ABSTRACT

Title of Dissertation: TECHQUITY IN THE CLASSROOM: DESIGNING TO INCLUDE EQUITY AND SOCIAL JUSTICE IMPACTS IN COMPUTING LESSONS

Merijke Coenraad, Doctor of Philosophy, 2022

Dissertation directed by: Assistant Professor, Dr. David Weintrop, Teaching and Learning, Policy and Leadership

Technology is ubiquitous in modern society. It affects our daily activities and exists in every household and on every street corner. Yet, research has shown that both the process of creating technologies and the technologies themselves are biased. New technologies are based on datasets, algorithms, and designs that encode developer and data biases. As youth increasingly use technologies in their daily lives, experience the effects of technologies and algorithms, and learn to be technology creators, it is important for them to critically explore and understand the ways that technology introduces and perpetuates inequities. In this three-article dissertation, I present a design study on the development and implementation of materials specifically designed to teach about *Threats to Techquity*. Threats to Techquity are aspects of computing and technologies that cause or could cause inequalities,

especially inequalities based on marginalized identities (e.g., inequalities due to race, immigration status, gender, sexual orientation, ability).

To understand how to bring Techquity into the classroom, I partnered with youth and teachers using participatory design to develop the "Talking Techquity" curriculum for middle grades (5^{th} through 8^{th} grade) students. Findings from this work revealed: (1) youth initially named and identified examples of visible Threats to Techquity, but as they learned more about these threats, they uncovered and discussed invisible Threats to Techquity more frequently and identified these threats as topics to be taught to peers; (2) youth and teacher designers had similar instructional priorities and utilized similar pedagogical strategies when designing and critiquing learning experiences about online data collection and data use, but had contrasting ways of discussing examples and different learning goals; and (3) when implementing "Talking Techquity," teachers who helped co-design the curriculum made adaptations to content and project requirements to provide more scaffolding and ensure students experienced success based on teachers' perceptions of student needs and other factors. This research encourages researchers, curriculum designers, educators, and students themselves to consider how to teach and learn about the Threats to Techquity affecting youth's daily lives and demonstrates how participatory design methods can help uncover key conceptualizations and instructional priorities that make this possible.

TECHQUITY IN THE CLASSROOM: DESIGNING TO INCLUDE EQUITY AND SOCIAL JUSTICE IMPACTS IN COMPUTING LESSONS

by

Merijke Elise Coenraad

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Advisory Committee:
Dr. David Weintrop, Chair
Dr. Tamara Clegg, Dean's Representative
Dr. Elizabeth Bonsignore
Dr. Diana Franklin
Dr. Diane Jass Ketelhut
Dr. Jean Ryoo

Dedication

To all my teachers, who taught me to wonder and explore, who gave me permission to bury my nose in a book, and who never gave up on me; and to all of my students, who taught me every day and inspire me to work toward a more just world and more just educational opportunities.

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AI	Artificial Intelligence
COPPA	Children’s Online Privacy Protection Rule
COVID-19	Coronavirus Disease 2019
ECS	Exploring Computer Science
GDPR	General Data Protection Regulation
LGBTQ+	Lesbian, gay, bisexual, transgender, and queer
OECD	Organisation for Economic Co-operation and Development
PSA	Public Service Announcement
UK	United Kingdom
UMD	University of Maryland – College Park

Chapter 1: Introduction

The COVID-19 pandemic has laid bare inequalities within society, including those related to algorithms and technology. One example comes from the experiences of students in the United Kingdom (UK). For them, years of schooling culminate in receiving A-Level exam results determining post-secondary options. However, A-Level exams were cancelled in the spring of 2020 due to the COVID-19 pandemic. Instead, teachers were asked to give students an A-Level grade based on their work and rank students in comparison to their peers. These teacher-based scores were fed into an algorithm that considered variables like schools' past performance to determine official scores for the year (BBC, 2020b). Based on the algorithm, nearly 40 percent of students were downgraded as compared to their teacher's assessment. Students who attended public schools were disproportionately downgraded compared to their private school-attending peers (BBC, 2020b), creating discrepancies based on class. Outraged students held protests over the use of an algorithm to determine their scores rather than allowing teachers to do so. They immediately took action and protested, holding signs that read *"Teachers know my potential algorithm does not [sic]"* and *"My grades not my postcode [sic]"* (BBC, 2020a). Within days, the government abandoned their use of the algorithm, instead opting to use teacher scores (BBC, 2020a, 2020b).

This example demonstrates how the use of an algorithm determined a significant outcome for a young, vulnerable population. An algorithm showing class-based bias dictated a score that determined students' future career opportunities by dictating their A-Level exam results. In response, the students affected by the algorithmic bias protested and caused changes and reconsiderations, sidelining the originally used algorithm. What many of the student protesters might not have known is how many algorithms affect other parts of their lives and the lives of their communities. With technology seemingly everywhere in today's society, algorithms play a role in many aspects of daily life, including policing, hiring, accessibility of social services, advertising, and access to information (Angwin et al., 2016; Benjamin, 2019; Crawford et al., 2019; Eubanks, 2018; Noble, 2018; O'Neil, 2016). In fact, technology has almost reached the ubiquity predicted by Weisner in his 1991 article that opened, "the most profound technologies are those that disappear" (Weiser, 1991, p. 94). As Weiser predicted of technological devices, people "simply use them unconsciously to accomplish everyday tasks" (Weiser, 1991, p. 98). Having reached a point where technology is ubiquitous, we must consider technology more seriously and the impacts, both overt and covert, technology has on the individuals interacting with it. This is particularly important because protest-worthy instances of algorithmic bias, such as that affecting UK students, abound.

As technologies and computing become more prolific within schools and society, they also become more dangerous. When Weiser first wrote of ubiquitous computing (Weiser, 1991), he wrote of devices designed by computer scientists being used by those same computer scientists. The user and the creator were one and the same. In the present day, a relatively select few design, create, and program for the masses. With this imbalance comes a greater possibility for biases to be programmed into these technologies (Wachter-Boettcher, 2017). This is particularly true when the groups for which technology is being designed are not included in the design process and designs are made for a perceived "normal" rather than for the needs of individuals (Costanza-Chock, 2020). In this work, I call these aspects of computing and technologies that cause or could cause inequalities, especially inequality based on marginalized identities, *Threats to Techquity*[1]. Threats to Techquity include identified instances of algorithmic or technological bias, such as those previously mentioned, as well as instances of inequity caused or exacerbated by technology that have not yet been identified. Identifying and illuminating these Threats to Techquity is a concern not only for technology developers, who need to develop technologies free of these biases, but also for technology consumers, who currently use biased technologies daily, many without knowing.

Despite computers and algorithms being presented as neutral and many consumers assuming technology and algorithms to be unbiased (Pew Research Center, 2018a), journalism (e.g., Ongweso Jr., 2019), academic research (e.g., T. Wang et al., 2019), reports (e.g., Crawford et al., 2019), and books (e.g., Benjamin, 2019) have demonstrated the bias, oppression, and prejudice inherent in and caused by technology. These biases target people from populations that experience marginalization, creating inequities due to one's race (Noble, 2018), gender (Scheuerman et al., 2020), disability (Whittaker et al., 2019), experience of poverty (Eubanks, 2018), or a combination of these (Buolamwini & Gebru, 2018). Although these biases might be unintentional, the internal biases of programmers, lack of diversity of workers in the technology industry, and the data that forms the basis for many of today's computer algorithms cause technologies to perpetuate longstanding stereotypes and biases and, at times, disadvantage or endanger their users. This means that each day, people are examining millions of search results, using sensor and voice-activated technologies, and trusting criminal justice decisions without considering how the technologies themselves are playing a role in the decisions being made and their outcomes.

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[1] "Techquity" is a portmanteau of "technology" and "equity."

Simultaneous with, and, in part, because of the rise of technology use within society and technology's profound capabilities, computer science education is expanding within K-12 schools. This includes an increase in the number of computer science courses (*2019 State of Computer Science Education Equity and Diversity*, 2019) as well as integration of computer science and computational thinking into disciplinary subjects (I. Lee et al., 2020), with the goal of bringing computer science to all students (Smith, 2016). Yet, students need to learn not only how to program and solve problems like a computer scientist, but also how to consider the equity and social justice implications of the technologies that they use and create. As such, the impact of computing within society is one of the five core concepts that should be taught as students learn computer science (*K-12 Computer Science Framework*, 2016). In studying these impacts, students should recognize that "computing affects many aspects of the world in both positive and negative ways at local, national, and global levels" across three spheres: culture, social interactions, and safety, law, and ethics (*K-12 Computer Science Framework*, 2016, p. 92). This means recognizing both the ways that technology impacts people's lives and how people impact technology, for better and for worse. While negative impacts of computing are included within the current computer science framework (i.e., cyberbullying, reduced privacy, online piracy and plagiarism, movement of jobs due to technology-aided globalization, cyber safety, lack of access to technology, and inaccessible technology), these impacts do not always cover the inherent biases described above, particularly for elementary and middle grade learners who are beginning to interact with these technologies and form online identities and sensibilities.

Introducing learners to Threats to Techquity could result in the broader impact of raising awareness of these problems for the general population as well as for those considering a career in programming or computer science. As such, it is essential that students are introduced to the ethical concerns of computing and computing in a socially responsible manner (Santo et al., 2019; Vakil & Higgs, 2019; Vogel et al., 2017). Such an introduction to Techquity concepts aligns with educational theories promoting the development of critical consciousness within students (Freire, 2000; Gay, 2000; Ladson-Billings, 1995, 2014; Paris & Alim, 2017). Opportunities to engage critically with content and with broader society gives all students, especially students of color, the opportunity to identify oppression and examine the role dominant norms and structures play in their lives. While past computing projects have used computer science as a means to critically examine society and the impacts of the dominant society on populations that experience marginalization (Isaac et al., 2020; e.g., C. H. Lee & Soep, 2016, 2018; Ryoo, 2019; Ryoo et al., 2013; Sandoval, 2019; Tissenbaum et al., 2017; Vakil, 2014, 2018), few, if any, projects have simultaneously developed computer science skills and critically engaged with Threats to Techquity.

In this dissertation, I present a design study that brings together three key ingredients to understand effective Techquity education: curricula, teachers, and students. Working collaboratively with students and teachers using participatory design techniques, specifically cooperative inquiry with the youth designers (Druin, 2002), I developed computer science lesson plans that integrate learning about Threats to Techquity with introductory computer science material. These lessons, called Talking Techquity, give middle grades (5^{th} – 8^{th} grade) students the opportunity to critically examine the potential oppressive impacts of technology in their lives and those of their communities. Then, the teachers who co-designed the lessons implemented them within the classroom, adapting them to the needs of the students. This work aims to study teaching Techquity alongside computer science to: (1) teach students about Threats to Techquity, an important and often-overlooked aspect of computer science; (2) give students the opportunity to think critically about the negative impacts of technology in their lives; and (3) provide an example for how Techquity can be brought into middle-grade classrooms in a responsive way.

Theoretical Frameworks

Two frameworks frame this work: the constructivist theory of learning and the participatory design approach to design. In the following section, I introduce each of the two guiding frameworks. Then, I conclude with an overview of the interplay between the theories and how they relate to the present work.

Constructivism

Constructivism is a theory of learning, pedagogy, and knowledge (Amineh & Asl, 2015). As such, constructivism describes not only how students come to understand new knowledge, but also how that knowledge can be effectively taught (Amineh & Asl, 2015). While there are several variations of constructivism within education (Amineh & Asl, 2015; Bada, 2015; Boudourides, 2003), in this work, I take a Piagetian cognitive view of constructivism and focus on the conceptions of individuals (Kim, 2010). Piaget focused on child development and knowledge construction as a part of the developmental process (Piaget, 1964, 1972). While Piaget himself was not focused on education and did not write about constructivism from an educational perspective, his ideas of child development and his perspectives are foundational to this theory (Sjøberg, 2010).

Based on the work of developmental psychologists such as Piaget, constructivism was popularized in education in the late 1970s and early 1980s (Sjøberg, 2010). Today, constructivist teaching is common, particularly in science, and has been applied across science and technology studies, including in computer science education (Ben-Ari, 2001; Boudourides, 2003). According to constructivism, learners actively construct their knowledge and new knowledge is based on previous learning and current experiences (Bada, 2015; Hoover, 1996; Piaget, 1964). Being told about something is not enough for learners to build understanding, even when they are told the same information repeatedly (Piaget, 1964). Rather, learning is constructed based on the context in which the learner is located and their own beliefs and attitudes (Bada, 2015). Learners build new knowledge as they interact with the physical and social world and collaboratively construct new ideas with peers in social environments (Sjøberg, 2010). Because of the interaction between learners and the world as they actively construct knowledge, constructivist learning is grounded in authentic contexts, which support student engagement (Bada, 2015).

Based on learning experiences and the world around them, learners develop their own conceptions of the world and constantly develop and adjust their mental models of how the world works (Bada, 2015). Because learners continuously build their own conceptions and understandings of the world, a constructivist viewpoint acknowledges that each person's understanding of reality can be slightly different and that their understanding affects their daily lives and learning opportunities (Kim, 2010). Learners bring these conceptions into any learning experience and use them to make sense of materials and build new understandings (Sjøberg, 2010). Taking a Piagetian stance on constructivism, learning is an active process that requires students to be constantly reflecting upon their prior knowledge and new experiences in order to build new knowledge and meaning (Amineh & Asl, 2015; Piaget, 1964; Sjøberg, 2010). Educators adhering to constructivist theory focus on creating active learning opportunities for students that begin with and foreground students' prior knowledge. The development of new knowledge relies on grounding it upon prior understandings, using simpler knowledge as the basis for developing more complex ideas and developing new understandings based on what they already know (Bada, 2015; Piaget, 1964). Additionally, learning experiences must take into account students' current conceptions and whether those conceptions are accurate understandings of the world. This understanding make is possible to re-educate students about misconceptions and support the development of new knowledge (Hoover, 1996). When teaching in a constructivist manner, teachers must first consider their students' existing knowledge and develop opportunities for students to activate and build upon that knowledge (Amineh & Asl, 2015). A large part of constructivist learning not involves only experiencing something new, but also reconciling the new experience with previous conceptions of the world and reflecting to create a new understanding in an active process (Bada, 2015).

Because of the focus it puts on learners' prior knowledge and active learning, constructivism de-centers the role of the teacher or more knowledgeable person within a learning environment. Rather than teachers being the enlightened individuals who must pass knowledge to learners, within constructivism, teachers serve as facilitators or guides to learning (Bada, 2015; Boudourides, 2003; Hoover, 1996). As such, teachers cannot impart information upon learners, nor can learners develop new understandings through passive methods (Boudourides, 2003). Within this model, learning is student-centered and new understandings develop based on students thinking and understanding rather than memorizing (Bada, 2015).

Participatory Design

Participatory design first emerged during a Scandinavian movement for worker participation in decision-making during the 1970s and 1980s. It focuses on the inclusion of user voices in the design and decision-making processes around new products (Muller & Kuhn, 1993) with an overall goal of equalizing power structures (Bjerknes & Bratteteig, 1995; Bødker et al., 2000; Kensing & Blomberg, 1998). While the exact design process varies by designer and team, design thinking within this process is an iterative, non-linear process of inspiration, ideation, and iteration (IDEO, 2015). Within participatory design, users can be involved in any or all the three phases. In the design process, designers identify and frame a design challenge in the *inspiration* phase. Then, they generate ideas about solutions to those design challenges in the *ideation* phase. Finally, the team creates a prototype and partakes in a cycle of receiving feedback and making improvements upon the design in the *iteration* phase (IDEO, 2015).

Throughout this process, users can take varied roles depending on the degree to which they are involved in the design process and the type of information or partnership sought by the designers that is possible within the context (Druin, 2002; Kensing & Blomberg, 1998). The degree at which a user or design partner needs to be involved in the design for it to be considered participatory design and, more importantly, to positively affect the design and lead to a more democratic design process has varied within participatory design literature. Consensus promotes the inclusion of users, particularly in design decisions, for better design and the greatest level of participation possible (Kensing & Blomberg, 1998). According to Druin (2002), at the lowest level, one's voice is incorporated through being a *user* of the designed product while developers observe to see how a user interacts with an existing innovation. A second level is the user as a *tester*, providing feedback on designs that have not yet been released to the public. The third level of user involvement is the user as an *informant*. In the informant role, the user is part of the design process both at the end and throughout at multiple stages, providing information that aids in the creation of an innovation. Finally, users can be incorporated in the design process as *design partners*. In this role, the user is an equal stakeholder to the professional designers and is involved throughout the entire process (Druin, 2002).

Since it began, participatory design has evolved to focus not only on the workplace, but also on the general public, everyday activities, and education. Within these spaces, participatory design takes on explicit equity goals to counter oppressive structures such as the traditional design approaches that design from the top-down rather than in collaboration with the users (Penuel et al., 2007). In doing so, participatory design is an emancipatory process that works to democratize design spaces (Björgvinsson et al., 2010; Iversen et al., 2004) and provide opportunities to promote user voices and identities (Coenraad et al., 2019).

Beginning in the 1990s, participatory design expanded into educational innovations and the development of educational technologies based on a design process that gives voice to users (Bonsignore, Ahn, et al., 2013; DiSalvo et al., 2014; Pinkard et al., 2017; Williams & Traynor, 1994). When designing for educational settings, an important user to include in the design is the teacher (Roschelle et al., 2006). Teacher involvement within the design of curriculum and technologies for the classroom is essential due to teachers' ability to "pay attention to broad goals for learning and for improving large-scale systems" (Penuel et al., 2007, p. 52). Teachers also help focus the design process on their everyday work practices and what happens in their classrooms (Roschelle et al., 2006). Additionally, students are important participants within the design process due to their ability to identify topics and ideas of interest to them, relevant narrative and design elements, and structures that relate to their lives and ways of knowing (Coenraad, Palmer, et al., 2021; Coenraad, Weintrop, et al., 2021; Pinkard et al., 2017; Proctor & Blikstein, 2019).

Given the importance of user voices within participatory design, design methodologies must actively work to develop design environments in which user voices are welcomed, shared freely, and heard. This is especially important when designing with youth. Cooperative inquiry, a participatory design methodology, considers the differences in power between adults and youth within dominant society and actively works to counter these structures. It centers around adult and child designers work together as design partners with equal footing in the project to design technologies for children (Druin, 2002, 1999). In cooperative inquiry, the designers work to build long-term relationships that allow for equal treatment of all designers based on knowing and developing respect for each other. In addition to the long-term relationships that are built, activities within the sessions work to break down the typical power dynamics between adults and children. Adults wear informal clothing to counteract their typical roles as authority figures, everyone sits on the floor together, and the team shares snack time at the beginning of every session (Druin, 1999; Fails et al., 2012).

Constructivism and Participatory Design within the Present Work

Participatory design and constructivism interact in three key aspects of this work: selection and participation of design partners, opportunities for designer learning, and understanding of youth conceptions of Techquity.

Participatory design affects not only who is involved within this work, but also how they are involved. I selected participatory design as both a theory and methodology because of the commitment to equity inherent within the theory. A major Threat to Techquity is the exclusion of designers who experience marginalization in computing (i.e., designers who identify as Black, Latinx/Latine, Indigenous, or Pacific Islander, designers with disabilities, and designers who identify as women or non-binary) from technology design spaces (Wachter-Boettcher, 2017). Given this pattern of exclusion, participatory design provides a way to specifically involve these designers within the current work. By including both teacher and youth voices, I honor the importance of both voices within the classroom. Given that constructivist theory highlights the importance of learners within the knowledge development process and the role of teachers as guides rather than experts (Bada, 2015; Boudourides, 2003; Hoover, 1996), both sets of voices prove essential to the design of a constructivist curriculum. Additionally, I aim to include the design partners at the highest levels of participation possible: as informants and design partners. This creates key opportunities for design partners to provide insights for and make decisions about the curriculum while creating room for youth and teacher voices to be heard and present in the final design (see Chapter 3).

Within the present work, the use of participatory design, and specifically cooperative inquiry, provides key opportunities to enact constructivist ideals. Participatory design is, itself, a constructivist learning process. Designers construct knowledge as they think about topics and develop their own design ideas, a concept embodied in the theory of constructionism.

Constructivism influences constructionism, which emphasizes not only that learners construct knowledge, but also that they do so to a higher degree when constructing or creating something sharable, such as a design (Papert, 1980). The participation of designers within the design process of a project grounded in participatory design both produces knowledge for use in a final design and permits design partners to construct knowledge from the process (McNally et al., 2017). The inclusion of youth and teachers within this project provides a learning opportunity for both groups. Youth are exposed to and develop knowledge around Threats to Techquity. Meanwhile, the design process acts as professional development for the teachers who will enact the curriculum within their classroom.

Participatory design broadly, and cooperative inquiry specifically, provides opportunities for researchers and designers to elicit designer views, to engage with potential users to integrate their voice into the final design, and to understand what youth already understand about a topic (e.g., Begnaud et al., 2020; Kumar et al., 2018; Yip et al., 2019). This third goal, understanding youth's current knowledge of a concept, is important to constructivism, as youth conceptions are the foundation upon which new knowledge is constructed and opportunities for learning must consider students' prior knowledge to build upon it (Amineh & Asl, 2015; Bada, 2015; Hoover, 1996). To ground learning in students' beliefs and knowledge (Sjøberg, 2010), first, those beliefs and knowledge need to be surfaced, a process made possible through participatory design. A core aspect of this work involves first understanding what youth know about Techquity and Threats to Techquity and how they conceptualize these ideas (see Chapter 2). By understanding these conceptions, the lesson materials can more accurately build upon youths' current knowledge. While every child would have slightly different conceptions and a constructivist teacher using Talking Techquity would still need to understand the prior knowledge of his or her individual students, the patterns that tend to emerge between learner conceptions of a topic in constructivist settings (Sjøberg, 2010) mean that understanding the knowledge of an initial group is sufficient to begin building curricular materials that are adaptable for specific contexts.

Relevant Literatures

Multiple bodies of literature influence and contextualize the research within this dissertation. In the following sections, I introduce the experiences of people who experience marginalization within computing profession and discuss curricula specifically designed to integrate cultural knowledge for the purpose of promoting a more equitable environment in which to learn computing and make connections to students' experiences. Then, I detail computing initiatives specifically focused on opportunities for the development of critical consciousness and critical analysis of the societal structures responsible for the oppression of minoritized populations. I conclude by introducing major Threats to Techquity, including bias caused by data and algorithms.

Broadening Participation in Computing and Culturally Responsive Computing

Within the technology industry people who identify as Black, Indigenous, Latinx/Latine, Pacific Islander, women, gender non-binary, or as a person with disabilities experience marginalization (Bureau of Labor Statistics, 2018, 2019). This marginalization plays a role in the perpetuation of Threats to Techquity (Wachter-Boettcher, 2017). Together, a combination of structural, social, and psychological barriers create a space where people who experience marginalization in computing do not have equal opportunities to participate in the technology industry and, therefore, are systematically barred from accessing high-paying jobs (Margolis et al., 2008; Margolis & Fisher, 2002; J. Wang & Moghadam, 2017). Schools mirror these patterns of marginalization. Research has shown that students attending schools in impoverished areas, particularly students of color, had less access to computer science courses and less rigorous computer science courses than students in better-funded districts (Google Inc. & Gallup Inc., 2016a; Margolis et al., 2008). Even when computer science courses are available, students from underrepresented groups report feeling uncomfortable enrolling or unwelcome in the courses; teachers have biased perceptions about who will do well in their courses; programming classes are often taught with pedagogies that are not contextualized to students' lives; and teachers are not provided with enough support due to limited teacher certification pathways and computer science teacher communities (Margolis et al., 2008). Further, high school guidance counselors have steered groups of students away from computer science courses based on race and gender stereotypes about who should excel in computing because the classes are perceived as difficult (Margolis et al., 2008). This occurs despite high levels of interest in taking a computer science course from both students of color and their parents (Google Inc. & Gallup Inc., 2016b, 2016a; J. Wang & Moghadam, 2017).

There is a need to focus on counteracting some of the social, psychological, and structural barriers within the field (Bobb, 2016). As a means to do so, research suggests the integration of equity pedagogies (Madkins et al., 2020) such as culturally responsive computing (Eglash, Gilbert, & Foster, 2013; Eglash, Gilbert, Taylor, et al., 2013; K. A. Scott et al., 2015); ethnocomputing (Tedre et al., 2006); and the Culturally Responsive-Sustaining computer science Framework (Kapor Center, 2021). Examples of learning opportunities that integrate students' youth and community culture and knowledge into computing lessons and curricula have been used within several different types of computing (Morales-Chicas et al., 2019) such as design (e.g., Babbitt et al., 2015; Eglash, 2007; Eglash et al., 2006, 2011), e-textiles (Kafai et al., 2014; Kafai, Fields, et al., 2019; Richard & Kafai, 2015; Searle & Kafai, 2015a, e.g., 2015b; Shaw et al., 2020), and programming environments and curricula (Franklin, Weintrop, et al., 2020; e.g., Goode & Margolis, 2011; Magerko et al., 2016; Mejias et al., 2018; Resnick et al., 2009; Ryoo et al., 2013; Alicia Nicki Washington et al., 2012). To promote greater access for students, these learning opportunities have also taken place in varied settings, including classrooms (e.g., Anohah & Suhonen, 2016; Sandoval, 2019; Weston & Biin, 2013, 2011), after-school programs (e.g., Allen-Handy et al., 2020; Codding et al., 2019; Leonard et al., 2016; Pinkard et al., 2017), and summer programs (e.g., DiSalvo et al., 2014; Franklin et al., 2011; K. A. Scott & White, 2013). These varied settings have also allowed for a focus on connecting with communities and community needs within projects (e.g, Duveskog et al., 2003; Gedawy et al., 2019).

Critical Computing

In addition to framing projects through the situated lens described above, other researchers incorporate a critical lens into computing initiatives (Kafai, Proctor, et al., 2019). Rather than focus only on integrating students' cultures, interests, and ideas within curricula, teachers encourage and teach students to have a critical lens and examine the structures and norms of both society at large and computing specifically (Kapor Center, 2021; Ladson-Billings, 2009, 2014; Paris & Alim, 2017; Alicia Nicki Washington, 2020). In computing, this includes projects, organizations, and applications that give students the opportunity to develop and express critical consciousness about, through, and with computing.

Critical computing projects often provide opportunities for students to be change agents within their communities using the work that they create with their computing skills (A. Scott et al., 2016). For example, multiple researchers have employed the creation of new apps to engage in critical pedagogy to broaden students' sociopolitical contexts, helping them to access computer science while also giving meaning to and deriving meaning from their work and creation. The apps they created supported peers finding after school programming, volunteers working in disaster relief, and teens managing mental health (Tissenbaum et al., 2017; Vakil, 2014). Outside of app creation, Proctor and Blikstein (2019) incorporated critical computing into a literacy platform, providing students with the opportunity to use writing and programming in interactive stories to write critical discourses. Isaac et al. (2020) developed a summer program centered around culturally relevant teaching that purposefully included opportunities for students to build cultural competence and leverage their knowledge about social justice issues in the creation of a Scratch project.

More broadly, Youth Radio gives youth the opportunity to critically examine the world and produce digital media "products [that] challenge audiences to engage with some of the most pressing issues of our times, including gentrification, sexual assault in schools, the lived experiences of LGBTQ+ youth, and the mental health struggles of urban youth of color" (C. H. Lee & Soep, 2018, p. 10). In addition to creating the mental health app that track's users' moods to support them in getting emotional support from friends when needed (Tissenbaum et al., 2017), the group also created a website about gentrification in the city of Oakland (C. H. Lee & Soep, 2016) and ran a social media campaign commemorating the sixtieth anniversary of the desegregation of Central High School (C. H. Lee & Soep, 2018). Each project gave youth the opportunity to examine facets of society and counter them with their work and design decisions, whether it was their changing neighborhood and how to present it to an audience without encouraging more tourism (C. H. Lee & Soep, 2016) or considering how black and white film and current media portray Black skin tones without variation (C. H. Lee & Soep, 2018).

Initiatives with the Exploring Computer Science (ECS) curriculum have also offered students a variety of different opportunities to think critically and develop critical consciousness. For example, students have explored food access through data collected using mobile phones and created a film using Scratch that allowed them to represent their new knowledge and make connections between the food data they had collected and their everyday lives (Ryoo et al., 2013; Sandoval, 2019). Additionally, an ECS researcher and an ECS teacher partnered to support students in creating serious video games that examined the social realities of their everyday lives. Students created video games relating to their lives as undocumented immigrants, the challenges of navigating high school and getting into college, and the gang violence in their neighborhood. Through these games, students were able to not only exhibit complex computer science skills, but also to critically examine and present realities of their lives (C. H. Lee, 2012; Ryoo et al., 2013).

While a growing number of projects are giving students the opportunity to think critically about society and present their understandings through computer science, few, if any, projects focus on the development of critical consciousness specifically around the technologies that youth are using and technological products and computer science more generally. This dissertation aims to take a step toward filling this gap by instructing students about Threats to Techquity and giving them the opportunity to use computer science to teach others.

Threats to Techquity

Threats to Techquity are those aspects of computing and technologies that cause or could cause inequality, especially inequality based on marginalized identities (e.g., race, immigration status, gender, sexual orientation, ability, etc.). While the use of the term "Threats to Techquity" is unique within my work, this concept draws from and is related to the work of other fields and research groups. It brings together work on singular issues (e.g., data and datafication, artificial intelligence, privacy) under an overarching thematic umbrella focused on how technologies and technological systems can cause or perpetuate inequalities within society. With regards to user privacy and the protection of user data, Threats to Techquity overlap with cybersecurity and privacy research (e.g., Kumar et al., 2017; Kumar & Schoenebeck, 2015; Zhang-Kennedy et al., 2016). Threats to Techquity relating to data collection and the use of user data align to work on data justice and the importance of foregrounding social justice concerns and societal inequality in conversations about data and surveillance (Dencik et al., 2016, 2019; Taylor, 2017). Additionally, Threats to Techquity related to or caused by artificial intelligence systems relate to and are drawn from the work of members of the Algorithmic Justice League (The Algorithmic Justice League, 2020), AI Now (Crawford et al., 2019), and other groups focused on equitable and accountable AI. More generally, many Threats to Techquity have been identified by and researched within the FAccT conference and community (e.g., Obermeyer & Mullainathan, 2019; Speicher et al., 2018) as well as by investigative journalists (e.g., Broussard, 2018). Furthermore, Threats to Techquity encompass ideas and concepts by foundational researchers focused on the impacts of technology on society including Ruha Benjamin's definition of the "New Jim Code" (Benjamin, 2019), Cathy O'Neil's characterization of algorithms as "Weapons of Math Destruction" (O'Neil, 2016), Safiya Umoja Noble's making visible instances of "technological redlining" (Noble, 2018), and Virginia Eubank's depiction of the "digital poorhouse" caused by algorithms, databases, and risk models (Eubanks, 2018). Beyond the Threats to Techquity themselves, ideas around educating youth and other users about Threats to Techquity relate to work extending computational thinking to include opportunities to combat societal challenges through computational action (Tissenbaum et al., 2019) and youth understanding and critically engaging with the effects of digital technologies on society through computational empowerment (Iversen et al., 2018).

In the following section, I present examples of common Threats to Techquity that have been identified by researchers, product developers, and investigative journalists, many of whom belong to the communities and organizations mentioned above. Importantly, these examples are not intended to be an exhaustive list of Threats to Techquity, but rather provide identified examples of inequitable experiences caused by technological and algorithmic bias. Given the continuous introduction of new technologies and the prevalence of data collection and algorithmic decision making within society, Threats to Techquity are continuously changing and new threats are designed, developed, and identified. Therefore, a concrete or finite list of Threats to Techquity cannot be developed. Instead, Threats to Techquity are identified within this work when technology or technological systems create, exacerbate, or perpetuate societal inequalities.

Due to the ubiquitous nature of technology within modern society, there are many potential Threats to Techquity that are omnipresent in daily life, and digitally automated systems are adding to inequality that is already rampant within society (Gangadharan et al., 2014). Yet, many people do not know about or consider Threats to Techquity. While investigative and data journalism (e.g., Broussard, 2018) has been especially influential in bringing Threats to Techquity to the attention of the public, many of these potential harms remain invisible within society. An assumption of technological neutrality prevails. While 58 percent of people in the United States acknowledge that computer algorithms reflect human bias at some level, 40 percent believe that computer programs can be designed bias-free, a number that is higher for young adults ages 18-29 (50 percent) than for older adults (Pew Research Center, 2018a). Marketing from technology companies fuel and support these views. For example, in a television commercial, Carvana, an online car dealership, touts that users simply need to enter a few basic facts about their cars and then “techno-wizardry” will determine the car’s value and make an offer. The commercial portrays an algorithm as all-knowing and infallible, as an unbiased assessment of a car’s value and the best deal for those who want to sell their cars. While this is a very specific example, similar marketing and the “black-boxing” of technology fuel the biases that technology can have. Threats to Techquity have roots in multiple, interconnected areas: algorithms, data, and design. Here, I focus on those concerns influenced by the creation and design of technologies such as algorithmic bias (including in artificial intelligence and machine learning) and the collection and use of consumer data. These concerns are centered within this introduction due to the role they play in the Talking Techquity curriculum, a choice that was made due to the input of the youth co-design partners. In the following sections, I overview my focal Threats to Techquity and mitigation measures to counter algorithmic and technological bias. I conclude with examples of education programs currently teaching about Threats to Techquity.

Algorithmic Bias

Almost all modern computing technology utilizes some algorithm to process information or perform tasks. Due to this prevalence, algorithmic bias is perhaps the most profound Threat to Techquity. Algorithmic bias is "roughly the worry that an algorithm is, in some sense, not merely a neutral transformer of data or extractor of information" (Danks & London, 2017, p. 4691). This bias is caused because the creator of the algorithm determines what variables are important enough to be included in the algorithm and the weight of said variables. The decisions made by the developer during the creation of the software encode the biases and opinions of that creator and of the datasets used to create it (O'Neil, 2016). Algorithmic bias can be found throughout the development and use of an algorithm, specifically in the training, focus, process, context transfer, or interpretation of that algorithm (Danks & London, 2017). This bias can also be found across types of algorithms, including in artificial intelligence and machine-learning algorithms (e.g., systems that make decisions as a human would based on programmed rules or rules "learned" from a dataset).

While algorithmic bias, as with all bias, is not inherently negative, and some algorithmic biases can be neutral or positive (Danks & London, 2017), negative algorithmic bias can harm individuals, particularly populations that are marginalized and minoritized within society. These harms include both individual and societal harms and exist across sectors (e.g., employment, housing, education, credit, and incarceration) (Future of Privacy Forum, 2017). Researchers and investigative journals have uncovered and reported on these negative biases. For example, an algorithm developed by Amazon for use during the hiring process had a gender bias toward men that resulted in fewer women being identified as strong candidates, thereby perpetuating gender disparities (Dastin, 2018). Bias in a national algorithm controlling healthcare screening that identified patients at high risk for additional care management identified Black patients for enrollment at a disproportionately low rate, resulting in an under-identification of Black patients who would benefit from the program (Obermeyer et al., 2019; Obermeyer & Mullainathan, 2019). Finally, bias can be seen in the use of algorithms in policing and criminal justice. ProPublica found that systems used in sentencing produced different results for white and Black defendants and did not accurately predict their likelihood of recidivism (Angwin et al., 2016).

Algorithms impute based on who one knows and to whom one appears similar (Gangadharan et al., 2014). For example, data is used to create profiles of users. These profiles then dictate the advertisements that users receive based on what they and others considered to be similar to them have purchased previously. But these profiles are based on assumptions and have mislabeled women who like science fiction and visit technology websites as men (Wachter-Boettcher, 2017). When companies utilize advertisement targeting to target vulnerable populations (e.g., a pay day loan company targeting individuals assumed to be low-income), the advertising can lead to further inequities within society (O'Neil, 2016; Wachter-Boettcher, 2017). In another example, computer scientists developed an algorithm that could predict sexual orientation based on Facebook friends, regardless of whether the person marked their sexual orientation on their profile. This has significant impacts on individuals' privacy and could cause harm due to both true and false positives (Jernigan & Mistree, 2009).

Within machine learning programs, researchers have identified inequities based on the data inputted into the programs and what the algorithms identify and use to categorize. For example, an algorithmic audit of artificial intelligence classification systems found they can more accurately classify images of males and light-skinned individuals than females and dark-skinned individuals, respectively. Intersectional inaccuracies compound these biases. The systems proved least accurate in identifying dark-skinned women, exhibiting a 20 to 35 percent error rate (as compared to a 0.0-0.8 percent error rate for light-skinned males) (Buolamwini & Gebru, 2018). Using the same dataset to analyze the quality assurance system for passport photos in the United Kingdom, similar findings emerged: the system rejected a greater number of photos for dark-skinned women than for other combinations of race and gender (Ahmed, 2020). Even in a model that is not trained to identify gender, but rather to identify tasks occurring in the images, image sets “leak” gender information due to other attributes of the images that can create a gender bias within the machine learning program (T. Wang et al., 2019).

Another area of marginalization, even within conversations of algorithmic bias, is disability. A core component of artificial intelligence algorithms is defining a “normal.” But this has significant consequences for individuals with disabilities, particularly because the technology companies encoding data into their systems determine the norm (Whittaker et al., 2019). Existing systems, even those specifically designed to be used by individuals with disabilities, have been shown to discriminate against them and center neurotypical society. Examples include when artificial intelligence is used in the hiring process, in disability diagnosis, and in trying to changing the behavior of autistic people (Whittaker et al., 2019).

American have varied views about whether it is acceptable for algorithms to make decisions that have human consequences, and acceptance rates differ by topic. For example, 42 percent of Americans believe that it is acceptable to use algorithms to determine criminal risk in parole cases, but only 31 percent believe algorithms should be used to create personal finance scores using consumer data (Pew Research Center, 2018a). Many Americans do not know the extent to which public services use algorithms. Algorithms even affect people who tend not to use technology or purposefully stay away from using cloud-based services, with algorithms making influential decisions about them and their lives. Currently, technologies are being integrated into public services to create fairer, more transparent, and more efficient systems, but these systems actually limit access to social services (Eubanks, 2018; Gangadharan et al., 2014). Part of the inequity caused by these systems stems, not from the systems themselves, but from how algorithms are used within society. They often function at the expense of those with less structural power (Whittaker et al., 2019).

