> *A lot of the materials given to us early on helped us get started. It gave me, "Oh okay, okay," and then we also would look at some of the playlists and try to see how we can make it ... fit our kids.*

Another educator mentioned she is constantly adapting the resources for her student groups, reporting, "We just keep structuring it as it goes."

Facilitating Discussions about Science

Facilitating discussion and reflection are key to all *Hero Elementary* activities, ranging from discussion following viewing of the videos to reflection questions posed to students during the hands-on investigations. A majority of educators mentioned that the design of the *Hero Elementary* resources supported them in making decisions around when to start discussions and how to prompt students to think and reflect, guiding them to effectively lead discussions. They also mentioned that the enjoyable activities and *Hero Elementary* narrative boosted student engagement in their discussions.

> *We give them an open discussion time and implementing the questions that we have from what [the* Hero Elementary *educator materials] has written out for us, and we address those questions to the kids to just give them an opportunity to express what they think. They're ready. They're just ready. They're full of*

> *energy, they're full of conversation.*
>
> *There's a curriculum that goes along with the video. So, we basically just talk about the "Superpowers of Science," and we just go along with the guide and then they might come up with some things that they are thinking, and we just discuss their thoughts, expand on their thoughts too.*
>
> *The playlist prep also gives us words and definitions and it gives us questions. There's even time-stamped [pause and discuss] questions of like, "When you get to this point you can ask this." So, everything is provided.*

All educators mentioned regularly engaging in rich discussions and reflections with students related to the science topics they encountered while using *Hero Elementary*. Educators reported high levels of engagement in these discussions.

One educator described a typical discussion session that occurred during a hands-on investigation.

> *We used foil, or plastic paper, cardboard, and other different textures, and we talk about their properties. So, when it was time to rip the aluminum foil, we just asked them for their input. What do you think will happen? Why do you think this will happen? … She ripped up her foil paper and she went, "I knew this was not going to work because this is just too thin." … when he had the cardboard, he took it and he went, "This is a little harder." And then they interact with one another telling each other why this was and that wasn't, which is really encouraging … They came up with more materials. Like when they did the raincoat lesson, other than the materials that were there, they started coming up with ideas of how other materials that you can come up with to make a raincoat and how to make it better. I think all of them have been engaged in it … because we make sure that every child gets a chance to participate and answer questions or tell their thoughts, what are they thinking, what do they think can happen next.*

Supporting Science Learning by Connecting to Home and Community

Nearly all educators mentioned that they were able to connect resources in the community with *Hero Elementary* activities and that this connection enhanced learning experiences for their students. Hero Elementary was designed to be used by educators and students in the classroom as well as by students and their families at home. Most educators mentioned they provided parents access to *Hero Elementary*'s parent website, a design feature that allows parents to learn about *Hero Elementary*, support their child as they learn with *Hero Elementary* and follow their students' progress.

> *For Hero Elementary, we've given the parents their access so they can look and see what some of the things are that we're doing…. [Our program] does try to incorporate the parents. For* Hero Elementary, *we … give them access to the playlists, the website, things like that.*

One educator said she sent home artifacts that would prompt a discussion with the student's family.

> *And I think the important thing is, our kids aren't the kids that go home and say, what they did today. So how do we send something back with them so that the parents can engage in the conversation with them? Like, "Oh, you did a science project today. You talked about pumpkins." Something that we can send to them so that they know. Because they're not going to go home and say, "Oh, we learned about X, Y, and Z." I can't even get out of them what they ate for lunch.*

One educator mentioned plans for additional parent participation using *Hero Elementary* parent resources.

> *[We will] probably do more family-oriented projects, something that the parents can work with the kids on. Say, okay, like the flower garden, maybe, doing a flower potting at their house and watching it grow together. So maybe just offering ideas where the family can do a project together.*

An educator described how she took advantage of community resources to enhance the science learning activities students were engaged in in their afterschool environment.

> *We would look at … how we can bring in community. Because that was one of the big things [for us], the community. We were talking maybe [connecting] the plant ones [playlists], or the animal ones, having someone within the community come in. Now, a [local organization] comes in and helps them learn about the plant life cycle and how to plant things. And then once they grow them, they get to cook and eat them.*

> *And then we've had field trips. We've gone to some of the wildlife reserves. So just about how to bring in the community. That was very helpful.*

Another educator mentioned that a partnership with their library allowed students to reflect back on the animals they had encountered in their classroom as they were completing the "Young Animals Live and Grow" playlist.

> *We have a partnership with a library, and they brought in some animals to our center at one particular time. And just reflected back on those animals that were brought in. So they know, they have some kind of idea of what animal I'm talking about.*

Educator Modifications and Adaptations of *Hero Elementary* Related to Students with Disabilities, English Learners, and Socioeconomically Disadvantaged Students

Data analysis highlighted the variety of ways that educators modified and adapted *Hero Elementary* to support their learners. Educators agreed that the flexible design of *Hero Elementary*, and the professional development they received, facilitated adaptations they made during instruction and that these often resulted in student engagement in learning, particularly for students with disabilities, English learners, and socioeconomically disadvantaged students.

Students with Disabilities

The findings suggest that *Hero Elementary* features, designed to promote access to science learning, can be used successfully to engage students with moderate cognitive disabilities. Nearly all educators who taught students with disabilities appreciated the accessibility features of the resources, as well as the variety of choices available in planning *Hero Elementary* lessons that allowed for choosing playlists and activities that were best suited to students' cognitive abilities. For example, an educator shared that students with disabilities exhibited greater facility to understand and relate to the more concrete content of the "Animal Parents and Their Young" playlist versus the "Pushes and Pulls" playlist, which includes more abstract concepts. The educator reported that students seemed to connect best with tangible, familiar objects or concepts from their own lives, such as the fruit or vegetables in their lunchbox (e.g., in the "Plant Parts" playlist).

The findings suggest that educators' adaptations of the resources, including accommodations and modifications, provided students greater access to learning content. In addition, the design features of the resources supported opportunities for students to engage in the science content more deeply. Analysis showed that educators made adaptations to *Hero Elementary* in response to students' individual preferences, abilities, mood, and perceived energy level. This generally meant that children worked as a class on different playlist tasks, rather than being paired with another student or working in a smaller group. By having some children work with an aide, the educator could better lead the class, as well as help students one-on-one and provide intensive scaffolding on playlist tasks.

Flexible Learning Environments and Multiple Modes for Learning

The flexibility of the *Hero Elementary* format allowed educators to adapt and improvise activities as needed. Multiple representations and formats of the science content allowed students to choose activities most suited to their abilities and learning styles. Being able to return to parts of a playlist to review and revisit content helped to reinforce the learning; educators were better able to elicit responses from students to questions about the content on the second exposure to new concepts and ideas. The adaptability of the curriculum also allowed for making changes depending on students' mood, preferences, and energy level. For instance, some highly active students were allowed to eat a snack while watching the *Hero Elementary* television episodes, providing for deeper engagement.

> *Those kids that learn better using different learning styles, it attributes [*Hero Elementary*] all in there and you can scaffold that pretty easily because the lessons are pretty laid out. So if you need to make it a little bit easier, there's ways to do that or to add a little bit more to it. So I think it's just really nice to have that ready for you, ready to go, you don't have to create it. And it's integrated with the videos and the games.*

The degree of interactivity of the *Hero Elementary* resources is critical to hold the attention of these students and engage them in the content and to help them demonstrate their knowledge. One of the administrators observed, "There's many different ways that they can be engaged in the subject matter. And so, that's just going to pull things from all the kids with different abilities." Another administrator added, "Especially for our kids that aren't as verbal. So, they know the information, they just may not be able to tell us. So, they'll be able to show us through their interaction with the game or different things on their knowledge."

Educators serving students with disabilities shared that a key strategy for facilitating student learning is maximizing exposure. *Hero Elementary* affords the opportunity to engage students in things they might not be exposed to, which is a great advantage for them. An administrator commented that it is important to never put a limit on what students can achieve and that exposure can help reveal students' interests.

> *I would never want to just say that I think that they couldn't do any one thing … You just never know with kids, especially our kids, they just will get an interest in something and become so into it and want to know everything about it. And you never know what that thing is going to be. You never know until you try to do something.*

Analysis of observation and interview data suggested that some students with disabilities displayed hyperactivity and would move away from a task or become overstimulated, while other students were more passive and often did not engage unless continuously prompted. Educators mentioned that the multiple representations of concepts and wide selection of playlist activities, and the ability to adapt them, helped them to engage students while they moved from child to child providing individualized support, continuously supervising each student to ensure they stayed on task. Educator accommodations allowed students to frequently redirect and reengage in the content to experience science activities and concepts, despite some time spent off-task.

The educators were mindful about various sensitivities of the students and understood that they needed to occasionally modify lessons to avoid problems and allow some students to participate. For example, in the "Five Senses" playlist, students use their senses to determine how something will taste. The first time this playlist was implemented, one student reacted very strongly to tasting something sour, while others could not be persuaded to try.

Use of an Interactive Whiteboard as an Accommodation

Due to uncertainty about students' ability to implement *Hero Elementary* on tablets, educators serving students with disabilities in Program 4 (an education center for students with disabilities) initially implemented *Hero Elementary* in a whole-class format using an interactive whiteboard. The students viewed the videos together on the interactive whiteboard and participated in class discussions about the content of the lesson. While some students had difficulty with the small motor skills needed to operate the tablets, and others had trouble remaining focused and on-task while working independently on a tablet, the introduction to *Hero Elementary* using the interactive whiteboard enabled most students to successfully transition to using the tablets for the games and other digital activities, including the Science Power Notebook.

> *Because some of them need some one-on-one assistance to follow the directions of the tablet. So being able to use the interactive whiteboard to help transition them into the tablet is a lot easier to [show] them.*

When Program 4 first used *Hero Elementary*, educators found that students tended to fidget with the devices while holding the tablets and often clicked out of the *Hero Elementary* web page, stopped the video, or quickly advanced through the pages of the e-reader. Having these students use the tablets necessitated headphones while listening to the audio to help keep them focused on the activity. Another educator used the interactive whiteboard for the videos, and she transitioned most students to the tablets for the games and other digital activities, including the Science Power Notebook. An administrator elaborated further.

> *One of our older students was working on the interactive whiteboard with the Notebook and he was just so excited to be able to do that and so excited that he could figure out what to do and that's really helped. Using the interactive whiteboard really helped a lot of the kids to understand what it was that they needed to do and it's really been a good thing as far as for them all to be involved in a group discussion … Because some of them need some one-on-one assistance to follow the directions of the tablet. So being able to use*

> *the interactive whiteboard to help transition them into the tablet, it is a lot easier to tell them [how to follow directions].*

At the same time, a student with a physical disability was able to use the interactive whiteboard successfully for the games, and the educator felt that this student had been drawn in more to the game by bringing him up to the interactive whiteboard rather than leaving him to struggle to use the tablet. Quite a few students had difficulties with small motor skills, so the interactive whiteboard offered an alternative to allow these students to fully participate in the activities. It also served for some as a way to transition to the tablets. Overall, educators expressed that *Hero Elementary*'s flexible design allowed for them to make implementation decisions to best facilitate successful engagement for individual students with disabilities.

Adapting Hands-On Activities

Nearly all educators who had students with disabilities mentioned making adaptations to *Hero Elementary*'s science investigations and other hands-on activities to provide students greater access to science content. One educator felt that replacing the materials in the "Heating and Cooling" lesson with objects that students could better relate to (such as an apple) would be critical to engage them with the curriculum.

> *And so I think having familiar items caused them to be like, "Yeah, I'm interested in this and all these things are happening." And even when we got to the Science Power Notebook, I was like, "Okay. Well, what happens to the apple? The apple was red but now what color is it?" So even drawing that they were like, "Oh, it's red and now it's brown." And so, they were still engaged throughout the entire lesson.*

In the "Animal Body Parts" playlist, another educator used the "Parts of an Animal Body" Science Power Notebook activity to engage students in creating a book about spiders for the class. For another playlist, the educator facilitated an art project.

> *And then it was like, "Okay, what does the spider look like? What's the spider's lifecycle? What's that look like?" And they were drawing that themselves and I, myself, did my own at the front of the class. And I would draw mine like, "Here, this is what a spider looks like. Now you draw your own version on your page." And we did that and they seem to really enjoy that whole process. And we added a project to the building one [playlist] with the buildings. After they created their tall towers, they made art projects of towers where the windows were aluminum foil and then they cut out rectangles for the buildings and they all glued it together to create their own cityscape.*

At Program 4, an adaptation was observed during the hands-on investigation for the "Heating and Cooling" playlist. Rather than having students complete the activity in pairs as suggested, the staff implemented it as a group discussion given the small size of the class. They used chart paper to write down lists of what the students thought was going to change when the material was cooled. In addition, when one of the educators had read through the investigation protocol and considered the abilities of their group of students, she thought they should show the video and then carry out the investigation. However, since the activity involved ice, she wanted the students to sit and wait to watch the ice melt. So, she decided to introduce the activity first, and then show the video during which the ice had time to melt.