Consumer Data Collection and Use

A core aspect to algorithms is the data they use to make decisions, particularly in artificial intelligence and machine learning algorithms. Currently, an unprecedented amount of data is collected about individuals. The amount of data globally has grown to be over eight times what it was in 2010 (Children's Commissioner, 2018). This includes large quantities of data on children. By the time a child turns 13, their parents have posted an average of 1,300 photos of them (100 per year) on social media (Children's Commissioner, 2018). One of the biggest associated Threats to Techquity is that people do not know or have control over all of the data collected about them (Gangadharan et al., 2014). Over 80 percent of people from the United States believe they have little or no control over the data collected about them by companies and the government, despite 79 percent expressing concern about data use (Pew Research Center, 2019). This is, in part, because data collection is occurring constantly all around us. Data is collected through internet searches, social media use, and online shopping (O'Neil, 2016; Wachter-Boettcher, 2017), using methods invisible to the user such as location-enabled technologies (Wachter-Boettcher, 2017), web-cookies (Children's Commissioner, 2018), and smart speaker home assistants such as Amazon Alexa and Google Home (Lynskey, 2019).

Not all uses of data are bad. For example, Garcia et al. (2017) use data to limit human rights violations in Mexico. Additionally, Gangadharen et al. (2014) suggest that if workplace algorithms focus on the effect of workplace policies rather than on candidates, data could be used to positively impact the work environment and the lives of oppressed and marginalized populations. But there remain many ways that data can cause Threats to Techquity.

One way that data is commonly used is in retail and advertising. Companies have developed ways to socially target consumers based on their location (Gangadharan et al., 2014). This location data has been used to increase the prices of products by 166 percent (Mikians et al., 2012). Companies also use web-cookies and meta-data to collect information about consumers that is "given-off" as they use the internet (Children's Commissioner, 2018). The amount of data collected through tracking clicks, web-cookies, and user history makes it possible to target online advertisements and more effectively sell products (John et al., 2018). Yet, this targeted advertising can become malicious and lead to further inequities within society, as described above (O'Neil, 2016; Wachter-Boettcher, 2017). While marginalized groups are protected from discrimination based on attributes such as their race or ethnicity, companies can use the amount of data available on individuals to develop profiles that provide advertisements according to one's "ethnic affinity" rather than one's provided ethnicity (Speicher et al., 2018). The ability to target advertisements on platforms such as Facebook using matching customer information such as a phone number or email address means that public records can be used to develop targeting lists, which can also be discriminatory (Speicher et al., 2018). But discrimination does not only occur in the advertisements presented to individuals. Searching online for Black-associated names is more likely to result in advertisements inferring that someone has been arrested or has a criminal record as compared to searching online for white-associated names (Sweeney, 2013).

As searching for applicants is a common process, this could impede job or schooling prospects for individuals, even if they have no arrest record.

One concern about the use of datasets is how they are used to train machine learning algorithms. Training such an algorithm requires large amounts of data for the machine to "learn" to recognize patterns. These training sets are problematic when they are not balanced. Existing training sets tend to be heavily male and light-skinned (Buolamwini & Gebru, 2018). But research has shown that when given limited exposure to other race or age group training data, deep-learning algorithms mimic the in-group biases of humans (Nagpal et al., 2019). While one potential improvement, based on these findings, would be to increase the presence of groups that experience marginalization within datasets, this raises issues of privacy and surveillance of groups that are already amongst the most surveilled within society (Whittaker et al., 2019). Another risk of these large datasets is over-collection of data. While datasets might be anonymized, the larger a dataset becomes, the more easily an individual or their activities can be identified based on the data (Gangadharan et al., 2014). For example, data collected about energy use with smart energy meters can be used to determine information about people, such as which electronic devices are in a house. While the use of the meters is not inherently bad, the problem lies in how the data is collected and used and whether individuals are informed of the data collection risks of installing such meters (Gangadharan et al., 2014).

When improving upon the datasets used for this process, it is important to pay attention not only to what is included in a dataset, but also to how and why the dataset was created (Denton et al., 2020). While photographic datasets for lighting and camera angles often document their sources, datasets with identified race and gender rarely provide sources to define the image categories used or document the annotation process (Scheuerman et al., 2020). Given that the field does not have a consistent classification schema, such annotations and documentations are important to understand how categories were developed, the identification process, and the sociohistorical contexts in which the labeling was completed. For example, many datasets are labeled as male or female, but these labels are given not by the person in the picture, but by someone else. This reinforces the male/female binary within society and overemphasizes gender presentation instead of actually identifying a gender (Scheuerman et al., 2020).

Mitigating Algorithmic Bias and Programming and Designing for Techquity

Given the ways that algorithms and data have been shown to be Threats to Techquity, researchers have begun focusing on how to mitigate bias within algorithms and promote more equitable technologies. This begins with defining fairness and documenting the assumptions defining the algorithm, given the beliefs of the algorithm's creator (Friedler et al., 2016). It also requires careful documentation of the data and choices going into an algorithm and forward-thinking about potential risks (Crawford et al., 2019). Given that not all bias is negative, it is necessary to identify what the biases are and determine whether those biases will have negative impacts within the specific context in which an algorithm will be used (Danks & London, 2017).

To remediate negative biases, researchers have suggested several different options. One common suggestion is the expansion or development of new training sets representing a more diverse subset of the population. While new datasets have been explicitly created for the purpose of greater diversity in race and gender (Scheuerman et al., 2020), large training sets only reduce own-age or own-race biases; they do not completely eliminate the issues (Nagpal et al., 2019). Even balanced datasets used within training can lead to algorithms that amplify stereotypes (T. Wang et al., 2019): additional data within datasets could still be considered an outlier by the program as it attempts to define a norm (Whittaker et al., 2019). It is also important to consider the burden put on groups that experience marginalization, who are already over-surveilled, when their data is needed to expand datasets (Denton et al., 2020). Despite the difficulties of creating more balanced and reliable training sets, an important step in developing more equitable training data is the removal of biased datasets (Scheuerman et al., 2020). Because training sets are shared widely, a biased dataset can affect many different products or algorithms. But simply recommending that it is taken down or taking down the original dataset is not enough to control the effects, since derived datasets are often created from the originals. The field needs to work together to not use, report on, or review products or manuscripts that use unethical datasets (Peng, 2020).

Algorithmic audits and fairness testing can also mitigate bias within algorithms. Yet, these audits are difficult because often, the algorithms themselves cannot be examined. Due to the proprietary nature of algorithms, companies are not required to be transparent about what is in the algorithms and users are forced to feel their effects without knowing exactly what is going into them and how factors are weighed (Noble, 2018; O'Neil, 2016). While researchers can identify what types of bias to look for or areas where bias might be introduced into an algorithm, it is rarely possible to examine algorithms created by others. When running algorithmic audits, researchers often examine the training data (as described above) as well as the algorithm before potentially developing post-processing modifications (Friedler et al., 2019). Some researchers have proposed statistical and algorithmic means for increasing fairness and equity in this post-processing stage once the main algorithm has run (Hardt et al., 2016). Others have run audit studies on algorithms using an equitably developed training set to reveal biases and develop improved algorithms (Gangadharan et al., 2014). Buolamwini and Gebru (2018), cited in the work above, provide an example of such an audit. On rare occasions, researchers have gained access to algorithms and discovered what is causing the observed bias to recommend changes (Obermeyer et al., 2019; Obermeyer & Mullainathan, 2019). Although audits can be an important tool for detecting bias, they do not necessarily catch everything, and researchers have identified ethical concerns with the auditing process itself (Raji et al., 2020). Auditors need to ensure that their process is not reproducing the same harms it is trying to prevent.

While it might seem intuitive to simply leave out variables that could cause bias, even task prediction models that are not trained to predict gender still amplify societal gender stereotypes (T. Wang et al., 2019). Yet, adversarial debiasing, or purposefully masking gender cues within images, preserved the ability for an algorithm to identify tasks within images while reducing bias by between 53 and 67 percent (T. Wang et al., 2019). Another method for mitigating bias is to have humans interrupt the results of the automated system (Danks & London, 2017), although assumptions of technological neutrality and intelligence discussed earlier can affect whether humans are willing to disagree with systems. To move toward more equitable algorithms and data use, companies are creating ethics statements. For example, Accenture developed a professional code of ethics for its data scientists (Accenture, 2016). Despite many new ethics codes being developed in recent years, there is concern over whether the codes perpetuate majority voices and actually attend to the ethical implementation of artificial intelligence (Crawford et al., 2019).

Although they have some benefits, one limitation of these current mitigation techniques is that they often do not take into account social and critical theories, instead focusing on the technical (Scheuerman et al., 2020). But biases within artificial intelligence cannot be solved by changing the engineering, data, or algorithm. Instead, the conversations need to consider the socio-historical and power structures surrounding the technical side of the algorithm and the way that groups that experience marginalization are treated and viewed within society (Whittaker et al., 2019).

Because these technical fixes are insufficient, community members, workers, journalists, and policymakers continue to advocate and push for change (Crawford et al., 2019). Given the blending of public and private that occurs as private companies control technologies in public places and, at times, with public data, advocates are calling for regulation and focus on the politics surrounding artificial intelligence and algorithms (Crawford et al., 2019). Gangadharan et al. (2014) call for an algorithmic auditing system or a non-profit or non-partisan entity that reviews algorithms. Learned-Miller et al. (2020) call for the development of a federal office that oversees regulation. Consensus is that the current legislation and policies about algorithms, particularly facial recognition and artificial intelligence algorithms, is not enough and that lawmakers need to expand protections (Crawford et al., 2019; Learned-Miller et al., 2020), particularly given the legal ramifications of automated decision-making (Future of Privacy Forum, 2017).

Current Efforts to Teach About the Impacts of Computing and Techquity Concerns

Policy leaders have emphasized the importance of educating children about Threats to Techquity. The Children's Commissioner of England issued a call for students to be educated on guarding their personal information that is collected as data in an effort to promote a greater balance of power between children and the companies that collect and use their data (Children's Commissioner, 2018). Currently, computer science curricular frameworks include some opportunities for students to learn about this and other Threats to Techquity. Impacts of computing on society are one of the five core concepts within the K-12 Computer Science

Framework (*K-12 Computer Science Framework*, 2016). This includes instructing students on the bi-directional interactions between computing and people that affect culture, social interactions, safety, laws, and ethics. The framework introduces students to ways that computers and technology can negatively impact individuals, such as cyberbullying, reduced privacy, automation of jobs, and inaccessible technologies (*K-12 Computer Science Framework*, 2016). But this framework does not point directly to teaching students about algorithmic biases and larger Threats to Techquity, especially before high school. While these can be included in the impacts of computing, such crucial analysis of the computing field is not inherent to the framework.

Despite this, several materials have integrated discussions of Threats to Techquity, particularly in curricula focused on artificial intelligence. In the five big ideas of artificial intelligence developed by the Artificial Intelligence for K-12 initiative, the societal impact of artificial intelligence is central (Touretzky, Gardner-McCune, Breazeal, et al., 2019). As students move through K-12 education, this examination of social impact becomes more complex to include thinking critically about the impacts of artificial intelligence (e.g., taxi drivers losing their job because of self-driving vehicles) and the ethical concerns surrounding artificial intelligence (Touretzky, Gardner-McCune, Martin, et al., 2019).

The “big ideas” of artificial intelligence for K-12 students appears in multiple curricula and learning materials. The optional unit of the Exploring Computer Science curriculum that teaches about artificial intelligence includes objectives and lessons about both data collection and algorithmic bias (Clarke, 2019). Code.org and Microsoft also partnered to create an artificial intelligence curriculum that includes a lesson on artificial intelligence ethics focused on having an artificial intelligence code of ethics (Code.org, 2020). Crash Course, an educational YouTube channel, developed a course on artificial intelligence and included a video on algorithmic bias (Crash Course, 2019). MIT Media Lab developed an artificial intelligence and ethics curriculum specifically for middle school students (Payne, 2019). The MIT Media Lab Personal Robots Group and the MIT STEP Lab have also developed a full artificial intelligence curriculum, DAILy Curriculum for Middle School Studies, that not only covers issues of artificial intelligence ethics, but also teaches students about artificial intelligence (MIT Media Lab Personal Robots Group & MIT STEP Lab, 2021).

Despite the number of curricula available that focus on bias in artificial intelligence and the inclusion of impacts of computing within the K-12 Computer Science Framework, few, if any, curricula focus on algorithmic bias more broadly and introduce students to a broader range of Threats to Techquity. This work aims to explore that gap and the design and development process of a curriculum about Threats to Techquity more broadly.

Researcher Narrative

Acknowledging that the research I do is influenced by who I am and my personal experiences, I offer the following statement of my positionality as a researcher. I am a mixed-race woman who grew up in Juneau, Alaska. I am currently a PhD candidate at the University of Maryland – College Park (UMD). I have spent the last four years helping to develop the Scratch Encore curriculum and learning about computer science and computer science education. I am also an adult design partner on the UMD KidsTeam.

Prior to coming to UMD, my focus was not on computer science, nor had I ever taken a computer science course. I am a former middle school teacher with training specifically in curriculum and instruction. I taught at an urban, Roman Catholic school in Boston, Massachusetts. My main teaching focus was social studies and Spanish, but I also taught a variety of exploratory courses relating to technology and ran the school's technology club, where I encouraged students to learn coding skills, although I had little coding experience. As a teacher, constructivism was central to my own philosophy of education. Beginning in my undergraduate teacher education courses, I researched and designed lessons from a constructivist perspective. As the leader of the design meetings, I recognize that my personal affinity toward constructivism as a learning theory is a lens I bring to the design process. While my view is only one of many contributing to the final design, I acknowledge that my constructivist theoretical perspective will likely affect some outcomes of the work.

Growing up in Alaska, I became acutely aware of how technology can serve as both an access point for some and a barrier to access for others. While I grew up in a small city, many Alaskans rely on technology for learning and access to information but suffer from limited bandwidth and cellular reception. This was my first introduction to Techquity. Since beginning computer science research, I have reflected on why I never learned computer science as a student. Although I built a small robot at the age of eight, constructed a computer in high school, and almost singularly focused on math and science courses, my school never identified me as a student who should learn computer science. In fact, as a high school and college student, I remained largely unaware of what a computer scientist was and all that computer scientists did. Like many, I viewed computer scientists as geeky, white men sitting at a computer terminal all day. No one ever challenged my viewpoint because my high school, despite having almost 2,000 students and being the only high school in my hometown, did not offer computer science. This realization served as another of my personal introductions to Techquity.

My doctoral focus is on the intersections of technology integration in classrooms and equity. I seek to conduct research through partnerships in the hopes that the work I do never separates me from the people who my research can support and is always done in collaboration with communities. I recognize that with each passing year my experiences as a classroom teacher become more antiquated, especially with regards to technology, and I become less of an authority on the classroom. For this reason, my dissertation partners directly with the youth and teachers that it affects.

Intended Outcomes

With technology already maintaining a ubiquitous role within society and the daily increases in technological presence, it is essential that students (as members of society impacted by technologies and algorithms they do not use themselves, current users of technology, and potential future creators of technology) critically consider Threats to Techquity and the related impacts of computing on society. This dissertation works toward two overarching outcomes with a focus on producing findings that can support the computer science education community to design and implement further opportunities for students to critically examine technology and Threats to Techquity. The first outcome is cooperatively developed learning materials created in partnership with the students and teachers using design features and significant Techquity topics as identified by the design partners. The second is an investigation of how teachers engage with and teach materials that combine computer science learning and lessons specifically about Threats to Techquity.

When the students in the UK learned how algorithms were affecting their lives, they spoke out against technological bias affecting their futures. With a greater focus on Techquity in schooling, students could broadly recognize technological biases affecting them daily and would be better equipped to fight bias in the technological spaces they inhabit. This dissertation contributes to knowledge about how to teach youth about Threats to Techquity. It provides insights into students' conceptualization of Threats to Techquity and how those conceptualizations change as students learn about Threats to Techquity. This research also explores teachers' experiences designing and implementing lessons about Threats to Techquity. Together, this knowledge will allow researchers and curriculum developers to better recognize the Techquity knowledge youth already have and how best to provide opportunities for students who experience the impacts of Techquity concerns daily to recognize and combat technological bias and discrimination.

Structure of this Dissertation

This dissertation is organized as a set of related papers. In the following sections, I present three manuscripts (chapters 2 through 4). The manuscripts represent findings from the three phases of this work: designing with youth, designing with teachers, and a classroom implementation. Each manuscript exists as a standalone work. To tie the works together, this dissertation concludes with a discussion and conclusion synthesizing all three articles and considering implications for researchers, educators, and future work.

After introducing the work in chapter 1, the second chapter examines youth conceptualizations of Threats to Techquity based on data from design sessions with eight youth co-designers. This chapter answers the following research questions: *(1) How do youth conceptualize Threats to Techquity in their lives? (2) How do youth perceptions and examples of Threats to Techquity shift after being introduced to examples of technological bias?* and *(3) When designing to teach peers, how do youth present Techquity and Threats to Techquity?* The paper analyzes both youths' initial conceptualizations of Threats to Techquity as well as how those conceptualizations change over time and appear within their designs.

In chapter 3, I present how youth and teachers designed around a specific Threat to Techquity, online data collection and data use. This chapter answers the following research questions: *(1) What topics and instructional priorities do youth consider and determine to be most salient when designing middle grades learning materials about online data collection and use? (2) What topics and instructional priorities do teachers consider and determine to be most salient when designing middle grades learning materials about online data collection and use?* and *(3) How can youth and teacher topics and instructional priorities be integrated into a curriculum presenting online data collection and use?* To answer these questions, I examine youth and teacher designs about data separately, then make connections to the unit of the Talking Techquity curriculum that discusses data collection and use to map teacher and youth ideas to the curricular materials.

In chapter 4, I examine data collected during the implementation of the Talking Techquity curriculum by one of the co-designing teachers. I specifically focus on the adaptations made by the teacher as he implemented the curriculum. In this chapter, I answer the following research questions: *(1) When implementing co-designed lessons, how does a teacher who co-designed the lessons adapt them for the classroom environment?* and *(2) What factors influence a teachers' adaptation of co-designed lessons when implementing them in the classroom environment?*

The final chapter of this dissertation, chapter five, provides a summative discussion of the work and conclusions. This chapter summarizes the findings from the three articles and provides a synthesis of their findings together. Then, I consider the implications of this work for educators, researchers, and curriculum designers and for future work building on the findings of this dissertation.

Chapter 2: "That's what Techquity is": Youth Perceptions and Knowledge of Social Justice and the Ethical Impacts of Computing

Abstract

Technology is ubiquitous within modern society and youth have access to technology at nearly universal rates. Yet, despite societal belief that technology is neutral, the technologies of today's society are rife with biases that harm and oppress populations that experience marginalization. While previous research has explored children's values and perceptions of technology, few studies have focused on youth conceptualizations of this technological bias and their understandings of how technology discriminates against them and their communities. In this paper, I examine youth conceptualizations of inequities in technology by analyzing co-design sessions and artifacts partnering with eight Black youth. Overall, the youth demonstrated an awareness of visible technological bias and provided examples of this bias within their lives, but they did not have a formal vocabulary to discuss said bias or knowledge of biased technologies less visible to the naked eye. Once presented with common technological biases, the youth recognized the importance of both visible and invisible biases. Then, when designing to teach peers about technological bias, the youth focused on ways to make the invisible visible to increase understanding. This work builds on the current body of literature around how youth view technology and provides a foundation to ground future pedagogical work around technological bias for youth.

Keywords: Technology bias, Techquity, Equity, Youth, Cooperative Inquiry, Co-design

Introduction

In 1991, Mark Weiser predicted that technology would become ubiquitous within society (Weiser, 1991). He imagined a world where people would use computers of all sizes that were interconnected on an omnipresent network. Technologies and their normalcy would "weave themselves into the fabric of everyday life until they are indistinguishable from it" (Weiser, 1991, p. 94) and then disappear. Thirty years later, society is approaching the ubiquity predicted by Weiser. Technology has exploded, and many emerging technologies are invisibly integrated into everyday life (Ley, 2007). For many people, the influence of computers on their lives goes unrecognized; people often view as neutral those computers that they do acknowledge (Pew Research Center, 2018a). But the technologies that daily affect the lives of individuals globally are not neutral, as people commonly assume, nor is it likely that a person in modern society will live a life unaffected by technologies, even if they do not use them themselves. Computing devices and the algorithms that run them are now part of everyday objects such as cars and watches. Government bodies use algorithms to make influential decisions about the likelihood of recidivism in sentencing (Angwin et al., 2016; Garvie et al., 2016) and welfare eligibility (Eubanks, 2018). The omnipresent technology of today's world passes on the biases of its creators and of society as a whole, leading to technologies that treat users differently as a result of their race, gender, class, ability, or a combination of these factors (Benjamin, 2019; Buolamwini & Gebru, 2018; Eubanks, 2018; Scheuerman et al., 2020; Whittaker et al., 2019). I call this phenomenon Threats to Techquity.[2] Just as many of these computers work invisibly within society, so does this bias.

[2] "Techquity" is a portmanteau of "technology" and "equity."

Technology use is prevalent amongst youth of all ages. Parents report that, overall, 67 percent of their children under the age of 17 use tablet computers and 60 percent use smartphones (Pew Research Center, 2020). Technology engagement tends to grow as children age. Seventy-eight percent of youth ages nine to 11 using tablet computers, 67 percent using smartphones, and 73 percent using desktop or laptop computers (Pew Research Center, 2020). Teenagers' technology engagement rates climb still higher: they have nearly universal access to smartphones (95 percent) and nearly nine out of 10 teenagers (89 percent) report being online several times per day or almost constantly (Pew Research Center, 2018b). With society becoming more technology-centered, the influence of the algorithms powering computer-based technologies only increases; with that increase comes an increased likelihood that youth will be exposed to and affected by the biases built into the very technologies they use. This means that they are encountering visible and invisible Threats to Techquity within their technology on a regular basis. Yet, little is known about how youth perceive these technological biases and how to educate youth about them. With youth and their communities impacted by the inherent biases of technology across many parts of their lives, it is important to understand how to educate youth around these threats as a first step towards preparing them to protect and advocate for themselves and their communities.

Laying the groundwork for future educational efforts, this paper explores youth conceptualizations of Threats to Techquity and how youth perceive Techquity in their own lives. Taking a constructivist view of learning (that learning occurs as learners actively build upon and adjust their conceptions) (Piaget, 1964), the paper examines both youths' initial conceptualizations of Techquity and Threats to Techquity as well as how those conceptualizations change and are replaced with new conceptions as youth are introduced to new information about Threats to Techquity. Using data from co-design sessions with eight youth, I analyze how they reason about Threats to Techquity, both those visible to them and those that remain invisible until revealed. In examining the visible examples of Techquity in their lives, I analyze how youth perceive Techquity in their lives and the examples of Threats to Techquity they provide. Then, after presenting them with design and algorithmic Threats to Techquity, I examine their reasoning about and presentation of previously invisible Threats to Techquity and how they use examples to make visible the invisible concepts I introduced. Bringing this together, I conclude with an analysis of how the youth present Techquity to their peers and how these designs illuminate ways they make visible the invisible aspects of Techquity. This paper answers the following research questions:

1. How do youth conceptualize Threats to Techquity in their lives?
2. How do youth perceptions and examples of Threats to Techquity shift after being introduced to examples of technological bias?
3. When designing to teach peers, how do youth present Techquity and Threats to Techquity?

Theory and Prior Work

This work builds on prior research around both Threats to Techquity and youth conceptualizations of technology. In the following section, I provide an overview of prior work in these areas and connections between the literature and the present work. This serves to both define Threats to Techquity as used within this work and motivate the current work based on prior research.

Algorithmic and Design Threats to Techquity

Although technology is often assumed to be neutral (Pew Research Center, 2018a), it exists within a sociohistorical context and is influenced by the thoughts, opinions, preferences, and actions of its creators and the companies that employ them (Whittaker et al., 2019). This causes Threats to Techquity, or ways that technology can cause or perpetuate inequitable and harmful experiences for users due to their membership within a group that experiences marginalization. As such, technologies are adding inequalities that manifest in overt and covert ways (Gangadharan et al., 2014). Increasingly, investigative journalists and researchers have surfaced these biases and brought them to light (e.g., Angwin et al., 2016; Broussard, 2018; Buolamwini & Gebru, 2018; Gangadharan et al., 2014). While many Threats to Techquity exist within society (e.g., inequitable access to the internet), in this research, I focus specifically on design and algorithmic Threats to Techquity that are built into technologies and have been shown to discriminate based on gender (Dastin, 2018; Kiritchenko & Mohammad, 2018; Scheuerman et al., 2020); race (Angwin et al., 2016; Kiritchenko & Mohammad, 2018; Noble, 2018; O'Neil, 2016; Obermeyer & Mullainathan, 2019); disability (Whittaker et al., 2019); and economic status (Eubanks, 2018; Gangadharan et al., 2014; O'Neil, 2016). For people who experience multiple of these forms of marginalization, the impacts of Threats to Techquity are compounded and amplified (Buolamwini & Gebru, 2018; Whittaker et al., 2019). Bias in algorithms, data, and design often cause these Threats to Techquity.

Algorithmic bias causes the privileging of one group over another. It can be caused by several factors, including decisions made during the design of the algorithm and the data included in training or writing the algorithm. When examining race and gender bias in sentient analysis systems, researchers identified bias in the majority of the systems (Kiritchenko &

Mohammad, 2018). This bias is caused by algorithms using data to make assumptions based on an individual's personal network, the preferences of others with similar data footprints (Gangadharan et al., 2014), and the algorithm creator's decisions regarding what is important and should be included (O'Neil, 2016). Algorithms, particularly those used in artificial intelligence (AI), also work based on a defined "normal." For individuals with disabilities, this can have significant consequences (e.g., autonomous cars not recognizing someone in a wheelchair) (Whittaker et al., 2019).

A key contributor to the bias of algorithms is the data used to create them. This can be caused by how and why the data is collected (Denton et al., 2020); how it is used within the algorithm (O'Neil, 2016; Obermeyer et al., 2019; Obermeyer & Mullainathan, 2019); the representation of current and historic societal biases within the data (O'Neil, 2016); the categories used to categorize data (Scheuerman et al., 2020); and unequal representation of all groups within the data (Buolamwini & Gebru, 2018; Nagpal et al., 2019). With unprecedented amounts of data now collected about consumers based on their internet searches, social media use, shopping tendencies, and locations, it is essential that this data is used ethically and responsibly. This avoids perpetuating and expanding biases (O'Neil, 2016; Wachter-Boettcher, 2017), highlights about whom data is being collected, and prevents the worsening of privacy and surveillance issues on highly surveilled communities that experience marginalization (Benjamin, 2019; Raji et al., 2020; Whittaker et al., 2019). Research has shown that, likely due to the data on which systems are trained, artificial intelligence systems less accurately identify women and dark-skinned people (as compared to men and light-skinned people, respectively). There is also an intersectional inaccuracy: the error rate for identifications of dark-skinned women (20 to 35 percent) is over twenty times the error rate for identifications of light-skinned men (0.0 to 0.8 percent) (Buolamwini & Gebru, 2018).

Finally, bias is present in the design of new technologies, both because of the lack of diversity among individuals who develop technologies and due to the culture of computer science and technology. Women, people of color, and individuals with disabilities are underrepresented in computing and technology jobs (Bureau of Labor Statistics, 2018, 2019). This systematic exclusion has led to development teams mainly composed of white and Asian men and a white male default in the settings and designs of websites and forms (Wachter-Boettcher, 2017). The hiring process perpetuates the homogeneity of design teams by considering whether new hires will fit into the current culture (Wachter-Boettcher, 2017) and systematically removing and excluding certain populations (Hicks, 2018). Even once hired, the cultures of computer science and technology development do not nurture diversity and often lead to team members who do not align to the dominant group leaving the technology industry and the creation of biased technologies (Broussard, 2018; Wachter-Boettcher, 2017; A. Nicki Washington, 2020).

Youth Conceptualizations of Technology and Technology Values

Likely due to their close and frequent contacts with technology, youth have developed conceptions of the structures of computing devices and how they function (Pancratz & Diethelm, 2020). Since computers first became broadly available, researchers have sought to understand youth conceptions of how computing devices function (Kodama et al., 2017; Rücker & Pinkwart, 2016) and how devices are physically structured (Brinda & Braun, 2017; Jayathirtha & Kafai, 2021; Mertala, 2019; Pancratz & Diethelm, 2020; Rücker & Pinkwart, 2016) in addition to youths' values and opinions surrounding computing devices (Kumar et al., 2017; Yip et al., 2019; Zhang-Kennedy et al., 2016). This research focuses on both children and teenagers. In this section, I examine youths' common conceptions of technology and their values surrounding it. Understanding these conceptualizations is important, as they inform pedagogical and educational efforts to tailor student learning to students' current understandings and to build upon students' existing knowledge (Jayathirtha & Kafai, 2021; Kodama et al., 2017; Mertala, 2019; Pancratz & Diethelm, 2020; Rücker & Pinkwart, 2016).

Research has found that youth conceptions of computing devices deviate from the reality of how those devices work (Brinda & Braun, 2017). In a review of research about how youth conceptualize computers, Rücker and Pinkwart (2016) found that youth perceive computing technology as: (1) intelligent, (2) omniscient databases, (3) mechanical, (4) wire networks, and (5) programmable. In these findings, Rücker and Pinkwart (2016) highlighted the tendency for youth to anthropomorphize computers by attributing human characteristics such as thinking, motivation, and intentions to the machines. This tendency to anthropomorphize technology and provide conceptualizations that differ from reality also permeated middle school students' models of how Google works. The students most often represented Google as a person; the least common depiction of Google was "Google as codes" (Kodama et al., 2017). This tendency can be partially explained both by Mertala's (2019) finding that, when asked, children did not know what coding or programming was and by people's attribution of their coding and programming knowledge to having been taught about it rather than knowing about it on their own (Rücker & Pinkwart, 2016).

Another deviation from reality relates to how youth perceive the internet and their online connectivity. Multiple studies have found that youth cannot reliably make a distinction between their behaviors occurring online and those occurring offline (Kumar et al., 2017; Mertala, 2019).

The research suggests: “the fluidity of the (wireless) Internet connection makes being online or offline an opaque phenomenon for children” (Mertala, 2019, p. 62). Because it is easy to connect to the internet and many devices do so automatically, children do not recognize when they are (and are not) performing activities online.

Other relevant literature further explores youth concerns over technologies in their everyday life; this includes youths’ perceptions of what makes a piece of technology “creepy” (Yip et al., 2019) and their ideas around their privacy and security online (Kumar et al., 2017, 2018; Zhang-Kennedy et al., 2016). When designing technologies they thought other children would find creepy, child designers identified deception, lack of control, mimicry, ominous physical appearances, and unpredictability as creepy attributes of technology (Yip et al., 2019). These attributes contributed to children’s fears over physical harm or loss of attachment due to technology; however, parents’ presence, acceptance, or interference mediated these fears (Yip et al., 2019). Regarding their privacy and security online, children could both identify potential threats to their online privacy and security (Zhang-Kennedy et al., 2016) and provide specific strategies to use when they encountered something unknown online or needed to keep their information or devices secure (Kumar et al., 2017). This pointed to children’s acknowledgement of the importance of privacy and security online, although many children relied on their parents to maintain their security and address privacy or security concerns (Kumar et al., 2017). Children sometimes struggled to ensure they had privacy and security online. This was because they failed both to identify privacy and security concerns when online (due to their aforementioned inability to know they were online) and to identify ways being online affected the visibility of their data and information (Kumar et al., 2017).

While past research has reported on how children conceptualize computing technology, including computers, smart phones, robots, and tools, and how children perceive creepiness and privacy within technology, few studies have focused on how children perceive the equity and social justice implications of the technology they use. Therefore, building on past research, this paper expands the topics about which we understand youth conceptualizations. Just as Yip et al. (2019) utilized co-design to understand children's perspectives on whether or when technology was creepy, in this research, I utilize co-design to understand when children view technology as inequitable and their views of inequitable technologies they encounter regularly.

Methods

This research utilizes cooperative inquiry, a method of participatory design with children as design partners, to learn about youth conceptualizations of Techquity. I selected cooperative inquiry (Druin, 1999, 2002; Guha et al., 2013) as a method for inquiry within this work due its roots in participatory design, its commitment to collaborating with youth as full design partners, and its prior use as a means for understanding what youth know and understand. Cooperative inquiry evolved from the participatory and co-design movements. Participatory design was developed to include the voice of the user within the design process and counteract the typical top-down, hierarchical structure of design (Bjerknes & Bratteteig, 1995; Bødker et al., 2000). More specifically, participatory design involves counteracting the hierarchical design structures that exist between adults and children by creating spaces that empower children through design (Coenraad et al., 2019; Iivari & Kinnula, 2018; Iversen et al., 2017). Participatory design has been used with the goals of creating a more democratic design process and promoting equity and emancipation of the oppressed within both the design and products created and society (Bjerknes & Bratteteig, 1995; Björgvinsson et al., 2010; Erete, 2021; Harrington et al., 2019; Iversen et al., 2004; Pinkard et al., 2017). Cooperative inquiry developed in the 1990s and focuses specifically on designing with youth around technology. In cooperative inquiry, youth are typically given the role of design partner (rather than the role of user, tester, or informant); it prioritizes not only the design and development of new technologies (e.g., Kumar et al., 2018) and techniques (e.g., Guha et al., 2004), but also opportunities for the youth to participate in a long-term design team and develop design skills (McNally et al., 2017). This co-design process makes youth the experts in what other youth know and want and acknowledges that adults often do not know the best design for a child (Druin, 2002). Finally, co-design has been used as a method for learning about youths' conceptualizations and values (e.g., Begnaud et al., 2020; Van Mechelen et al., 2017; Yip et al., 2019). While youth might not understand everything within a topic, co-design provides an opportunity to learn about their values through their designs and what they share.

I completed a series of six design sessions with eight youth. In this paper, I present my analysis of the data from the four sessions specifically focused on designing around Techquity (as opposed to those focused on critiquing created designs). In the following section, I detail the context, participants, data collection, and data analysis from these four sessions.

Context

The four cooperative inquiry sessions were completed in two sets, with two sessions in April and May 2020 and two sessions in December 2020. Each session lasted 90 minutes and utilized a format typical to cooperative inquiry (Druin, 1999, 2002; Guha et al., 2013). Within this format, attention is paid to balancing power dynamics between adults and youth and building long-term relationships. In these iterations, to limit power differences between adults and youth, adults dressed casually and first names were used for all designers, whether adult or youth (e.g., "Allison"). Each day began with an informal snack time, during which the team talked together and transitioned from prior activities like school or work into designing (Druin, 1999, 2002; Guha et al., 2013). Due to social distancing requirements and the COVID-19 global pandemic, all four design sessions took place virtually using Zoom video conferencing and online collaboration tools. Since youth also attended school in virtual environments, the design sessions were made into more collaborative and equal environments by allowing youth to choose how they communicated (e.g., via reaction, voice, chat, etc.), whether they used their videos, and whether they wanted to share their screens (particularly during snack time, when they could share online games and other things of interest).

Participants

A total of eight youth participated in the design sessions, with six or seven youth participating in each session alongside four adults. All eight youth identify as being Black. Five youth identify as boys and three identify as girls. Youth ranged from ages eight to 13 at the first session in which they participated and were all members of an intergenerational co-design team at the University of Maryland called KidsTeam (Table 2-1). KidsTeam is an ongoing design team that meets two times per week during the school year (September to May) and partners with companies, agencies, and researchers to design technology for youth with youth. The youth designers who participated in this research had between one and four years of design experience on the team when the project began. As part of the intergenerational team, the youth designed collaboratively alongside adult design partners. The adult design partners were undergraduate and graduate students from the University of Maryland iSchool and College of Education as well as the KidsTeam director, a researcher with extensive experience in youth co-design, cooperative inquiry, and KidsTeam. All of the participating adults identify as women and are of varied races.

I was a member of the co-design team at the time of the sessions and had worked with all the youth designers for at least one year at the time of the sessions.

Table 2-1. Participants in collaborative inquiry sessions

Child (Pseudonym)	**Age** (years, at first session)	**Gender**	**Race**	**Session Attendance**			
				1	2	3	4
Aman	12	Boy	Black		✓	✓	✓
Barry	8	Boy	Black	✓	✓	✓	✓
Brian	8	Boy	Black			✓	✓
Desta	11	Girl	Black	✓	✓	✓	✓
Gabby	10	Girl	Black	✓	✓	✓	✓
Joshua	10	Boy	Black	✓	✓		
Kabede	13	Boy	Black	✓	✓	✓	✓
Persinna	12	Girl	Black	✓	✓	✓	✓
Adults	-	Women	Varied	4	4	4	4

Data Collection

In this paper, I analyze youth designs from a variety of design activities across four design sessions. Each design session followed a typical 90-minute format that began with snack time. This was followed by circle time with a question of the day (e.g., “What technology do you use the most?”) to transition into the topic of the design session. Then, I introduced the topic and design activities, after which the youth designers worked in small teams to complete the activities. Finally, youth shared their designs while an adult wrote down and presented the “Big Ideas” that emerged from the design activities. While working on the design activities, youth were divided into three small groups, with one or two adults working with each group of two to three youth. See Table 2-2 for details on each design session and the design activities completed.

Table 2-2. Collaborative inquiry session details

Session	Design Goal	Question of the Day	Design Activities
1	• Identify ways youth believe technology can be good and bad for them, their community, and society. • Identify the Threats to Techquity that are of most salience to youth.	What technology do you use the most?	Design Activity 1: Brainstormed ways technology can be good and bad using sticky notes. Discussion: Presented youth with common Threats to Techquity and invited them to provide real-life examples or connections Design Activity 2: Youth rated Threats to Techquity using line judging (Begnaud et al., 2020) based on relevancy, interest, and importance. Wrap-up: Youth shared the Threats to Techquity they rated highest and lowest. An adult designer tracked "Big Ideas" and presented them to the youth for confirmation of completeness and correctness.
2	• Generate ideas and preferences to teach peers about Techquity.	Thinking about the examples from last session and others you might have, how does technology lead to things being unfair in the world? Can you give an example from your life?	Design Activity: Youth designed how they would teach peers about Techquity using big paper (Fails et al., 2012). They chose an environment in which to teach other kids (e.g., school, online, hanging out), what to teach, and interesting ways to learn the information. Wrap-up: Youth presented their big paper designs. An adult designer tracked "Big Ideas" and presented them to the youth for confirmation of completeness and correctness.
3/4	• Use computer programming to create a public service announcement (PSA) about Techquity.	Session 3: Have you ever coded before? If so, what platform did you use (Code.org, Scratch, Tynker, etc.)? Session 4: On Tuesday we started working on Techquity PSAs using Scratch. What	Design Activity: Youth made their own PSA about Techquity using the Scratch programming environment. Wrap-up: Youth shared their PSA projects. An adult designer tracked "Big Ideas" and presented them to the youth for confirmation of completeness and correctness.

		is your Techquity PSA about and what is your goal for today?	

I recorded each of the design sessions using the record feature of Zoom video conferencing. I recorded both the full group and small group design sessions for a total of about 11 hours of video. I also captured transcripts of the chat feature to preserve non-verbal conversations. I collected and catalogued all design artifacts for analysis. I downloaded copies of youth PSAs from the Scratch environment for analysis to ensure further changes were not made to the programs after the end of the design sessions. Finally, I took field notes immediately after each session.