One educator employed one-on-one classroom aides in order to assist students with cognitive developmental delays who needed individualized assistance. This freed up the educator to lead the activity, which was particularly important to facilitating hands-on science investigations. The educator explained the importance of this support.

> *So I think the more help we have in there, the easier the lesson definitely goes because the more that they can have one-on-one help with what we're doing, the better it is.*

In observations, researchers noted that students with disabilities often struggled with following series of directions in the *Hero Elementary* activities. Educators facilitated success by providing simplified directions for students to complete tasks one step at a time. Educators also demonstrated and modeled the activities for students and continuously provided verbal cues and redirection as students completed each step.

When considering adaptations made by educators, researchers noted instances when educators specifically made accommodations and modifications to support students with disabilities in accessing the content. For

example, one activity in the "Plant Parts" playlist involves placing a leaf under a sheet of paper to create a leaf rubbing and reveal the pattern in the leaf. A student initially had difficulty with this activity, reportedly due to sensory processing differences and motor challenges. The student struggled to use colored pencils to lightly shade and reveal the leaf shape. The educator provided an accommodation that had the child take a picture of the leaf using the Science Power Notebook and examine and discuss the photo.

Multiple Representations to Engage All Learners

Repetition can afford increased exposure to the concepts and scientific questions included in every lesson, which may help students to remember those concepts better. Nearly all educators serving students with disabilities attempted to implement multiple activities in order to reinforce the science content and make the afterschool program even more enriching for students. One of the administrators commented, "It's probably one of the most engaging [programs] that I've seen for special needs kids in our community." She felt that the "Superpowers of Science" questions, aided by the flexibility of the playlist order, helped educators meet students where they were and adapt the curriculum in response to students' interests.

Analysis of observations and interviews suggests that e-readers were particularly engaging and informative for students with disabilities. Educators could launch the book for the class (either on a tablet, working directly with a small group of students, or using an interactive whiteboard with a larger group of students), while having a lively discussion with the students and asking them questions. Even students with significant attentional difficulties were able to focus on the activity and the images. Students were able to relate to recognizable themes and objects in the e-readers.

One educator recalled being unsure about how engaged her students with disabilities would be when first implementing an e-reader with the class. Her instinct about modifying how to make use of the e-reader proved to be apt. She paused before clicking "play" to set up the activity and reported asking, "'Oh, what do you think I'm about to press play on? What is a solid? Do you know already?' And some already had the answer, 'Oh, this is a solid, I'm a solid.' 'Okay, well, let's learn some more, this is exactly what a solid is.'" The educator shared that this experience encouraged her to incorporate the e-readers more into her lessons. She appreciated having additional reading activities, as reading with the children was a focus in the afterschool program.

When implemented with students with disabilities, the Science Power Notebook activities took on additional significance, as they provided needed fine motor skill building for some students. One educator shared that students were able to draw pictures if she first drew something for them to copy, and that this served an important purpose, even if it was not the intended goal of the activity.

> *And so, because just to work on those motor skills, because not all of them are good at writing or holding the pencil. And so being able to use their finger, it will help them with the wrist motion of writing. And so as long as they're following along, and using the same color, if I'm drawing a red apple, like, "Oh, you draw something." And then sometimes they draw, it's scribbles, but they will point to it and say, "That's my apple." So, they know what they're trying to do. And that's the main thing that we're trying to go for is like, "Oh, I'm drawing a picture with the purpose."*

STEM as Literacy: Language and Vocabulary

Another frequently observed adaptation for students with disabilities involved educators adjusting their language with students to provide more simplified instructions and explanations than indicated in the *Hero Elementary* materials and guidelines. For example, one educator was observed adapting the suggested discussion question, "How are the two plants the same, or how are they different?" to "What color is this one? Red. What color is this one? Green. Okay. This one's red, this one's green. Are they the same or are they different?"

Findings suggest that students with disabilities required less advanced vocabulary to understand concepts. For example, when discussing plant parts, the educator avoided words like "midrib," and used more familiar words, like "stem," "leaf," "branch." One educator explained that as *Hero Elementary* is designed to get students into a questioning mode with respect to science, simplifying vocabulary facilitates meaningful inquiry dialogue with students. In addition, the analysis showed that educators framed lessons around things students could relate to directly in their own lives.

English Learners

All educators reported that their English learners were able to successfully access and engage with all aspects of *Hero Elementary* content. The findings detailed below describe how educators used and adapted *Hero Elementary* for English learners and how the equity-focused design features of *Hero Elementary* resources facilitated engagement of English learners in science and literacy learning connected to their lived experiences.

Language and Literacy Support

Educators appreciated that *Hero Elementary* supported their English learner students in building both English and literacy skills. The videos and e-readers were particularly mentioned as being helpful in this regard. Educators shared that they made efforts to incorporate new vocabulary from *Hero Elementary* into their direct instruction to reinforce literacy learning and science concepts in English. Educators also shared that English learner students looked to their bilingual peers for guidance and were encouraged and supported by them. These peers often translated for classmates who needed help understanding instructions and content, and students encouraged each other to master activities and move through the playlists.

> *One student had [a] very difficult time learning English, and watching the videos and reading the book, it helped her a lot. She was able to speak a little better, was able to recognize letters.*
>
> *We try for [educators] to explain to [English learners] in Spanish and in English for them to know the definitions and for them to understand. We try to make them more fluent in English, and for them to not be so embarrassed of their accent: "It's okay. Let's practice with each other."*
>
> *Or sometimes we have some other students that are a little bit more fluent in English tell the others what a word means. We try our best to be repeating and repeating and they will go with their parents or grandparents and tell them the words they learned that day and you can hear how happy they are.*

Flexible Learning Environment and Experiences

Educators reported that the bilingual peer support for English learners mentioned above was sometimes intentionally facilitated by grouping bilingual students with English learners or grouping older and younger children. In addition, educators sometimes facilitated whole-group *Hero Elementary* activities, such as watching a video or reading an e-reader together and then talking about what they learned. In general, educators ensured that individual needs were met through flexibility around whether students used *Hero Elementary* individually or with a partner, and through availability to support students one-on-one, as needed, and to engage students in whole-group viewing and discussion. Whether using *Hero Elementary* individually or in pairs, students engaged in social learning, sharing their experiences and assisting and encouraging each other. In addition, educators appreciated the flexibility allowed by the program for students to choose playlist activities that they found most engaging. For example, some students' learning styles and capacities lent themselves more to engaging with the hands-on activities and games, rather than the more literacy-heavy portions of the playlist.