Data Analysis

Data analysis consisted of three phases. First, at the end of each design session, I tracked the main ideas from youths' presentations of their designs and performed real-time theming of these ideas into "Big Ideas." Following a presentation of these "Big Ideas" to the participating youth, the youth designers had the opportunity to member-check the ideas by sharing if anything was missing in the summary or list of themes. I added any new suggestions to the "Big Ideas."

Second, I brought together all of the design artifacts into a single display in order to analyze across design groups. Simultaneously, I watched the recordings from each of the design sessions in their entirety. While watching, I used analytic memos (Saldaña, 2015) to take note of what happened during the design session and to capture designers' thoughts and utterances that expanded on or were not displayed in the design artifacts. Within these analytic memos, I transcribed youths' descriptions of Techquity topics, their incorporation of Techquity into their designs, and their presentations of their designs at the end of each session.

Next, I open-coded the artifact displays and the analytic memos (Saldaña, 2015) with the goal of identifying how youth conceptualized Techquity and how youth taught others about Techquity. Based on this coding, I developed inductive, descriptive codes. Two codes related to how the youth designers conceptualized Techquity: visible and invisible. I defined these codes as follows:

> **Visible:** Process or effects that can be seen by a person living their daily life without looking across cases to notice intergroup differences or moving beyond a surface level understanding of how a technology works. Examples of this include the identification of Black teenagers as gorillas in a photograph tagging program, sensors not functioning for individuals with dark skin, or a passport photo application's rejection of a picture of an Asian man because it perceived that his eyes were closed.
>
> **Invisible:** Process or effects that cannot easily be noticed on an individual scale, instead becoming apparent only when examining the data of many people or after obtaining an in-depth understanding of how a technology works. Examples of this include a healthcare prevention algorithm under-identifying Black patients, AI systems having different outcomes based on race or gender, and continuous or covert data collection (such as the collection of location data or the collection and recording of data by smart speakers).

The third code related to how the youth designers sought to teach other youth about Techquity and Threats to Techquity: making the invisible visible. This code related to the prior two codes by applying youths' conceptualizations of Techquity to their designing. I defined this code as follows:

Making the Invisible Visible: Youth designing that teaches peers or community members about Techquity in a way that demonstrates or reveals invisible Threats to Techquity.

I utilized these three codes in the final round of analysis (Saldaña, 2015): a detailed, chronological coding of all data, including field notes, analytic memos of the videos, and design artifacts.

To draw conclusions from the design artifacts, I completed further analysis on both design activities from session 1 (using sticky notes to brainstorm good and bad parts of technology and line judging the importance of Threats to Techquity). I thematically coded the sticky notes from the youths' brainstorm of good and bad parts of technology to determine categories of technological influence across the groups (e.g., effects on users, usability, privacy, etc.). Additionally, I analyzed the results of the line judging through a qualitative approach used with small-scale card sorting analyses (Hanington & Martin, 2012) as has been previously used with modified line judging activities focused on ranking (Begnaud et al., 2020). This approach recognized that the youth rankings of Threats to Techquity were not necessarily placed at equal intervals (e.g., the difference in importance between the first- and second-most important Threats to Techquity might not have been the same as the difference in importance between the eighth- and ninth-most important Threats to Techquity) and analyzed both the artifacts and the youth designers' descriptions and explanations of their rankings.

Results

Based on data from cooperative inquiry sessions with eight youth, I present three findings about youth conceptualizations of Techquity:

1. Without an introduction to the idea of Techquity, youth conceptualized Techquity mostly based on the visible aspects of Techquity, particularly those that were highly salient in their lives.
2. When formally introduced to Threats to Techquity, including invisible threats, youth conceptualizations expanded to include those invisible Threats to Techquity and they elected to design mostly around invisible Threats rather than visible ones.
3. When youth presented Techquity to their peers, they found ways to make the invisible visible to scaffold their peers' understanding of more complex Threats to Techquity.

In the following section, I detail each of these findings. Finally, in the discussion, I consider how these three findings come together to create a continuum of how youth conceptualize Techquity.

Visible Techquity and Threats to Techquity

Answering my first research question (how do youth conceptualize Threats to Techquity in their lives?), I examined data from the first design session when youth identified good and bad aspects of technology prior to being introduced to the idea of Threats to Techquity. I found that youth conceptualizations changed based on whether or not they received a formal introduction to Techquity or common Threats to Techquity. **Without an introduction to the idea of Techquity, youth conceptualized Techquity mostly based on visible aspects of Techquity, particularly those that were highly salient in their lives.** In the following section, I explore this finding and the youths' conceptualizations of Techquity and Threats to Techquity that were visible to them without introduction. In the second findings section, I explore youths' conceptualizations of Techquity after being formally introduced to Threats to Techquity.

Without a formal introduction to Techquity or common Threats to Techquity, youth could identify both good and bad parts of technology. When asked to brainstorm ways that technology was good and bad in session 1, design teams developed examples from their own knowledge. As they did this, the multiple design teams separately decided they needed a third category for some of their brainstormed examples. They named this category "*both*" or included multiple notes on the same subject in recognition that technology was often not *only* good or *only* bad. For example, Desta identified that television could be addicting, but Barry, who often discussed watching Netflix during snack time, thought that television was a good part of technology and that the addicting quality of television was positive. To represent this, the group put the sticky notes "*TV and games and shows can be addicting!!!!!*" and "*TV and games are sometimes toooooooo addicting*" on their brainstorm board. Other design teams placed specific notes such as *"Makes things viral"* in the middle category rather than having two notes.

Across ideas presented by the youth designers, I categorized twenty of the "both" or "bad" parts of technology as visible threats in my follow-up analysis and eight of the "both" or "bad" ideas as invisible threats. Figure 2-1 shows the brainstormed ideas the youth categorized as "bad" or "both," categorized by whether it is a visible or invisible threat along with themed subcategories I developed during coding. I marked ideas designated by the youth designers as "both" with an asterisk (*). Examples of visible threats include when technology "glitches", difficulty getting online or slow Wi-Fi, addicting technology, and sketchy people. In these examples, it is possible to see themes of access, usability of technology, and the effects of technology on users. Notably, the youth grounded many of the examples of how technology was good and bad in their own current experiences. Due to the timing of the session and the COVID-19 pandemic, at the time of the sessions, all the youth had transitioned to learning and socializing fully online four to six weeks prior to the session. As such, they based many of their examples (e.g., "*harder to learn online*") on their experiences. When youth identified invisible Threats to

Techquity, they were typically related to privacy (e.g., "*Tracks your activity*", "*SIRI CAN LISTEN To uS [sic]!!!!*") and difficult-to-use technology ("*sometimes technology can be too hard*").

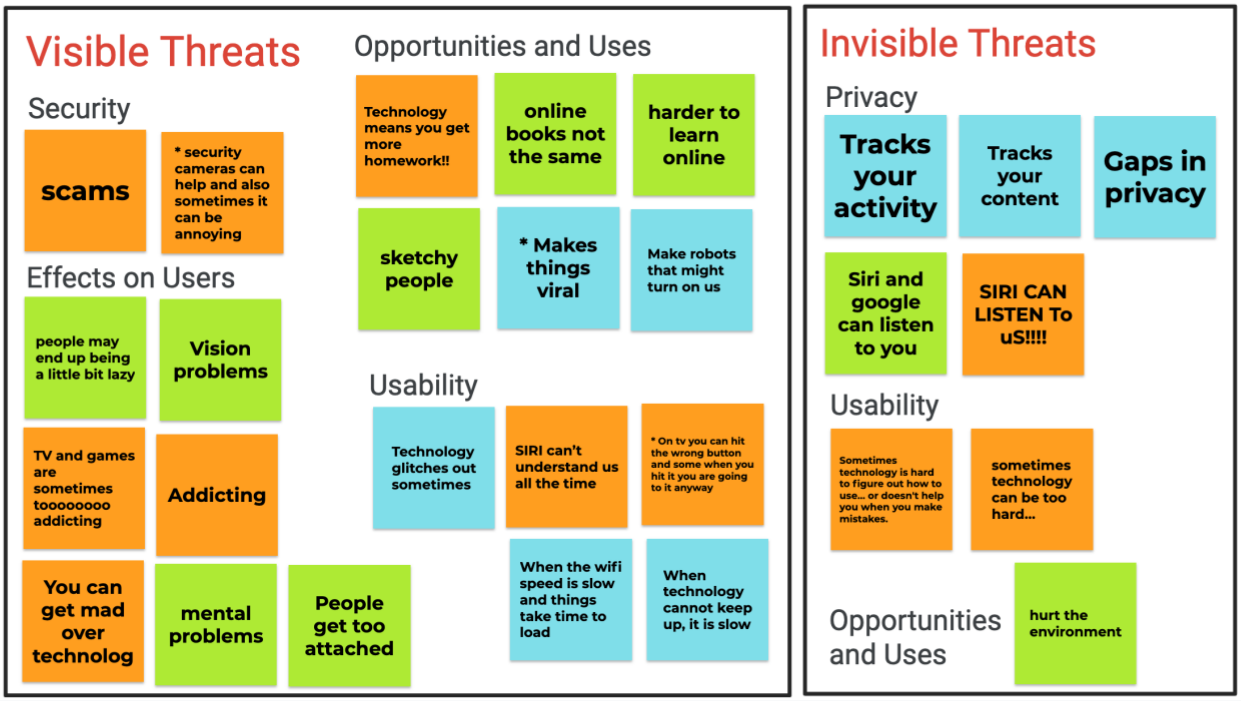


Figure 2-1. "Both" and "bad" parts of technology sticky notes sorted by researcher categorization as visible and invisible threats and themes; ideas designated as "both" by youth designers are marked with an asterisk (*) (orange = Barry and Desta, green = Gabby and Persinna, blue = Joshua and Kabede).

While youth primarily identified visible Threats to Techquity before they were introduced to the idea of Techquity, they did identify some invisible threats. At times, the visible and invisible threats they identified were tied to the same technologies. One technology they raised as an example of both a visible and invisible Threat to Techquity was Siri, the voice-activated assistance on iPhones and other Apple products. Barry described it as annoying: "*Siri...you can ask her something and she doesn't know what you are talking about*." He later explained, "*My brother does it [uses Siri] sometimes and it doesn't work.*" For Barry, Siri not working was a visibly bad part of the technology, although he did not recognize the invisible causes behind voice recognition software not "understanding" a human's particular accent or dialect. Gabby, who was working in a different design group, identified as another "bad" part of technology "*that, like, Siri and, like, Google can listen to you.*" Rather than only focusing on visible occurrences (e.g., when smart speakers or voice assistants do not function), Gabby identified a more invisible threat (e.g., the fact that most consumers do not know how much their smart speakers record).

Based on their examples of times when technology was either partially bad or always bad, youth could clearly identify examples of technological bias in their lives, even if they could not fully explain why it happened. Although youth could not unpack all of their examples and align them to specific Threats to Techquity, their associations with technology being "creepy" and "annoying," along with their hesitancy about some technologies, indicated their understanding that technology was not always a positive influence in their lives (despite being something they all clearly enjoyed using that served as a keystone in their daily lives, particularly during pandemic-induced social distancing and lockdowns). This was further highlighted in the discussion after the first design activity, when the youth were asked after their brainstorms whether technology was good or bad. While Joshua opined that "*technology is the best thing ever*," Persinna shared a more nuanced view. She believed that technology was both a little bit good and a little bit bad. When first considering the good and bad parts of technology, the youth drew clear examples of bad parts of technology, but they were not yet aware of how the design of technology played a role in whether it was good or bad. Gabby initially agreed with Persinna, but she later changed her mind: "*[Technology is] neither [good or bad]; it depends on how you use it.*" For Gabby, technology being good or bad depended on its user rather than the creator.

As youth conceptualizations of Techquity continued to grow and evolve over the design sessions, these characterizations of technology represented a starting place from which the youth built their understandings of new Techquity topics. In the next section, I examine how youths' conceptualizations of Techquity changed when they were introduced to Threats to Techquity and how the youth grounded invisible Threats to Techquity in examples to help make sense of opaque threats.

Invisible Techquity and Threats to Techquity

Youths' conceptualizations of Techquity changed and broadened once they were formally introduced to Techquity and Threats to Techquity. Answering my second research question, (how do youth perceptions and examples of Threats to Techquity shift after being introduced to examples of technological bias?), I examined data from the second half of the first design session including the conversation within the design team introducing Threats to Techquity (during which youth volunteered examples from their lives) and the second design activity where youth used line judging to rank common Threats to Techquity. Additionally, I examined youth designs of learning scenarios and PSAs from the second, third, and fourth design sessions to explore the topics they chose. I found that **when formally introduced to Threats to Techquity, including invisible threats, youth conceptualizations expanded to include those invisible Threats to Techquity and they elected to design mostly around invisible Threats rather than visible ones.**

In the following section, I present my findings regarding this shift in youths' conceptualization of Techquity and Threats to Techquity and youth designers' discussions of invisible Threats to Techquity.

An interactive presentation introduced youth to 10 common Threats to Techquity (Table 2-3). I designed this non-exhaustive list to include a range of Threats to Techquity, including some about which the youth would have knowledge or be able to connect to their own lives. Seven out of the 10 Threats to Techquity on the list are invisible; the remainder are visible.

Table 2-3. List of Threats to Techquity shared with and ranked by youth and whether they were considered visible or invisible

Threats to Techquity Shared with Youth
• Alexa, Google Home, and Siri are always listening to me. (Invisible) • Algorithms (computer programs) don't treat everyone fairly. (Invisible) • Companies sell my data. (Invisible) • I get personalized advertisements based on data companies collect about me. (Invisible) • Machine learning and facial recognition isn't trained well enough to recognize everyone. (Invisible) • People assume Google results are unbiased and based on how relevant results are to you. (Invisible) • People don't understand how technology works. (Visible) • Sensors and systems like Alexa, Google Home, and Siri get confused about how I look or what I say. (Visible) • Technology development teams are not diverse (i.e., they don't contain many women or people of color). (Invisible) • Technology is not always accessible for individuals with disabilities. (Visible)

While youth were presented with these Threats to Techquity, they had the opportunity to comment on the topics, add details from their own lives, and expand upon them. These expansions translated invisible threats into more visible outcomes or included examples from the youths' lives. When discussing the opacity of results from Google and other search engines, Barry explained, "*sometimes, when you try to search sometimes it doesn't show exactly what you want. It shows something close, but not exactly what you want*." To which Persinna added, "*Yeah...it's not accurate.*" In this exchange, the youth reasoned about the influence of advertising and the unknown contents of search engine algorithms by discussing the accuracy of results or difficulty of finding what they wanted by referencing what they saw and experienced. While two

Threats to Techquity (not getting the results for which you are looking and accuracy of information) are not the same, they are analogous, particularly for youth.

As they connected with the Threats to Techquity, youth often gave examples from their everyday lives and their experiences. When discussing targeted advertising and companies selling data, Kabede, a middle school student who liked video games and recently got a virtual reality (VR) headset, shared,

> *All the ads are...related. So whenever I search up a video about gaming like Minecraft...or if I search up a video about VR, they always send me advertisements about the Oculus Quest or things you would want for the Oculus Quest.*

Kabede connected the advertisements he saw to his previous online searches for videos. As such, this Threat to Techquity became more visible for him. Overall, Kabede balanced his view of targeted advertising with on the intent of the advertisers. During the design session, he shared, *"it depends on what the advertisement is doing: is it trying to help you, or is it trying to just make you waste your money?"* Kabede viewed these advertisements as negative when they tried to convince him to "*waste*" his money, but he viewed them as potentially positive if they helped him and showed him something that he actually needed. In the same conversation, Persinna shared an opaquer experience with targeted advertisements:

> *I think like Siri, like she and like Google, they like know where you are...they know like where your location is because one time me and my mom we were driving by Bed, Bath, and Beyond and...the notification came to my mom's phone saying...'buy this' and stuff because right when we drove by...notifications kept coming to her phone.*

In this example, Persinna guessed that she was receiving these notifications due to her location and proximity to the store, but she was not positive. When asked by an adult if this use of her information was okay with her, she replied that it was not.

When ranking Threats to Techquity from “very important to me” to “not very important to me,” youth ranked algorithmic bias, lack of diversity on design teams, selling data as demonstrated by advertisements, and smart speakers always listening as topics of most importance to them (Table 2-4). These topics received all the “most important” top rankings from youth and youth consistently ranked them highly. Notably, all four of these Threats to Techquity are either fully invisible or opaque, depending on whether youth can reason about why they occur (see Table 2-3 for classification of visible and invisible for Threats to Techquity).

Table 2-4. Table of youths’ rankings of Threats to Techquity (1 = most important, 10 = least important; some youth used a “tie” to share the same ranking. Threats ranked “most important” are marked in green and those ranked second “most important” are marked in yellow. Note: One youth designer lost internet connectivity during this activity, so only five youth designers participated.

	Alexa, Google Home, and Siri are always listening to me.	Algorithms (computer programs) don't treat everyone fairly.	Companies sell my data.	I get personalized advertisements based on data companies collect about me.	Machine learning and facial recognition isn't trained well enough to recognize everyone.	People assume Google results are unbiased and based on how relevant results are to you.	People don`t understand how technology works.	Sensors and systems like Alexa, Google Home, and Siri get confused about how I look or what I say.	Technology development teams are not diverse (i.e., they don`t contain many women or people of color).	Technology is not always accessible for individuals with disabilities.
Barry	4	1	2	10	4	3	6	7	9	8
Kabede	3	5	1	2	10	7	6	9	4	8
Joshua	10	6	9	7	4	3	2	5	1	8
Gabby	2	4	6	3	7	10	9	8	1	5
Persinna	3	1	7	5	10	4	9	8	2	6

Youth explanations of their rankings provided context to these rankings and described why these four topics were the most important. Persinna ranked "algorithms (computer programs) don't treat everyone fairly" as her most important topic. She explained, "*something that is very important to me is…algorithms because...everybody should be treated equally and...if people don't fit in, they should...allow people to fit in*." Gabby explained the importance of both "Alexa, Google Home, and Siri are always listening to me" and "technology development teams are not diverse," saying, "*I think that it's important that people should always be…included and Alexa and Google shouldn't listen to you all the time, but...only...hear you when they're called."* Finally, Kabede explained his focus on data and advertising, saying, *"I put for very important [that] companies sell my data. Because they're selling all the things...I search and stuff and all my person[al] data. And it's really…really, really, weird that they're selling my data."* Not all the youth could explain their rankings. Barry, who ranked "algorithms don't treat everyone fairly" as his most important topic, when asked why it was the most important, could not explain his rationale:

Barry: *I don't know how to explain it.*

Adult: *You don't know? It just feels like it is really important?*

Barry: *No, it is. I already know it is very important. I just don't know how to explain it.*

In this exchange, Barry was adamant that algorithmic bias was the most important topic to him, but he could not explain why this invisible Threat to Techquity was of such importance.

The topics youth identified as of most importance to them were the topics they continued to design around when teaching peers and community members about Threats to Techquity in the subsequent design sessions. After being introduced to invisible Threats to Techquity, youth chose to focus mainly on invisible threats within their designs (Table 2-5). For example, when designing a learning scenario, Kabede and Aman elected to teach about data and how companies collect, use, and sell users' data. Joshua and Gabby elected to teach about all Techquity topics, but they focused on the lack of diversity on technology design teams. In her PSA, Persinna highlighted that technology was not always good, that it was everywhere, and that technology can use tracking and other data to learn about users. These focuses could stem from the salience of these topics to the youth (the topics aligned with their previous rankings of the importance of Threats to Techquity) and the need the youth perceived for these topics to be taught (since they are not easily noticed in everyday life like visible Threats to Techquity). Within their designs, the youth focused on how to make the invisible Threats to Techquity they identified visible for those they taught. In the next section, I explore how youth achieved this within their designs.

Table 2-5. Threats to Techquity topics in youth designs

<table>
<tr><th rowspan="2">Youth Designer</th><th colspan="2">Learning Scenario (Session 2)</th><th colspan="2">PSA (Sessions 3 and 4)</th></tr>
<tr><th>Topic</th><th>Visibility</th><th>Topic</th><th>Visibility</th></tr>
<tr><td>Aman</td><td rowspan="2">Collection, use, and sale of user data</td><td rowspan="2">Invisible</td><td colspan="2">(Unable to finish due to internet difficulties)</td></tr>
<tr><td>Kabede</td><td>Targeted advertising</td><td>Invisible</td></tr>
<tr><td>Barry</td><td rowspan="3">Access to technology, unfairness, and discrimination based on race and gender</td><td rowspan="3">Mixed, mostly invisible</td><td>Getting rid of companies that do not promote Techquity</td><td>Mixed</td></tr>
<tr><td>Desta</td><td>Inaccurate Google results</td><td>Invisible</td></tr>
<tr><td>Persinna</td><td>Tracking and data use by technology</td><td>Invisible</td></tr>
<tr><td>Joshua</td><td rowspan="2">All Threats to Techquity, particularly diversity on design teams</td><td rowspan="2">Mixed, mostly invisible</td><td colspan="2">N/A</td></tr>
<tr><td>Gabby</td><td>Spam and sharing information</td><td>Invisible</td></tr>
<tr><td>Brian</td><td colspan="2">N/A</td><td>Good and bad aspects of technology</td><td>Mixed</td></tr>
</table>

Making the Invisible Visible

Answering the final research question (when designing to teach peers, how do youth present Techquity and Threats to Techquity?), I examined data from the second, third, and fourth design sessions. In the second design session, youth designed learning scenarios to teach peers about Threats to Techquity and in the third and fourth design sessions youth developed a PSA about a Threat to Techquity of their choice. Data from these sessions includes both the youths' design artifacts and presentations as well as conversations between design teams while designing. I found that **when youth presented Techquity to their peers, they found ways to make the invisible visible to scaffold their peers' understanding of more complex Threats to Techquity.** Just as invisible Threats to Techquity were made visible to the youth designers when they were introduced to common Threats to Techquity and added to the repertoire of threats they could discuss, the youth designers developed opportunities to make the invisible visible for other learners. In the final findings section, I present ways youth designers did this in their design artifacts by developing adaptive technologies, focusing on experiential and interactive learning, highlighting a threat to explain it, and modeling conversations about Threats to Techquity.

Highlighting and Explaining a Threat to Techquity

The most common way the youth designers made invisible Threats to Techquity visible was by highlighting and explaining one or more Threats to Techquity. For example, the youth designed robots that taught by displaying the Techquity information from a screen on their stomach or by providing verbalized information. Gabby and Joshua developed a robot that used tutorials displayed on a screen located on its stomach to teach Threats to Techquity (Figure 2-2a). When describing the final design with adult co-designers who worked with them, they explained,

> Adult 1: *And then, what about the tutorials?...What happens on the screen of the robot?*
>
> Joshua: *It tells you the tutorial, about like what you're trying to find out about the technology…*

Gabby: *It teaches you through games.*

Adult 1*: Yep, and they require you to choose diverse people. Only then you can win.*

Adult 2: *So, I have a quick question...you said that, so it shows you pictures with its stomach, like a TV or something? Is that what the tutorial is? Or does the robot talk to you?*

Joshua: *The robot...tells you...what you're going to learn and...shows you what things you should avoid.*

In this description, Gabby and Joshua discussed the role of the robot as a tutor and the use of games to provide opportunities to experience Techquity. These features, along with the adaptability features of their robot described below, ensured that the learner could understand Techquity and learn about it, helping to make the invisible concepts the robot taught (e.g., how technology works and the diversity of design teams) more visible to that learner.

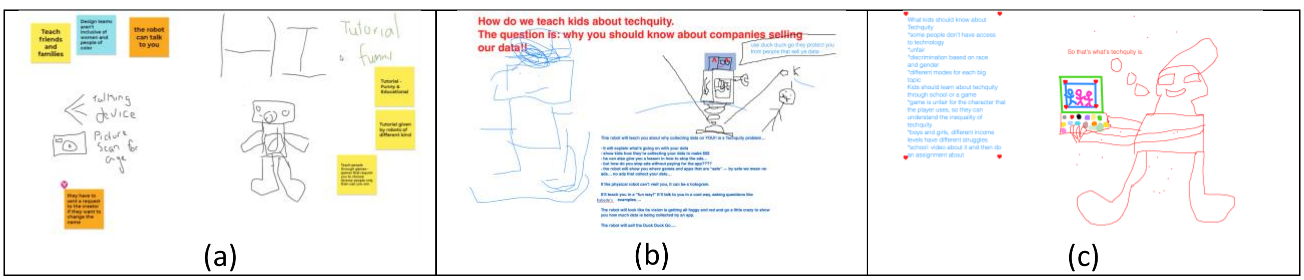


Figure 2-2. Youth designs of learning scenarios to teach about Techquity

Multiple youth designers also used this technique within their PSAs. For example, Desta created a PSA about the accuracy of search results on Google (Figure 2-3a). She described the PSA, saying, *"It's about Google and how sometimes the answers might not be accurate."* In her PSA, a chick walked across the stage and told the audience, *"Hello. / I like Google! / It helps me find answers. / Sometimes google might not be accurate."* In this PSA, Desta demonstrated her own evolving understanding of using Google and shared her understanding with the audience through the chick. In design session 3, when Desta started working on her PSA, she supported taking the result from what Desta described as *"in the box"* (referring to featured snippets and the knowledge panel on Google search results). After a conversation with an adult co-designer during the design session in session 4, she explained, *"I changed my mind."* When the adult designer asked her, *"Now you think that it isn't necessarily the most accurate information? ...What do you think might be better information?"* She replied, *"Yeah…go to an accurate site."* For Desta, this Threat to Techquity was still being made visible, but she shared her understanding through the PSA and demonstrated that she could still like Google and the information it provided, even if that information might not be accurate.

At a larger scale, Barry used his PSA to highlight a cause of Threats to Techquity and demonstrate what he believed should happen to alleviate Threats to Techquity. While his PSA did not focus on a single Threat to Techquity, it highlighted the larger context in which threats emerge and a root cause of Threats to Techquity: the technology companies (Figure 2-3b). Barry described his PSA as follows:

> *A dragon who was flying around and eventually he was going to stop...where there was no Techquity, and then he was going to...put fire to send a message that they [the technology company]...have to start with Techquity or else he's going to burn down the place...not the city, but the place where the person who doesn't have their Techquity, [their] office or something…And it gives them a warning and if they don't follow it, he burns down the companies.*

When asked whether a person can stop a company perpetuating Threats to Techquity, Barry stated, *"a person can, but what if the person does it but the company doesn't listen? It's going to be very hard to get the company down. But if it was...the dragon or something, he can burn it down"* (Figure 2-3b). Through this description, Barry demonstrated his own knowledge of the sources of Threats to Techquity and implicitly warned about the power of technology companies that perpetuate Threats to Techquity in society and the difficulty of stopping them. Although this was not a Threat to Techquity previously discussed by the design team, it revealed some of the underlying causes behind Threats to Techquity and the reasons why Threats to Techquity remain.

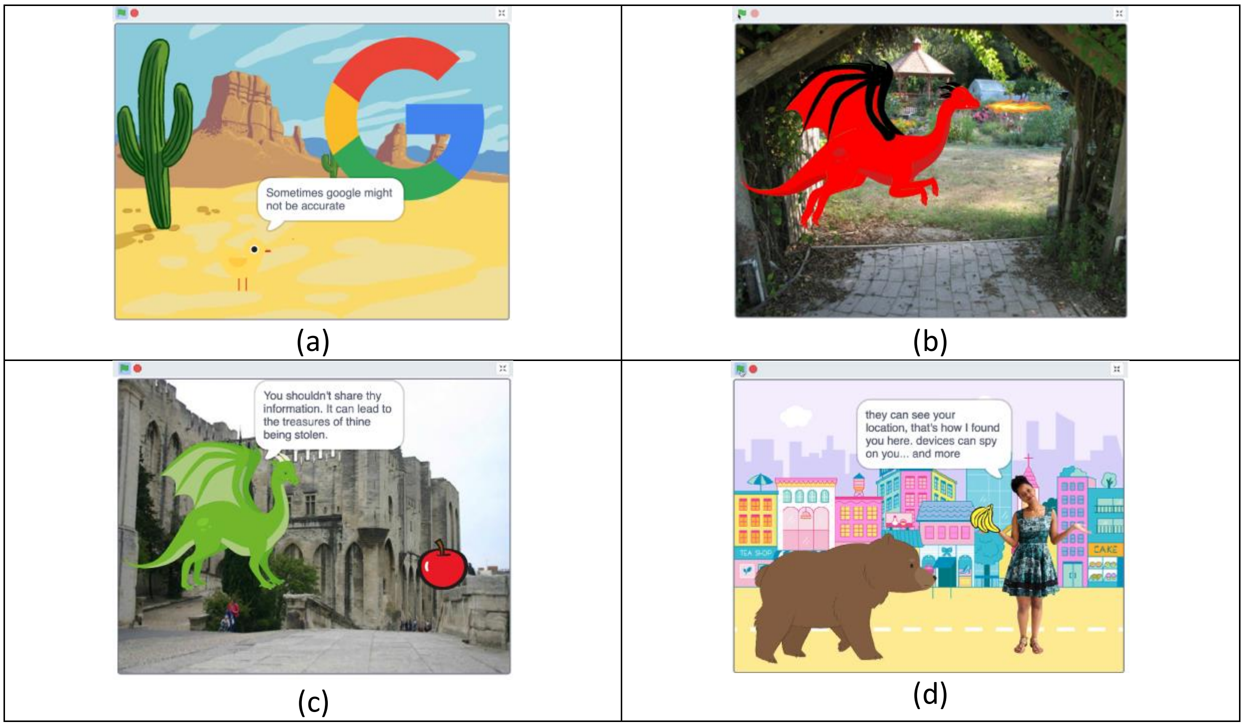


Figure 2-3. Youth PSAs about Techquity

Adaptive Technologies

Particularly when the youth designed learning scenarios, they utilized adaptive technologies that provided age-appropriate tutorials or experiences for the person learning about Techquity. This ensured that the information provided to make invisible Threats to Techquity more visible was comprehensible to the user. For example, multiple youth design teams developed robots that taught the user about Threats to Techquity. Because the youth identified users as other youth of all ages as well as family members, their robots needed to adapt to the age and needs of the user. Joshua and Gabby designed a robot that used a scanning feature to determine the age of the learner (Figure 2-2a). In their description of the robot with an adult designer with whom they worked, they described their robot as follows:

Joshua: *The robot helps you...if you are learning about new technology that you've never tried before.*

Adult 1: *What does the camera do?*

Joshua: *Takes your photo. To see how old you are, so...if you need help understanding something they'll know...how to speak to you...if you're young, like six or something, it will talk to you on your level.*

Adult 1: *So it talks to people in a way that they'll understand.*

Joshua: *Yeah, or...if you only speak Spanish, too*.

Through their robot, Gabby and Joshua ensured that all users, no matter their age or preferred language, would be able to understand the information about Threats to Techquity that the robot provided.

Experiential and Interactive Learning

Another way the youth designers focused on making invisible threats more visible to learners was the use of experiential and interactive learning. Of the three learning scenario designs (Figure 2-2a-c), two included playing interactive games. For example, Barry and Persinna designed a game to teach about Techquity by having players experience Threats to Techquity through their avatars. Figure 2-2c depicts a child learner modeling a game they are playing to learn about Techquity. Rather than selecting just one Techquity topic, the game covered visible and invisible topics such as access to technology, fairness, and discrimination based on race or gender. Barry described the game as follows:

> *He is playing a game about Techquity and now he is thinking...“That’s what Techquity is”…there’s different things about Techquity like what kinds of Techquity, some people can’t access Techquity, and all of them are in the game...these are the buttons down here (points to the buttons on the “keyboard” of the computer). This is the game that he’s playing…And the thing about the game is...you have a character and the character is going through...Techquity so then the person who is playing it finds out what Techquity is if they don’t know. So, that’s how...they learn about Techquity.*

In his description of the game, Barry highlighted how the different game modes controlled by the keyboard allowed players to experience different Threats to Techquity and how their learning centered around their in-game experiences. On their design, Barry and Persinna further described the experience of the player, writing that the “*game is unfair for the character that the player uses, so they can understand the inequality of Techquity”* and “*boys and girls [and] different income levels have different struggles.”* Through these descriptions, the youth creators highlighted how the avatar selected by the player learning about Techquity could change their experience within the game. These experiences took the often-invisible Threats to Techquity and made them more visible by directly demonstrating how they could affect individuals with minoritized identities.

Modeling Conversations about Threats to Techquity

Through their designs, the youth also developed models of how to have conversations about Threats to Techquity with others. These conversations demonstrated how the youth themselves (or a knowledgeable other) could make invisible Threats to Techquity more visible in response to everyday examples. While the previously described robots (Figures 2-2a and 2-2b) both held conversations with their users, the use of modeling conversations was more visible in the youth designers' PSAs. For example, Gabby developed a PSA that depicted a conversation between a dragon and an apple using old English (Figure 2-3c). The apple asked for advice about what to do when a company asked her for information. The dragon replied, "*You shouldn't share thy information. It can lead to the treasures of thine being stolen."* Gabby described her PSA, saying, "*It's about when companies spam you...when you look at stuff it directs you to all the stuff you look at and try [sic] to steal your information."* This scene described a Threat to Techquity via the concrete example of a company trying to get unnecessary information and the dragon directly explaining how to handle the threat. Gabby provided her viewer, the person learning about Techquity, with information about a common threat and what to do about that threat while also modeling how a trusted friend could help you confront Threats to Techquity and make an invisible threat (like companies collecting and selling data) more visible.

Like Gabby, Persinna created a PSA that demonstrated a conversation between two characters: a bear who did not know about Threats to Techquity and a woman, Marian, who did and told the bear about what she knew (Figure 2-3d). Within the PSA, Marian explained to the bear that Technology could be dangerous. She held up a pack of bananas, saying,

Marian: *hey! you should buy this!!*

Bear: *How did you know I wanted these?*

Marian: *well...technology knows a lot !*

Bear: *oh no, that's scary!*

Marian: *Yes! but it doesn't have to be that way.*

Bear: *what do you mean?*

Marian: *we can change that.*

Bear: *how?*

Marian: *By making more people aware of how dangerous technology can be!*

Bear: *What?? dangerous?! i thought technology was cool!*

Marian: *well, it can be but technology can be dangerous.*

Bear: *Really! like what?*

Marian: *they can see your location, that's how I found you here. devices can spy on you... and more*

Bear: *WOW!! we need to tell people about this. Lets go*

In this conversation, Marian made the threat of data collection and use, particularly through location tracking, visible to the bear and modeled a conversation about a Threat to Techquity that many people might not recognize. But, while she named the Threat to Techquity in the description of her project, Persinna demonstrated how the root causes of Threats to Techquity were still becoming visible to her. Persinna described her project by saying,

> *My project is about...let[ting] people know to be aware of how dangerous technology can be and in the project it's showing how...technology is like everywhere basically and it's like, they can, I don't know how to explain it, but, they can like kind of like know what you're doing most of the time.*

In this description, Persinna both described how she taught about Threats to Techquity and admitted that for her, the Threats were still not completely visible. She warned about how technology knew things like what people want to buy and where they are, but she admitted that she couldn't explain why that was. In other words, that aspect of the technology remained invisible to her. For Persinna, it was important to discuss these Threats and raise awareness, even if she could not explain why it was happening. The conversation was important to have so that the other person would become aware of a threat even if the causes of that threat could not be made fully visible.

Discussion

Before being able to teach youth about Techquity, it is essential that we understand their initial conceptualizations of Threats to Techquity and how those conceptualizations change as their awareness of Threats to Techquity expand. By understanding youth conceptualizations of Techquity, it is possible to design learning experiences that can build off the knowledge they already have. Utilizing co-design with a group of eight youth, I sought to understand these conceptualizations. Based on an analysis of the youth designs and design sessions, I found that, prior to being introduced to a set of conical Threats to Techquity, youth conceptualized Techquity mostly based on the visible aspects of Techquity, and particularly on those that were highly salient in their lives. When formally introduced to Threats to Techquity, including to invisible threats, youth conceptualizations expanded to include these invisible Threats to Techquity, and the youth elected to design mostly around invisible Threats rather than visible ones. Finally, when youth presented Techquity to their peers, they found ways to make the invisible visible to scaffold others' understandings of more complex Threats to Techquity. In doing so, the youth designed ways to reveal both hidden Threats to Techquity and how threats affected them, their peers, and their communities. Given that many Threats to Techquity are at least partially opaque, the knowledge of which Threats are the most visible and methods for revealing invisible ones is essential in the learning design process.

The importance of making explicit the invisible Threats to Techquity builds on prior research that showed that, in their initial conceptualizations of how computers worked, youth did not identify more invisible parts of computers or technology (Jayathirtha & Kafai, 2021; Mertala, 2019; Pancratz & Diethelm, 2020). Instead, youth often based their conceptualizations of technology on what they could see, on that with which they could interact, and on that with which they previously experienced a problem (Mertala, 2019; Pancratz & Diethelm, 2020). Similarly, youth's initial conceptualizations of Threats to Techquity consisted of those things they had previously noticed or with which they had experienced issues . Just as prior research demonstrated the importance of authentic examples and real-life stories (Kumar et al., 2018), youth providing relevant life examples created opportunities for exploration and concept building. This research also extends the work of Yip et al. (2019), which found two types of fears elicited by technologies: physical harm and loss of attachment. When discussing these fears and creepy technology, youth did not explicitly include the invisible Threats to Techquity identified within the present work; instead, they described visible aspects of creepy technologies. The present work expands these conceptualizations of technology as creepy or predatory by discussing invisible Threats to Techquity rather than just the technologies themselves. It is important that these invisible threats, rather than just the visible ones that youth can already identify, are included in considerations of how technologies can negatively impact youth. This importance is supported by the focus of the youth designers in the present study on invisible Threats to Techquity in their learning scenario designs and PSAs and their focus on revealing invisible Threats to Techquity through those designs.

Connections Between Threats to Techquity and Youth Designer Identity

Threats to Techquity can be felt by any technology user, but they remain especially egregious and prevalent for people who experience marginalization within society. Ruha Benjamin (2019) has labeled this "the New Jim Code" (a reference to the Jim Crow Laws, anti-Black laws that legalized racial segregation in the United States after the Civil War) due to the effects biased technologies and technological systems can have due to race. Given the more prominent effects of Threats to Techquity on people with marginalized identities, designing with a group of youth who all identify as Black (with some coming from immigrant families and some identifying as girls) focused this work and the resulting conceptualizations on their lived experiences. The youth designers could identify Threats to Techquity within their own lives using examples, some of which connected to their or their families' specific identities (e.g., Siri not understanding Barry's brother). However, the design group did not include youth who openly identify as LGBTQ, gender non-binary, or differently abled. Given the discrimination that individuals face based on these and other marginalized identities, the conceptualizations and examples given by a more diverse group of youth could reveal differing conceptualizations. Future work could explore how youth conceptualizations of Threats to Techquity differ based on the identities of youth designers and the interactions between youths' minoritized identities and the examples they provide from their own lives.

Connections between Conceptualizations of Threats to Techquity and Youth Designer Age

Previous research has explored youth conceptualizations of technology at various ages. For example, Yip et al. (2019) explored the conceptual models of seven- to 11-year-old children; Kodama et al. (2017) explored the mental models of middle school students; and Jayathirtha and Kafai (2021) explored the conceptions of high school students. In this research, I worked with a group of eight- to 13-year-old youth. Barry and Brian were the youngest youth designers and Kabede was the oldest. Examining the youths' designs, some variation can be seen based on age, but the effect of a youth designer's age on their input in the design process and the final product is unclear. Although Brian returned to a more simplistic view of Threats to Techquity in his PSA by talking about the good and bad aspects of technology and Kabede had the greatest number of examples when discussing his experiences and ideas, it is unclear whether this is due to age or the two youths' varying access to technology (Kabede is a self-described gamer who has a virtual reality head set as well as a YouTube account where he posts videos; Brian's parents limit his access to technology and video games). Additionally, a linear relationship between age and the complexity of youths' conceptualizations is challenged by Barry's PSA, which demonstrated a nuanced view of the effects of technology companies on the creation of technological systems that produce Threats to Techquity and the ability of the companies to place a greater focus on Techquity. Given this, questions remain about how conceptualizations might change for younger or older youth; the age at which youth begin to notice Threats to Techquity; and the effects of surfacing and discussing Threats to Techquity for high school students as they prepare to enter the workforce or higher education where they might encounter greater and more varied opportunities for advocacy around these topics.

Changes to Threats in Techquity over Time

As referenced in the introduction, technology has become increasingly prevalent within society over the last 30 years; technological systems, and therefore the Threats to Techquity they can perpetuate or exacerbate, have grown more complex and more common. Whereas 15 years ago the iPhone had not yet been presented to the public, today, smart phones are virtually universal. As technology changes, so do both the Threats to Techquity present within our society and youth conceptualization of those technologies. Yet, I posit that some Threats to Techquity will remain more visible than others to youth and that the need to reveal invisible Threats to Techquity will remain. This need to reveal invisible threats will potentially only grow as algorithms increasingly make decisions within society and the number and complexity of AI and machine learning systems increase. With time, research should continue to examine youth conceptualizations of Threats to Techquity and how those conceptualizations change as technologies change. It is possible that threats in some technologies are more visible to youth than others, particularly based on youths' likelihood to use the technology, or that Threats to Techquity become more invisible over time as they become more deeply embedded within society. The visibility of Threats to Techquity could also change based on policies and the public's influence over how much information technology companies reveal about their products. Future work could explore whether the categories of visible and invisible Threats to Techquity shift as technologies change and other effects that technological change may have on youth conceptualizations of Techquity and Threats to Techquity.

Limitations

This work was limited by the necessity to collaborate virtually while designing. Although all youth designers tried to remain engaged during the sessions, technology problems such as malfunctioning microphones and poor internet connections made it difficult for all youth to participate equally. In addition, this work focuses on the conceptualizations of a small group of youth within one time and geographic space. Since they participate in a design team focused on technology design, the youth regularly work with technologies and think about how to design or redesign what is currently available. Future research could consider whether these conceptualizations change with groups of youth in different times and spaces or whether a group of youth who do not spend as much time using or thinking about technology have different conceptualizations. Additionally, as mentioned above, future work should consider the role that youth identities and age play on their conceptualizations of Threats to Techquity, particularly due to the connections between having a marginalized identity and experiencing the impacts of Threats to Techquity.

Implications for Designers and Educators

This work grounds future efforts concerned with educating youth about Threats to Techquity and algorithmic and technological bias. Youth are noticing Threats to Techquity in their everyday lives; it is important to help them make sense of what they are seeing to better understand the implications for them and their communities. The examples and findings from this work provide building blocks for future curriculum design, but bridges need to be built between current conceptualizations and an understanding of both the algorithmic and technological roots of the Threats to Techquity youth are noticing and the sociohistorical systems in which these threats are ingrained. There is also a need to translate the youths' methods of making the invisible visible into both formal and informal educational contexts. Future work within this project will consider how to build upon these conceptualizations and the examples provided by youth to teach about Threats to Techquity within a classroom setting.

Conclusion

Even if a child does not use a single piece of technology or the internet, it is likely that they are still experiencing some harm based on algorithms and technology. Since we know that, in reality, youth interact frequently with technology, it is essential that youth are educated about Threats to Techquity and how those threats affect their lives and the lives of their community members. To move toward teaching youth about Threats to Techquity, this research focuses on understanding youth conceptualizations of the topic. Youth identified the visible, then saw the importance of the invisible and worked to make the invisible visible by revealing how Threats to Techquity affected them and their communities. Given that youth have a conceptualization of Techquity and experience when it is threatened, we need to focus how to teach youth about the range of Threats to Techquity so that they understand not just the visible, but the invisible as well.

Chapter 3: Designing about Data: Designing a Curricular Unit about Online Data Collection and Data Use

Abstract

Data is constantly being collected through phones, websites, and other internet-connected devices. This data is used by companies in algorithms that provide recommendations, advertisements, and more. With the rate at which youth are using internet-connected devices, their data is continuously stored, creating increasingly large digital footprints and data trails as they age. Yet, many youth are not aware of or have misconceptions about how data is collected about them and used. To educate youth about online data collection and data use, I partnered with a group of youth designers and two teachers to co-design the Talking Techquity curriculum through participatory design methods. In this paper, I focus on online data collection and use, presenting topics and instructional priorities shared by the youth and teacher designers for inclusion within the curriculum. I examine the learning goals, pedagogical strategies, classroom activities, broad ideas, and examples ideated and iterated upon during the design sessions and investigate how these topics and instructional priorities were integrated into a unit about online data collection and use. This paper provides knowledge about how youth and teachers perceive online data collection and data use and the topics and instructional priorities they value when developing a curriculum focused on this topic. By inviting educator and youth voices to the design process, this work presents insights into their distinct design priorities, which hold potential for richer, more meaningful learning outcomes and engagement.

Keywords: co-design, cooperative inquiry, data collection, Techquity, curriculum design

Introduction

Today, online activities and internet-connected devices collect more data about youth than ever before (Children's Commissioner, 2018). This data is tied to what parents share online, the activities of the youth themselves, and the prevalence of internet-connected devices within homes (Children's Commissioner, 2018; Kumar & Schoenebeck, 2015; Pew Research Center, 2018b). According to Forbes (Marr, 2018), each day, over 2.5 quintillion bytes of data are created and the pace of data creation, collection, and storage is only increasing. This data is often used to make recommendations, used for targeted advertising, or sold. Consumer response to this data use is mixed (John et al., 2018), and the propensity for data collection within modern society has resulted in adults being wary of data collection and how that data is used, despite feeling as though they have little control over it (Pew Research Center, 2019).

With so much data being collected and the concern of adults about this data collection, what is happening to data from and about youth? According to polling by the Pew Research Center (2018b), in 2018, 95 percent of youth had access to smartphones and 89 percent reported being online several times per day or almost constantly. Given the use of technology by youth and their parents who share about them (Kumar & Schoenebeck, 2015), a portion of the data collected, sold, and used online each day comes from their activities. Laws protect youth data (e.g., Children's Online Privacy Protection Rule (COPPA) in the United States and General Data Protection Regulation (GDPR) in the United Kingdom) (Children's Commissioner, 2018; *Children's Online Privacy Protection Rule ("COPPA")*, 1998), but data is still collected about youth every day based on their activities online and the connected devices around them. As such, it is important the youth understand the data that is being collected about them and how that data is being used so they can make informed choices about their online activities and advocate for themselves and their communities to promote more equitable data practices.

Online data collection and data use is an example of a Threat to Techquity, or a way technology can cause or perpetuate inequitable and harmful experiences for users due to users' membership within a group that experiences marginalization. Data collection and use is a Threat to Techquity because of the privacy implications it has for youth and the ways that the collected data can be used maliciously within larger technological systems to cause harm to youth and their communities (Benjamin, 2019; O'Neil, 2016; Wachter-Boettcher, 2017). For example, data is used to develop profiles of users based on their online activity and publicly available information. These profiles rely on assumptions based on presumed trends that can be incorrect and, over time, can become more inaccurate (Wachter-Boettcher, 2017). These profiles are used for targeted advertising and can become predatory toward consumers; this happens when companies direct specific advertisements (e.g., those for payday loan services or for-profit universities) to individuals based on who might be most likely to require and pay the high prices for these services (O'Neil, 2016). Youth using online services also experience targeted advertising (see Chapter 2 of this dissertation for youth examples).

With the goal of educating youth about online data collection and other ways technology can threaten societal equity, I partnered with youth and teachers to develop computer science lessons about the social justice impacts of computing (the Talking Techquity curriculum). In this paper, I discuss one unit of this curriculum focused specifically on online data collection and data use. The Talking Techquity curriculum was developed through co-design. By using participatory design, the work centers the voices of the very people using the curriculum: teachers and students. It celebrates the knowledge and experiences that both groups bring to the design process and aims to create curricula that are more relevant and responsive to the needs of both students and teachers within the classroom.

This paper examines the inputs of both design groups – youth and teachers – when creating the Talking Techquity curriculum, a novel computer science curriculum focused on educating students not only about computer science topics, but also about the social justice impacts of computing. The paper will trace ideas from the design sessions to how ideas are presented in the final design. I will focus specifically on how these two groups perceived online data collection and the use of that data. The paper answers the following research questions:

1. What topics and instructional priorities do youth consider and determine to be most salient when designing middle grades learning materials about online data collection and use?
2. What topics and instructional priorities do teachers consider and determine to be most salient when designing middle grades learning materials about online data collection and use?
3. How can youth and teacher topics and instructional priorities be integrated into a curriculum presenting online data collection and use?

To answer these questions, first, I use data from a series of co-design sessions with youth to present their views on teaching and learning about online data collection and the use of that data. Then, using data from design meetings and iterative curricular design, I present parallel design considerations about data made by teachers during the curriculum design process. Finally, I bring these considerations together to present how data is discussed in unit two of the Talking Techquity curriculum. By examining and presenting these design considerations, this paper presents how youth and teachers perceive online data collection and use as well as their instructional priorities when designing learning opportunities around online data collection and use. It demonstrates how youth and teacher perceptions of online data collection and data use can be integrated into a co-designed curriculum and adds to previous literature highlighting the value of including both youth and teacher voices in the design process, particularly because of how their perceptions and learning goals can differ.

Literature Review

This work draws both on prior research about online data collection and data use and on participatory design as a methodological approach. In the following section, I provide an overview of both literatures as they pertain to the current work: the first to provide an overview of the topic covered within this curricular unit and the second as a grounding for the design methods used.

Online Data Collection and Data Use

Researchers, investigative journalists, and consumers have increasingly raised awareness of Threats to Techquity. One such threat is the collection of personal data using internet-connected devices and the use of that data within potentially biased algorithms and targeted advertising. Today, devices that collect data about people are virtually omnipresent within society. For example, smart speakers (e.g., Amazon Echo and Google Nest) are internet-connected devices that use speech recognition technology to perform tasks. These devices pose Threats to Techquity via their impact on people's personal and cyber security (Lynskey, 2019) and how the devices function for people based on their dialect (Benjamin, 2019). In the United Kingdom, the number of smart speakers doubled in just six months between fall 2017 and spring 2018 (Children's Commissioner, 2018). Additionally, although only 2 billion "Internet of Things" devices were in use in 2006, that number was projected to increase to over 200 billion by 2020 (Marr, 2018). Given these and other devices, an unprecedented amount of data is now collected about people, and most adults do not think they can do anything to stop or control the data collection (Pew Research Center, 2019). In fact, the Organisation for Economic Co-operation and Development (OECD) estimated that eight times more data existed in 2018 than in 2010 (Children's Commissioner, 2018). This data is collected from internet searches, social media sharing, shopping history, location collection, voice data from home assistants, and click tracking through web cookies (John et al., 2018; Lynskey, 2019; O'Neil, 2016; Wachter-Boettcher, 2017). Children are especially at risk in this data collection because children and their parents share photos of and information about children at astounding rates. On average, parents share 100 photos of their child online each year; once children can access social media themselves, they post an average of 26 times per day (Children's Commissioner, 2018). In addition, inter-connected toys, other internet-connected devices such as tracking watches, and apps and programs used by parents and teachers share data indirectly (Children's Commissioner, 2018). Children are also early adopters and prolific users of internet-connected devices and social media, exposing them to risks that adults might not even recognize (Children's Commissioner, 2018; Pew Research Center, 2018b).

There are benefits to data collection, including the personalization of services, improved customer and patient experiences, and the development of new products and services; some consumers even appreciate individualized targeted advertisements (Children's Commissioner, 2018; John et al., 2018). Yet, for some, the use of data online can become malicious and lead to further inequities within society and threats to safety (Benjamin, 2019; Children's Commissioner, 2018; O'Neil, 2016; Speicher et al., 2018; Wachter-Boettcher, 2017). For example, past research has demonstrated that advertisements included in returned search results for Black-associated first names (e.g., Latanya) were more likely to use the word “arrest” than advertisements presented with search results for white-associated first names (e.g., Kristen) (Sweeney, 2013). These advertisements presented alongside search results could affect future job or schooling prospects. It is common practice to search for an applicant’s name, and having results (even advertisements) that imply a criminal record could bias decision-making. Additionally, organizations such as for-profit universities and payday loan companies use targeted advertising to provide advertisements to individuals presumed to have greater need and less knowledge about these systems. These organizations use data not only to decide who to target with advertisements, but also to select which advertisements will prove most effective (O’Neil, 2016). Consumer data also leads to discriminatory pricing and differential treatment and targeting of customers based on their locations and attributes, resulting in price differences of up to 166 percent (Gangadharan et al., 2014; Mikians et al., 2012). There is also danger in the size of compiled data sets. The larger a dataset, the easier it becomes to identify a specific person based on data about them (Gangadharan et al., 2014). In other words, the more data collected on people and the longer a digital footprint exists, the easier it is to identify an individual from their data, posing additional safety and discrimination risks.

Laws exist that protect youth data (e.g., COPPA in the United States and GDPR in the United Kingdom) (Children’s Commissioner, 2018; *Children’s Online Privacy Protection Rule (“COPPA”)*, 1998). Additionally, research has focused on how youth understand data privacy (Kumar et al., 2017) and on designing resources to teach youth about data privacy (Kumar et al., 2018). Yet, there is more to be done to protect youth from online data collection and data use, educate them about these Threats to Techquity, and help them advocate for themselves. In response to the increasing amount of data collected within society, particularly about children, the Children's Commissioner of England has called upon schools to teach students about data collection and how it is used, including educating students about what they can do to control their own data footprints (Children's Commissioner, 2018). Existing messaging about online safety and data tends to focus on data shared directly, but children and parents often remain unaware of how data can be collected through web cookies and metadata or created using algorithms (Children's Commissioner, 2018). This work and the larger study with which it is associated works to provide this education, aiming to arm students with knowledge about Threats to Techquity and, specifically, data collection and use.

Participatory Design

To create a more relevant and equitable curriculum that considers the current needs of students, the development of the Talking Techquity curriculum utilized participatory design to incorporate the voices of stakeholders (in this case, students and teachers) in the design conversation.

Participatory design originated during the Scandinavian movement for workers' rights in the 1970s and 1980s. The movement advocated for the participation of workers within the design and decision-making process for new workplace products and technologies due to workers' roles as users of those products (Kensing & Blomberg, 1998; Muller & Kuhn, 1993). A grounding principle of participatory design is transferring control from the researchers and designers creating new products to the users of those products. Originally, this centered around providing workers with greater agency over their working conditions (Kensing & Blomberg, 1998). Since the origination of participatory design, these goals have grown to more generally focus on the equalizing of power structures between designers and users, even outside the workplace, thereby dismantling the hierarchical power structures within design relationships, developing a more democratic design process, and creating more emancipatory design spaces that counter oppressive structures present within traditional design approaches (Bjerknes & Bratteteig, 1995; Björgvinsson et al., 2010; Bødker et al., 2000; Coenraad et al., 2019; Erete, 2021; Harrington et al., 2019; Iversen et al., 2004; Penuel et al., 2007; Pinkard et al., 2017). Not only does participatory design aim to create a more equitable design process, but co-designed products developed through participatory design can better meet the needs of the end user due to the consistent feedback loop they provide (Scaife et al., 1997). This feedback can come in various forms. Within participatory design there are varied levels at which a user is involved in the design process and a variety of roles that users can play (Druin, 2002; Kensing & Blomberg, 1998). These roles range from that of a more traditional user or tester to those of informant and design partner, two roles in which the user has a greater hand in the design process and final design (Druin, 2002).

Since its inception over 50 years ago, participatory design has expanded into the development of educational innovations, including educational technologies and curriculum (Bonsignore, Ahn, et al., 2013; Williams & Traynor, 1994). In many projects designing for educational settings, teachers have been included as essential partners in the design process (Roschelle et al., 2006). Teachers have been valuable design partners due to their knowledge of students' broad learning goals, the larger systems in which learning opportunities will take place, and teachers' knowledge of daily classroom practices (Penuel et al., 2007; Roschelle et al., 2006; Scaife et al., 1997). Past research has incorporated co-design with teachers in various ways, including through meetings or conversations with teachers (e.g., Carroll et al., 2000; Hundal et al., 2014; Kyza & Georgiou, 2014; Leary et al., 2016; Tan & Guo, 2009); teacher feedback using surveys and interviews (e.g., Barab et al., 2001; Cooper & Brna, 2000); and feedback about teachers' experiences implementing new designs (e.g., Duell et al., 2014; Y. H. Wang, 2017). Yet, teachers are not the only important informants when it comes to designing for the classroom. Students are able to share about their own experiences and what engages them in their learning (Scaife et al., 1997). Their ideas and design partnership have also been incorporated into the development of curricula and other learning tools (e.g., Coenraad, Palmer, et al., 2021; Franklin, Weintrop, et al., 2020).

In the present work, I utilized participatory design methods with both youth and teacher co-designers. I selected methods both to align the design techniques with the design partners and to attend to logistical needs, such as the amount of time teachers had available to collaborate on the designs. With the youth design partners, I utilized cooperative inquiry, a design technique centered around designing on intergenerational design teams where adult and child designers collaborate to develop new technologies for children (Druin, 2002, 1999). Cooperative inquiry focuses on building long-term relationships between adult and child designers and taking specific steps to break down the typical power dynamics between adults and children (e.g., sitting on the floor and wearing informal clothing) to create a more equitable design space (Druin, 1999; Fails et al., 2012). Researchers have developed a catalogue of common cooperative inquiry design techniques to be used with child design partners in person and at a distance (Fails et al., 2012). With the teacher design partners, I utilized more general participatory design methods that involved the teacher designers throughout the design process. These methods provided opportunities for the teachers to provide initial information about their classrooms on which designs could be based and iterative feedback throughout the design process.

Methods

I selected participatory design as the primary methodological approach within this research because of its emphasis on creating space for the inclusion of community voices within the design process and the democratization of that process (Bjerknes & Bratteteig, 1995; Björgvinsson et al., 2010; Coenraad et al., 2019; Harrington et al., 2019; Pinkard et al., 2017). By including youth, this work builds on their valuable ideas and insights about something that could affect them. These youth voices draw upon their experiences, ideas, and values, adding information to the design that could not be provided by an adult (Druin, 2002; Scaife et al., 1997). The inclusion of teachers in this work celebrates their role as unique knowledge-bearers with a profound understanding of curricula, students, and the school setting in which the curriculum will be implemented (Penuel et al., 2007; Roschelle et al., 2006; Scaife et al., 1997).

Design work for this project occurred between April 2020 and March 2021 (Figure 3-1). The design processes began with inspiration and ideation sessions with youth, progressed to ideation with the teachers, and concluded with iteration with both the youth and teacher design partners. In this paper, I present analysis of data from five design sessions with youth and five design meetings with teachers. All of these sessions included discussions around online data collection and data use and designing learning experiences centered on this topic. Within each of these design sessions, I focus specifically on the development of unit 2 of the Talking Techquity curriculum and youth designs around data collection and use (such as targeted advertising).

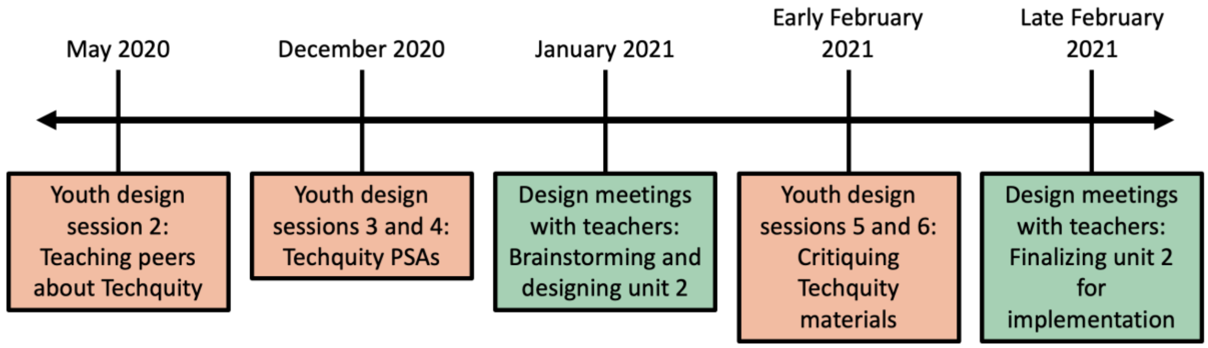


Figure 3-1. Timeline of design sessions with youth and teachers

Context and Participants

I first analyze and present the data from five cooperative inquiry sessions with youth. In total, I completed six design sessions with youth, but the first focused more broadly on defining Techquity and Threats to Techquity and did not include any designs specifically focused on data (see chapter 2 of this dissertation for more information on session 1). I completed the sessions in three sets: April/May 2020, December 2020, and February 2021. Each 90-minute session followed a typical routine for cooperative inquiry sessions: each began with snack time to help everyone come together in the design space before continuing with a question of the day in circle time, the design activities, and an opportunity to share designs (Druin, 1999, 2002; Guha et al., 2013). Due to the COVID-19 pandemic and the need for social distancing, all five design sessions took place virtually on Zoom video conferencing software and using online collaboration tools (e.g., Zoom whiteboards, Miro).

In total, eight youth participated in the design sessions, with six or seven youth attending each session alongside four to six adult design partners (Table 3-1). As of the first session they attended, the youth ranged in age from eight to 13; all were members of the KidsTeam intergenerational co-design team at the University of Maryland. I was a member of the co-design team and had worked with all the designers for at least one year.

Table 3-1. Participants in collaborative inquiry sessions

Child (Pseudonym)	**Age** (years as of first session)	**Gender**	**Race**	**Session Attendance**				
				2	3	4	5	6
Aman	12	Boy	Black	✓	✓	✓	✓	✓
Barry	8	Boy	Black	✓	✓	✓	✓	✓
Brian	8	Boy	Black		✓	✓	✓	✓
Desta	11	Girl	Black	✓	✓	✓	✓	✓
Gabby	10	Girl	Black	✓	✓	✓	✓	✓
Joshua	10	Boy	Black	✓				
Kabede	13	Boy	Black	✓	✓	✓	✓	✓
Persinna	12	Girl	Black	✓	✓	✓	✓	✓
Adults	-	Women	Varied	4	4	4	6	6

In addition, I analyze and present data from five design meetings with teachers in which we discussed the design of the second unit about online data collection and data use. The design meetings occurred between January and March 2021 between myself and two teachers, Mr. Johnson and Mr. Sanchez. As with the KidsTeam sessions, the design meetings with the teachers occurred virtually using Zoom video conferencing software due to the COVID-19 pandemic and need to socially distance.

At the time of the research, Mr. Johnson[3] and Mr. Sanchez both taught at an urban middle school in the Mid-Atlantic region of the United States. Mr. Johnson was a classroom teacher with a background in English Language Arts who taught a sixth-grade enrichment course required for all students at the school. He identified as a Black or African American man between the ages of 35 and 44. He was a veteran teacher in his 19th year. While Mr. Johnson had an extensive teaching background, he did not have any prior experience teaching computer science. In design conversations, Mr. Johnson shared that he was very motivated to incorporate computer science into his course to prepare his students for the jobs of the future, many of which

[3] All teacher and youth designer names are pseudonyms.

he believed would require computer science and technological knowledge. He hoped to expose his students to computer science to build interest and ensure his students were prepared. Mr. Sanchez was the school librarian. He identified as a Hispanic or Latino man between the ages of 45 and 54. Mr. Sanchez was in his fifth year of teaching and had taught computer science to students in prior years. Mr. Sanchez did not have any computer science experience prior to when he began teaching. Following the design of the lessons, Mr. Johnson implemented them within his classroom, while Mr. Sanchez assisted when possible.

I acted as a design partner within both the KidsTeam sessions and in the design meetings with teachers. At the time of the research, I was a Ph.D. candidate in the same geographical region as the school where the teachers taught. Prior to beginning graduate school, I was a middle school teacher instructing classes in social studies, Spanish, and technology (including technology courses in computing and three-dimensional design). I identify as a mixed-race woman between the ages of 25 and 34. Besides the courses I led as a teacher, I had little prior experience with computer science education. However, as a graduate student, my work focused on computer science education and I completed a course in JavaScript programming.

Data Collection

Each set of KidsTeam design sessions focused on different goals, beginning with inspiration and ideation and moving through the iteration of materials developed based on the youth designs. The sessions discussed Techquity and Threats to Techquity generally, but in each of the sessions, some youth designs revolved specifically around the Threat to Techquity of online data collection or data use. Therefore, I focus on the artifacts youth created about data during the general design sessions. (See Table 3-2 for details on each design session and the design activities completed). Each design session was recorded using the record feature of Zoom video conferencing. This included both the full group conversations and the small group design activities, which occurred in breakout rooms. In total, the analyzed sessions include about 12.5 hours of video. Additionally, I used transcripts of the chat feature to capture non-verbal conversations. I saved all design artifacts (e.g., big paper ideation on Zoom whiteboards, Miro boards, etc.) as screenshots. I downloaded copies of the youth public service announcements (PSAs) created on Scratch from the Scratch environment and subsequently analyzed them. Finally, I took field notes immediately after each session.

Table 3-2. Collaborative inquiry session details

Session	Design Goal	Question of the Day	Design Activities
2	• Generate ideas and preferences to teach peers about Techquity.	Thinking about the examples from last session and others you might have, how does technology lead to things being unfair in the world? Can you give an example from your life?	Design Activity: Youth designed how they would teach peers about Techquity using big paper (Fails et al., 2012). They chose an environment in which to teach other kids (e.g., school, online, hanging out, etc.), what to teach, and interesting ways to learn the information. Wrap-up: Youth presented their big paper designs. An adult designer tracked Big Ideas and presented them to the youth for confirmation of completeness and correctness.
3/4	• Use computer programming to create a public service announcement (PSA) about Techquity.	Session 3: Have you ever coded before? If so, what platform did you use (Code.org, Scratch, Tynker, etc.)? Session 4: On Tuesday we started working on Techquity PSAs using Scratch. What is your Techquity PSA about and what	Design Activity: Youth made their own PSA about Techquity using the Scratch programming environment. Wrap-up: Youth shared their PSA projects. An adult designer tracked Big Ideas and presented them to the youth for confirmation of completeness and correctness.

		is your goal for today?	
5	• Critique Scratch Projects from the Teaching Techquity lesson plans developed by teacher and researcher co-design team.	Besides school, where do you learn new things?	Design Activity: Youth used sticky notes to critique Scratch projects from the curriculum by identifying likes, dislikes, and design ideas (Fails et al., 2012). Wrap-up: Sticky notes from all three design teams were divided into thematic categories that were presented to the youth designers to verify all ideas had been captured and to invite the students to add to the ideas.
6	• Critique activities and class structure in the Teaching Techquity lesson plans.	During online learning, what is the most interesting or engaging way that your teacher(s) have taught?	Design Activity: Youth used emojis to react to and rate outlines of each unit in the Teaching Techquity lessons. Wrap-up: Each design team shared their ratings overall and reactions to specific activities within the lesson plans. These ideas were collected and Big Ideas from across the group were developed.

I audio and video recorded my design meetings with Mr. Johnson and Mr. Sanchez and transcribed them for analysis using the Zoom record feature. In addition, I took field notes immediately after each design meeting. Using information and ideation from the design meetings, I developed an initial set of curricular materials. Mr. Johnson and Mr. Sanchez reviewed all materials and offered feedback and suggestions for improvement through email and design meetings until we agreed upon a final set of materials. I used a design log to track the origination of ideas and changes made to the curricular materials. I saved each iteration of curricular materials to analyze changes made between iterations.

Data Analysis

To answer the first research question, I used the GLID method (Van Mechelen et al., 2017) to analyze the youth designs specifically focused on online data collection and data use. GLID is a multi-modal analysis method designed specifically for analyzing artifacts designed by youth through co-design. It examines the material creations and the verbal explanations of the designs to identify values embedding within the final designs. GLID consists of four stages: (1) grounding the analysis, (2) listing design features, (3) interpreting orientation and organization, and (4) distilling discourse and values. For each data-centered artifact developed by the youth in the KidsTeam design sessions, I used the GLID method to analyze the final artifact, design conversation, and final presentation of the design. Throughout the analysis, I compared emerging themes against the "Big Ideas" developed at the end of each design session to identify commonalities or areas where ideas might be missing. These "Big Ideas" were member-checked with the youth during the design sessions. Although these "Big Ideas" were limited because they spanned all the designs created in each session (e.g., not just those related to data), they provided a triangulation point for findings.

To answer the second research question, I analyzed transcripts of the design meetings with the teachers through an iterative coding process (Saldaña, 2015) designed to align loosely with the steps of the GLID process. First, I reviewed the complete transcripts of the design meetings and extracted for further coding those portions of the design meetings pertaining specifically to discussion of online data collection and data use and the planning of unit 2. For example, in this initial process, I extracted conversations about targeted advertising and data in natural language processing algorithms, but I did not extract conversations about the overall structure of the curriculum or algorithmic bias. Then, I deductively coded these extracted portions of the design meetings to identify topics and instructional priorities pertaining to the teaching of online data collection and use in unit 2. I selected these categories based on the specific research questions this paper aims to answer. For example, the quote, *"...One aspect that I see...is...that's how Facebook and all these things fool us...saying, 'oh, let's play this game,' and then you play the game and they're collecting data about you"* was coded as a "Topic" because it talks about a specific instance of data collection. Finally, I inductively open coded the topics and instructional priorities to identify themes in the types of topics and instructional priorities the design team discussed. I identified two types of topics: broad ideas and examples Additionally, I identified three types of instructional priorities: pedagogical strategies, classroom activities, and lesson goals. I coded the previous quote as "Topic: Example" because it gave a specific example of data collection. To ground the shared ideas and distill values as aligned to the GLID method, the coded utterances were moved to a spreadsheet by code to track where the ideas came from distill related themes and values.

To answer the third research question, I coded the unit plan from unit 2 to trace the topics and instructional priorities discovered in the prior analysis of youth and teacher design sessions within the unit. Using the codes developed from the inductive coding of the teacher meetings (topic: broad idea, topic: example, instructional priority: pedagogical strategy, instructional strategy: classroom activities, and instructional strategy: lesson goals) and the list of themes from each design group (youth and teachers; Table 3-3), I deductively coded the unit plan (Saldaña, 2015). As I applied the codes, I labeled each coded section of the unit plan with the code, theme, and design group with which the idea aligned. I compared the identified alignments to the design log to verify the origin of the topics and instructional priorities.

Findings

In the following section, I answer each of the research questions separately. As described in the Methods section, I focus specifically on instances when the youth and teachers elected to discuss and create designs concentrated on online data collection and data use. I first focus on the design sessions with youth and the topics and instructional priorities they considered and included within their designs. Next, I turn to the design meetings with teachers and their salient topics and instructional priorities and topics. For clarity and parallelism between the two sections, I organize the findings into the categories derived from the research questions and from the sub-categories that emerged from the coding and analysis of the design conversations with teachers. Those categories are Instructional Priorities (learning goals, pedagogical strategies, and classroom activities) and Topics (broad ideas and examples) (Table 3-3). I conclude this section with an analysis of unit 2 of the Talking Techquity curriculum to explore how the design ideas and topics from both groups were incorporated into the lessons.

Table 3-3. Topics and instructional priorities related to teaching about online data collection and data use discussed by youth and teachers (themes in red font were identified by both youth and teachers)

	Youth	Teachers
Topics		
Broad Ideas	• Data collection • Privacy • Companies selling data • Targeted advertising	• Data for decision making • Facial Recognition • Good and bad biases • Sales and marketing • Self-driving cars and sensors • Targeted advertising
Examples	• Advertisements in phone games • Duck Duck Go • Location-based advertisements • Online shopping • YouTube	• Games • Music • Online advertisements • Online shopping • Recommendations • TikTok • Variable pricing • YouTube

Instructional Priorities		
Learning Goals	• Advocacy • Awareness • Protection	• Promote awareness of technology being both good and bad • Prepare students for future careers
Pedagogical Strategies	• Conversation and discussion • Expert or authority • Relevance to student lives	• Making students the marketers using data • Relevance to student lives • Video as a hook in the lesson
Classroom Activities	• Direct instruction • Gamified learning (e.g., Kahoot) • Learning through videos	• Create a Scratch project marketing something • Kahoot as a survey to collect data • Learning through videos

Research Question 1: What topics and instructional priorities do youth consider and determine to be most salient when designing middle grades learning materials about online data collection and use?

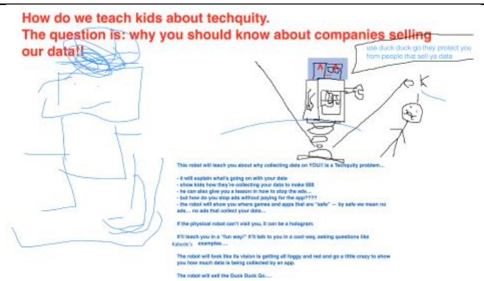
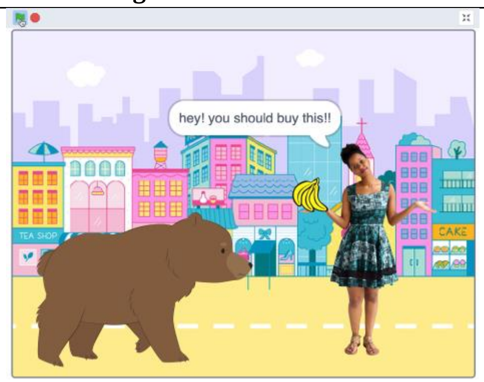
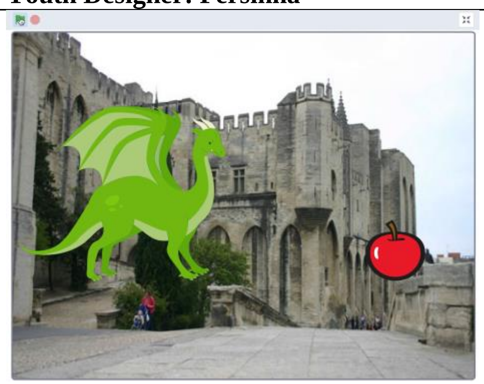
To analyze the design sessions with youth and their final designs, I utilized the GLID method (Van Mechelen et al., 2017). Table 3-4 presents a summary of this analysis and a synopsis of each stage of the analysis (grounding the analysis, listing design features, interpreting orientation and organization, and distilling discourse and values) for all of the youth-developed designs that pertain to online data collection and data use. For clarity and later reference, I labeled each artifact with a letter (e.g., Artifact A) chronologically by when they were developed in the design process. Artifact A was developed during design session 2, Artifacts B and C were developed during design sessions 3 and 4, Artifact D was developed during design session 5, and Artifacts E, F, and G were designed during session 6. In the first column of the table, I present an image of the design and the names of the designers who developed the specific design. Then, in the subsequent columns, I present the analysis by stage in the GLID process. Due to space, this table does not include the full analysis, instead offering a summary of the results by category. Throughout this section of the findings, I refer to Table 3-4 and specific artifacts to make connections between the findings and the analysis.

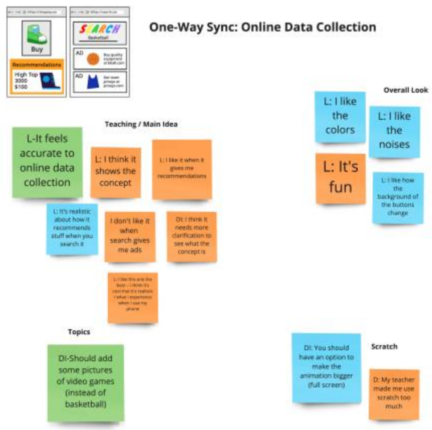
Topics

While designing, the youth designers identified specific focal topics related to data collection and data use. In this section, I present each of the four broad ideas suggested by the youth designers: data collection, privacy, companies selling data, and targeted advertising. Throughout their designing, youth drew upon experiences from their own lives and personal examples to explore data privacy issues and concerns, which helped them to make online data collection and data use more concrete and visible (see Chapter 2). In presenting the findings, I integrate these examples as they relate to broad ideas.

Data Collection. The dominant topic that I observed and coded within conversations and designs included how and which data is collected and how that data collection can be prevented. This topic is present in all three of the youth ideation designs about data collection and data use (Table 3-4, Artifacts A, B, C). In describing the robot he designed with Aman to teach and answer questions about data collection (Table 3-4, Artifact A), Kabede explained, *"The robot is gonna explain to them [users] what is going on...with your data. How they're [tech companies] selling all the things that you have been searching up, by using his [the robot's] screen that is on his belly."* Persinna's and Gabby's PSAs address similar concerns. Persinna's PSA (Table 3-4, Artifact B) warned about technology knowing too much. Persinna described her project as *"about, like, to let people know to be aware of how dangerous technology can be and in the project, it's showing how...technology is like everywhere basically and...they can…know what you're doing most of the time."* While Persinna doesn't speak directly about data, her description referenced data collection as it is how technology could "know" where a person is or what they

Table 3-4. Overview of GLID analysis of youth designs about data collection and data use

	Artifact	Grounding the Analysis	Listing Design Features	Interpreting Orientation & Organization	Distilling Discourse & Values
A	 **Youth Designers: Kabede and Aman**	• Kabede had prior interest in data. • Adult co-designers asked open-ended questions. • Based on experiences in the youth designers' lives.	• Teaching robot explains what is happening with data, how companies make money, how to stop ads, "safe games" without ads, and using Duck Duck Go.	<u>Orientational:</u> Interacts independently giving information about data collection. <u>Organizational:</u> One teaching tool with the ability to instruct through a variety of different means and functions.	• People do not know (but should) about data online. • The robot is an all-knowing being. • The robot provides clear and actionable answers.
B	 **Youth Designer: Persinna**	• Persinna had conversations with adult design partners. • Based on interests from previous design sessions. • Based on Persinna's personal experience.	• PSA with speech bubbles to communicate. • A bear and woman discuss purchasing recommendations and dangers of technology. • Bear and woman decide to educate others on what the bear learned.	<u>Orientational:</u> Acts as an authority on data use. The artifact cannot run on its own. <u>Organizational:</u> Shares about the dangers of technology and gives examples of ways technology can use data.	• Danger of technology is counteracted through education. • PSA points to a distrust of technology due to its dangers.
C	 **Youth Designer: Gabby**	• Gabby elected to create her PSA about companies selling data and stealing people's information. • Gaby educated about targeted advertisements and data because she has seen it "everywhere."	• PSA with speech bubbles to communicate. • A dragon and an apple have a conversation about providing information to companies. The dragon advises not to share information.	<u>Orientational:</u> User runs PSA by clicking a series of buttons. The dragon is the authority to the apple and indirectly to the audience. <u>Organizational:</u> The PSA teaches about not giving companies more data than necessary and the consequences of data sharing.	• Negative connotation with this data collection • Something is taken from the user when data is sold.