> *English learners follow their classmates. And then, when they have questions or they don't know the instructions or what to do, then they come up to us or ask another classmate. But they never get frustrated. That's the main thing when they're learning a new language, we don't see them frustrated. They're just like, "Okay, I know I can do this, but how do I cancel it? How do I erase it?" Very basic. They will raise their hands or they will just approach one of the teachers, and we'll tell them.*
>
> *We like to encourage them to do it individually for some stuff. But we found out that for some activities, they like to share their experience, like, "Oh, what did you get for this?" Or, "What do you do for this thing?" So that's cool because they use communication to compare what they are doing and what others are doing. So I like how they share their own experiences. Every time that someone is struggling with something, other kids are enjoying to help them. So, they're helping each other while they're working. They encourage each other, as well.*

Discussion and Reflection

According to educators, a central part of implementing *Hero Elementary* with English learners was leading

groups of students in discussion and reflection about what they were learning and how it applied to their lives. These discussions accomplished dual goals of encouraging English learners to dialogue in English and practice new vocabulary learned through the program, and also to reinforce inquiry concepts and connect learning with lived experience. This was largely done through asking students targeted questions and allowing them to share their ideas and opinions. For example, educators would ask students how they think *Hero Elementary* characters felt and why they took particular actions. They would also ask students if they had ever had similar feelings and experiences, and to describe how the themes applied to activities happening in the afterschool program and in students' home lives. Giving students relaxed and fun opportunities to reflect and make connections while participating in discussions in their second language was a strength of the *Hero Elementary* program shared by educators.

> *We like to talk about how it's related to us. We always try to connect it with our own perspective and our own experiences so they can fully understand what they're talking about.*
>
> *It's a very accessible program, where you can connect it to a lesson plan and what you are doing in class and what they are doing in their daily life.*

Science Connected to Sense of Place/Home Culture Connections

Relatedly, educators shared that they also prompted discussion and reflection with their English learner students to connect *Hero Elementary* activities to children's familiar local contexts and places. These discussions and experiences allowed students to practice and reinforce new English and science vocabulary and to connect science to their everyday lives. Educators emphasized that students may not have the opportunity to travel beyond their local communities but that through *Hero Elementary*, they could experience new concepts and environments, while also making connections to home and the local community. Intentional lesson planning by educators facilitated these opportunities, as they developed coordinated activities and discussions around *Hero Elementary* themes.

> *For example, we took the vocabulary that they were learning in* Hero Elementary *and then, during the lesson plan, trying to relate it and connect it so it was very clear to them.* Hero Elementary *also helped give us ideas for the lesson plan [so] students can make connections and they don't get so lost or forget what they saw on the [*Hero Elementary*] application. We wanted to make sure that it stayed fresh.*
>
> *I like to practice the language and also implementing the words that they see on the application. We try to use stuff we have in our classroom to make them understand.*
>
> *We try to connect it to the theme of the week. So we have our circle time, we talk about the theme, we have a video we watch about it, and we have the art and everything connected. For example, the one we did about animal body parts — I explained and I showed pictures about the animal. And I explained to them the kind of animals there are … My curriculum, my lesson plans, I implement it with what we are doing with the playlist.*

Real-World/Hands-On Experiences

As mentioned above, educators reported employing hands-on activities to help English learners engage more fully with the content, to reinforce English, science, and literacy abilities. This was mainly done through whole-group activities, such as bringing objects from home with relevance to *Hero Elementary* themes for students to interact with hands-on as part of lessons developed around the *Hero Elementary* topics. Educators also mentioned implementing science investigations with students, tied to *Hero Elementary* themes. A high level of intentionality by educators was indicated by comments describing the ways they helped students make connections between their recreational play and the science concepts and vocabulary they were learning through *Hero Elementary*.

> *I will use some of the vocabulary. Or I'll bring something from home. Not only showing pictures to them but showing an actual example — things that they can see and they can touch. For example, when we're outside doing our outdoor activities, when we're playing with the ball, when we're with their bicycles, they relate that with* Hero Elementary*: "Okay, we did that pushing and pulling motion." So, they do have the*

> *concept and they do relate that with their outside activity. We have been doing a science experiment each week and we try to connect that to what they are learning in* Hero Elementary.

Greater Access to Science Content

While educators of English learner students emphasized that their priority was for children to learn English, they reported providing some accommodations to ensure that English learners could successfully engage with the content. These consisted mainly of translating instructions and words or phrases for English learners who asked for help or seemed confused. Educators also sometimes explained what was happening in videos to make sure that students were understanding the content. Educators described this individualized support as focused more on helping students to understand meaning rather than directly translating. To support English learners in becoming proficient in English, educators shared that they were careful to provide the minimum of translation assistance to enable students to successfully use the program. Some educators reported providing their students with worksheets and books related to the *Hero Elementary* science content to reinforce science concepts, language, and literacy. In addition, educators accommodated English learners who were struggling with *Hero Elementary* implementation through flexible grouping, such as pairing English learners with bilingual peers, providing one-on-one support, and facilitating whole group learning and discussion. In general, educators reported intentionally keeping accommodations to a minimum to facilitate English learning.

> *I don't like using translating because sometimes you can interpret the word in a different meaning. So what I like to do is show them a picture or something, or maybe in the program, show how that word applies, so they can connect it with the word: "Oh, it was that thing."*
>
> *We will translate, for example, the questions after the videos — they just want the translation to see if they understood or they have it right.*

Socioeconomically Disadvantaged Students

A central goal of the *Hero Elementary* program is to increase science engagement for children from historically underrepresented communities in STEM. Because nearly all students served across the sites were socioeconomically disadvantaged, findings for these students overlap with the findings discussed above. Overall, the findings suggest that *Hero Elementary* is effective in engaging socioeconomically disadvantaged students in science learning and in helping them to see science as an academic topic in which they can excel.

Building a STEM Identity

Having a strong STEM identity is a factor that supports students in their science studies and careers (Hazari et al., 2013). Because historical patterns of systemic racism and socioeconomic privilege have excluded people from low income households from participation in the sciences, students from socioeconomically disadvantaged households and communities may find it difficult to see themselves as scientists. *Hero Elementary* helps to address this issue by presenting students with programming and resources that brings science into their realm of lived experience. Educators emphasized the relatability of *Hero Elementary* characters to their students and how they used the "Superpowers of Science" in ways that were accessible and familiar to their students. Educators also expressed that *Hero Elementary* provided opportunities for students to express their ideas and opinions regarding science phenomena.