	Artifact	Grounding the Analysis	Listing Design Features	Interpreting Orientation & Organization	Distilling Discourse & Values
D	 **Youth Designers: All youth in session 5**	• Ideas were mainly elicited through questioning by adult co-designers.	• Feels realistic. • Dislike that advertisements come up when you search (in real life). • Needs clarification on the concept is/ more background information. • Should have pictures of video games rather than basketball. • Like the colors and the noises.	<u>Orientational:</u> Sticky notes provide ideas for curriculum designer. Youth designers spoke from a personal standpoint. <u>Organizational:</u> Sticky note colors denote design teams. When big ideas were shared, the youth designers agreed their ideas are represented.	• Value realism of the Scratch project. • Want the results and search categories to be more relevant to them and their interests.
E	 **Youth Designers: Barry and Brian**	• Barry gravitated to the Kahoot because he likes Kahoot after he won first place in class. • Barry said that data collection is a boring topic, but could be less boring by having a video. • Barry suggested a mixture of the teachers telling and showing so that students can look for themselves. • Brian suggested there should be superheroes in the unit somewhere.	• Unit gets a thumbs up, sunglasses emoji, smiley face, and a big smiley face. • Barry promoted the Kahoot activity, giving it 8 sunglasses emojis, a black sticky with "Won first place," and a heart eyes emoji. • The team placed a thumbs up by the Personal Data Audit and debrief, with the former coming more from the adult designer.	<u>Orientational:</u> This artifact was designed to help the designer improve upon the lessons. The design team doesn't talk about other students using the unit; they mostly talk about themselves and how they would feel if this unit were taught in their class. <u>Organizational:</u> Design ideas were shared by posting on a Miro board of the outlined lesson. Youth used a mixture of words and emojis to react	• Connection between enjoying activities and winning. • Supportive of methods because of past experiences.

	Artifact	Grounding the Analysis	Listing Design Features	Interpreting Orientation & Organization	Distilling Discourse & Values
F	 **Youth Designers: Kabede and Desta**	• Kabede selected the man singer emoji to be a positive sign. • The idea to flip the discussion and video was introduced by an adult co-designer, but agreed upon by the youth designers. • Kabede discussed his own experience with his YouTube channel and privacy/data concerns he has.	• Team used 3 man singer emojis, a thinking emoji, a smiley, a money emoji, a questioning emoji, and a thumbs up. • Heavily annotated with text around discussions with youth examples. • Suggested that the Kahoot and Data Audit could be combined and the teacher can talk through the implications.	<u>Orientational:</u> This artifact was developed for the curriculum designer to improve the curriculum. The group discussed the lesson as it would be taught to other students by a teacher. <u>Organizational:</u> The design team treated the individual parts of the lesson as segments and focused mostly on them individually. Design ideas tended to pertain directly to one section of the lesson.	• Focus is placed on the stories of the youth designers. • Designers place importance on the voices, questions, and stories of the students who are in the classroom. • Value students being able to make connection to their lives and personal context.
G	 **Youth Designers: Gabby and Persinna**	• Adult co-designer guided the discussion through the segments by introducing each. • Gabby lead the discussion, but Persinna joined in at specific points.	• The team used 3 thumbs up, 2 meh faces, one heart eyes emoji, one thumbs down, and one frowny face. The group added one sticky note. • Overall, reactions to the discussion, video, and teacher presentation were all positive. • Mixed, but slightly negative, reactions to Kahoot.	<u>Orientational:</u> Developed to be used by the curriculum designer for improving the curriculum. The group discussed themselves as students, but did not discuss the teacher or students who will use the lesson. <u>Organizational:</u> Design has a section with more positive reactions (the opening discussions and video) and one with more negative reactions (Kahoot and the following discussions).	• Value understanding the topic more deeply through the video and discussion and being able to participate. • The youth do not want to be left without answers, which is their main reason for disliking Kahoot.

might be doing. Finally, Gabby's PSA (Table 3-4, Artifact C), as described further below, focused on what data a person should allow to be collected by providing it to a company to protect them and their "treasures."

Examples from their own experiences and knowledge, such as the use of Duck Duck Go to prevent data collection through online searches and data use in search, highlighted the youth designers' conversations about data collection. During the design session, Kabede mimicked the robot he and Aman designed reminding the users, *"Don't forget kids, use Duck Duck Go"* and discussed Duck Duck Go in multiple other sessions. Kabede also shared an example of data collection through videos he uploaded to YouTube. He explained, *"I have some videos on YouTube of basketball because our school did basketball and I recorded the games and posted it. So...since it's actually collecting data on people, it recognized some faces."* He explained that the videos now come up when you search for one of the people's names whose face is in the video and noted his dislike of this feature. In Gabby's PSA (Table 3-4, Artifact C), the apple asked the dragon about data collection, saying, *"Yesternight amazon asked me for my phone number, and has continued to ask me even though they don't call people. What should i do about this insolent problem?"* In this example, Gabby demonstrated her experience with data collected during online shopping and consumers sharing data directly with companies.

Privacy. Discussion of data collection and what personal information to share related to privacy within the products of the youth designers. In their designs and design conversations, the youth designers shared and incorporated information they knew about data privacy and protecting data, such as not giving more data than is required. For instance, in Gabby's PSA (Table 3-4, Artifact C), the dragon replied to the apple, saying,

> You shouldn't share thy information. It can lead to the treasures of thine being stolen. I advise of you to NOT share thy information and, instead, say: 'Thy foolish trickery shall not get to me, I hereby deny your hubris request.'

With this reply, the dragon highlighted a way for the apple to both keep its information private as well as a motivation for doing so: namely, the potential for identity theft or the use of the stolen information to trick the apple into giving up its possessions.

A desire for privacy is interwoven into some of the conversations and examples about data collection. In the Duck Duck Go example highlighted above, use of the search engine promoted privacy. Additionally, when youth discussed YouTube, their examples highlighted privacy concerns. In the example above, Kabede was concerned that *"the people that were actually in...the video…Google recognized."* Finally, Gabby's PSA used online shopping to model data collection and privacy through the conversation.

Companies Selling Data. Companies selling data was a topic discussed by the youth designers and used to describe their designs. This is highlighted by Kabede and Aman's robot design (Table 3-4, Artifact A). For example, in Kabede's quote in the data collection section above, he mentioned that one of the things the robot would teach about was *"How they're [tech companies] selling all the things that you have been searching up."* Additionally, on the design artifact they created (Table 3-4, Artifact A), Kabede and Aman identified their main question as not how to teach kids about Techquity, but *"why you should know about companies selling our data!!"* Throughout their design conversations and final design, the youth designers focused not only on the collection of data, but also on how it could be sold.

Targeted advertising. The final salient topic related to data collection and data use that emerged from the youth designs was targeted advertising. This was a topic that the youth were very aware of due to their personal experiences with technologies such as mobile games and YouTube. For instance, while Kabede focused on how the robot he designed with Aman would teach about companies selling data, Aman focused on it *"giv[ing] you a lesson about how to...not get ads at all."* For Aman, the goal was to have "safe games" that did not include advertisements to limit the targeted advertising to which youth were exposed. In Gabby's PSA (Table 3-4, Artifact C), the content of the PSA was mostly about data collection and privacy, as described above, but Gabby included targeted advertising in her explanation, introducing her PSA by saying, *"It's about when companies spam you with all the...when you look at stuff it directs you to all the stuff you look at. And try to steal your information."* Here, she talked not only about companies getting your information, but also the targeted advertisements or recommendations that they might send.

Persinna discussed location-based suggestions in her PSA (Table 3-4, Artifact B). In the PSA, Marian told the bear, *"they can see your location, that's how I found you here. devices can spy on you…and more."* This part of the conversation was likely tied to an earlier example of receiving targeted advertisements based on location that Persinna shared in our first design session (see Chapter 2). The adult designers reminded her of this example when she was brainstorming topics. Persinna received targeted advertisements based on her location while using her mother's phone and was able to bring this lived experience into the PSA to share with others about the different types of data that can be collected.

Instructional Priorities

Learning Goals. Within their designs, the youth designers presented three different learning goals: raising awareness, promoting advocacy, and providing information on how others can protect themselves.

The most pervasive of these within designs and conversations was raising awareness, particularly in the designs from sessions 2, 3, and 4 (Table 3-4, Artifacts A-C), when the design goals centered around inspiration and ideation rather than iteration and critique. Within each of these designs, the youth focused on raising awareness about topics relating to data collection and data use, a learning goal that aligned with the overall design goal of teaching others about Techquity. For example, as quoted previously, when discussing the design with his group (Table 3-4, Artifact A), Kabede described that, *"The robot is gonna explain to them [users] what is going on with...your data. How they're [tech companies] selling all the things that you have been searching up, by using his [the robot's] screen that is on his belly."* When asked about whether it was important to raise awareness about Threats to Techquity, Kabede replied specifically about online data collection and data use, saying, *"It's important… everybody needs to learn about it [selling data]."*

Raising awareness included the use of an all-knowing robot (Table 3-4, Artifact A), a knowledgeable person within a conversation (Table 3-4, Artifact B), and an intelligent dragon (Table 3-4, Artifact C). In all three designs, one being shared information and ensured that others knew about the topics of interest. Yet, awareness was not only an outcome of the youth designs, but also a topic discussed and promoted. In her PSA, Persinna presented not only information that can raise awareness, but the two characters in the animation also discussed the importance of awareness itself (Table 3-4, Artifact B). After one character, Marian, educated the second character, the bear, about data collection and the potential dangers of technology, the two decided that to stop technology from being scary and dangerous they needed to make people more aware. After Marian explained the Threats to Techquity to the bear, he replied, *"WOW!! we need to tell people about this. Lets [sic] go."*

Beyond a baseline awareness of topics relating to data collection and data use, the youth also expressed educating others on protecting themselves and their data and advocating for change in how data is used as additional goals. This theme was especially salient in Artifact A (Table 3-4). Kabede knew about Duck Duck Go, a search engine that does not collect and store private information or use data to produce search results. Throughout the design session, Kabede discussed the inclusion of Duck Duck Go within the design and included it as the robot's utterance on the design artifact: *"use duck duck go they protect you from people that sell ya data [sic]."* In her PSA, Gabby modeled a conversation between two characters in which one demonstrated ways to protect oneself, including by limiting the amount of information one provides, thereby limiting the data collected (Table 3-4, Artifact C). Finally, when describing her project, Gabby discussed this data as "stolen" by companies – a term which connotes wrong-doing on the part of the person taking the data. Persinna demonstrated a similar distrust of technology in her PSA (Table 3-4, Artifact B). When she warned that technology could be dangerous and emphasized the importance of educating others to help them keep themselves safe, she promoted both the need to protect oneself and teach others so they know what they need to do.

This distrust of technology companies pointed to a need for change through advocacy. Kabede and his design partner, Aman, suggested that if more people "complain" to tech companies about data collection, it would compel them to stop using advertisements and collecting data for targeted advertisements. Kabede suggested that *"everybody should go against Google, Facebook, and everything and say, 'Stop selling our data, man! Like, come on now, just stop it, we know what you're doing, just stop.' ...Everyone could just be, like, protecting [data]."* Kabede suggested a flash mob or huge protest to help the technology companies realize their errant ways and stop the practice of selling data that Kabede identified as a Threat to Techquity. Kabede's suggestions pointed to a larger focus on advocacy and not only finding ways to protect himself, but also to advocating for a change in practices and structures that cause inequality.

With the goals of protection and advocacy came the need for concrete methods. The youth demonstrated a desire to have a clear answer or set of action steps. Most designs included either an authority or expert who shared information with the other people in the design or used the design to highlight a dislike of not knowing answers, as demonstrated by both Gabby's and Persinna's critique of the lesson outline (Table 3-4, Artifact G).

Pedagogical Strategies. The youth designs highlight three pedagogical strategies for ensuring that learners get the information they need: utilizing an expert or authority figure, learning through conversations and discussions, and making learning relevant to the life of the person learning the information.

In their early designs (Table 3-4, Artifacts A, B, C), youth designers employed an authority or expert on the topic of data collection to provide information. The level of knowledge presented by these experts fit into the overall themes of their designs and varied from a dragon who answered one specific question (Table 3-4, Artifact C), to a person who provided information and was prepared to educate others (Table 3-4, Artifact B), to an all-knowing robot that could answer any question (Table 3-4, Artifact A). Particularly in the two PSAs (Table 3-4, Artifacts A & B), the knowledgeable authority or expert modeled how to have conversations with others about Threats to Techquity and the ways people might protect themselves. Despite variety in the authority figures, notably, none of the designs used a teacher as the authority figure. In fact, when critiquing the lesson designs, some groups of youth designers minimized the role of the teacher as an information-sharing authority, placing greater importance on class discussions and youth examples with the teacher playing the role of expanding upon or describing implications of these examples within the lessons (Table 3-4, Design F).

Information was often shared through conversation, which translates to class discussions when in a classroom setting. The PSAs demonstrated these conversations occurring between an all-knowing or more-knowing beings and someone who needed to learn. Within the PSAs, all learning by the character and the audience occurred through this type of exchange. When critiquing the unit activities and overall unit structure, the youth designers promoted having class discussions by positively ranking the discussions already included in the lesson plans and suggesting ways to make these conversations more central. For example, when rating the lesson outline using emojis, Kabede and Desta placed value on student voices and youth being able to share their ideas and experiences (Table 3-4, Artifact F). As a group, they discussed how the youth experienced data collection and use within their lives in a similar way to how it might occur in a classroom. Kabede and Desta were invited to share examples, experiences, and their views on data collection in addition to rating the unit. Additionally, Gabby discussed liking the questions written into the unit outlines and preferring class discussions to having only a teacher present information (Table 3-4, Artifact G).

Finally, the youth designers highlighted opportunities for the materials to have relevance to students' lives. This was suggested and enacted through making real-life connections to things of which the youth were aware, inviting students to share their own examples, and providing opportunities for personalization. Throughout the designs, connections were made to everyday activities, items, and companies, such as advertisements in mobile games (Table 3-4, Artifact A), Amazon (Table 3-4, Artifact C), and location-based advertisements and tracking (Table 3-4, Artifact B). A positive feature of the Scratch project the youth designers critiqued was that it felt like what happened when they received advertisements or recommendations (Table 3-4, Artifact D). Desta specifically discussed liking this Scratch project because of its realism. When asked which of the Scratch projects (those from all three units) were her favorite, Desta replied, *"The second one [unit 2 about online data collection and data use]…I think it's...cool...when...you...search it up on a phone it would be like that too. I just like how it is."* When an adult suggested it was very realistic, Desta agreed. In addition, Brian suggested that the Scratch project, which showcased the sale of sneakers and searching for information about sports, *"should add some game pictures or something…pictures of...video games or...boardwalks or something."* Within his group, this led to a conversation about the importance of personalization and being able to change what the graphics were in the project to make it more personalized to students' own interests. Lastly, as previously mentioned, the design conversations provided ample opportunities for the youth to share their own examples. When critiquing the unit outline, Kabede and Desta suggested that the discussions also provide opportunities for youth to share their examples and, if possible, to act as experts within the conversation.

Classroom Activities. When given the opportunity to openly design educational experiences, the youth designers elected to design learning that occurred outside of the school classroom. Although they knew the final goal of this design work was to create curricular materials for school, they focused elsewhere. Therefore, conversations of classroom activities mostly centered around design activities and prompts where the youth were given curricular materials for critiquing (Design sessions 5 and 6; Table 3-4, Artifacts D, E, F, G). This limited the curricular-focused design ideas but resulted in valuable information about how the students felt about activities presented to them, their conceptions and misconceptions about the materials, and how they reasoned about Threats to Techquity.

One activity on which the youth designers focused was gamified learning in this unit and in their past experiences. In this lesson, gamified learning was presented through the platform Kahoot. Kahoot is an educational technology-based game where teachers develop multiple choice questions for students using words and pictures and the students answer from their own personal devices. Feelings across the youth designers and design teams about gamified learning and this specific platform varied. Barry was excited to see Kahoot as a part of the lesson plans (Table 3-4, Artifact E). He immediately began discussing this aspect of the lessons with his group, even though the document his team was critiquing included additional units. Barry described previously winning Kahoot and liking it because of his personal success in this pedagogical approach. Gamified learning motivated him because he had previous success. In the next group, Kabede and Desta supported the use of Kahoot, but suggested expanding it to combine with a personal data audit that was already a part of the lesson (Table 3-4, Artifact F). In this way, the Kahoot platform was used not only for gamified learning, but also for collecting information students would use later in the lesson. Their team annotated the unit outline to suggest that the students use Kahoot as a poll, after which the teacher could use the results to discuss data collection and data use as connected to students' lives. The final group, Gabby and Persinna, were split about the inclusion of Kahoot within the lesson (Table 3-4, Artifact G). Just as Barry based his opinions of gamified learning on his past experience, Gabby and Persinna relied on their experiences to fuel their opinions. Gabby previously had negative experiences with Kahoot because she was not able to see the answers (answers are shown only on the screen the teacher uses to present, not on students' individual devices). Because of her negative feelings toward Kahoot, she did not like gamified learning on Kahoot as part of the lesson plans. Persinna was more open to the inclusion of gamified learning, although she discussed struggling to know the answers or identify the correct answer once the contest had ended.

The youth designers also had split reactions to the use of direct instructional methods and a teacher's explanation of the content. As described previously, youth designers often included an expert that provided information (e.g., a robot, a dragon, or a knowledgeable woman) in their inspiration and ideation designs. Yet, the youth wanted to increase the role of students, discussions, and student examples in the unit plans, with teachers playing the role of elaborator. Despite this, when providing sticky note critiques to the Scratch project, one design team was confused about what exactly they should learn from the Scratch project because it was detached from the overall lesson. In the activity, their team included a sticky note design idea that stated, *"I think it needs more clarification to see what the concept is."* The team identified the need for information to be shared directly rather than relying on indirect methods like observation of the Scratch project. Students suggested using videos to share this additional information. Gabby explicitly mentioned liking the video about data in a real-life scenario (the music industry), saying, *"I liked the video; it told us about what was happening."* Additionally, Kabede and Desta added the "man-singer" emoji by the video, signifying that their group liked the video. But, when talking to an adult designer, Desta suggested that the videos should be viewed before being discussed:

> Adult: *Do you think...the discussion's easier to have after the video or is it...the same?*

Desta: *After the video.*

Adult: *Yeah, I kind of felt similarly; after the video, I could think of more examples of data.*

The team then annotated their design board (Table 3-4; Artifact F) with arrows saying, *"Flip these!"* and a note to *"Discuss After!!"* to make the videos more supportive of student learning by allowing the youth to learn some information first and subsequently bring that information to their conversations.

Research Question 2: What topics and instructional priorities and topics do teachers consider and determine to be most salient when designing middle grades learning materials about online data collection and use?

Topics

Within our design conversations, the teacher designers and I discussed a variety of topics, ranging from how data is used to make decisions to self-driving cars. Due to the diversity of these topics and the amount of material to cover, we decided that the third unit would cover data as used in machine learning (e.g., facial recognition, self-driving cars, etc.) while the second unit would begin with data collection and some common uses like decision-making (e.g., using algorithms and data to decide locations for music tours) and targeted advertising. Because of this decision, the main topics selected for the unit on online data collection and data use were: (1) data use for decision making; (2) good and bad biases; (3) targeted advertising; and (4) sales and marketing. In the following sections, I elaborate on each of these topics. As occurred previously with the youth, as the teachers learned more about data collection and use, they grounded their understandings in examples. I provide examples that the teachers drew upon from their lives and the lives of their students when discussing these topics.

Data for Decision-Making. A recurring topic within design conversations was how data is used for decision making, particularly within algorithms. These conversations centered around both examples I shared to help the teacher designers identify Threats to Techquity (e.g., predictive policing and bias in natural language processing), and examples that the teachers discussed. Their examples tended to relate to what they knew their students were interested in and did in their free time. Mr. Sanchez identified that, when you play online games, *"you play the game and they're collecting data about you."* He specifically mentioned games available through websites like Facebook. Based on the integration point of music, another example of data for decision making was the use of data to make decisions within the music industry. Mr. Johnson explained, *"kids love music and...the artists, they do go on tours and I thought it'd be good for them [students]...to know that...[artists] use these programs to decide what city to go to."* This connection also related to how YouTube uses data in its decision making. Mr. Johnson gave the example of someone using YouTube on his phone and how afterwards, he noticed, *"these are not my videos...you gotta sign in to your own account...if you're gonna use somebody else's device so you don't mess up what they have."* Similarly, Mr. Sanchez made a connection with TikTok and the algorithm used on the app to suggest videos. In this case, Mr. Sanchez described the algorithm as opaque. He explained, *"when you watch a TikTok video, you have to see what's going on behind...are they sending me stuff? are they…what's happening there?"* Through these examples, Mr. Johnson and Mr.

Sanchez highlighted the importance of discussing how the collected data is used to make decisions and discussing concrete ways that students regularly see the outputs of these data-based decisions.

Good and Bad Biases. As described further below, the teachers wanted to ensure a balanced view while having conversations about online data collection and data use. While they acknowledged the importance of being aware of biases regarding how data is collected and used, they also wanted to ensure students were aware that not all biases are bad. This was particularly true regarding data collection related to sales and marketing. As Mr. Johnson viewed it, people have biases toward products and the goal is to play off these biases as the marketer. He explained, *"advertisement should be bias, but it should be positive, right? Because you're targeting certain audience[s]. You don't want to market to people who don't want to buy your product."* Yet, while advertisements aim to build on consumers' biases for products, it is also important to highlight the point when marketing to a certain population becomes inequitable. We further explored how biases can be good and bad within this unit alongside the next two topics: targeted advertising and sales and marketing.

Targeted Advertising. While discussing sales and marketing, the teacher design team and I had multiple conversations about the role that online advertisements and targeted advertising play in modern marketing. Mr. Sanchez likened the current practice of targeted advertising to how tobacco was advertised. He explained:

> Newport cigarettes, they were only advertised in African American neighborhoods, in poor neighborhood[s] because they knew that...Black

> people will buy Newports...so they were targeting that. So, the same thing is happening now, maybe with Nikes. You know, they go into Google and Nike will put an ad because they know Black people are buying Nike.

In this example, taken from Mr. Sanchez's experiences and prior knowledge, a certain product, whether Newport cigarettes or Nike shoes, are targeted just to one race or just to one income level. Without current technological systems, this targeting was done by placing advertisements in neighborhoods. Now, technology allows for targeting through online environments and available data about users. While this specific connection was not considered for discussion within the lesson plan due to it being a topic potentially unfamiliar to the students, it grounded the teachers' understanding and provided an example of how they learned more about targeted advertising and presented the material to their students.

Sales and Marketing. Mr. Johnson and Mr. Sanchez identified sales and marketing as a synergistic topic through which to introduce online data collection and data use in a way that would be relevant to students and connect to their potential careers. For Mr. Johnson, this was important. He explained, *"the idea of sales...these are jobs, these are careers...this is marketing and marketing is...digital marketing."* Discussing online data collection and data use through the lens of sales and marketing would introduce students not only to the Threat to Techquity, but also to careers. When discussing sales and marketing, Mr. Johnson and Mr. Sanchez discussed connections with their students' lives, such as online shopping and getting recommendations. Mr. Johnson identified that students might be receiving recommendations and doing online shopping related to gaming and video. Mr.

Sanchez and Mr. Johnson also discussed sales and marketing as they related to Threats to Techquity. Mr. Sanchez identified that sales and marketing online can use variable pricing. He described this based on his knowledge, saying,

> they know which computer you use because I noticed or I've read that if you buy a plane ticket, depending if you're using an Apple or a PC or...Android, the tickets, the price, changes…and also the zip code, depending on that number, they know where you are, they will raise your price, or it would be less...

In this example, Mr. Sanchez made a connection between the use of data for decision making and sales and marketing and provided an example of negative biases in the use of data.

Instructional Priorities

Learning Goals. When designing, Mr. Johnson and Mr. Sanchez had two main learning goals for students within the online data collection and data use unit. The first was to prepare students for future careers, which both teachers recognized would require awareness of and skills with technology. Further, these careers were ones that Mr. Johnson and Mr. Sanchez could not yet predict or were just learning about. When discussing future careers, Mr. Johnson discussed his own middle school-aged son, who wants to become a famous YouTuber. This dream has required Mr. Johnson to adapt his mindset. He shared, *"I have to push myself to change...the way of thinking, my…son could become a millionaire online at the age [of] 17."* Despite the newness of this job, Mr. Johnson thinks that his son would need to understand business and marketing to be successful, two skills Mr. Johnson believed he would likely need to pick up outside of formal education. More generally, Mr. Sanchez recognized that *"those are new careers...that are out there, [and] our kids need to be aware of how to get them."* In both instances, the teachers recognized the importance to their students of a variety of new skills.

The second learning goal was to provide students with a balanced view of how technology could be both good and bad, particularly as it related to data collection. Although the focus of the curriculum was to raise awareness of Threats to Techquity, Mr. Johnson and Mr. Sanchez wanted to ensure that the unit about online data collection and use and the associated learning experiences were not always negative toward technology. As Mr. Sanchez connected the two goals:

> I think that way...we're giving both messages...I know it's about equity and everything, but then we also...want to give the kids that...tool also, we want to...show, you use it for good, you use it for bad.

Together, these goals provided a basis for the pedagogical strategies and classroom activities suggested for use within the unit.

Pedagogical Strategies. While other pedagogical strategies were discussed more broadly, to achieve their learning goals for this unit, the teachers focused on three pedagogical strategies specific to data collection and use: making students the marketers using data, connecting the unit to students' lives, and using videos as a hook within the lessons.

To provide a more balanced view of technology, Mr. Johnson and Mr. Sanchez decided the students should take on the role of marketers, using data collected about their peers and the class's overall interests. Instead of the students being only consumers, they wanted to focus on the students as sellers. Mr. Sanchez suggested, *"we're putting more emphasis on individuals as consumers[,] and maybe this is our opportunity for this project to...have our kids become marketers."* To do this, the teachers focused within the unit design process on the ways that the students themselves could use data to market to others and sell a product. To ensure a connection with the equity goals of the curriculum, the team agreed that the students would think about how their marketing could be biased and how to prevent that bias to ensure a more equitable use of the collected data. For example, students would be encouraged to consider how marketing a certain product, like Nike sneakers, to a specific group, like people who identify as Black, could represent a bias about race and shoe preferences.

Focusing on the students as marketers allowed the teachers to also have the students make connections to their own lives and interests. They suggested that the students should market to their peers, tweens and teens, and focus on marketing techniques that might work specifically for that population. Mr. Johnson explained, *"we marketing [sic], we want to show them, first of all, they're teenagers or soon-to-be-teenagers, so that's the age group."* Additionally, the teachers focused on making the lessons relevant to their students through the content. As a team, we focused on things familiar to students and discussed what websites and streaming services they used and common practices like buying things online or having their parents do so. While the students might not be ordering from Amazon on their own, Mr. Johnson discussed them seeing boxes arrive at the house and the increase in online ordering due to the COVID-19 pandemic.

Finally, the teachers supported the use of videos as a hook for students to introduce the topic of data collection and use, activate students' background knowledge, and capture the students' attention. The video, which introduced data use in the context of the music industry, also provided an opportunity to connect to students' lives through something with which they were familiar.

Classroom Activities. The early conversations about the data collection and use unit focused on the larger picture. Therefore, most discussions about specific classroom activities occurred after my initial outline of the data collection and use unit and walkthrough of the overview with the teachers. To put the students in the roles of marketers rather than consumers, Mr. Johnson and Mr. Sanchez proposed that the students develop their Scratch programs to market something. Mr. Sanchez suggested,

> We want to use data and we know what they're doing to us, but let's turn it around and then let's have used [it] for the benefit of our future entrepreneurs...this is data, and this is how you can use it. So, instead of having a program where you want to buy shoes, they say, how about if I want to sell my shoes?

To support the creation of these projects, the teachers wanted to add data collection about students in the class to the Kahoot. Mr. Johnson suggested,

> What if we did...a survey through Kahoots? You can find out what students like, you know what shoes they like, what clothing line they like, what music they like. What if, like you said, Mr. Sanchez...we took that information and then we develop[ed] a Scratch with that information? …This is your class,

> and...these are the product[s] they like, so I want you to take these products and I want you to create...ads that target them.

Adding to the Kahoot could not only act as a personal data audit and platform for discussing the potential biases within data collection and use, but could also provide the students with small-scale market research on their class. This research, as Mr. Johnson suggested, would provide students with the information they needed to market to their peers.

As previously mentioned, the teachers supported the use of a video to hook students' attention and help them get into the topic of data collection and use. However, the utility of videos went beyond just the hook. While iterating upon the lesson plans, Mr. Sanchez suggested the addition of two videos about marketing specifically made for kids. The inclusion of these videos could provide opportunities for the students to continue their learning in a different modality and obtain information that a teacher might not be able to share.

Research Question 3: How can youth and teacher instructional priorities be integrated into a curriculum presenting online data collection and use?

Each Talking Techquity unit is constructed of four lessons. The first lesson focuses on a Threat to Techquity (in this case, online data collection and use). The second and third lessons scaffold the learning of computer science skills by moving students through the use-modify-create pedagogical strategy (I. Lee et al., 2011) to scaffold their programming of a project in Scratch. Finally, the fourth lesson is devoted to students sharing their work through presentations of their Scratch projects. In the final version of unit 2, we incorporated the topics and instructional priorities of both youth and teacher designers into the curriculum through learning goals, pedagogical strategies, classroom activities, broad ideas, and examples. While not every idea generated by the designers ended up in the final plans, most ideas are represented in the final unit plan. This is particularly true in the first lesson, which focuses more on Threats to Techquity than on instructing students on programming. The computer science content within the unit is based on Module 6 of the Scratch Encore curriculum about one-way synchronization (Franklin, Weintrop, et al., 2020). In the following section, I provide examples of the integration of youth and teacher ideas. An overview of this integration is provided in Table 3-5. This table delineates each activity within the unit, alignment between those activities and the original Scratch Encore lessons, and youth and teacher topics and instructional priorities.

Table 3-5. Alignment between Unit 2 activities and results from the design sessions with youth and teachers

	Present in Original Lessons	Alignments			
		Youth		Teacher	
Unit Activity		**Topics**	**Instructional Priorities**	**Topics**	**Instructional Priorities**
Lesson Objectives	✓	✓	✓	✓	✓
Lesson 1: Exploring Online Data Collection					
Engage: Introductory Discussion					
Introduce objective and lesson				✓	
Video about data in the music industry			✓	✓	✓
Video debrief and data discussion		✓	✓	✓	✓
Explore: Online Data Collection					
Online Data Collection Kahoot		✓	✓	✓	✓
Product Marketing Plan					✓
Reflect and Discuss					✓
Lesson 2: Exploring One-Way Synchronization					
Introductory Discussion	✓				
Using TIPP&SEE	✓	✓		✓	
Modify Project	✓	✓	✓	✓	✓
Reflect and Discuss	✓				

Lesson 3: Creating with One-Way Synchronization					
Engage: Introductory Discussion					
Online business and marketing videos			✓	✓	✓
Review conversation		✓	✓	✓	
Create Project	✓	✓	✓	✓	✓
Review and Discuss	✓				
Lesson 4: Presentations					

Topics

Broad Ideas. As previously mentioned, we did not include all the broad ideas discussed in initial brainstorms with the youth and teacher designers within this unit, although we included most ideas in other units within the curriculum. Based on design ideas from both the youth and teachers, this unit focuses on data collection, data for decision making, sales and marketing, and targeted advertising. We highlighted these topics in one of the overall unit objectives (Table 3-6): “Students will be able to describe data collected about people and how it is used in online advertising.” To fulfill the objective, the ideas are woven throughout the material covered in the unit, from the information provided to students in discussions to the Scratch project they use and modify in lesson 2 (Figure 3-2; Tables 3-7 and 3-8). The unit also includes a brief reference to companies selling data to others in one of the explanations to a Kahoot question, although this idea is less prominently explored within the work.

Table 3-6. Unit objectives and overview from the coversheet of Talking Techquity Unit 2

Unit Objectives Students will be able to: • create scripts that use message passing for one-way synchronization between two sprites. • create scripts that use message passing for one-way synchronization that initiate simultaneous actions on multiple sprites.

- describe data collected about people and how it is used in online advertising.

Unit Overview

Lesson 1: Examining Online Data **60 minutes** Students learn about online data collection and how data is used online. Then, they consider how they could use data as marketers.	**Lesson 2: Exploring One-Way Sync** **120 minutes** Students are introduced to the concept of one-way synchronization. They modify a Scratch project to pass messages with one-to-one and one-to-many synchronization.
Lesson 3: Creating with One-Way Sync **120 minutes** Students develop a project about or using data utilizing one-to-many synchronization in an open-ended create project.	**Lesson 4: Presentations** **60 minutes** Students present the projects they created using one-way synchronization and data.

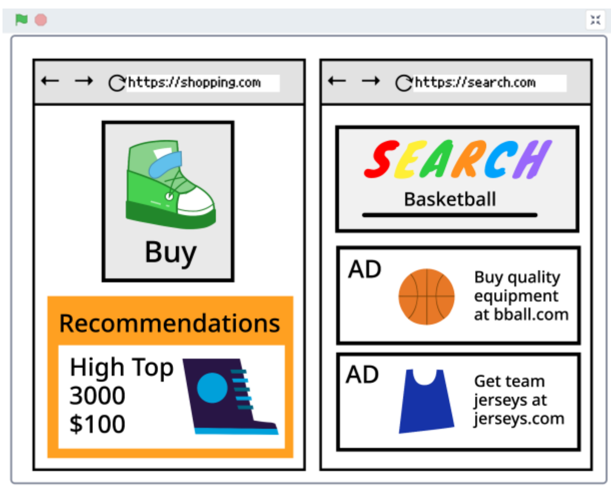


Figure 3-2. Scratch project used during the "use" and "modify" portions of the use-modify-create strategy in lesson 2

Table 3-7. Introductory discussion from lesson 1 of unit 2 of the Talking Techquity curriculum

Introductory Discussion (10 minutes) Preview for students that today the class Is going to be thinking about data, online data collection, and how companies use data to make decisions. Show students A Visit to Chartmetric, a video about how a music company uses data. As students are watching, ask them to listen for how the people in the video discuss data and use data to make decisions for their company.

Debrief the video and discuss data and online data collection with students. ❓ **What is data?** *[Data is pieces of information that are collected and brought together.]* In computer science, individual points of data are combined into datasets and used in algorithms and decision making. ❓ **When have you used or looked at data before?** *[Graphing in math class, running an experiment or analyzing data in science class.]* Just like you have collected and analyzed data, companies are doing the same. ❓ **In the video, how did the computer scientists describe using data at their music company?** *[tracking 1.3 million artists and 1 million playlists, who buys music, when music is bought, and how it is bought, Instagram followers, Wikipedia views, etc.]* ❓ **What other types of data do you think would be helpful if you were trying to help a new musician to be successful?** *[YouTube views, social media followers, visits to website, etc.]* Introduce students to the idea of their data being collected and used with YouTube as an example. Explain that every time you make a decision online such as which video to watch, the websites track what you picked. This data is then used to try and get you to make more selections and stay on the website. One common example of this is YouTube. ❓ **How does YouTube personalize the content that you receive?** *[Autoplay, suggested videos, creating personalized playlists)]* The website can do this using the data it collects about what you have watched before. If you spend time watching videos of the latest video game, it will suggest similar gaming videos. But, if you watch exclusively music videos, it will suggest videos with music in the genre you like.

Table 3-8. Online Data Collection activity from Unit 2 of the Talking Techquity curriculum

Online Data Collection (40 minutes) As a class, complete the Online Data Collection Kahoot (https://create.kahoot.it/share/exploring-online-data-collection/96613eff-32bc-4fd5-aa5f-c3c02e43e005). This Kahoot starts with questions that have students consider how their own data might be collected online and different types of data collection

and then collects some data about what students are interested in that they can use to plan how they would use data in marketing.

Use the summary slide after each question or the "Reports" page after the class has completed the entire Kahoot to go through the students' answers. As you go through each question, provide students with a bit more information about why the question is important and ask students for their thoughts, opinions, or experiences with getting targeted advertisements or suggestions. Below is some information about online data use related to each question. Share this as well as any other recent or relevant information you have. Some of these points pertain to multiple questions from the report.

1. Searches on Google (Q1): Google is designed mainly as an advertising tool. Google and other search engines use information about what you have searched to make suggestions for products or websites to visit.
2. Videos on YouTube (Q2): As we talked about before, YouTube uses information about the videos that you have watched previously to make suggestions about other videos you might like. The company's goal is to keep you on the website watching videos so they earn money through ads. To do this, they want to make sure you find content that you will find interesting.
3. Audio and Video Streaming Services (Q3, Q4): Like YouTube, both audio and video streaming services use information about what you have watched previously to suggest new content that you might like. They suggest content by compiling data about what everyone on the site has watched to determine trends.
4. Smartphone Location (Q5): Allowing apps to use your location means they can locate where you are. This is used by companies to identify when people are in their store, potentially providing coupons or ads for things relating to where you are located. Rideshare apps have also tracked where people go immediately after getting out of their ride.
5. Music and video suggestions (Q6, Q7): As discussed above, suggestions are used to help you find content that is relevant to you and help keep you on the website or service. Invite students to give examples of when suggestions have been relevant or not relevant to them.
6. Ads and Suggestions (Q8, Q9, Q10, Q11): Students have likely seen ads online or been suggested products. Invite them to share examples of when the ads have related to things they have done online. For example, a student looking up getting the newest Xbox and later receiving ads for Xbox games or accessories.
7. Should companies be allowed to collect data? (Q12): Based on the information you have provided and students' examples, discuss whether companies should be allowed to collect and use data. Invite students to share whether they think that companies should be able to collect the data online that they are currently or alterations that students would suggest to protect individuals who use technologies. Explain that sometimes

companies use the data to make assumptions about the person and this can lead to offering different products based on presumed race or gender. Have student discuss when this is helpful and when it harms people. Companies also sell data to other companies to use. As a class, discuss whether companies should be allowed to sell data about you and your online activity to others without you knowing. *This is a focal discussion within this unit, so ensure all students can contribute and make connections between the first 11 questions on the Kahoot and this conversation.*

8. What students do and look at online (Q13, Q14, Q15, Q16): The remainder of the questions are about what student do and look at online. This data will help students in the next activity, so review the results as a class. If students answered "Other" for any of the questions, ask them to share what else it is that they do online or other places they visit.

Now, have students imagine that they are working in marketing and want to sell products to middle school aged consumers. Have students complete the Product Marketing Plan thinking about how their classmates answered the questions about what they do online. Students select a product they are working to market and decide who to market to and how to best reach consumers who are their age. Finally, students consider how to do this in a way that does not discriminate against anyone. As students are considering how to market, encourage them to consider whether they thought the current data collection practices were fair and how they might act differently if they were in charge of marketing.

Examples. While we did not integrate all examples referenced by the youth and teachers into the final unit plan, we used several key examples to help students make connections between their experiences online and the information they learned about data collection and marketing. For example, the lesson utilizes YouTube to explain data collection in youth, since both the youth designers and the teachers' students (as described by the teachers) are knowledgeable about YouTube (Tables 3-7 and 3-8). This example allows for discussions not only of recommendations, but also of online advertisements. In a discussion, students are asked to contribute to the conversation by offering the ways that YouTube personalized the content they received and to make connections between previously watched videos and suggested content. In addition, the opening video creates an opportunity for the lesson to use music as an example in the initial conversation (Table 3-7).

Additionally, examples are present in the Scratch project students use during the “use” and “modify” portions of the use-modify-create framework (Figure 3-2). This project animates two areas where students might be familiar with getting content based on their data: recommendations and online advertisements. We integrated all of these examples, as well as location-based advertisements, into the Kahoot questions and teachable moments (Table 3-8).

Instructional Priorities

Learning Goals. The learning goals of both the students and the teachers are central to the overall goals of the unit, particularly to the first lesson, which aims to teach about data collection and data use before students utilize that information in their Scratch projects and learn new computer science skills (Table 3-6). Within the lesson plan, the lesson 1 overview states, “In this lesson, students learn about online data collection and consider data collection in their own online behaviors. Then, students consider how they would use data if they were in charge of online marketing.” In this overview, it is possible to see both the youth learning goals of awareness and protection and the teacher learning goal of preparing students for future careers. These goals are represented and reinforced throughout the unit as activities are introduced to students and through the activities themselves (described below). In addition, the current version of the unit strikes a greater balance between the good and bad parts of technology as compared to the initial unit outline shared with both the youth and teacher designers. While this goal is not explicitly stated in the unit objectives nor lesson overviews, it is woven throughout the activities with a decreased focus on the negatives of data collection. Instead, the activities highlight opportunities for the students to use data in positive ways rather than only discussing how data collection could harm the students and their communities.

Pedagogical Strategies. The unit plan incorporates all the pedagogical strategies identified from the youth and teacher design sessions. This includes using an initial video to hook students into the lesson and to introduce the idea of data collection and data use (Table 3-7). Each lesson also includes at least one discussion that gives students the opportunity to take an active role in their learning and share their expertise. For example, in lesson 1, students are asked, “When have you used or looked at data before?” in the initial introduction to data collection (Table 3-7). This helps activate students’ background knowledge and provides them with opportunities to connect with the topic. Students are given further opportunities to connect to the topic when examples of data collection and data use are presented, when students are asked to offer their own examples, and when students inventory potential areas in their lives where data could be collected on them (Table 3-8). Finally, in both the initial lesson and in their final Scratch project, students are given the opportunity to take on the role of marketer and consider how they would use data to sell something to their peers. They do so by creating a marketing plan in lesson 1 (Table 3-8) and a Scratch project describing or demonstrating how an object will be sold in lesson 3 (Table 3-9).

Table 3-9. Open-ended "create" project from Unit 2 of the Talking Techquity curriculum

Explore

Create Project (100 minutes)

Introduce today's activity: To create a new project that uses one-to-many synchronization to shares about using data collection or suggestions and advertising online. Students may choose a project of their choice. Pass out the One-Way Sync: L3 Student Sheet to give students guidance throughout the project.

To complete this task, students will:

- ❑ Plan the one-to-many interaction: what actions will the sprites carry out when another sprite is clicked?
- ❑ Complete the graphic organizer to plan their one-to-many synchronization.
- ❑ Add 5 sprites and a backdrop to a new Scratch project.
- ❑ Create a one-to-many interaction that includes 4 sprites that do something when another sprite is clicked - one sprite sends a message that is received by all the other sprites.

Explain to students that they can create any project that is interesting to them about online data collection, but some ideas are:

- Imagine that you are working for a marketing company. Use the data collected about what your class likes to create a project that demonstrates marketing to youth of your age. Think about what data you would collect and the resulting ads or suggestions.
- Think about online data collection in your life. Create a project that shows where you receive ads online or in apps based on choices you have made.
- A topic of students' choice!

Students can also look back at the Product Marketing Plan they created in lesson 1 for ideas.

Remind students to run their project to test that it works as expected. Remind students that they need to share the project so it is accessible to you and others.

Classroom Activities. Similarly, the unit incorporates all the classroom activities discussed by the youth and teacher designers, including the updates to the activities suggested by the design teams. Both lessons 1 and 3 begin with videos to provide the students with an initial opportunity for learning. In lesson 1 (Table 3-7), the video (as previously described) is about how a music company uses data to make decisions about dissemination and shows. This is the same video included in the lesson outline to which the youth designers responded positively. In lesson 3 (Table 3-10), the videos, both suggested by Mr. Sanchez, are about marketing. As suggested by the youth designers, the videos come at the start of each lesson to provide information before students are asked to participate in a discussion. After watching the videos in lesson 3 and having a short discussion reviewing both information about data collection and use and the computer science concept focal to the unit (Table 3-10), the students are given the opportunity to create a Scratch project marketing to their peers (Table 3-9) with the following prompt:

> Imagine that you are working for a marketing company. Use the data collected about what your class likes to create a project that demonstrates marketing to youth of your age. Think about what data you would collect and the resulting ads or suggestions.

This is balanced by a second option for students to think more about the negative ways that data is used and to become more aware of data in their lives: "Think about online data collection in your life. Create a project that shows where you receive ads online or in apps based on choices you have made" (Table 3-9). Together, these prompts help provide students with choice over their final project and the ability to take on either the good or bad view of technology present within the teachers' learning goal.

Table 3-10. Introductory discussion from Lesson 3 in Unit 2 of the Talking Techquity curriculum

Introductory Discussion (10 minutes)
Motivate students by showing one or two video clips about starting a business online and marketing. BizKids has videos for kids about Building Your Business Online and Marketing.

Then, review online data collection and the data the class collected during the first lesson.

What data do companies collect online? *[Views, links you follow, likes, things you search for, etc.]*

How do companies use the data they collect for marketing? *[Decide what you might like to see or buy, give personalized advertisements, etc.]*

What data did we collect about the class? *[The class' preferences about where they see ads, and products they would be most interested in buying.]*

If you worked in marketing, how would you use that information? *[To decide what people my age liked and how to sell products to them.]*

Brainstorm with students how they would sell things online. Then, ask students to brainstorm ideas for a project that uses one-to-many synchronization. Remind them that they used this type of synchronization in the previous lesson when they added a start button to the One-Way Sync: Online Data Collection Scratch project. Ask students to think-write-pair to discuss ideas for a new one-to-many project that talks about or uses the data they collected to explain online data collection.

The main activity within lesson 1 is a gamified learning experience through Kahoot (Table 3-8). This classroom activity demonstrates how ideas can be traced through the design sessions and into the unit plan. Originally, the use of Kahoot was a suggestion by Mr. Johnson when discussing ways to survey or quiz students. He suggested Kahoot as a platform that he had used previously and was successful with students. Following that conversation, the Kahoot was built into the unit outline presented to both the youth and teacher designers. Based on suggestions from these design teams, the updated version of the Kahoot acts as both a personal data audit and a means for collecting data about the class that the students can use when designing their marketing plans and final projects. In addition, the Kahoot is built such that the teacher can use the questions and class data to offer short teachable moments of ways that data can be collected and used (Table 3-8). For example, after students are asked how often they watch YouTube videos, the teacher is provided with the following information they can share with students:

> As we talked about before, YouTube uses information about the videos that you have watched previously to make suggestions about other videos you might like. The company's goal is to keep you on the website watching videos so they earn money through ads. To do this, they want to make sure you find content that you will find interesting.

These explanations offer short opportunities for direct instruction, aligning with the instructional priority suggestions of the youth designers and promoting awareness of Threats to Techquity.

Discussion

Co-design is an important tool for integrating the ideas of teachers and youth into curricula and lesson materials that are more accurately aligned to the classroom contexts in which the curricula is being used (Penuel et al., 2007; Roschelle et al., 2006) and to the interests of youth (Scaife et al., 1997). Both teachers and youth are important stakeholders in the process, and while co-designing classroom materials with teachers is a common method, the ideas of youth are important to consider, as adults do not always accurately predict or know the needs and interests of youth (Druin, 2002; Scaife et al., 1997). In this research, I identified topics and instructional priorities related to online data collection and data use shared by youth and teachers in co-design sessions. Both groups of designers agreed that online data collection and data use was an important focal topic, but the individual topics and examples around which they centered their designs varied between the two groups. While the youth focused on making people aware of data being collected and privacy concerns related to data collection and the sale of data, the teacher designers focused on the use of data to make decisions and how that data was used in sales and marketing. Additionally, although the two groups shared some examples (e.g., online shopping and YouTube), the ways in which they used and discussed these topics differed. For the youth, online shopping was an area where data was being collected and a place to be wary of companies having too much information, whereas for the teacher designers, it represented an example of online sales and marketing. Additionally, the youth designers discussed ways that YouTube was collecting data about what they had uploaded, whereas the teachers discussed YouTube's recommendation system as an example of using data for decision making. Topics from both design teams are integrated into the Talking Techquity curriculum in a way that incorporates not only the topic, but also how it was discussed by each design team. The curriculum highlights both the more negative views of data collection expressed by the youth designers and the more balanced views of the teachers.

More similarities can be seen in the instructional priorities of the youth and teachers, particularly in pedagogical strategies and classroom activities. Across the two groups of designers, a focus was placed on instructional methods that were mostly student-centered and relevant to students' lives. The youth and teachers focused on ways to allow the students participating in the implementation of the unit to share their own ideas and play an active role in the learning process. These opportunities were integrated throughout the final curriculum, which aims to be student-centered and provide opportunities to learn through experiences and discussion, with the teacher playing the role of elaborator and clarifying topics when needed. This is seen in the gamified learning experience with Kahoot, where the teacher explains the importance of each question after students have the opportunity to answer and connect the technology in question (e.g., search engines, video streaming, etc.) with their own lives and experiences.

An area of major difference between the youth and teacher designers is in their learning goals. While the teachers focused on taking a balanced view of data collection and data use and preparing students for future careers, such as those in marketing, the students expressed a need to raise awareness about online data collection and data use to provide users with the opportunity to protect themselves and advocate for change. The teachers had a college and career focus, as Mr. Johnson mentioned when discussing sales and marketing as a topic, and centered their designs around providing a balance between the good and bad parts of data collection and use. The teachers focused on supporting the students to be ready for a career within the current technological systems and on how students could take control and be the ones using data rather than just having their data used. This meant preparing students with the knowledge of online data collection and data use for the purpose of using it themselves, although hopefully in ways less predatory than some current practices. In contrast, the youth designers focused on raising awareness and then providing students with ways to protect themselves and begin advocating for change. While the adults sought to increase the amount of power youth could have within the system, the youth sought to change that system.

Within designs and conversations, teaching youth about online data collection and data use is important because it gives youth the ability to protect themselves and work toward more just technical systems. Their concerns about online data collection and data use point to places where the system can change. That is, just because bad parts of technology currently exist does not mean that they must continue to exist. In considering both views, the Talking Techquity curriculum attempts to strike a balance between the desires of youth and teachers to meet the needs and wants of both groups of stakeholders. But, examining the final curriculum, there is not an exact balance between the ideas of youth and teachers, particularly with regards to their learning goals. Whereas the final unit balances discussing the positive and negative consequences of online data collection and data use and frames the curriculum within the context of marketing and the students as marketers, the curriculum does not include aspects of advocacy. Students are made aware of online data collection and data use so they can take steps to protect themselves, but how to do this and opportunities for advocacy to change the technological system are not included. This was caused, in part, by the teachers acting as the final designers working on the unit and actually implementing the curriculum in their classrooms. As the ones implementing the unit, they needed to agree with the framing and feel comfortable implementing it. This placed a preference on their ideas when finalizing the lesson plans, despite the participation of youth designers throughout the process.

The combination of youth and teacher ideas within this research builds off prior work within computer science education. In that work, co-design with mixed groups of youth, students, teachers, and administrators has yielded ideas that can be integrated into lesson themes and contexts, student-led project prompts, and design elements for Scratch projects (Coenraad, Palmer, et al., 2021). The resulting curriculum attends to the various spheres of influence within youth lives (Coenraad, Weintrop, et al., 2021) and focuses on cultural relevance within the resulting curriculum (Franklin, Weintrop, et al., 2020). But, this prior work engaged design partners as informants, rather than as full design partners (Druin, 2002), meaning they were only involved at the beginning of the design process for ideation. The current work on the Talking Techquity curriculum builds on this previous work by exploring the participation of youth and teachers within separate design teams as ongoing design partners. Through their continued participation within the design of the units, each group of designers had input not only on initial ideas, but also on iterations of the curriculum, with additional power and say over the result. I posit that this continued involvement led to a curriculum that better aligns to the needs and interests of both design groups than if they had only been initially involved in the design of the curriculum.

Limitations

The Talking Techquity curriculum was developed with a relatively small group of youth and teachers. While this limited group was necessary due to the nature of the research, which aimed to develop strong relationships and long-term design partnerships, it is limited to the ideas to a small group of youth and teachers. Future research should implement the Talking Techquity curriculum outside of the geographical region in which it was created and with teachers that were not part of the design team to further understand the relevance and potential generalizability of the curriculum across contexts. Additionally, design sessions with youth and teachers in different areas or larger groups could examine whether these topics and instructional priorities are replicated with different groups. Finally, this research was affected by the COVID-19 pandemic, resulting in a need to complete all design work virtually. Although the youth designers had been designing online for other projects and had experience doing so in a distanced manner, online platforms may have resulted in differences in design relationships between youth and adult co-designers and in how youth and adult co-designers participated, as the platforms used mediated their participation. While it was not possible to measure the potential changes or predict how results would differ in-person, the designs could have been limited by more difficult communication (e.g., text rather than speaking aloud due to microphone difficulties, drawing with a mouse vs. drawing with a marker, etc.) and the design team not being physically together.

Future Work

Given the importance placed on advocacy by the youth designers, two avenues of future work and exploration could increase these opportunities within the curriculum. The first is considering the discipline in which Threats to Techquity, particularly online data collection and data use, are explored. Within this work, the topics and instructional priorities developed for integration through the co-design process were implemented into computer science lessons (Appendix). Yet, the nature of Threats to Techquity, particularly those around data collection and use, makes them a multi-disciplinary topic. Technologists and computer scientists speak to the technical side of how data is collected and used (e.g., Mikians et al., 2012; Speicher et al., 2018; Sweeney, 2013), but the social sciences and other disciplines shed important light on the impacts of the topics (e.g., Benjamin, 2019; Eubanks, 2018; Noble, 2018; O'Neil, 2016). Given this connection and the importance that social scientists have played in identifying Threats to Techquity, future research could focus on the integration of the youth- and teacher-identified topics and instructional priorities within another context, such as social studies, or on the development of a multi-disciplinary unit that presents data collection and data use across classes. This multi-disciplinary integration could provide more natural opportunities for students to explore topics and instructional priorities that were not included in the Talking Techquity unit, such as advocacy, privacy, and variable pricing. A potential benefit of this multi-disciplinary integration or integration within social studies is that teachers of social sciences and the humanities would likely have greater background and efficacy in leading students through conversations about equity and advocacy, since these are topics often included within their subjects. Given that curricular materials cannot prepare teachers for difficult conversations and provide the skills needed for tasks like leading advocacy campaigns, working with teachers who already have these skills could be a necessary component for success of curricula like the Talking Techquity curriculum that focus on both technical and social science knowledge. Future research could focus on the use of the current curricular materials within these different settings or the inclusion of a more disciplinarily diverse group of teacher designers on the teacher co-design team.

Additionally, future research could consider a deeper integration of critical pedagogy within lessons about Threats to Techquity; specifically, it could consider a deeper integration of critical pedagogy into lessons about online data collection and data use and how youth design advocacy opportunities around the topic. Within this research, a desire to be more critical of technological systems emerged from the youth design sessions. This points to an eagerness within youth to explore the topic in a more critical manner and a readiness to consider power and structures within lessons about online data collection.

Conclusion

Children are taught not to talk to strangers, yet they (and adults on their behalf) share data about themselves constantly (Children's Commissioner, 2018; Kumar & Schoenebeck, 2015). This data gives access to information about who they are and the ability to use that information to affect their everyday lives, including what they see online, to not just one stranger, but to a multitude of individuals, companies, and algorithms. Given the impact that data collection and data use have on youth, it is important to provide students with educational experiences about this Threat to Techquity and support youth in becoming aware of and protecting themselves against data collection. Examining topics and instructional priorities shared by youth and teachers during co-design sessions, I discovered learning goals, pedagogical strategies, classroom activities, broad ideas, and examples about data collection and data use. By inviting educator and youth voices to the design process, this work presented insights into their distinct design priorities, which holds potential for richer and more meaningful learning outcomes and engagement. While the youth and teacher designers shared some overlap in topics, how they discussed those topics differed, as did their overall learning goals around data collection and data use. The teacher designers focused on how data is collected and used to make decisions, particularly within the realm of sales and marketing. Teacher designers discussed the importance of preparing students for future careers as marketers with the knowledge of online data collection and data use. Youth designers focused on the harms of online data collection and data use within their examples and on raising awareness to help users protect themselves and advocate for changes to the technological systems in which online data collection and data use exist. Their designs and examples focused on how online data collection and data use could violate privacy, lead to the sale of data, and be dangerous for the person whose data is collected. A balance of these topics and instructional priorities were integrated into unit 2 of the Talking Techquity curriculum to provide students with opportunities to learn about and protect themselves from data collection and use through a co-designed curriculum. Students are having their data collected and are being exposed to advertisements, recommendations, and other algorithmically derived results daily. It is essential that they learn about the ways that data collection is affecting their lives to give them the tools they need to protect themselves and their communities.

Chapter 4: Adapting Our Design: An Analysis of Teacher Adaptations in the Implementation of a Co-Designed Curriculum

Abstract

Co-design with teachers is a method of innovation development that includes the voices and expertise of teachers during the design process to incorporate their curricular and classroom knowledge. While innovations developed through co-design with teachers have been studied and show positive teacher and student outcomes, less is known about the process of implementing these innovations and the adaptations made by teachers who were part of the design process. The Talking Techquity curriculum was co-designed with youth and teachers to develop a relevant, student-friendly, and engaging set of educative materials that support student learning. This paper explores the implementation of the curriculum: how teachers who co-designed the lesson materials adapt those materials when teaching them and the factors that lead to that adaptation. When implementing the Talking Techquity curriculum, teachers made adaptations to structural and interactional components of the curriculum aimed at increasing scaffolding and support for students due to characteristics of both the innovation and the users as well as the environment in which the curriculum was being implemented: online learning due to the COVID-19 pandemic. These contextualized and in-the-moment adaptations were in addition to the design decisions they made as part of the co-design process. The findings point to potential differences in how teachers perceive student needs within design sessions

and during classroom implementation and surface tensions to be discussed during the design process. This contribution furthers implementation research knowledge of the adaptations teachers make when enacting an educational innovation by considering the context of a small-scale co-designed innovation. It will support future co-design efforts with teachers by providing an understanding of the adaptations necessary to a co-designed curriculum, the reasons why teachers make those adjustments, and how co-design conversations can support adaptations to be supportive of student learning and align with design goals.

Keywords: co-design, teachers, innovation implementation, productive adaptation

Introduction

Mr. Johnson[4] *starts the video conference for his sixth-grade enrichment class. It's third quarter and the class will be learning computer science with a focus on technological biases using a new curriculum Mr. Johnson has co-designed. One by one, students join class on the video conferencing platform Microsoft Teams. Each student is a small gray box with initials in the middle – few turn on their cameras for longer than a quick hello. Mr. Johnson smiles to his class, adorned by his virtual backdrop of his university's logo in celebration of the schoolwide college tribute. Since students are transitioning from other classes, Mr. Johnson waits five extra minutes to ensure all his students have the time and space they need to join class. Then, he says good morning to each student: "Good morning, Samara. Good morning, Josue." Most students reply in chat or with a quick hello. For some, it will*

[4] Names of teacher designers and students are pseudonyms.

be the only time they speak during class because of background noise at home, caring for a sibling while in class, or technological difficulties like their microphones not working well. Once each student has been greeted, class begins by honoring a hero or heroine. In February, Mr. Johnson showcases Black honorees for Black History Month. Mr. Johnson passionately shares about Jack Johnson, the world's first Black American heavyweight champion, and Sam Cooke, a singer and songwriter. In March, the honorees are women for Women's Month. Classes begin by paying tribute to Mary McLeod Bethune, an educator and civil rights activist; Rapsody, an American rapper; Malala Yousafzai, a women's rights activist; Serena Williams, an American tennis star; and influential women in technology like Ada Lovelace and Katherine Johnson. These parts of the class, although not written explicitly into the curricular innovation Mr. Johnson is piloting, provide students with examples of people living their passions who are relevant to the students and their cultural backgrounds.

Class moves on to focus on the topic of the day by connecting to prior learning and using questioning to bring students into the topic. On one of the first days using the Talking Techquity curriculum, Mr. Johnson introduces bias by first asking, "What is bias?" and inviting students to reply out loud or in the chat. Based on student input, Mr. Johnson defines bias and then asks, "Based on the definition, can anybody give me an example of bias?" The class continues with students, Mr. Johnson, and the school librarian, Mr. Sanchez (who is supporting with some of the lessons), sharing their own examples and prompting through questioning. Once independent work gets underway, screensharing is used to demonstrate student *examples and troubleshoot questions. Mr. Johnson celebrates students who are on task by showcasing what they have accomplished and provides opportunities for them to be the experts for their classmates. He invites them to share new blocks they have learned in Scratch (a block-based programming environment where programmers write code by connecting Lego-like blocks into sequences) or describe methods for coding what they are interested in doing in their projects. Class ends with a wrap-up, final questions, and an invitation to visit Wednesday office hours for more help. As gray boxes with student initials disappear off the screen, Mr. Johnson says goodbye with a smile and a wave as everyone prepares to log into their next class.*

This paper focuses on the design and implementation of a novel curriculum developed through co-design. In the vignette above, I introduce Mr. Johnson, a co-designer and pilot teacher of the Talking Techquity curriculum. This vignette provides a snapshot of Mr. Johnson's classes, sets the stage for the environment in which the Talking Techquity curriculum was implemented, and introduces Mr. Johnson's teaching style and demeanor. It highlights the virtual environment in which Mr. Johnson implemented the curriculum, the participation of students within this environment, and the purposeful celebrating of heroes and heroines who share identities with his students. While teachers have always been designers of learning experience, they are increasingly being included in the curriculum design process through co-design to develop curricula that are better than currently available pre-made and mass-produced materials. Through co-design, researchers and curriculum designers hope to better align to teachers' context and incorporate their valuable knowledge about experiences in the classroom (Penuel et al., 2007; Scaife et al., 1997). The inclusion of teachers through co-design is motivated by a desire to improve experiences using the curriculum for both teachers and students, create student-relevant learning experiences, and develop curricula that are supportive to teachers (Coenraad, Palmer, et al., 2021; Franklin, Weintrop, et al., 2020). Yet, while the design and development process has been studied extensively, less is known about how teachers implement curricula they participated in co-designing and how their involvement in the co-design process affects their classroom implementation and in-the-moment adaptations. This study aims to expand knowledge about this implementation process and the adaptations made when implementing a co-designed curriculum.

During the classes described in the vignette, Mr. Johnson taught using the Talking Techquity curriculum. Talking Techquity is a curriculum introducing students to computer science and the social justice impacts of computing. The three-unit series focuses on Threats to Techquity, or the aspects of computing and technologies that cause or can cause inequalities, especially inequalities based on marginalized identities. It was developed through co-design with youth and with the teachers implementing the curriculum (Mr. Johnson, with the assistance of Mr. Sanchez). The curriculum was developed in the months leading up to its implementation with the goals of being relevant to students' lives and aligning to the needs of the teachers and their classroom. This design process utilized co-design between the two teachers, Mr. Johnson and Mr. Sanchez, and me, a researcher. Co-design is a technique of innovation development where experienced designers partner with users to develop a product together. Co-design with teachers has been successfully used to develop new curriculum and learning innovations. These innovations have proven successful from the perspectives of both teachers and students (e.g., Carroll et al., 2000; Coenraad, Palmer, et al., 2021; Lui & Slotta, 2014; Penuel et al., 2007).

When implementing a curriculum, a teacher must balance their teaching experiences with a variety of competing interests: those of the curriculum developers, policymakers, students, and parents (DeBarger et al., 2013). Given these competing interests, it is routine for teachers to make adaptations to curriculum and lessons to meet the perceived needs of their students within the context of their classroom environment, whether these needs relate to the level or delivery of content or to making the content more applicable to students' lives. Mr. Johnson demonstrated just such an adaption in the introductory vignette when he added the celebration of heroes and heroines at the beginning of each class and aligned the identities of those heroes and heroines to his students' identities.

Within education, we need to understand the implementation of innovations, such as the Talking Techquity curriculum, and the ways teachers adapt materials, even after co-designing them. Implementation research has identified context and conditions such as existing materials or practices in the classroom, teacher ability or confidence, student needs, time, and ease of use as reasons for teachers to make adaptations to an innovation (Century & Cassata, 2016; B. De Vries et al., 2017; Harn et al., 2013). Yet, as mentioned previously, more research is needed to determine if and how teachers who co-design a curriculum further adapt these curricular innovations. This research investigates the curriculum implementation of co-designed units to learn about how teachers adapt co-designed curriculum after their initial unit design. To date, most research on co-design with teachers focuses on the *design process*. In this work, I propose that it is equally important to focus on the *implementation process* once an innovation has been created. While curriculum design and classroom instruction are, at times, treated separately, they are interconnected processes that speak to each other. Co-design is one step in creating this dialogue between processes, but knowledge can also be gained from attending to the implementation of designs and ensuring the goals of an innovation are met. Teacher knowledge affects implementations, and even small misconceptions can lead to adaptations that transform or weaken innovations (Pintó, 2005). Therefore, knowledge about how a teacher implements and adapts a curriculum can support the field in creating more robust curricular materials and supporting teachers in how to make the adaptations they need to support their students and improve upon curricula. It can also support teachers and researchers working together in co-design processes to ensure that adaptations lead to positive outcomes based on the goals of both the teachers and researchers. As demonstrated in the introductory vignette, not only did Mr. Johnson make adaptations, but his classroom at the time he piloted the Talking Techquity curriculum was not his typical teaching environment due to the COVID-19 pandemic. The online context, student participation, and his beliefs about his students' other needs affected his implementation, and he adjusted to meet the perceived needs of his students.

In this paper, I analyze the implementation of the Talking Techquity curriculum, an innovation co-designed with the implementing teacher (Mr. Johnson), to understand how he adapted materials developed through co-design when implementing them in his classrooms and what factors led to this adaptation. I seek to identify if and how critical components of the co-designed curriculum were productively adapted when implemented by a teacher who co-developed the materials a short time before implementing them. In this work, I answer two research questions:

1. When implementing co-designed lessons, how does a teacher who co-designed the lessons adapt them for the classroom environment?
2. What factors influence a teachers' adaptation of co-designed lessons when implementing them in the classroom environment?

Based on my analyses, I found that even when a curriculum intervention is co-designed with the implementing teachers at a time when they are aware of many factors affecting the classroom, these co-designed innovations still require adaptations to meet students' needs.

Theory and Prior Work

This work is guided by the innovation implementation framework and the factor framework (Century et al., 2012; Century & Cassata, 2014) and is informed by prior work in the field of education on co-designing innovations with teachers and curricula implementation (see literature review below for further details). In the following section, I detail this prior literature and the theory guiding this work and how the research presented in this paper builds on work in the field.

Co-Designing Innovations with Teachers

Co-design is a type of participatory design that has been used frequently with teachers over the last two decades. Participatory design is a design technique that includes the users of a product or process within its design through partnership between the users and trained designers (Muller & Kuhn, 1993; Sanders & Stappers, 2008). This design technique first emerged in the 1970s and 1980s during the Scandinavian worker's movement with a focus on the inclusion of workers in the design of new workplace innovations (Kensing & Blomberg, 1998; Muller & Kuhn, 1993). Participatory design is grounded in goals of equalizing power structures between designers and users and making a more democratic design process (Bjerknes & Bratteteig, 1995; Björgvinsson et al., 2010; Bødker et al., 2000; Iversen et al., 2004; Kensing & Blomberg, 1998). Partners in the design process can play a variety of roles (i.e., user, tester, informant, or design partner; Druin, 2002). This includes a range from low-involvement participation, which gives researchers and designers access to the skills and experiences of the users, to high-participation involvement, which encourages design partners to have a stake in the outcome of the design process (Kensing & Blomberg, 1998). Beginning in the 1990s, participatory design expanded to educational settings, with both teachers and students taking part in the design process (Bonsignore, Yip, et al., 2013; Williams & Traynor, 1994). In these settings, participatory design is commonly referred to as co-design.

While co-designing with youth can provide insights into what is engaging and relevant to them, teacher input into educational innovations provides expertise on learning goals, teaching practices, and what curriculum and procedures currently exist in schools (Scaife et al., 1997). Additionally, teachers play an integral role in the classroom and are able to "pay attention to broad goals for learning and for improving large-scale systems" (Penuel et al., 2007, p. 52), giving them an important vantage point from which to design for learning. Additionally, considering education through a design framework in which education innovations are designs for learning, Halverson et al. (2010) suggest that “by integrating users (and their experiences) into the design process early on, real-world practices can inform an iterative design process, leading to greater faithfulness in enacting the intentions of the artifact” (p. 177). Given the expertise and relevant experiences of teachers, researchers and designers have increasingly included them in the innovation development process through co-design. As defined by Penuel et al. (2007), co-design is “a highly facilitated, team-based process in which teachers, researchers, and developers work together in defined roles to design an educational innovation, realize the design in one or more prototypes, and evaluate each prototype’s significance for addressing a concrete educational need” (p. 53). Aligning with the original intent of the participatory design movement from which co-design emerged, teachers’ involvement in the development of an innovation through co-design replaces the typical top-down design process in which researchers and developers play the main roles in the design of new innovations. Instead, the co-design process places importance on teachers’ classroom practices and context and their everyday experiences (Penuel et al., 2007) and requires teachers’ continuous involvement as designers (Roschelle et al., 2006).

Literature on co-designing educational innovations with teachers includes studies of and reports on the participatory design process (e.g., Hundal et al., 2014; Matuk et al., 2016); studies of or reports on the innovation (e.g., Barab et al., 2001; Cooper & Brna, 2000); or a combination of the two that presents both the process and the innovation (e.g., Frossard et al., 2012; Kyza & Georgiou, 2014; Zuiker, 2014). Co-design projects with teachers have resulted in online platforms and learning environments (Barab et al., 2001; Duell et al., 2014; Sun & Looi, 2013); mobile- and technology-enhanced science learning and assessment (Leary et al., 2016; Lui & Slotta, 2014; Penuel et al., 2007; Yarnall et al., 2006; Zhang et al., 2010); and curriculum and technology tools for language and writing instruction (Y. H. Wang, 2017; Wong et al., 2015). Within the literature on co-designing with teachers, there is varied reporting on both the co-design process and the implementation of the designed innovation. Papers range from only including a sentence or two about the use of co-design (e.g., Duell et al., 2014; Lui & Slotta, 2014) to the entire paper being about the design process (e.g., Kyza & Georgiou, 2014; Leary et al., 2016; Penuel, 2019). Involvement of teachers within the design process also varies, from teachers who are asked to complete a questionnaire (e.g., Y. H. Wang, 2017) to participation in a one-time design session (e.g., Hansen et al., 2016) to a years-long ongoing partnership (e.g., Carroll et al., 2000). When reporting on the implementation of co-designed innovations in the classroom, research typically focuses on student and teacher outcomes (Tan & Guo, 2009; Wong et al., 2015; Zhang et al., 2010).

In this research, I build upon the prior work on co-designing educational innovations with teachers by examining the implementation of that innovation from an adaptation perspective. By examining *how* a partnering teacher implemented a co-designed innovation rather than examining the design process or outcomes, this work provides further insight into the utility of co-design and the implementation following a co-design partnership. In the following section, I provide a review of implementation research, including common ways of examining implementation. This prior work is essential to better understand how teachers implement co-designed innovations.

Implementation Research on Curricula

Implementation research is a growing field within education (Century & Cassata, 2016; O'Donnell, 2008). This field of research seeks to "understand if and how educational efforts are accomplishing their goals…[through] systematic inquiry regarding innovations enacted in controlled settings or in ordinary practice, the factors that influence innovation enactment, and the relationship between innovation, influential factors, and outcomes" (Century & Cassata, 2016, pp. 169–170). To do this, implementation research includes studying the implementation of an innovation, factors influencing that implementation, and the outcomes of the innovation (Century & Cassata, 2016). Generally, this analysis occurs across two dimensions: structural and process (Harn et al., 2013). Together, these elements highlight not only whether an innovation is adopted, but also what happens during the adoption and enactment and the factors influencing that enactment (such as the context) (Century & Cassata, 2016).

The aspect of implementation research relevant to this work is the study of adaptations made by teachers when implementing a curriculum or innovation. Within adaptation studies, authors take as a given that teachers will transform innovations when they adopt them and that this transformation is purposeful rather than accidental (B. De Vries et al., 2017; Pintó, 2005). These often neutral transformations provide opportunities for teachers to "take ownership" or adapt the innovation to their context

(Pintó, 2005). These transformations can be desirable within the implementation process because the adaptations embrace the complexity of society and the social systems in which the innovation is being implemented (Century & Cassata, 2016). Given the assumption that teachers will make adaptations, researchers focus on how to support the process of adaptation during the design, planning, and enactment of the curriculum and how to ensure that the most important components of the intervention are not altered as adaptations occur (DeBarger et al., 2013; Harn et al., 2013). Within an adaptation view of implementation, researchers have suggested a perspective focused on measuring the integrity of the implementation. When measuring integrity, researchers focus on making accommodations based on local needs, contexts, and circumstances while maintaining the core ideas of the innovation (LeMahieu, 2011). These adjustments are known as "productive adaptations," or "evidence-based curriculum adaptation[s] that are responsive to the demands of a particular classroom context but still consistent with the core design principles and intentions of a curricular intervention" (DeBarger et al., 2013, p. 298).

Past research has demonstrated that the adaptations a teacher makes when enacting a curriculum and how they do so can affect the outcomes. Given that a lack of knowledge and misconceptions can lead to problematic transformations and that even small changes from critical details of a plan can be of concern and weaken the effect of an innovation (Pintó, 2005), understanding the adaptations made by teachers and the factors influencing them is an essential part of implementation research. Research has found that teacher adaptations can occur not only to materials, but also to the approach of the curriculum (e.g., shifting evaluations to focus on content knowledge rather than on process knowledge) (B. De Vries et al., 2017). Teacher adaptations can also occur such that teacher intentions take precedent over those of the designers (Pintó, 2005). When examining the implementation of an out-of-school STEM camp as it scaled and its implementation transitioned from being the responsibility of the project developers to that of educators, Barker et al. (2014) found that slight differences in student scores were explained by the number of hours spent on modules and the number of modules completed. Educators elected to make these changes to a certain module due to a lack of time, the module's age-appropriateness and difficulty, teacher confidence about the module's topics, and the support provided by facilitators during the module (Barker et al., 2014). Likewise, researchers examining the implementation of the computer science curriculum EarSketch found that teachers implemented the tool in differing ways (McKlin et al., 2019). Quantitative and qualitative results found that the implementation of the curriculum influenced students' intentions to persist in computing. A particularly salient element was teachers' elaboration on the curriculum, or the extent to which they added optional activities or new experiences to extend learning (McKlin et al., 2019).

Focus on implementation research within projects developed through co-design is limited, particularly within the field of education. While co-design research provides both teacher and student level outcomes, this research typically does not examine the implementation or adaptations or factors that could affect the implementation. Yet, a few studies have examined teacher adaptations of co-designed innovation and found that even when teachers are part of the initial design of innovations, they adjust when enacting them in their classrooms. Ye et al. (2014)

examined the implementation of a curriculum co-designed within a community of practice. They found that while teachers generally followed the structure and sequence of the activities, teachers enacted the curriculum with adaptations to fit the learning needs of their students. This included allowing differing opportunities for autonomy, particularly during scientific experimentation (Ye et al., 2014). DeBarger et al. (2013) used design-based implementation research to develop tools for assessing middle school Earth science collaboratively across multiple stakeholders. Because they anticipated teacher adaptations to the curriculum, they used professional development to support teachers in making productive adaptations to the tools and noted multiple adaptations made by teachers to enhance student understanding and meet the needs of specific student populations (such as emerging multilingual students) (DeBarger et al., 2013). This team purposefully anticipated the likelihood of adaptations and created a process of co-design and professional development to ensure the adaptations were productive, not detrimental, to the innovation and that teachers had the resources and support they needed (DeBarger et al., 2013). This view aligns with that of Halverson et al. (2010), who view education through a design lens. They propose that design provides a unique view of implementations that examines the interaction between intentions and affordances and analyzes how iterative design can create a stronger match between innovations and classroom enactments, a process that can support the iteration and redesign of innovations (Halverson et al., 2010).

In this paper, I take an adaptation perspective of innovation implementation and build on the prior research of how and why teachers adapt co-designed innovations during implementation. While prior research has focused on the scaling of co-designed adaptations developed by a group of teachers working across schools and the adaptation of a co-designed curricula through productive adaptation aided by professional development, I examine how a curriculum designed by two teachers at a school for a class they were already teaching is adapted during the implementation process. Bringing together these two literatures on co-designing with teachers and implementation, I seek to understand how co-designed lessons are enacted and to document productive adaptations made by those involved in the design.