> *So we like to watch the episodes and then encourage them to express about what they like or their favorite character, which one you can relate to.*
>
> *I like, for example, the [investigation] videos on [*Hero Elementary*], because [the students] can share their opinion and what they think.*
>
> *The activities encourage them to share their opinions and how to problem-solve situations.*

Science Connected to Sense of Place/Home Culture Connections

Students were well served by *Hero Elementary*'s emphasis on relating the science content to students' lived

experiences, intersectionalities, funds of knowledge, cultures, and local community. Educators facilitated these connections through leading students in discussion and reflection about how the stories and science experienced through *Hero Elementary* related to their everyday lives. Educators encouraged students to share their own experiences related to the plotlines of the *Hero Elementary* characters and to share their opinions and hypotheses based on their lived experiences and the community around them.

In addition to connections to the local context, educators particularly appreciated that *Hero Elementary* exposed their students to experiences and concepts outside of the realm of their everyday lives that they would not otherwise be able to experience, and to think about how their environment is connected to others.

> *Maybe some of them, they don't have the opportunity to go visit other cities. Now that they have this opportunity to watch something on* Hero Elementary, *so they can start using their imagination. "How do you think it feels? How do you think it smells? How do you imagine that you're there?" Every single part is very important to make them feel connected to what we're talking about.*
>
> *We like to engage them, to make it their own experience and have them share their own thoughts. "Does this happen to you?" "Have you looked at this? Have you felt that? Have you watched that?" Just to make them feel really connected to the situation.*

Increased Science and Literacy Exposure and Reinforcement

As mentioned previously, many of the socioeconomically disadvantaged students served by *Hero Elementary* were not receiving science instruction during the regular school day. In addition, as socioeconomically disadvantaged students are less likely to have experiences that encourage the development of fundamental literacy skills (Buckingham et al., 2013), *Hero Elementary*'s dual emphasis on science and literacy is particularly advantageous for these students. The educators who were working with students identified primarily as socioeconomically disadvantaged reported that the resources were a "good fit" for their students because students could improve their literacy and engage in a variety of learning activities related to science topics, including hands-on and real-world experiences.

> *I think it's a perfect fit for our program because it implements STEM, it engages the kids, and it has hands-on activities. And by them adding things that we can do virtually [digital games, Science Power Notebook, e-readers], well, of course we use those. So, I think it's perfect for us. As far as the educational aspect of it, they are responding because they not only see it, they're getting an opportunity to get involved with it. Doing the experiment, it's just total involvement.*
>
> *It also helps our students to get their reading level up because … our students' reading levels are really low, so that can help them.*

Educator Adaptations and Modifications to Provide Socioeconomically Disadvantaged Students Greater Access to Science Content

Adaptations for socioeconomically disadvantaged students overlapped with adaptations discussed above for English learners and students with disabilities, as nearly all students across the sites were socioeconomically disadvantaged. Targeted adaptations to facilitate learning for these students included an individualized approach that allowed educators to understand and address student needs, including continuous checking for understanding, scaffolding instructions, providing language and literacy support, reinforcing concepts across *Hero Elementary* and non–*Hero Elementary* content and activities, and implementing flexible learning environments that included intentional groupings and frequent reengagement strategies.

Similarities and Differences Between In-Person and Virtual Implementation of Hero Elementary

As mentioned previously, during the spring of 2020, with the onset of the COVID-19 pandemic, some afterschool classes that were using in-person *Hero Elementary* implementation had to be adapted to allow for virtual implementation. Many educators in the study had implemented *Hero Elementary* in person before schools were

closed. Therefore, they could reflect on the differences between implementing *Hero Elementary* virtually and in person. Other educators included in the data collection and analysis had only implemented *Hero Elementary* either in person or virtually. This section addresses guiding question 3: What are the similarities and differences in how *Hero Elementary* is implemented in person and virtually?

Findings from the data analysis indicate that educators were able to successfully implement *Hero Elementary* in person and virtually. Two educators implemented hybrid versions of the program, implementing some activities in the classroom and some virtually. Though implementation looked quite different in each of the two methods of implementation, both produced, for the most part, lively and productive learning environments. It appears that in both implementation modes, educators were able to adapt resources to address the needs of their students.

Differences in Interaction with Hero Elementary *Learning Resources*

One of the most striking differences between in-person and virtual implementation of *Hero Elementary* involved the way students interacted with *Hero Elementary*'s learning resources, and the role educators played in these interactions. The four programs used a broadly similar approach to implementation. The data indicated that for in-person implementation that usually involved approximately 40 minute sessions 2–3 times per week, the many *Hero Elementary* learning resources, including the episodes, science investigations, and other hands-on activities, Science Power Notebook, and e-readers were often used in whole or small groups or in student pairs. Digital games were often played individually or in pairs in the classroom. As described previously, educators, usually more than one in each classroom, would move about the classroom during implementation, checking on student progress, discussing and reflecting on the science learning aspects of the activities, answering questions, and supporting students who might be struggling.

In contrast, in the two programs that used *Hero Elementary* virtually, educators would log on to Zoom one, two, or three times a week and spend between 30 minutes to an hour in a *Hero Elementary* session with their students. During their time on Zoom, educators would usually share their screen with students and focus on one of two activities: the television episode or the science investigation (either showing the video of the investigation or having children view and participate in the hands-on investigation). As a result, the pacing for virtual classes differed from in-person sessions due to the reduced number of activities used in each playlist. Educators would encourage students to complete other playlist activities, including the digital games, Science Power Notebook, and e-readers at home on their own time. If students were able to log in to their *Hero Elementary* account on their home tablet, educators could monitor students' progress on playlist activities using the teacher dashboard; however, this did not appear to be a tool that educators used regularly. Rather, educators asked students about their progress during Zoom sessions or via phone calls. Educators sent email and text reminders to students encouraging them to complete all playlist activities and helped students and families to troubleshoot if they were having technical problems. Even with concerted support from educators, the majority of participating students were unable to log in to their *Hero Elementary* account from home. Barriers included a lack of internet access, lack of device, or lack of adult or sibling support.

> *We do it through Zoom. So, the first thing is usually a 10-, 15-, 20-minute video that gets them started on the topic. I will share my screen and we'll watch it, and we'll pause, and we'll talk about it, or we'll wait till the end.*
>
> *We show it as a whole group over Zoom. We all watch it together. And then we have a group discussion afterwards with all the science questions, like whether it's investigating or comparing. We have those discussions afterwards. We use the [Co-Viewing Guide] that gives the questions.*

Educators implementing virtually mentioned that they encouraged students to log in to their *Hero Elementary* account after their Zoom sessions and to engage in other activities in the playlist that the educator introduced. One educator described how she assigned the Science Power Notebook, digital game, and e-reader to students, asking students to complete these activities on their own during free time at home. "The Notebook, and there's a game they can play. And there's e-readers. Those three parts, I encourage them to do that on their own."

The educators that were virtual implemented each playlist over a two- or three-week time period.

> *It might take me a couple of days to get the video [episode and hands-on investigation] completely in, and then I'll ask them questions and stuff. Then it's up to their own [efforts]. I give them a couple of weeks to try to go play the games and look at the reading books, the material on the iPads to do.*

Educators also mentioned making use of the affordances of the virtual format. They encouraged students to use the chat feature on Zoom during the investigation to express ideas, predictions, and encouragement.

> *We get the kids to use their chat. Kindergarten to second grade, they know how. They use the chat not so much with the cartoon [episode] part of it, but when we do the actual [investigation].*

All educators mentioned using materials from children's homes during virtual sessions.

> *We have to do scavenger hunts or different things to make it hands-on with the different materials. We don't know what they have at home, but we encourage them to find things that they have at home.*

Several educators implementing *Hero Elementary* virtually welcomed siblings and older students from the afterschool program to join virtual *Hero Elementary* sessions. Older siblings could support their younger siblings in using *Hero Elementary* virtually, and siblings and friends sitting in on Zoom sessions frequently praised and encouraged younger students as they made predictions and discussed possible outcomes and results. Educators mentioned that these students did not interact with their afterschool students during in-person *Hero Elementary* implementation.

> *We do have some siblings in our group. I mean, usually an older sibling in third, fourth, or fifth grade whose got an iPad and then [her enrolled student] has got the loaner one [iPad].*

> *This [*Hero Elementary*] program, being the base … we've been honestly blessed to [be in] touch with these [older] kids, to not just befriend them, but be friends to them and to be with them. When you hear [younger] kids say, "I love you." And [the older students respond], "We love you. We love you all. We miss you." They're supposed to log on it at 4:00 and they're logging on it at a quarter 'til, so that, that kind of thing happens.*

Educators who implemented a hybrid version of *Hero Elementary* focused on having children engage in the digital games, Science Power Notebook, and e-reader activities in the classroom, while implementing other playlist activities virtually. Administrators reported that the strategy worked well and that most students were able to complete the majority of playlist activities.

Adaptations to Conduct Successful Science Investigations Virtually

A playlist activity that differed greatly in the virtual environment was *Hero Elementary*'s hands-on science investigations. Results of the data analysis suggest that educators used different strategies to implement the investigations virtually and in person, but were able to successfully conduct the investigations in both environments with robust student engagement. Educators reported that when implementing in person, they guided the process as students participated in the hands-on aspects and engaged students in discussion and reflection. For virtual implementation, educators made use of *Hero Elementary*'s investigation demonstration videos, which they shared on Zoom. They would often instruct students to find materials in their home that they could use to do part of the investigation virtually during the Zoom session. Those educators using the recorded video would use the "advance" and "pause" features to discuss and reflect on the process with the students, often mentioning the "Superpowers of Science," and then have children try aspects of the investigation with the materials they had on-hand. Students were then prompted to report their results to the group. Several educators provided examples of how they implemented virtual science investigations.

> *They had to test different materials to see whether they are good to make the raincoat. They had to get materials around the house and get two glasses of water and test the material. So, we had to do things like that. First, we had them run and do a scavenger hunt and find the materials that they actually had at home. And if it was something they didn't have, they just had to look at someone else's screen to see whether it was waterproof or whether it would absorb the water. So, just things like that, we had to change up to make it work, to still be able to do the experiment and still have the kids be able to do something hands-on.*

Some investigations involved activities that required an adult to execute steps that might not be safe for children to do on their own. In this case, educators either asked family members to implement the activity, or they would show and discuss the video of the investigation with students without doing any of the "hands-on" steps. Educators found it difficult to set up and conduct a live demonstration at home over Zoom. For example, educators explained how they implemented the "Heating and Cooling" investigation, which involved watching the video and discussing aspects of the investigation, rather than actually heating materials until they melted.

> *Things were science-based, so some of the playlists have experiments. The last one we did was the "Heating and Cooling" [playlist]. Watching me when I cook or having them at home try to heat stuff up or cool stuff off, that wasn't really doable. But the playlist prep gave us access to videos of the actual [investigation] activity.*

Incentives to Boost Participation and Engagement in Virtual Learning

Another practice used by educators during the virtual implementation of *Hero Elementary*, but not during in-person implementation, involved the use of rewards for students' participation. Educators mentioned that, unlike during in-person afterschool sessions, students attending virtually can forget to, or choose not to, attend. As one educator commented, "They may or may not show up." Nearly all educators implementing *Hero Elementary* virtually mentioned building incentives into their routine.

For example, educators mentioned in their interviews that they prepared goodie bags for students and their parents to pick up on-site on Thursday evenings for those students who had fully participated in *Hero Elementary* that week, including attending Zoom meetings and doing playlist activities at home on their own. Another incentive involved educators incorporating games into their session that tested students' science learning related to *Hero Elementary* activities. Students could win small rewards for participating and demonstrating their science knowledge in these games, included receiving candies and small toys in gift bags delivered to their families. One educator described the game, reporting, "On Thursdays, we have a competition, and we include some of the *Hero Elementary* questions that they learned from the week. We do a trivia thing. So, they have to pay attention if they want to win something."

Reduced Opportunities for Engagement and Participation in the Virtual Format

Educators who implemented *Hero Elementary* both in person and virtually noted that one disadvantage to virtual implementation was the reduced possibility to connect science concepts that students were encountering in *Hero Elementary* to their local environment. Several educators mentioned that when they implemented *Hero Elementary* in person, they were able to observe and discuss local animals when implementing certain playlists. Others mentioned connecting visits to their local community garden. When implementing virtually, educators also said they would sometimes remind students of the animals and plants they had seen in person earlier in the school year, occasionally putting photos of them on their shared Zoom screen.

In addition, when reflecting on the differences between implementing *Hero Elementary* in person and virtually, the majority of educators who had implemented both formats mentioned that one of the biggest obstacles to implementing virtually was the reduced ability to support students one-on-one when they were struggling. In particular, educators were not able to give the targeted support they would provide in person to their students with disabilities, their English learners, and others who were struggling largely due to lack of physical proximity, scheduling issues, and inability of family members to provide sufficient support at home.