The Innovation Implementation and Factor Frameworks

This work is guided by two interconnected frameworks: the innovation implementation framework and the factor framework (Figure 4-1). The innovation implementation framework was designed to remove the black box of implementation of innovations (Century et al., 2010) and create "shared conceptual frameworks for measuring innovation implementation and factors that affect implementation" (Century & Cassata, 2014, p. 81). As a component-based framework, the innovation implementation framework focuses on identifying the critical components within the innovation, or those parts of an innovation that the innovation's developers deem to be essential to attain the intended outcomes (Century et al., 2012; Century & Cassata, 2014), and measuring the use of those components when an innovation is implemented (Century & Cassata, 2014). As such, it focuses on the use of the components as identified by all design stakeholders and participants. Within the innovation implementation framework, the critical components are broken into two categories: structural components and interactional components (Century et al., 2012; Century & Cassata, 2014). Structural components are "the organization, design, and support elements that are the building blocks of the innovation" (Century & Cassata, 2014, p. 88). Typically, structural components are further divided into two subcategories: procedural and educative. This subcategorization separates the procedural and design elements of the innovation that tell the user what to do from those that support the user in successfully implementing the innovation (Century et al., 2012; Century & Cassata, 2014). Interactional components are "the behaviors, interactions, and practices of innovation 'users' during enactment" (Century & Cassata, 2014, p. 88). Interactional components are organized by user groups. Within education, this often includes, but is not limited to, pedagogical components related to the actions engaged in by the teacher and learner engagement components related to the actions of the learner during the implementation of the innovation (Century & Cassata, 2014).

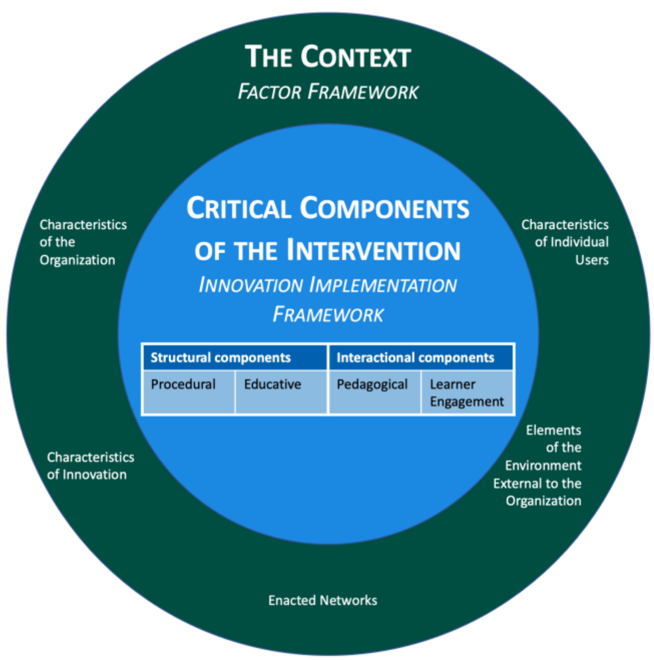


Figure 4-1. The Innovation Implementation and Factor Frameworks
Image adapted from Cassata et al. (2015); Century et al. (2012); Century & Cassata (2014)

The factor framework was designed alongside and complements the innovation implementation framework. While the innovation implementation framework focuses on the what and how of innovation implementation, the factor framework provides a conceptual structure through which to examine why an implementation occurs as it does (Century & Cassata, 2014). The factor framework is constructed of five research-based categories of factors: characteristics of the innovation, characteristics of individual users, characteristics of the organization, elements of the environment external to the organization, and enacted networks (Century et al., 2012; Century & Cassata, 2014). The factors that affect implementations (e.g., complexity and understanding of the innovation) fit within these categories. Century and Cassata (2014) provide a list of potential factors. While the categories of the factor framework are defined, they also are designed such that a single factor can fall into multiple categories; the final category, enacted networks, knowingly spans two other categories (elements of the environment and characteristics of the user) (Century & Cassata, 2014). Using these categories, the factor framework provides a structure for understanding the "why" of innovation implementation that comes together with the innovation implementation framework to allow for a clearer view of the implementation of a novel innovation.

In my analysis, I apply both the innovation implementation and factor frameworks to data collected during the classroom implementation of the Talking Techquity curriculum (see Data Analysis, below). The innovation implementation framework sheds light on the critical components of the curriculum and frames the analysis of adaptations made to Talking Techquity during implementation.

Subsequently, the factor framework provides insights into possible factors affecting the implementation and the resulting adaptations.

Methods

This paper examines data collected during the design and implementation of a novel computer science curriculum that introduced students to the social justice and equity impacts of computing. In this section, I detail the context, participants, data collection, and data analysis of this work.

Context and Participants

This work utilizes the Talking Techquity curriculum. Talking Techquity is an introductory computer science curriculum focused on developing students' computer science skills while simultaneously introducing social justice and equity impacts of computing. The curriculum uses the Scratch block-based programming environment (Maloney et al., 2010; Resnick et al., 2009) and includes computer science material adapted from the Scratch Encore curriculum (Franklin, Weintrop, et al., 2020). Talking Techquity is constructed of three four-lesson units and a final project (Table 4-1). Each unit is comprised of an introductory lesson providing background and an interactive experience with a Threat to Techquity and three lessons scaffolding students' learning of a focal computer science concept with the use-modify-create pedagogical strategy (Franklin, Coenraad, et al., 2020; I. Lee et al., 2011). Curriculum materials include unit plans, student worksheets, and Scratch projects. To support teachers who are new to the concept of Techquity, the curriculum materials also include a two-page "getting started" guide with definitions and resources that can provide further information about Techquity. The curriculum was developed through co-design with the University of Maryland KidsTeam and the two teachers implementing the curriculum, Mr. Johnson and Mr. Sanchez. Design ideas from both the youth co-designers as well as the teacher design partners were central in the development of the curriculum. For example, the topics of each unit were selected based on design priorities of the youth co-designers. In this paper, I specifically focus on the co-design completed with teachers, as the co-designing with youth was intended to provide ideation for and critiques of the curriculum designed with the teachers. With teachers in the roles of informants and testers (Druin, 2002), the curriculum was developed in the months leading up to and during the implementation.

Table 4-1. Outline of the Talking Techquity Curriculum

<table>
<tr><th colspan="2">Unit 1</th><th colspan="2">Unit 2</th><th colspan="2">Unit 3</th></tr>
<tr><td colspan="2">Computing Focus:
Animation with loops
Techquity Focus:
Algorithmic bias in image search results</td><td colspan="2">Computing Focus:
One-way synchronization
Techquity Focus:
Online data collection</td><td colspan="2">Computing Focus:
Conditional loops
Techquity Focus:
Training machine learning algorithms</td></tr>
<tr><th colspan="6">Final Project (Project available for use after Unit 2 or after Unit 3)</th></tr>
<tr><td colspan="3">Computing Focus:
Skills in Units 1 and 2
Techquity Focus:
Students choose a Techquity topic or computer scientist who identifies with a group marginalized in computing</td><td colspan="3">Computing Focus:
Skills in Units 1, 2, and 3
Techquity Focus:
Students choose a Techquity topic or computer scientist who identifies with a group marginalized in computing</td></tr>
</table>

Mr. Johnson was the primary teacher on the project who implemented the curriculum in his classroom. He identified as a Black or African American man between the ages of 35 and 44. He was in his 19th year of teaching at the time of the research and taught English and the enrichment course in which the curriculum was implemented. Mr. Johnson did not have prior experience with computer science before participating on this design team. Within design conversations, Mr. Johnson advocated heavily for computer science based on economic and job motivations and his desire to expose students to computer science in the hopes that he will build interest. While talking about coding and different coding languages in an early design meeting, he shared, “I just want to connect the dots for the kids…because you're thinking about the job market...just trying to get them to understand...how it works.” He recognized that the world is changing and aspired to prepare his students for the jobs of the future, which included ensuring they had access to computer science education in school. Mr. Sanchez was the school librarian at the same school where Mr. Johnson taught. He identified as a Hispanic or Latino man between the ages of 45 and 54. Mr. Sanchez was in his fifth year of teaching and had taught computer science each of those five years, although he did not have experience with computer science other than his prior teaching experience. Mr. Sanchez joined the class whenever possible to support Mr. Johnson and the students. I was the final member of the design team. At the time of the research, I was a PhD candidate and former middle school teacher who identified as a mixed-race woman between the ages of 25 and 34. While teaching, I taught social studies, Spanish, and technology courses that included coding and 3D design. Before teaching, I had no prior experience with computer science, but I participated in computer science education research for four years and completed a course in JavaScript programming.

The Talking Techquity curriculum was implemented at an urban middle school in the mid-Atlantic region of the United States. As part of the implementation, Mr. Johnson taught the first two units of the curriculum and the final project. During the 2019-2020 school year, when the curriculum was designed and implemented, the school served just over 350 students. Of those students, approximately 86 percent were Black, 13 percent were Hispanic/Latino, and one percent were white. Eight percent of students in the school were English language learners, 20 percent were in special education, and 100 percent of students were identified by the district as economically disadvantaged. The curriculum was designed for use in an enrichment course in which all sixth-grade students participated. The sixth-grade students were divided amongst five class periods. The course met on a block schedule twice per week for 80 minutes per session. Due to the COVID-19 pandemic, students joined the class online using the video conferencing software Microsoft Teams. The district ensured that all students had access to both a device and internet.

Data Collection

The design team met weekly beginning five weeks before the curriculum was first implemented. The initial design meetings focused on brainstorming and developing the curriculum while later meetings focused on implementation and supporting the teachers as they implemented the Talking Techquity lessons. Based on the preferences of the teachers, curricular units were designed immediately before they were needed (e.g., unit 2 and the final project were developed as students were learning the previous units). Design meetings took place over Zoom video conferencing software and were audio- and video-recorded. I took field notes immediately after each design meeting. The design team discussed and brainstormed curriculum materials I developed before Mr. Johnson and Mr. Sanchez critiqued and edited them for iteration. In addition to the design meetings, the teachers participated in three interviews throughout implementation, one after each unit. Interviews lasted between 30 and 60 minutes and were audio- and video-recorded. During implementation, I observed at least one class period in which each lesson was taught. Since Mr. Johnson utilized the curriculum in all five classes he taught, observations varied by unit (i.e., Unit 1 during period 1, Unit 2 during period 5, etc.) to see different classes and observe the implementation of the materials at different times of the day, on different days, and with different students. While observing classes, I kept field notes about what Mr. Johnson did and the flow of the class.

Data Analysis

I iteratively analyzed the collected data to develop a comprehensive list of critical components, verify this list based on conversations between the entire design team, and analyze the enactment of the critical components within the classroom as well as the factors affecting those components during design and implementation. As recommended by Century and Cassata (Century & Cassata, 2016), I utilized a variety of approaches to identify the critical components of the curriculum. This included gathering information from developers, observing the curriculum implementation within the classroom, and reviewing curriculum artifacts.

To develop the list of critical components (Table 4-2), I first reviewed the list of components developed by the framework authors (Century et al., 2010) and extracted all those relevant to the design of the Talking Techquity lessons (15 of 40 components identified by Century et al., 2010). Of the identified components, all are represented in the final taxonomy of critical components (Table 4-2). In two instances, I expanded single factors from the framework into multiple components (e.g., I expanded “Student choice and relevance” into components 5, 6, and 15 in Table 4-2 based on the subsequently described steps). In two other instances, I combined components (e.g., I combined the facilitation of manipulatives, materials, and tools with the facilitation of using Scratch in component 13). Then, I framed these factors specifically for the Talking Techquity curriculum and verified their significance. To do so and bring in the voices of all designers during the design discussions, I deductively coded all the design meeting transcripts and field notes using the broad categories of structural-procedural, structural-educative, interactional-pedagogical, and interactional-learner engagement (Century et al., 2012; Century & Cassata, 2014). I compared this coding to the list of components I developed from the framework to determine whether all initial codes were present in the design discussions, if there were missing components, and to identify which components were critical and given high value in the conversations (rather than just those present in the curriculum). At that point, I also adjusted the language from the general components presented by Century et al (2010) into language specific to the Talking Techquity curriculum. Using this process, I identified 16 critical components (Table 4-2). Of the 16 critical components, six are structural-procedural, two are structural-educative, three are interactional-pedagogical, and five are interactional-learner engagement. As Gale et al. (2020) found previously, some of the interactional components included a parallel teacher and student activity. As such, three of the interactional components are paired based on their parallel structure: discussion-based learning, Techquity content, and the use of Scratch for computer science learning.

Table 4-2. Critical components in the Talking Techquity curriculum

Structural		**Interactional**	
Procedural	**Educative**	**Pedagogical**	**Learner Engagement**
1. Include all lesson segments and lessons in order 2. Scaffold with use-modify-create 3. Introduce both computing and Techquity concepts 4. Support student autonomy and knowledge of requirements 5. Create opportunities for student choice 6. Incorporate topics of relevance	7. Content background information 8. Unit plans and curriculum materials	**Discussion-based Learning**	
		9. Teacher facilitation of discussion	10. Students contribute to discussion
		Techquity Content	
		11. Teacher introduces and guides students through engagement with Techquity topics	12. Students engage with Techquity topics
		Use of Scratch for computer science learning	
		13. Teacher facilitates use of Scratch to learn computer science concepts guided by curriculum worksheets	14. Students view, manipulate, and create code in Scratch, guided by curriculum worksheets to learn computer science concepts
			15. Students make decisions about their work
			16. Students share their work

I used the 16 components to code the unit plans to identify where and how the components were written into curricular materials and the expected enactment of the critical components. For example, I coded the unit objectives within the lesson plan as component 3, *introduce both computing and Techquity concepts.* The opening section of unit 1, lesson 1 reads, “In order to introduce the idea of bias, generally, and algorithmic bias, specifically, lead a class discussion about bias and the ways that it can be harmful” and includes guided questions and sample student answers. This section is coded as component 9, *Teacher facilitation of discussion.*

Then, I similarly coded the teacher interviews and observation field notes with the 16 critical components to identify where and how the critical components were enacted during the teaching of the Talking Techquity lessons. For example, during the first interview, Mr. Johnson said, “I think it went pretty, pretty well; I think the instructions and everything were pretty much on point.” I coded this observation as component 8, *unit plans and curriculum materials.*

Finally, I completed a side-by-side analysis of the coded lesson plans and the classroom observations to identify instances of adaptation and categorize them according to the critical component to which they aligned.

The identification of factors followed a similar process. First, I identified factors based on those highlighted by the framework authors (19 of 61 factors identified in Century & Cassata, 2014). Then, I extracted factors from the design meeting field notes and transcripts, interviews, and observation field notes. I only extracted factors related to adaptations made to the curriculum, not those related to original design intentions. I compared these factors to the list identified based on the framework to confirm, add, or remove factors that were not present or emphasized in the data and develop a final list of factors (10 factors added and five removed for a total of 24 final factors; Table 4-3). Finally, I coded the previously extracted factors from the design meetings and observations using the final set of factors. For example, I coded Mr. Johnson’s observation that “unit two was a level up when it comes to Scratch and when it comes to the skill and understanding the skill and Scratch” as *complexity*.

Table 4-3. Factors influencing adaptions by teachers

<table>
<tr><th colspan="2">Factors</th></tr>
<tr><td colspan="2">Characteristics of Innovation</td></tr>
<tr><td colspan="2">• Adaptability
• Complexity
• Duration
• Modality
• Novelty
• Specificity</td></tr>
<tr><td colspan="2">Characteristics of Individual Users</td></tr>
<tr><td>Teacher</td><td>Student</td></tr>
<tr><td>• Attitude toward innovation
• Self-efficacy
• Understanding of innovation</td><td>• Attitude toward and knowledge of things related to the innovation
• Ease of use
• Engagement level
• Patience and persistence
• Presence
• Time management and organizational skills</td></tr>
<tr><td colspan="2">Characteristics of the Organization</td></tr>
<tr><td colspan="2">• Environment
• Organizational goals
• Shared beliefs and values
• Time</td></tr>
<tr><td colspan="2">Elements of the Environment External to the Organization</td></tr>
<tr><td colspan="2">• COVID-19 pandemic
• Political environment
• Students’ home lives</td></tr>
<tr><td colspan="2">Enacted Networks</td></tr>
<tr><td colspan="2">• Co-design partnership between teachers and university researchers
• School District / University of Maryland Research Practice Partnership</td></tr>
</table>

Results

I analyzed the implementation of Talking Techquity from an adaptation perspective. Through this perspective, I considered the extent to which the curriculum was implemented and the adaptations made by the implementing teacher with a particular focus on how and why Mr. Johnson adapted the curriculum. In addition to the design decisions he made to tailor the curriculum to his class during the design process, Mr. Johnson made contextualized and in-the-moment adaptations to the Talking Techquity curriculum when he implemented it. Specifically, Mr. Johnson adjusted how he presented the content and project requirements. He made these changes to provide more scaffolding and ensure students had the opportunity to be successful. These adaptations were made based on all five types of factors from the Factors Framework (Century & Cassata, 2014). While the curriculum was aligned to Mr. Johnson's beliefs about what his students would need during the design sessions, factors emerged that could not be predicted in the design environment. Mr. Johnson believed these factors warranted adaptation either in the moment during the lesson or based on the successes and difficulties students faced in prior lessons. In the following section, I detail the findings relating to the implementation of the Talking Techquity curriculum, including the adaptations made and the factors causing them. I present these findings in three sections. In the first section, I answer research question 1 and provide an overview of the adaptations made by Mr. Johnson during the implementation. Next, I answer research question 2 with an overview of the factors affecting the implementation. Finally, I provide two illustrative examples of how the adaptations and factors converged and the resulting instruction within the classroom implementation.

Research Question 1: When implementing co-designed lessons, how does a teacher who co-designed the lessons adapt them for the classroom environment?

Overall, Mr. Johnson made adaptations broadly that affected nearly all critical components within the curriculum. Of the 16 critical components within Talking Techquity (Table 4-2), 11 were adapted at varying levels during implementation. Specifically, adaptations were made to five unpaired components as well as to the three paired components. Adaptations occurred in both units implemented by Mr. Johnson and in the final project. Mr. Johnson made adaptations in each of the 12 lessons Mr. Johnson implemented across the two units and the final project. These adaptations ranged from providing students with additional time to work on projects and adjusting how students presented their work to removing entire lessons from the units. Example adaptations for each critical component that was modified are presented in Table 4-4.

Table 4-4. Critical components adapted during classroom implementation

Type	Critical Component	Example Adaptation
Structural-Procedural	Include all lesson segments and lessons in order	Removing the "create" project from unit 2 and having students instead continue individualizing their "modify" project.
Structural-Procedural	Scaffold with use-modify-create	Completing the worksheet that guides the "use" portion of the lesson as a full class rather than having students complete it individually.
Structural-Procedural	Introduce both computing and Techquity concepts	Removing the reading assignment about algorithmic bias in lesson 1.
Structural-Procedural	Incorporate topics of relevance	Replace a universal example of a service that uses recommendations (YouTube) with a school-specific example (iReady).
Interactional-Pedagogical;	Discussion-based Learning	Changing the order of questions, adding additional questions, and replacing

Interactional-Learner Engagement		discussion questions with vocabulary or ideas through definitions.
Interactional-Pedagogical; Interactional-Learner Engagement	Techquity Content	Removing follow-up explanations of Threats to Techquity associated with data collection in an interactive class activity.
Interactional-Pedagogical; Interactional-Learner Engagement	Use of Scratch for computer science learning	Removing discussion-based review of how to animate in Scratch and replacing it with a demonstration of specific Scratch skills or concepts.
Interactional-Learner Engagement	Students share their work	Expanding student opportunities to share to include not only sharing their Scratch projects, but also demonstrating how they performed certain tasks (such as having two characters talk to one another).

While Mr. Johnson was on the design team for the curriculum and co-created the lesson plans he was following, he felt the need to adapt Talking Techquity in his classroom, as is necessary with many curricula that teachers use (particularly new curricula when implemented by a teacher for the first time). Co-designing the curriculum did not eliminate the need for specific adaptations to meet student needs in the moment or based on changing classroom and educational contexts. Mr. Johnson's adaptations made modifications to a variety of aspects of instruction, including the order of the lessons, the exact content covered, and how content was presented. Adaptations were not limited to a single part of instruction, nor did all adaptations affect instruction in the same way.

Research Question 2: What factors influence a teachers' adaptation of co-designed lessons when implementing them in the classroom environment?

In total, 24 factors affected the implementation of Talking Techquity and led to Mr. Johnson making adaptations to the curriculum (Table 4-3; Table 4-5). These 24 factors exist across all five categories defined by the factor framework (Century &

Cassata, 2014). As such, factors relate to characteristics of the innovation (Talking Techquity: six factors), users (teachers and students: nine factors), the organization (the school: four factors), the external environment (United States and global events: three factors), and networks (within and outside the school: two factors). The identified factors originate both from within the framework (Century et al., 2010) and represent factors unique to this implementation. Table 4-5 presents each of the 24 factors with an example of how it affected the implementation and quotes from Mr. Johnson and Mr. Sanchez about the factor affecting the implementation. Although Mr. Johnson was the teacher performing the implementation, both teachers took part in some classroom implementation and discussed factors that were affecting it in the design meetings.

Table 4-5. Factors leading to adaptations of Talking Techquity

Factor	**Example of Factor**	**Teacher Perspective**
Characteristics of Innovation		
Adaptability	Ability to change the curriculum as Threats to Techquity change over time	Mr. Sanchez: "*In order for these lessons to be, like 10 years from now...we have to be on top of what's happening in technology. Because, for example, maybe algorithm is something that we're dealing with now or that bias. But maybe 10 years from now, you'll be able to hit the button and...it will change the algorithm or it will do something [so] that all these biases can be avoided. So...that's part of what I like, that they can be modified.*"
Complexity	Difficulty and amount of content covered	Mr. Johnson: "*Unit two was a level up when it comes to Scratch and when it comes to the skill and understanding the skill and Scratch. It required a bit more concentration.*"
Duration	Teaching the curriculum for the first time	Mr. Sanchez: In the future, *"we can deal with all that stuff [setting up Scratch and Scratch IDs] before we actually...all those little, not barriers, but obstacles there. So,*

		when they start, they already know...that part's done, so it's more of the creative, which is what we want."
Modality	Teaching the curriculum through distance learning without paper worksheets	Mr. Johnson: If distance learning continued for the next school year, *"have a packet already ready with...this material in it for the students to come pick up at the beginning of school."*
Novelty	Limited prior knowledge of computer literacy and computer science	Mr. Sanchez: *"Our students don't have, didn't have...an introduction...to computers…so we're just throwing them there and we have to realize that we're teaching a whole new language, a whole new way of thinking…I'm aware that...Mr. Johnson had to be working with other programs before, computer programs before. And that probably helped a lot, but...if we had something like just an introduction to computers class, and you [sic] keyboard, and all these things that happened before you can get into actually programming, that would have been helpful."*
Specificity	Guiding students through requirements by providing step-by-step instructions for students	Mr. Johnson: *"When it came to kids who...came late…or wasn't [sic] there for the first lesson...I would tell them, 'hey, listen, if you go through that lesson step-by-step...I believe that if you paid attention and went through each step, you will be in a good place and I can help you better.'"*
Characteristics of Individual Users: Teacher		
Attitude toward innovation	The curriculum needed to teach students and be impactful, but it didn't need to be entertaining when engaging students	Mr. Johnson: *"Everything that you need is not gonna be entertaining, but that doesn't mean it's not important."*
Self-efficacy	Teachers' comfort levels discussing Techquity topics and computer science	Mr. Johnson: *"I wasn't really uncomfortable really talking to them about Techquity. Now, I can say I was leaving room for uncomfortability [sic], if that's even a word, wondering...what conversations were going to come from them...because kids might have a misunderstanding… so I would say more so if I was uncomfortable, I was*

		probably more uncomfortable about what conversations might come from them out of it.”
Understanding of innovation	Being familiar with the curriculum and preparing steps to implement it ahead of time	Mr. Sanchez: *“For us as teachers, also, there is a baseline or something that we need to be prepared before we embark in this…I know, for example, next year, if Mr. Johnson does this project, he already knows that he has to create a classroom, he has to...give the codes to the students.”*
Characteristics of Individual Users: Student		
Attitude toward and knowledge of things related to the innovation	Knowledge of how technology is affecting society or the importance of computer programming	Mr. Sanchez: *“This generation is so different from ours…I like that they’re aware of what’s going on.”*
Ease of use	Student ability to use Scratch, particularly with limited teacher support due to online learning	Mr. Sanchez: *“Years previous[ly], when we were in school...kids...could catch it easier, I think, when we were there. Cause we were all working together, and then, if one is not getting it, we’ll pair another student with that student, and...they will work together.”*
Engagement level	Students being attentive in class and taking part in class discussion and classroom activities	Mr. Johnson: “*We’re distance learning so, one of the biggest challenges that have [sic] been faced, and we knew that was coming, was just student engagement. You...want students to be engaged, and it’s hard to tell how engaged they are. Then again...to me...that was the challenge...to keep them engaged long enough to grit through the challenges of Scratch when it comes to coding, to grit through that, so that they can smile at their end...result.”*
Patience and persistence	Students taking time to complete work and overcome difficulties	Mr. Johnson: *“I think there’s a big grapple with patience in our society right now, and so a lot of kids...they kind of want to rush and get at it...and get through it really fast.”*
Presence	Students missing classes, particularly because the class was taught in 80-minute blocks two days per week	Mr. Johnson: *“You missed that one day [that] really puts you back...because you might not see. You miss two days a week, then...I haven’t seen you at all, so that was a challenge.”*

Time management and organizational skills	Supporting students to manage time on large projects and make sure they meet all requirements using checklists	Mr. Sanchez: "*These sixth graders, they don't have the skills yet to work on their own...'Here, do this, and boom, bring me a project.' ...We're trying to help them develop those skills and independence...So if we...have it right there, 'this is the checklist...did you go and open your Scratch ID? Did you link it?'*"
Characteristics of the Organization		
Environment	Students have access to computers because of the need to go online	Mr. Sanchez: *"They [the students] have the resources, so that's a positive...[A] year ago, we will [sic] have to fish for computers all over the building and just bring the cart to the room and then take the cart back, and it was a mess. By the time the kids will [sic] sit with a computer in front of them, it will [sic] be 20 minutes of class."*
Organizational goals	Aligning with the school's goals to increase equity for students and provide opportunities to discuss inequity within society	Mr. Sanchez: *"I think this program is doing it exactly...we're on track to...what our principal or our school wants to do…assisting kids, giving them skills to think…differently, and how do I resolve these issues in society."*
Shared beliefs and values	Being open and transparent with students about sociopolitical contexts	Mr. Johnson: *"Maybe it's just because of...how we are at [school name]...we are really transparent with our students."*
Time	Changing schedules due to priorities at the end of the quarter	Mr. Sanchez: *"It's always something that we have to be aware that...we can plan, but things would change. And maybe that also had something to do with this, because now you have kids...[for] a whole two weeks not working on the sequence."*
Elements of the Environment External to the Organization		
COVID-19 pandemic	Magnification of challenges students face due to the ongoing pandemic	Mr. Johnson: "*I will say that it is amplified so anything that takes place normally that can affect the student negatively right now, in the pandemic, it's amplified. So relationships with parents, things of that sort, everything is amplified. If it's negative...it's amplified: if it was at a five...it's at an eight. So anything that's going on in student life that can*

		happen...that can really hurt them academically, emotionally, socially emotionally [sic] as well, it's amplified."
Political environment	The Black Lives Matter movement and protests over racism within society during 2020	Mr. Johnson: *"You're looking at...2020 and everything that we witnessed as a society, despite the coronavirus, the Black Lives Matter, and what our kids see on a day-to-day basis."*
Students' home lives	Students babysitting sibling during the school day or not being able to turn on their microphones due to noise in their house during the day	Mr. Johnson: "*Every student...have [sic] their own set of challenges. We have some light challenges, and we have some different challenges. I know where we are at [school name], we have students in different situations, we have students who are still looking for housing...we have students who are...[in] foster care, we have students who [have] parents who lost jobs, we have students [with] parents [who] are going through divorces...life is still moving."*
Enacted Networks		
Co-design partnership between teachers and university researchers	Mr. Johnson and Mr. Sanchez getting to work more closely and collaborating with the author.	Mr. Johnson: "*This is the most I've ever worked with Mr. Sanchez. I've always liked to come and have [a] conversation with him, but...the chance I got to really...work with him was really great. And meeting you, Ms. Coenraad...and looking at you know the technology field when it comes to education…see what they're doing and see where they're headed."*
School District / University of Maryland Research Practice Partnership	An ongoing partnership between the University of Maryland and the school district to support computer science education	Mr. Johnson: "*Speaking...with you...getting a chance to know you and University of Maryland, and see you guys with your spirit and your energy, that was also very helpful and influential."*

It is important to note that while these factors are listed and explored here individually and within their larger categories, the interconnection between factors and categories cannot be ignored. Although causal connections cannot be made, there is likely interplay between factors, such as between students' presence in class and the external factors of the COVID-19 pandemic and their home lives. The factors are not, in fact, discrete influences, but rather manifestations of the larger sociohistorical and political environment in which the implementation occurred. In the following sections, some of this interplay, as well as the connections between factors and adaptations, are explored in two illustrative examples from the classroom implementation of Talking Techquity.

Adaptation Example: Introductory Discussion

As class begins, Mr. Johnson explains that the class will be moving forward with learning about Techquity. It's early on a February morning and the first day that the class will be starting the Talking Techquity curriculum. Mr. Johnson displays a daily presentation and invites a student to read the overview of today's class: "In this lesson, students learn about algorithmic bias through readings and experimenting with Google Image searches. The class discusses bias and how bias is present in image search algorithms."

Then, the class transitions to talking about vocabulary. Mr. Johnson asks students, "What is bias?" and invites the students to reply through chat or out loud. For the most part, students remain quiet as Mr. Johnson waits, but he eventually calls on one student. Mr. Johnson changes his slide to a definition of bias: "Bias is an unequal weight in favor of or against an idea or thing, usually in a way that is closed-minded, prejudicial, or unfair.[5]" Mr. Johnson again addresses the students, asking, "Based on the definition, can anybody give me an example of bias?" After waiting a

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[5] This definition is quoted almost directly from the Wikipedia page on bias: https://en.wikipedia.org/wiki/Bias.

few moments for a student to respond, Mr. Sanchez joins the conversation, stating, "For me, pistachio ice cream is the best, so maybe I'm biased for pistachio ice cream and maybe I like it more than chocolate." Mr. Johnson adds to this conversation, discussing his bias toward mint chocolate chip ice cream and inviting students to give examples. Mr. Johnson extends the conversation, discussing the real-world example of men making more money than women while doing the same job. Mr. Sanchez asks a female student whether Mr. Johnson should make more money driving a bus around the city than she does just because he is a man. The student answers and Mr. Sanchez revoices her idea that the difference should be due how difficult the bus route is to drive or how long the driver has been driving rather than due to gender.

Mr. Johnson then poses another question to students: "Is bias always bad?" Discussing with a student, Mr. Johnson scaffolds the student to help the student identify that bias is not always bad. He follows up by asking, "When is bias bad?" Mr. Johnson waits for the student to identify that biases are bad when they hurt someone else. He then changes the slide and presents the answer: "Bias is bad when the perceptions aren't true or when the bias means that people are treated differently or unfairly due to their identity or preference." Making a connection to students' lives, Mr. Johnson provides an example of when ice cream bias might be negative. Using a specific student as an example, he asks whether her bias toward vanilla ice cream would be bad if her sibling liked a different flavor, but she only had her mom buy her favorite type of ice cream. He prompts the student to identify that this would hurt her sibling, even though her preference for vanilla wasn't negative initially. Mr.

Johnson provides an opportunity for students to give examples of negative bias in society and fields a short conversation with a student over their example of voting.

Next, Mr. Johnson transitions the conversation to talk about algorithms. He first poses a question to the class: "What are algorithms?" He then provides students with the opportunity to answer before presenting his definition via the presentation. He defines algorithms as "a process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer.[6]*" As he introduces algorithms, Mr. Johnson explains that there are people who design and create algorithms within society and that those algorithms use data to make inferences. Highlighting the vocabulary word, "inference," Mr. Johnson makes a connection to English language arts and asks students what inferences are. He revoices a student's answer that an inference is an educated guess, stating, "algorithms use data to make inferences or educated guesses about something like what video someone might want to watch. One example of this is the suggested videos that come up on YouTube." Mr. Johnson extends this example, asking students why they might not want to let someone else watch videos on their phones. Based on the comments of a student, Mr. Johnson discusses how the videos that someone else watches might affect the suggestions they get later.*

Mr. Johnson plays the video "Bias in Search Algorithms" for students. Initially, he needs to troubleshoot because students are not able to see the video on their screens when he plays the video through PowerPoint, but he is then able to play

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[6] This definition is quoted directly from Lexico: https://www.lexico.com/en/definition/algorithm

the video in a browser for all students to watch. Mr. Johnson uses this video as a segue to introduce the activity of the day: experimenting with Google Image Search results to see bias.

As described in the above example, Mr. Johnson engaged his students in the interactional critical component **discussion-based learning.** Using the unit plan as a guide (Table 4-6), Mr. Johnson employed questioning to elicit information from students and build knowledge together through a sequence of questioning, eliciting student answers, and clarifying. This discussion **incorporated both computing and Techquity concepts** and provided opportunities both for **students to engage with Techquity topics** and for Mr. Johnson to **introduce Techquity topics to students.** When teaching, Mr. Johnson made some modifications to this discussion. He adapted the lesson by adding a short introduction to the day's content by highlighting the objective of the day and having a student read the objective early in the class. Then, he provided an opportunity for students to give an example of bias, providing opportunities to **incorporate topics of relevance.** In the conversation, Mr. Johnson not only provided the opportunity for students to incorporate topics of relevance, but he also did so himself. For example, he engaged a specific student by asking about her siblings. Despite these opportunities to make the learning relevant, Mr. Johnson removed some examples of relevant technologies by only mentioning the example of algorithms in YouTube suggestions. He did not connect to other platforms with which students might be familiar (as suggested in the lesson plan).

Table 4-6. Engage and Explore portions of Talking Techquity Unit 1, Lesson 1

Engage

Introductory Discussion (10 minutes)

Explain to students that for this term the class is going to focus on computer science and learning about ways that technology can be inequitable, or Threats to Techquity. To introduce the idea of bias, generally, and algorithmic bias, specifically, lead a class discussion about bias and the ways that it can be harmful.

What is bias? *[Bias is how someone perceives things are or should be, including when the perception is not correct.]*

Is bias always bad? *[No, there are biases that aren't harmful. For example, if you have a bias that chocolate is the best ice cream flavor no one is harmed by your preference.]*

When is bias bad? *[Bias is bad when the perceptions aren't true or when the bias means that people are treated differently or unfairly due to their identity or preference, such as being treated differently because you are a woman or because of your race.]*

> In the ice cream example above, the bias can be harmful if chocolate ice cream is given away for free but people who eat vanilla ice cream must pay or if people who like chocolate ice cream were treated better than those who like vanilla ice cream by having chocolate ice cream served in clean bowls, but vanilla ice cream served on a paper towel. This example seems a little funny when we think about it based on ice cream preference, but negative biases are very common in our society.

Can anyone give an example of negative bias within our society? *[women and people from minoritized races earn less than men and white people, age bias that assumes younger people are more capable, etc.]*

Once students have discussed the term bias, introduce the idea of algorithmic bias. An **algorithm** is a set of instructions or steps that are used to solve a problem. Make sure students are aware that algorithms are everywhere in their lives, particularly when they are using technology. Explain that algorithms use data to make inferences, or educated guesses, about something like what video someone might want to watch. One example of this is the suggested videos that come up on YouTube.

What other platforms do you know of that might use algorithms? *[Amazon (product suggestions), Netfix, Hulu, Disney+ (suggested shows and content), Tik Tok, Instagram (Ordering of content and suggested content)]*

On all these platforms, what you see differs depending on what the algorithm has selected for you. For example, if you spend a lot of time on YouTube watching music videos, the algorithm is going to suggest new music videos for you, but if you tend to watch screencasts of people gaming those videos are going to be recommended.

Explain to students that while it might seem like algorithms are neutral because the decisions are being made by a computer, these algorithms are actually biased because the humans that create the algorithms can write their own biases into the programs based on decisions they make about the algorithm. A lot of algorithms also use data from the past. Since we know that the past and present include many continuing examples of structural racism, this data can encode negative biases. This results in **Algorithmic Bias**. Algorithmic bias is an example of a Threat to Techquity because it is a technology that can cause inequality within our society.

Introduce today's activities: learning more about algorithmic bias by reading some background information and investigating algorithmic bias in image search results.

Explore

Algorithmic Bias in Image Search Results (40 minutes)
As a class, watch Bias in Search Algorithms. Then, explain to students that they are going to learn more about algorithmic bias through a reading. Distribute either Even Kids Can Understand that Algorithms Can Be Biased or Racial bias can impact the formulas doctors use to decide how to treat their patients (Newsela) to students to read independently. If time permits, once students have completed their reading, have them complete the algorithmic bias quick comprehension check or comprehension questions on Newela.

To further explore the algorithmic bias the students have read about, students complete the Algorithmic Bias in Image Search Results activity. Students can work individually or with a partner.

Note: Due to the pushback about image searches that Google has received, there are improvements made to specific searches. Before assigning this task, check to ensure the bias is still visible within these specific search terms and adjust the

	terms as necessary to depict searches where the bias is prevalent.

While **incorporating both computing and Techquity concepts** into the conversation, Mr. Johnson elected to use definitions different than those in the lesson plans. Although the lesson plans provided definitions of “bias” and “algorithm,” Mr. Johnson selected definitions he found online. Finally, Mr. Johnson removed the reading about algorithmic bias from the lesson. Although he completed the other two portions of the “explore” section of the lesson plan (the bias in algorithms video and exploration of image search results), he did not have students complete the reading or comprehension questions. This affected the **incorporation of both computing and Techquity concepts** as well as **students engaging with Techquity topics.**

These adaptations were likely a result of several factors. The first is the **novelty** of the topics. As Mr. Sanchez identified (Table 4-5), students at the school did not have extensive prior experience with computer literacy or computer science. While they had engaged in some introductory computing in Mr. Johnson’s class prior to beginning the Talking Techquity curriculum, terms like “algorithm” were likely new to the students in the class. Additionally, the discussion was affected by students’ **engagement level**. Despite Mr. Johnson leaving wait time and trying to engage individual students, most questions went unanswered until Mr. Sanchez stepped in or Mr. Johnson selected one student to answer. Some questions went completely unanswered. In the moment, Mr. Johnson attempted to increase engagement via different engagement strategies with students, such as allowing answers through various modalities (i.e., out loud or via chat) and alternating between calling on specific students and asking for volunteers. Despite this, in an interview after the unit, Mr. Johnson shared,

> We're distance learning so one of the biggest challenges that [we] have...faced, and we knew that was coming, was just student engagement...You want students to be engaged and it's hard to tell how engaged they are. Then again, sometimes it's not, so that to me...was the challenge, just to keep them engaged enough…to keep them engaged long enough to grit through the challenges of Scratch when it comes to coding, to grit through that, so that they can...smile at their...end result.