> *I think they all participate [in person and distance learning], but in person, you could reach out individually more if you notice that one student needed more attention.*

Another educator mentioned that she was able to keep more students on-task when implementing in person:

> *We were doing much more when I had them in class [in person]. I get them all on reading the story together. We'd look at the different pictures. I had them playing the games. Each day we did the same thing, so I could go around and help them if they couldn't do it. Because we had a lot of these kids that needed assistance, and that's what I think the problem is.*

Educators were particularly worried about the participation levels of their students with disabilities:

> *He doesn't really participate that much. The last time he was mostly asleep, because again, we are from 3:30 to 5:30 and if you've been in school all day and you sit still long enough and hold an iPad, it's a wrap. You're out.*
>
> *I think their deficit is not understanding [technology] unless they have a parent that's knowledgeable enough to help them with the iPads and stuff. That's one of the biggest problems. Like the little girl in my room, she's smart and I can show her on the iPad how to do it, how to scan her card and stuff, so she can do it. But I know with this special needs girl that I know, she's in one of our special ed classes, I don't know if she's getting on, because I really don't think she can do it on her own and I don't know if her parents are that good at the technology that we have nowadays.*

Program 4 that primarily serves students with disabilities chose not to implement *Hero Elementary* virtually, in part because their educators felt they would not be able to provide the individualized support their students would need in a virtual setting.

Educators' Reflections on Differences between In-Person and Virtual Implementation

In terms of educators' preferences regarding using *Hero Elementary* in person or virtually, most educators indicated that they preferred in-person implementation. Nearly all educators who had used both methods mentioned that they found virtual implementation more difficult than in-person implementation.

Educators commented that having students together in a classroom allowed for individual, small group, and whole group instruction to take place.

> *It was easier to do it face-to-face because they're here and you can just pass out the materials and show them, this is how it goes. You wouldn't have to do as much [group instruction] either, because they could be on their individual path, like if one person was farther along than the other.*

Educators also frequently mentioned the difficulty of observing and providing individual support for students in the virtual environment.

> *You can't really know exactly what a child is thinking per se over the internet. And they're not going to ask [as many] questions. Their questions are different than say if they were there physically [together] looking at a hands-on activity, rather than doing it over the Zoom.*

Other educators mentioned a particular positive energy and enthusiasm that often arose when working together in person as a group.

> *The interaction with the kids is what I miss the most, because they seemed to really enjoy it last year when we did it together and everything. I don't get to really see what I saw last year.... I do miss that interaction with the kids, because when they get excited, I get excited, too. I'm not a quiet teacher. I'm kind of loud. When they have fun, I like to have fun, too.*
>
> *It was thrilling for me just to see [in-person] the kids, when I could see their faces and stuff as they were working on the stuff. They'd get real excited. "Ms. C, look what I've done." I don't get to see all that kind of stuff this year, because I'm depending on them to do that on their own .... I've missed that interaction with the kids, having it ... in front of me so I can see stuff like that.*
>
> *It [virtual] seems to be much harder to do it with the kids, actually because of the way they switch us [during the afterschool's virtual schedule].... There's three of us that rotate with the children. I just wish we had more time with them, but I know we don't have that much time. That seems to be more of a problem, with the time limits.*

Not being able to observe and support students as they worked on playlist activities, other than during use of the playlist episode or hands-on activity, was frustrating for several educators.

> *I just wish there was a way we could get some time with me watching them, get on the iPad and play the different games where I could see them do it, not just tell them [to play] on their own time.*

Despite their frustration with virtual implementation, educators frequently mentioned that the engaging qualities of *Hero Elementary* contributed to the success of their efforts. Educators reported that students were

eager to engage in *Hero Elementary* activities, which allowed for successful lessons.

> *What's so encouraging is that these kids continue to come on [*Hero Elementary*] virtual learning to participate after being in [virtual] school continuously. They're enjoying it and they love it. That means whatever we put into them [the lessons] is productive. If not, then they wouldn't continue to return.*

Discussion

In 2015, TPT received funding from the U.S. Department of Education's Ready to Learn program to produce educational media programming over a five-year period. The grant provided funding to create a transmedia collection of digital and non-digital learning resources, including narrative-connected television episodes, digital and analog games, curated nonfiction e-books, hands-on activities and science investigations, digital science notebook activities, as well as educator professional development and educator resources designed to support science and literacy learning in children ages five to eight years old. The collection was designed with research-based methods to create learning experiences that are engaging and accessible to children living in low-income communities. Early in their development of resources, TPT reviewed relevant research and created frameworks and actionable guidance for best practices in the design and use of science learning resources with young learners representing a range of backgrounds and identities. By developing and subsequently sharing these frameworks and actionable guidance with those designing and producing *Hero Elementary* content, TPT planners had the expectation that *Hero Elementary* resources would be designed with a focus on both equity and accessibility and be well suited for use with student populations that are historically underrepresented in STEM.

The current study and report describe an examination of how the design and use of *Hero Elementary*'s learning resources affect students' science learning experiences in the context of four afterschool programs serving K–2 students. It should be noted that nearly 100 percent of the students enrolled in these programs are designated as socioeconomically disadvantaged. The content was designed to be adaptable and customizable, as research suggests this is important to creating learning resources that promote equity and provide accessibility for a broad range of diverse students. TPT was intentional about not having a "one size fits all" curriculum, but rather designing for students with diverse abilities and backgrounds and supporting educators as key facilitators who know their students well and know what will resonate within their community.

The findings of the study suggest that the design features of *Hero Elementary* learning resources strongly support students' access to science and literacy content. Design features such as a) including multiple modes of representation, b) connecting learning to students' cultural knowledge and experiences, and c) providing opportunities to engage in scientific investigations and discussions, along with educator professional development that supports educators in implementing *Hero Elementary* using strategies that promote equity and accessibility in science learning, supported students' access to the learning content. Findings included robust evidence showing that, for each of the particular student groups of focus in the study (students with disabilities, English learners, and socioeconomically disadvantaged students), *Hero Elementary*'s equity and accessibility features promoted students' engagement in and understanding of science. Findings also strongly suggest that afterschool educators were able to adapt *Hero Elementary* resources and activities to provide their students greater access to the learning content.

When the COVID-19 pandemic affected schools across the country, two afterschool programs that participated in the study adopted the distance learning version of *Hero Elementary*. This version included *Hero Elementary* learning resources adapted for virtual implementation and educator professional development that include the successful training provided during in-person trainings, but also adapted for distance learning. The current study provides insights to the benefits and challenges related to moving a highly interactive in-person model of science learning for young children to a distance format. The virtual format proved to be engaging for students and led to them participating in science investigations, such as the heating and cooling experiments, and having rich discussions together as they predicted, conducted, and explained their results. On the other hand, many students were not able to experience many of the *Hero Elementary* playlist activities in the virtual format because of difficulties logging on to the *Hero Elementary* platform without educator direct support. Also, providing

individualized support for students was more challenging during virtual implementation of *Hero Elementary*. Educators reported that, during virtual implementation, the inability to provide one-on-one support for students with disabilities and English learners when they struggled was a barrier to learning, especially when compared to their experiences with in-person implementation. This finding reflects current research in distance learning and students with disabilities (Tremmel et al., 2020; Vasquez et al., 2015) and English learners (Kim & Padilla, 2020; Moorhouse & Beaumont, 2020). Another difficulty regarding virtual implementation of *Hero Elementary* involved a lack of digital devices as well as internet access in students' homes. During virtual implementation, students would use their one digital device to log in to Zoom to meet with their afterschool class. Because their devices were in use, the students could not work on any playlist activities using their device. Educators reported this issue led to reduced interaction in *Hero Elementary* and fewer opportunities to learn.

The current study contributes to a growing effort to identify effective design and pedagogical strategies to promote equity and access to learning content. A review of current literature suggests that there is broad interest in identifying and implementing best practices in the design and implementation of learning resources to address the diverse strengths and needs of learners in today's schools (Smith & Abrams, 2019; Davey & Marx, 2020; Dyjur et al., 2021). At the same time, there is a concerted effort in the research and design communities to identify effective strategies to promote equity and access in STEM, including how the design of learning resources and pedagogical approaches can support historically underrepresented groups of students to participate in STEM learning (Heaster-Ekholm, 2020; Lee et al., 2015; Ryoo & Calabrese Barton, 2018; Vossoughi et al., 2016).

Hero Elementary provides an example of the use of effective design strategies, including pedagogical practices, to create equitable and accessible science learning experiences for populations of students that are represented in U.S. schools. The TPT design team used a thoughtful and deliberate process to review research literature, discuss ideas and best practices with experts, and test early content in order to create frameworks and guidance for the developers and producers who would ultimately create *Hero Elementary* resources. Particularly in transmedia learning, the narrative and characters involved in a transmedia story are of crucial importance in engaging students, drawing them into characters' experiences, and building excitement as storylines evolve (Hovious, Shinas, & Harper, 2021; Jenkins, 2007). TPT used their unique equity and accessibility design processes to guide the development of each *Hero Elementary* character, narrative, and storyline that would become *Hero Elementary*. By using these deliberate strategies early on, TPT was able to embed features of equity and accessibility into nearly all of its science learning resources. Evidence of TPT's equity and accessibility design features can be seen in *Hero Elementary* resources, including television episodes, with supports for comprehension of science concepts, including on-screen discussions that model scientific thinking, presentation of key background knowledge about science, and frequent focus crosscutting concepts. For instance, all television episodes specifically include equity and accessibility features, including:

- A diverse cast of characters modeling the NGSS Science and Engineering practices
- Narratives that balance simplicity, complexity, and clarity versus distractions and excitement
- Characters making frequent connections to science topics during episodes
- Co-viewing options that allow educators to pause the video and discuss important points occurring in the on-screen action

Hero Elementary digital games and other resources have also been designed to provide support for learning of science concepts by students with diverse cognitive, cultural, and language backgrounds. Some examples of resource design include providing essential background knowledge for students, highlighting critical features and main points, and including concept maps. Other examples include:

- Hands-on activities provide shared background knowledge and connect to real-life experiences.
- e-readers have built-in scaffolding that adjusts to students' ability level.
- Game levels build on previous conceptual patterns and practices.

These and other examples from *Hero Elementary* can inform researchers and developers who strive to create

digital and blended educational resources that support learning for all students. The *Transformative Transmedia Framework for Early STEM Learners* and *Effective Strategies for Engaging All Young Learners in Science* documents, along with specific examples illustrated in *Hero Elementary* resources, can provide further guidance to those designing blended learning resources for students in informal and formal learning environments.

The case study described in this report has a number of limitations. The study addresses a limited set of topics, with a relatively small sample of educators and administrators (n=30) in afterschool programs in four states in the United States. Data were collected just before and during the COVID-19 pandemic, when some afterschool sites transitioned to distance learning. Participants' experiences and attitudes about *Hero Elementary* may have changed during the pandemic, and as they return to normal in-class activities. Because not all educators and administrators were asked to participate in interviews and observations, and those who did self-selected, there is a possibility they may have had a more favorable view of *Hero Elementary* than those who did not participate. To address these issues and strengthen the credibility of this case study, several strategies that qualitative researchers typically engage in to enhance the trustworthiness of their work were used, including the use of theoretical sampling, triangulation, and peer debriefing (Thomas, 2011; Yin, 2018).

Conclusion

There is a growing awareness in formal and informal education environments of a need for learning resources that are engaging, equity-focused, and accessible to all students. Educators in formal and informal settings support students with widely different strengths and needs, including a significant percentage of their students with disabilities, English learners, and those who are socioeconomically disadvantaged. The current case study examined the design features of *Hero Elementary* science learning resources and the resources' use with students from a variety of backgrounds, strengths, and identities. The study provides rich examples of design strategies that can guide researchers, resource designers, and educators as they seek to create and use learning resources that can engage diverse learners in science and other content areas. In addition, the study provides evidence of how educator professional development focused on equity and accessibility prompted educators to use research-based practices to provide further access to the learning content with their students. The current study also highlights how a blended science curriculum can be successful in afterschool programs, where many educators do not have teaching credentials or expertise in science instruction.

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Appendix A: Synopsis of the Key Features of the *Transformative Transmedia Framework for Early STEM Learners, Including Notes for Television Production*

1. **Help young learners connect their racial, cultural, and STEM identities.**
   - Emphasize community and sense of belonging and that they are a viable part of a STEM community.
   - Where can we find the balance? How can we connect what our characters do in STEM with who they are?
   - STEM is not just for the "special" ones; everyone can do science.
   - Develop interests in the characters so that they make sense for who they are — what are their interests, hobbies, quirks, etc.?

2. **Create real-world STEM experiences grounded in the realities of diverse learners' lives.**
   - Feature realistic environments that feel familiar to Black and Hispanic children.
   - Superpowers of children grounded in their realities as Black and Hispanic children.
   - Hmm, the stories start when they get to school; how to bring in their lived realities?

3. **Integrate social and cultural assets in young learners' STEM powers and experiences.**
   - Focus on STEM powers to support community and social justice outcomes.
   - Creating something out of "nothing" — games, toys, etc. — resourcefulness, initiative, stick-to-it-ive-ness
   - Navigating culture when you do not speak the language.
   - Strengths of being female in a male-dominated world.
   - Superheroes are not special, they are just representative.
   - Difference between supers and non-supers, what does it mean to be a Superhero Elementary in a power and non-power world, what is expected from them?

4. **Engage young learners in Science and Engineering Practices in ways that build equity.**
   - Utilize the "superpowers of science" prominently in TV episodes.

5. **Help young learners experience STEM as literacy.**
   - Feature multiple modes of communication in TV episodes.