This engagement level is likely intertwined with the following factors: the **environment**, online learning due to the **COVID-19 pandemic**, and the fact that students were learning from home and, therefore, were affected to a greater degree by their **home lives.** Although not in this lesson, in other observations, Mr. Johnson responded to students unable to turn on microphones because of noise in their house or malfunctioning technology. Even in this example, it is possible to see how technical difficulties slowed down the class and provided an interruption when the video would not play. These technical difficulties, as well as the time it took students to navigate their assignments and computers on their own, affected the **time** available for the lesson and for students to complete activities. The adaptations were also affected by Mr. Johnson's own **self-efficacy** with regards to Techquity content. His confidence in being able to both have a conversation about equity in general and Techquity more specifically supported his use of discussion-based learning (Table 4-

5). This confidence is likely due, in part, to the alignment between the curriculum and the school's **organizational goals** to discuss equity with students.

Adaptation Example: Use-Modify-Create Sequence in Scratch

It's the second day of unit 2 of the Talking Techquity curriculum. Earlier this week, students explored the collection and use of data online. Now, it's time for them to jump into Scratch, the block-based programming environment where they are writing computer programs. As Mr. Johnson begins, only six students are in class, less than half of the number usually present. Mr. Johnson asks a student to read the objective for the day: "In this lesson, I will learn about one-way synchronization using message passing between two sprites using broadcast & receive blocks while modifying a Scratch Project." Mr. Johnson explains that the class might not get to the "modify" project today, but that they will complete the TIPP&SEE worksheet as a class. Mr. Johnson introduces the vocabulary words "message passing" (sending and receiving messages between sprites that trigger specific scripts or actions) and "one-way synchronization" (message passing that goes in one direction from one sprite to another without a returned message). Then, he explains that the class is going to see how these programming concepts work and shares the agenda for the day: (1) watch a video about one-way synchronization; (2) download the worksheet form Canvas (their school's learning management system); (3) open the associated Scratch project; (4) complete the assignment as a class; and (5) discuss. He emphasizes that "everyone will get done today; we don't want anyone lagging behind." According to Mr. Johnson, the class will complete the worksheet together to support each other and learn from one another.

Mr. Johnson plays the Scratch Encore Module 6 "Engage: One-Way Synchronization" video on YouTube. When a student can't hear the audio, Mr. Johnson instructs her to leave class and come back, because her technical difficulties are likely caused by her Wi-Fi connection since everyone else can hear. After showing the video, Mr. Johnson models how to split his screen with the Scratch project and TIPP&SEE worksheet. He instructs students to do the same and follow along. By calling on students, he has them read the questions. Mr. Johnson demonstrates the project as instructed by the worksheet and then asks students which answer to circle from the worksheet. To encourage participation, he offers participation points for students who volunteer. Mr. Johnson talks through the answers as the class completes the worksheet and demonstrates what happens with each new block and concept. Once the class has completed the worksheet together, Mr. Johnson instructs students to save it and upload it to Canvas to make sure they get credit for the assignment. He gives students the remainder of class to finish work from prior classes.

The next class period, Mr. Johnson begins by sharing the objective of the day: "In this lesson, I will revisit one-way synchronization & message passing between two sprites using broadcast & receive blocks while modifying a Scratch Project." He points out that the vocabulary of the lesson is the same as the previous lesson: one-way synchronization and message passing. Mr. Johnson provides students with a link to the Scratch project they will be modifying and gives instructions to decide what product the students want to sell online as a marketer, to remix the project, and to modify it. He demonstrates the process on his screen, making sure to show students *how to share their projects. He asks students to share what they would sell in the Microsoft Teams chat, then transitions back to Scratch to demonstrate what students will do with their ideas. He demonstrates for students how they can copy codes between sprites to personalize the project by adding new sprites without losing the sample code. Mr. Johnson gives students 15 minutes to work on their projects. While students are working, he troubleshoots with a student who needs additional support by having her share her screen and talking her through the steps. At the end of the work time, Mr. Johnson brings the students back together and tells them they will continue working in the next class. He encourages students to attend office hours on Wednesday (when students do not have any scheduled classes) if they need additional assistance.*

Students continue to work on their "modify" projects in the next class, with Mr. Johnson checking in with students and helping them individually by sharing their screens. He emphasizes students "remixing" the project and making it their own. Mr. Johnson asks students for status checks throughout the work period, asking students to share how they are doing aloud or in the chat and providing support as needed. Students will share their projects in the next class.

This example demonstrates two major adaptations to the lesson plans of the second unit of Talking Techquity (Table 4-7): completing the "use" activity with the TIPP&SEE worksheet as a class and removing the "create" project to provide more time for students to continue the "modify" project. These changes affected several the critical components within the curriculum. Broadly, it affected the structural-procedural components of **scaffolding using use-modify-create** and **including all**

lesson segments and lessons in order. By removing or changing portions of the use-modify-create pedagogical approach, he adjusted part of the scaffolding built into the unit. Modeling TIPP&SEE and completing the worksheet as a class rather than having students complete it individually or in pairs also changed how **students viewed, manipulated, and created code in Scratch**. Rather than students manipulating the project themselves, they watched the Scratch environment being manipulated. While students were given the link to view the project on their own, they did not need to do so to complete the assignment. Additionally, the completion of the worksheet as a group shifted the **discussion-based learning** from reviewing answers to being completed as the class worked through the questions rather than as a review at the end (as described in the lesson plan). While the adaptation to the "use" portion of the lesson affected how students interacted with Scratch, this adaptation, as well as the demonstration of the "modify" project, increased modeling, affecting the **use of Scratch for computer science learning**, particularly from the pedagogical standpoint. Adapting the "modify" project also provided students with increased opportunities to **incorporate topics of relevance** as they decided what they would sell and completed the project. This was an optional extension in the original "modify" project tasks but was not a requirement for students. Yet, this shifted focus within the lesson to individualizing the "modify" project rather than completing the tasks to modify the code (e.g., experimenting with and adding one-way synchronization through message passing). With this focus, students were able to show how to copy code between sprites to help them complete the project, but this limited the number of scripts they built themselves.

Table 4-7. Relevant portions of Talking Techquity Unit 2, Lessons 2 and 3

Lesson 2: Exploring One-Way Synchronization
Lesson Overview
In this lesson, students are introduced to the concept of one-way synchronization with message passing between two sprites using broadcast [message] and when I receive [message] blocks. Students modify Scratch projects to use both one-to-one and one-to-many synchronization with message passing.

Explore

Using TIPP&SEE (50 minutes)
Students open the One-Way Sync: Online Data Collection (https://scratch.mit.edu/projects/490453259/) project. Remind students to use the TIPP&SEE strategy: Read the **Title**, **Instructions**, and **Purpose** of the project, **Play** it and notice what is happening. Pay particular attention to the actions that happen for each event. Click See Inside to show the **Sprites**, **Events**, and **Explore** the code. Students should pay particular attention to the blocks that are used for the events and actions inside the scripts.

Have students complete the One-Way Sync TIPP&SEE Worksheet. Explain that they will use the TIPP&SEE Strategy to preview and help them understand the program. They will Explore the project by making a set of modifications designed to reveal information that will be useful as they start to modify and create code.

Once students have finished, as a class, discuss the importance of sending and receiving the same message name in a project, and that the same message can be broadcast by one or more sprites - or received by one or more sprites. Discuss the Explore the project! tasks to uncover some of these ideas.

> On the Buy Button sprite, you created a new message in the broadcast block, "Go". Did the Recommendation appear when you clicked the Buy Button? *[No, the Buy Button broadcasted "Go!" but the Recommendation didn't appear. The message "Go" was passed, but the Recommendation sprite was waiting for the message "Buy."]*
>
> On the Buy Button sprite, you changed the receive message to "Go." Did the Recommendation appear when you clicked on the Buy Button? *[Yes. The Buy Button passes the message "Go" and the Recommendation receives it and appears.]*
>
> > When one sprite sends a message and another receives it and carries out an action - this is called **one-to-one synchronization**. A message is sent by one sprite and received by one sprite.

You created a new script for the Ads sprite that received the message "Go." What did the Ads do when you clicked on the Buy Button? *[When the Buy Button is clicked, the other sprite appears, too! Two sprites are receiving the same "Go" message.]*

When more than one sprite receives a message sent by another sprite, this is called **one-to-many synchronization**. A message is sent by one sprite and received by many other sprites.

You created a new script for the Search Button sprite that broadcasted the message "Go". What happened when you clicked on the Search Button? What happened when you clicked on the Buy Button? *[Now, the Ads will appear if either the Buy Button or the Search Button is clicked. The Recommendation does the same actions because both the Buy Button and Search Button send the same message.]*

Modify Project (50 minutes)
Pass out the [One-Way Sync: L2 Student Sheet](). Remind students to **R**oa**R** and h**iSS** (**R**eload, **R**emix, **S**hare and +Add to **S**tudio) the One-Way Sync: Online Data Collection project: https://scratch.mit.edu/projects/490453259/. Remind students that they need to share the project so it is accessible to you and others.

In this activity, students will modify the project to do the following:

- Finish the costumes for the Search Button and Ads with something you would search for and ads that might appear.
- Make it so that when the Search Button is clicked: the Search Button changes costume and makes a sound AND the Ads appear on the stage.
- Make the Start sprite show and have it start all the sprites at once. When the Start Sprite is clicked: the Buy Button changes costume and makes a sound AND the Recommendation appears AND the Search Button changes costume and makes a sound AND the Ads appear on the stage.

Make sure students have tested their projects for correct functionality.

Lesson 3: Creating with One-Way Synchronization
Lesson Overview
Students develop a project about or using data and utilizing One-Way synchronization in an open-ended create project.

Explore
Create Project (100 minutes)
Introduce today's activity: To create a new project that uses one-to-many synchronization to shares about using data collection or suggestions and advertising

online. Students may choose a project of their choice. Pass out the One-Way Sync: L3 Student Sheet to give students guidance throughout the project.

To complete this task, students will:

- ❑ Plan the one-to-many interaction: what actions will the sprites carry out when another sprite is clicked?
- ❑ Complete the graphic organizer to plan their one-to-many synchronization.
- ❑ Add 5 sprites and a backdrop to a new Scratch project.
- ❑ Create a one-to-many interaction that includes 4 sprites that do something when another sprite is clicked - one sprite sends a message that is received by all the other sprites.

Explain to students that they can create any project that is interesting to them about online data collection, but some ideas are:

- Imagine that you are working for a marketing company. Use the data collected about what your class likes to create a project that demonstrates marketing to youth of your age. Think about what data you would collect and the resulting ads or suggestions.
- Think about online data collection in your life. Create a project that shows where you receive ads online or in apps based on choices you have made.
- A topic of students' choice!

Students can also look back at the Product Marketing Plan they created in lesson 1 for ideas.

Remind students to run their project to test that it works as expected. Remind students that they need to share the project so it is accessible to you and others.

The most significant adaptation was the removal of the "create" project at the end of the unit. Rather than having students start a new project from a blank project and create it from nothing, Mr. Johnson elected to have students continue working on their "modify" project. As previously mentioned, this modification interrupted the **scaffolding using use-modify-create** within the curriculum and the opportunity for students to move from a project around which they had only some control and choice to a project in which they could make decisions about both how they wanted to incorporate the computer science concept (in this case, one-way synchronization) and the information they wanted to share. This also limited the **incorporation of both computing and Techquity concepts** and students' ability to **engage with Techquity topics** because the "create" project includes options that invite students to develop a project sharing Techquity information with the audience.

The implementation of unit 2 of the Talking Techquity curriculum was affected greatly by the **complexity** of the curriculum, particularly in the second unit. These concerns included a combination of the content covered as well as the speed at which that content was covered. Reflecting on the second unit, Mr. Sanchez noted, "*I don't know if it's too much too quick, like the pace of it...because right now kids…are still having issues...we don't want to set up kids for failure.*" Mr. Johnson made adaptations to the implementation of unit two that decreased the overall complexity of the content (e.g., completing a worksheet as a class and only completing the "modify" project and not the open-ended "create" project). In a short debrief after the class in which he presented the second lesson (where he led the class through completing the TIPP&SEE worksheet), Mr. Johnson explained that he had adapted the lesson because he wanted students to feel successful, echoing the comments of Mr. Sanchez. He chose the walkthrough to emphasize how things worked rather than focusing on definitions. Since students had been struggling to turn in assignments, he wanted the class to complete the assignment together to ensure everyone could do it and learned the information.

An element of added complexity was the **modality** in which students were completing the work and the overall **environment** of online learning, two elements that affected the overall **ease of use** of the curriculum and platforms that the students were using. As mentioned in the example, students faced technical difficulties and had questions about implementing what they wanted within Scratch. Mr. Johnson could not be there with students to see what was happening and help. He needed to stop class to troubleshoot something happening on students' computers. This occurred by sharing the student's screen and talking through the challenge, but this was much more public than in a face-to-face setting. Whereas the teachers described their normal classroom behavior during similar activities as walking around the room, being able to see what was on students' computer screens, and providing support one-on-one for students, this was not possible in the online environment. This was difficult for both teachers, who prided themselves on supporting students. Mr. Sanchez noted, "I wish we could be in person to help the kids when they struggle."

As mentioned in the previous example, student **engagement** and **presence** were ongoing challenges. When Mr. Johnson started the first lesson described in the example, only six students were in class. After lesson 3 (the first lesson where students worked on their "modify" project), Mr. Johnson shared that students were really struggling and had fallen behind. Some students had missed class while others were just not making connections between the lessons and transferring that knowledge. Even for the students who attended class, **patience and persistence** was a continued factor affecting the implementation. Mr. Johnson discussed trying to do all he could to support students, but they did not ask for help and did not respond when he asked. At their cores, many of his adaptations were designed to increase **supportiveness** and help students overcome other factors of the curriculum, including its complexity. Speaking about the modifications he made to the second unit of the curriculum and the choice to have students continue the “modify” project rather than begin a new “create” project, Mr. Johnson explained,

> We chose to modify that project because of…I would say [a] couple things: absence...student engagement, and...all those things tie into whether the student’s going to understand the lesson or not and thoroughly...wrap themselves around the tools that you give them to help them understand that particular skill in Scratch...That’s the reason why I decided...to let them, ‘hey, we’re going to give you this to work with’ ...because I believe that starting from scratch...things would have been kind of everywhere. I think we would have seen a combination of unit 1 and then we would have probably seen some things that really weren’t...tied to the skill that we were trying to teach when it came to Scratch. So I figured they needed...a launchpad.

For Mr. Johnson, creating a supportive launchpad within the innovation was a way to increase student success as they were influenced by several different factors. His adaptations and implementation of the curriculum continuously focused on supportiveness and helping his students be successful and do well.

Discussion

Education researchers and curriculum developers need to not only create curriculum, but also understand how it is implemented and what affects those implementations. In this paper, I answer two research questions: (1) When implementing co-designed lessons, how does a teacher who co-designed the lessons adapt them for the classroom environment? and (2) What factors influence a teachers’ adaptation of co-designed lessons when implementing them in the classroom environment? I found that Mr. Johnson made adaptations across the majority of the critical components identified within the curriculum (11 out of 16), including structural and interactional components. He made modifications to structural-procedural, interactional-pedagogical, and interactional-learner engagement components. The adaptations affected both implemented units as well as the final project, including how Mr. Johnson presented material and the work students completed in the class.

The adaptations Mr. Johnson made were triggered by his perceived need based on 24 factors. These factors include all five categories of the factor framework (Century & Cassata, 2014), including characteristics of the innovation (Talking Techquity); users (teachers and students); the organization (the school); the external environment (U.S. and global events); and networks (within and outside the school). All 24 factors were based on needs that were realized or more pronounced in the implementation as compared to what was expected during the design sessions (e.g., the complexity of the material, student engagement level, and the impacts of teaching in an online environment due to the COVID-19 pandemic). Within this research, many of the adaptations were spurred or exacerbated by the online learning environment. Yet, as described in the opening vignette, Mr. Johnson worked to make his classroom a welcoming and inclusive space for his students. He did all he could to engage each of his students and give them a space in the room. Based on his focus on meeting his students' perceived needs, I posit that no matter the classroom environment, Mr. Johnson would have adjusted the curriculum to ensure it was supportive to students. Although factors may differ, particularly in how they present themselves and how they might be addressed differently in a face-to-face learning environment, there would likely be a need to adjust for unpredictable and unexpected factors that arise in the moment. It is possible that, during the design phase of creating a curriculum, teacher beliefs about students' needs differ from their beliefs about students' needs while implementing the curriculum (when they can perceive said needs in the moment).

Based on these findings, despite being a designer of the original curriculum, Mr. Johnson needed to make in-the-moment or mid-unit adaptations based on the context of the classroom that could not be predicted within the design environment. Co-design with teachers is motivated by the ability to incorporate the expertise and experiences of teachers and to better align innovations to their context and needs (Penuel et al., 2007; Scaife et al., 1997). However, as past research has also found, this method of innovation development does not mean that teachers do not need to make adaptations to co-designed curricula upon implementation, particularly when the innovation is scaled (DeBarger et al., 2013; Ye et al., 2014). The current work demonstrates that the perceived need for adaptations remains even when the design team is small and focuses on developing an innovation for a single context in which the teachers already work.

These findings surface several tensions that warrant further exploration and research. First, because the design sessions occurred while the teacher design partners were teaching in an online context, a tension arose between designing for the current virtual setting and designing for future in-person implementations. While the curriculum was being designed for use during online learning in the current school year, the plan was to use the curriculum in future years, likely once students had returned to the classroom and face-to-face teaching resumed. Mr. Johnson and Mr. Sanchez discussed future use of the curriculum (both in the next school year and 10 years in the future, as Mr. Sanchez references when discussing the adaptability of the curriculum in Table 4-5) and how the curriculum could work differently in an in-person setting. The consideration of two settings generated a tension between creating something supportive for the current environment while not atypical of curricula implemented within face-to-face environments. The fact that all three designers (the two teachers and I) mostly taught in in-person contexts previously exacerbated this tension. As a result, the default in every conversation was to design lessons as we typically would for an in-person context rather than to design lessons for a virtual context. It was not until after the units were created that virtual-friendly versions of worksheets were made for the students and Mr. Johnson created his class presentation based on the unit plans.

A second tension was how to ensure that adaptations were aligned to both teacher and researcher goals. Since this and past research has shown that adaptations are perceived to be necessary even when teachers are part of the design team, focus within co-design teams needs to include methods for ensuring these adaptations are in alignment with the goals of the curriculum. According to DeBarger et al. (2013), when productively adapting a curriculum, teachers need to: (1) be responsive to multiple stakeholders; (2) make adaptations that reflexively relate to responsive discourse practices; and (3) maintain or enhance task complexity and engagement. Co-design inherently works toward some of these criteria. The adaptations made by

Mr. Johnson aligned to the first two requirements of productive adaptation according to DeBarger et al. (2013), but they did not necessarily align with the third (maintaining the complexity of the tasks). As described in the second example, when adapting the second unit, Mr. Johnson removed the final stage of the use-modify-create pedagogical approach. This stage, "create," is the most complex of the tasks and requires students to program a project from nothing rather than using model code (like what is available during the "modify" task). Further, by focusing the "modify" task on customizing what was marketed rather than on coding-centered goals, the adaptations simplified the complexity of this task.

Not only did some of the adaptations decrease the complexity of the task, but the adaptations did not always align with the researcher goals for the project. As mentioned previously, Mr. Johnson and Mr. Sanchez both supported the broadening of computer science education and providing a more equitable learning environment and more equitable educational outcomes for students. I was the main proponent of focusing those equity goals on educating students about Threats to Techquity specifically. Throughout the design sessions, we discussed goals for the work and elements to include within the curriculum. A balance of these elements was agreed upon and included within the final unit plans. But Pintó (2005) found that, when implementing an innovation and making adaptations, teachers "often demote the goals of innovation designers" (p. 8). In the present work, when teachers were part of the design team, the goals of the non-teacher designer, who did not implement the curriculum, became less salient in the moments when Mr. Johnson needed to make implementation decisions. As described in the findings, Mr. Johnson made modifications to the curriculum to increase scaffolding for students and help them to be and feel successful with the topics covered, but these modifications decreased opportunities for students to engage with Techquity topics. The contextualized and in-the-moment adaptations created a tradeoff between the original design goals, particularly those of the researcher, and Mr. Johnson's perception of student needs when actually implementing the curriculum.

When examining the adaptations made to Talking Techquity, there was a third tension between a pro-adaptation perspective of innovation implementation (Century & Cassata, 2016) and the changes created by the adaptations. A pro-adaptation view sees the adaptations to curricular innovations that teachers make as contributing positively toward the outcomes of the implementation because the adaptations can align to strategies the teacher knows to be effective with the students they are teaching and can add contextual relevancy to the curriculum. Throughout this work, I adopted this pro-adaptation view, viewing adaptation by the teacher as necessary to personalize lesson content to student needs. Yet, at times, the adaptations made by Mr. Johnson to create a more equitable learning environment appeared to have also countered some of the goals he helped set for the curriculum. For example, whereas in the design process Mr. Johnson advocated for inclusion of students' interests, student autonomy, and choice (as seen in the critical components), some curriculum modifications resulted in fewer opportunities for students to personalize their projects, have agency over their work, and use creativity within the curriculum. Due to the factors affecting the implementation, Mr. Johnson needed to make contextualized adaptations that were impossible to predict during the design phase of the process, causing a change in the methods he felt were necessary to best support his students. This can be seen in the second example provided in the findings. Students had fewer overall choices when they did not have the "create" project. Therefore, it is possible that Mr. Johnson's attempts to make the curriculum more equitable actually led to less personalization because of the elements that he removed. Yet, Mr. Johnson removed the "create" project because he felt that students would not be able to meet the project objectives and did not want them to be given a task that would be difficult for them to accomplish given their progress on earlier stages of the use-modify-create approach. While Mr. Johnson perceived that students needed to have less complexity in the tasks they were completing and he wanted to provide students with opportunities to feel successful, whether these adaptations were positive or not depends on the set of goals used to measure success and requires consideration of how goals changed based on factors affecting them. A blanket pro-adaptations stance might not be a beneficial means for considering adaptations to curricula. More scaffolding and support might be needed to ensure teachers can select positive adaptations and that they have ways to measure the success of adaptations as they are being made. Simultaneously, researchers need to understand the evolving goals teachers have and how this might affect the definition of success within the curriculum or specific lessons.

Implications

To alleviate these tensions, both the researchers and teachers on design teams need to receive professional learning opportunities from the other participating designers. For researchers, this professional learning should center around learning more about the contextual constraints and norms in which the teacher operates. Receiving this professional learning from the teachers and other sources will allow researchers to support teachers as they are designing and implementing the curriculum; will help legitimize and validate the experiences of the teachers for the researchers; and will modify researcher goals to align with the constraints. For teachers, this professional learning should center around the philosophy of the curriculum or innovation, what the researcher goals are, and the past research in which the goals are grounded. While this professional learning could take a variety of forms, it should include explicit conversations about the following: the context for which the co-design team is designing and how that context relates to present and future implementations; the critical components and curriculum goals that should not be changed; and how to align modifications to teacher and researcher curricular goals even when decisions need to be made in the moment.

Based on this work, it is recommended that teams have ongoing and explicit conversations about contexts and design goals. In addition to familiarizing researchers with the specific contexts and constraints that exist within it, this conversation should include whether the innovation being designed is for the current context or a future one and, if necessary, discuss how to balance these goals. This is particularly important if the current and future environments will differ significantly, as was true in this work, where current implementation occurred online but future implementation would be in-person.

Additionally, within this work, our design conversations did not include explicit identification of aspects of the curriculum that should not be adapted.

Although we designed together, either the small group meetings were insufficient professional learning for the teachers to be aware of the researcher goals or factors within the implementation led to prioritizing goals in the moment, with the perceived immediate needs superseding previously established goals. Co-design projects need to add conversations that purposefully identify critical components and discuss adaptations to support teachers in adapting a curriculum in a way that improves it and ensures the adaptations reflect the goals of teachers and researchers regarding the innovation. While the co-design process makes the critical components of a curriculum more explicit than a curriculum simply assigned to a teacher, these explicit conversations about the critical components need to take place during the design sessions to ensure researchers and teachers align in their identification of critical components. As Pintó (2005) highlights, within these conversations, it is important to focus not only on the critical components, but also on the rationale for them and their value.

Finally, the conversations should focus not just on meeting the initial goals of the curriculum, but also on ensuring that adaptations support student learning. Prior research has shown that teachers can make problematic transformations to curricula based on their own misconceptions or lack of knowledge (Pintó, 2005). Given prior research and the findings of this current research showing teachers adapt co-designed innovations whether they are designed for a small- or large-scale implementation, co-design conversations could be essential in making sure that when teachers adapt, they do so in ways that enhance the innovation. Simultaneously, the conversations should ensure that researchers understand how design goals might change based on the specific moment in which they are being made and what is happening in the classroom. This could include design goals evolving over time as the curriculum is implemented and necessitating iterations upon the co-designed curriculum based on needs identified within the implementation phase of the work.

Limitations and Future Work

This study was purposefully completed on a small scale. While this allows for the deep examination of one implementation, further research is needed to determine whether similar trends occur in other co-design teams and settings. Given that the teachers themselves think implementing the curriculum in person will be different than online, future work could examine the implementation of the Talking Techquity lessons in a face-to-face teaching setting and the adaptations made when using it in this manner. From the factor findings, it is apparent that the learning environment had a significant impact on the implementation and led to adaptations; thus, future work could examine whether the adaptations remain the same as the learning environment changes. Additionally, further research should examine whether there is a relationship between the adaptations and factors and the content area or technology used within the adaptations. Within this work, the implementation used an equity-focused computer science curriculum within a required enrichment class. Since the critical components of each innovation will be different, it is likely some of the adaptations will be as well.

Although students were invited to participate in the research, no parents or students completed and returned consent or assent forms to be part of this study. Only having teacher research participants limited my ability to make claims about the outcomes of this innovation implementation and prevented the inclusion of student voices regarding the implementation of the curriculum. As such, this research is focused on data collected from and with the participating teachers. Future studies should consider student outcomes when implementing the Talking Techquity curriculum and how teacher adaptations affect those student outcomes.

Finally, since it is routine for teachers to make modifications to lessons in their classrooms, particularly lessons new to them, future research could consider how, if at all, the amount of adaptation needed for a curriculum is different when the curriculum is co-designed verses when a curriculum is created without teacher input. It could also explore whether there are trends in adaptations or the amount of adaptation across a larger group of teachers implementing the curriculum.

Conclusion

Even when teachers are core members of the team developing an innovation through co-design, they make adaptations when implementing that innovation due to ever-evolving factors that influence their students, classrooms, and teaching. Knowing how a teacher adapts a curriculum can prevent changes to the curriculum based on their misconceptions or lack of knowledge by illuminating professional learning necessary during design sessions or professional development. The findings presented in this paper further implementation research knowledge of the adaptations teachers make when enacting an educational innovation by further considering the context of a co-designed innovation. It supports future co-design efforts with teachers by providing an understanding of the contextualized and in-the-moment adaptations necessary with a co-designed curriculum, the reasons why teachers make those adjustments, and the methods for ensuring curricular integrity while designing for teacher adaptation. Co-design of innovations is a key method for including the voices of teachers in the development of innovations they will be using, but further support is needed to ensure that as teachers make necessary adaptations to fit their contexts, they do so in ways that enhance the innovation in alignment with both teacher and researcher goals.

Chapter 5: Discussion

We live in a technological society where adults and youth are in perpetual contact with technology, including with internet-connected devices. Even without devices, technology still constantly affects people's lives. The omnipresence of technology and its effects leads to Threats to Techquity, or those aspects of computing and technologies that cause or could cause inequalities, especially inequality based on marginalized identities. This design study brought together teachers and students to develop a curriculum that would allow for effective Techquity education. Specifically, I co-designed a curriculum to teach students about Techquity alongside computer science. Using participatory design methods, I collaborated with a group of eight youth using cooperative inquiry (Druin, 1999, 2002) to understand how youth conceptualize Techquity and their design preferences for learning experiences about Threats to Techquity. I also partnered with two teachers to co-design the curriculum. Finally, I observed while one of the designing teachers implemented the curriculum in his classroom with the support of the second teacher.

Overall, this work was guided by three main goals: (1) teach students about Threats to Techquity, an important and often overlooked aspect of computer science; (2) give students opportunities to critically consider the negative impacts of technology on their lives; and (3) provide an example for how Techquity can be brought into middle-grade classrooms in a responsive way. In working toward the first goal, the resulting curriculum integrated computer science lessons using Scratch with the Techquity content. Following the model of Scratch Encore (Franklin, Weintrop, et al., 2020), relevant Techquity topics were used as themes within the computer science lessons to make those connections. To work toward the second goal, each unit not only included Techquity topics as themes for the computer science lessons, but also began with a first lesson that provided hands-on opportunities to learn about a specific Threat to Techquity. Students both viewed a Threat to Techquity and considered that threat specifically within their lives. The three units introduced students to algorithmic bias through image search results, online data collection and data use, and bias in machine learning algorithms (such as facial recognition and the algorithms in self-driving cars). Finally, working toward the third goal, this project utilized varying design techniques with both youth and teachers to gain an understanding of their knowledge and conceptualizations of Techquity as well as how to design the lessons. These understandings were factored into the design process, which resulted in the creation and implementation of the Talking Techquity curriculum (Appendix), a three-unit, middle grades (5th through 9th grades) curriculum constructed of 12 lessons and a final project. The curriculum focuses on teaching introductory computer science and programming using the Scratch block-based programming environment while simultaneously introducing students to common topics in algorithmic and technological bias.

Techquity in the Classroom

In this three-article dissertation, I presented independent manuscripts from each of the three phases of the work that aligned with the overarching goals. Chapter 2 explored youth conceptualizations of Techquity and Threats to Techquity, how those conceptualizations changed as youth learned more about Threats to Techquity, and how youth conceptualizations of Techquity played a role in their design of learning scenarios around Threats to Techquity. The chapter answered the following research questions: *(1) How do youth conceptualize Threats to Techquity in their lives? (2) How do youths' perceptions and examples of Threats to Techquity shift after being introduced to examples of technological bias?* and *(3) When designing to teach peers, how do youth present Techquity and Threats to Techquity?*

Chapter 3 explored how youth and teachers designed around the specific Threat to Techquity of online data collection and data use. Focusing on one specific Threat to Techquity, the paper explored the instructional priorities and topics of salience to both groups. I considered the similarities and differences between teachers' and youths' priorities and topics and explored how the youth and teacher ideas could be traced to the curriculum itself. The chapter answered the following research questions: *(1) What topics and instructional priorities do youth consider and determine to be most salient when designing middle grades learning materials about online data collection and use? (2) What topics and instructional priorities do teachers consider and determine to be most salient when designing middle grades learning materials about online data collection and use?* and *(3) How can youth and teacher topics and instructional priorities be integrated into a curriculum presenting online data collection and use?*

Finally, chapter 4 investigated the implementation of the curriculum and how the implementing teacher, one of the co-designers, made adaptations to the curriculum. The paper considered both the adaptations made and the factors that contributed to those adaptations. The paper answered the following research questions: *(1) When implementing co-designed lessons, how does a teacher who co-designed the lessons adapt them for the classroom environment?* and *(2) What factors influence a teachers' adaptation of co-designed lessons when implementing them in the classroom environment?*

Participatory Design in the Talking Techquity Curriculum

Participatory design has been previously demonstrated as a productive tool for developing novel learning experiences and curricula (Coenraad, Palmer, et al., 2021; Lui & Slotta, 2014; Pinkard et al., 2017; Proctor & Blikstein, 2019). In the past, it has been used to develop narratives within learning materials (Pinkard et al., 2017), tools (Proctor & Blikstein, 2019), and curricula (Franklin, Weintrop, et al., 2020). This work extends prior successes with participatory design in identifying both what is important and influences youth (Coenraad, Weintrop, et al., 2021) and how to integrate those important influences within a curriculum (Coenraad, Palmer, et al., 2021). Participatory design was an essential part of the design process within this work. The design scheme centered the designs and ideas of the future users of the curriculum (teachers and students) and created a more equitable design process and educational experience through the participation of teachers and students. While teachers often act as learning designers, creating lessons for them and their students within their contexts, youth are not always part of the process. Cooperative inquiry specifically counters this by shifting children from the role of technology consumer to that of technology creator (Druin, 1999; Guha et al., 2013), a role shift supported within computing education (Resnick et al., 1996). Including youth, as this project did, also allows the range of youth's ideas and influences to be included within designs (Coenraad, Weintrop, et al., 2021) and ensures their ideas are represented; this is particularly important because adults do not always accurately represent what youth want or need (Druin, 2002).

Previous research focused on the integration of just students, just teachers, or students and teachers together (Coenraad, Palmer, et al., 2021; Penuel et al., 2007; Pinkard et al., 2017). In the current work, success was found by working with youth and teachers separately to ensure that their unique sets of knowledge were included in the curriculum. The roles that the co-designers took within the design process (Druin, 2002) were constrained primarily by the time the designers had to commit to the project and the duration of the project. While the youth designers participated in an intergenerational design team that met twice per week (Guha et al., 2013) and, therefore, had more time to engage with design ideas and a longer timeline on which to work, the teachers were constrained to meeting only during the extra time they had during the school year. As such, the teachers were not able to build parts of the curriculum; instead, they provided ideas for and feedback on the curriculum I created.

One consideration for projects that seek to design with both teachers and students revolves around how the groups interact. Despite the success of the groups designing separately to ensure all voices and ideas were heard throughout the process, the structure required a designer to act as an intermediary between the groups instead of having the groups represent their own ideas. This role introduced the intermediary’s biases into what information was presented to each group and prevented dialogue between all the designers. It also placed more power on the intermediary, granting them knowledge not shared by all participants. This top-down power imbalance between designer and user is something participatory design aims to prevent (Penuel et al., 2007). Therefore, in future work, researchers and co-designers should consider other ways to balance student and teacher voices, potentially by having the groups meet at strategic points in the process to share their own ideas with each other, thereby eliminating the need for an intermediary.

Constructivism in the Talking Techquity Curriculum

This work demonstrated both how constructivism informed curriculum development throughout the entire process from conceptualizations to the classroom, particularly when paired with participatory design, and the importance of youth voices in developing a constructivist curriculum. Drawing on the work of Piaget (1964), the Talking Techquity curriculum builds on youths' conceptualizations of Techquity in order to ground the work on their foundational understandings. Then, highlighting the use of active learning and reflection to build knowledge, it explored the development of a Techquity curriculum that itself was constructivist in nature. Finally, when the curriculum was implemented in the classroom, the teacher constructed a learning environment around the constructivist curriculum and adopted the role of supporter and guide rather than that of all-knowing imparter of information. By attending to constructivist ideals throughout the work, the design of the Talking Techquity curriculum centered learners' current knowledge and opportunities to actively build new knowledge through hands-on experiences and reflection. It began with what youth knew and already understood and placed the teacher as a guide to support new knowledge development through activities and experiences.

A key component to this work was beginning with the conceptualizations of youth. As mentioned in the introduction, understanding learners' conceptions is essential to building upon their prior knowledge and jumpstarting their knowledge construction (Bada, 2015; Sjøberg, 2010). By grounding the early KidsTeam design sessions in revealing these understandings, I was able to use these conceptualizations when discussing the design process with the teacher designers and developing the curriculum. These early design sessions also demonstrated the importance of learner examples when making sense of Threats to Techquity.

Not only did the curriculum build on youths' current conceptualizations, but it did so while promoting ways the youths wanted to construct their new knowledge and providing opportunities for active learning, both of which are important parts of constructivism (Bada, 2015; Hoover, 1996; Piaget, 1964). By centering the lessons that covered Threats to Techquity on active learning experiences (e.g., viewing algorithmic bias through image search results), the curriculum aligned both to a constructivist theory for learning and to youths' preferences as shared in the design sessions. Similarly, by engaging students with the use-modify-create pedagogical strategy (Franklin, Coenraad, et al., 2020; I. Lee et al., 2011) and the TIPP&SEE approach (Salac et al., 2020), students built knowledge about computer science through experiences and were, therefore, able to learn through immersion in the Scratch platform. Due to lessons' tendency to emphasize active experiences, the role of the teacher as an expert was largely (although not completely) removed from Talking Techquity. This aligned with design features suggested by both youth and teachers and with core tenets of constructivism (Bada, 2015; Boudourides, 2003; Hoover, 1996).

One aspect of the Talking Techquity curriculum that I have not yet discussed was its incorporation of regular opportunities for reflection. Reflecting on prior knowledge and new experiences allows learners to build meaning and develop new knowledge (Amineh & Asl, 2015; Piaget, 1964; Sjøberg, 2010). In Talking Techquity, most lessons concluded with opportunities for youth to reflect on the information or skills they learned and to try to connect that information to their own lives and future ways they might utilize the skills. While some of this focus on reflection comes from the adaptation of the Scratch Encore curriculum (Franklin, Weintrop, et al., 2020), the existing opportunities for reflection in Scratch Encore were mirrored and expanded in both the Techquity lessons and the added lesson in which students presented at the end of each unit.

Constructivism and Participatory Design in Techquity in the Classroom

As referenced in the prior two sections, there was interplay between the constructivist and participatory design framings of this work. In the introduction, I identified three key interactions: the selection and participation of design partners, opportunities for designer learning, and understanding youth conceptions of Techquity. In addition, during the work, the interaction between constructivism and participatory design revealed a synergy between the design ideas and instructional priorities of the youth and teacher designers and constructivist theories. Together, these four aspects demonstrate synergies between the theories when developing novel curricula and the way they can be used in conjunction with one another to develop student-centered learning opportunities. In the following section, I limit my discussion to the selection and participation of design partners, opportunities for designer learning, and connections between design ideas and constructivism, since I discussed the importance of understanding youth conceptualizations earlier in this chapter.

Co-design was a central component of developing the Talking Techquity curriculum, particularly in identifying co-designed ideas that could be integrated in alignment with constructivism. Within this work, partnering a researcher with both youth and teacher design partners provided opportunities for the teachers to share their expertise in their unique contexts, learning goals, and larger systems (Penuel et al., 2007; Roschelle et al., 2006; Scaife et al., 1997). It also allowed for learning about youth interests and ideas that could be integrated into the curriculum (Coenraad, Weintrop, et al., 2021), their preferred learning modalities, and their conceptualizations of topics from the beginning of the design process. Particularly given the more significant impacts of Threats to Techquity on people with marginalized identities, this work included the voices of youth and teacher designers who identified as having marginalized racial identities. Additionally, there were parallels between the identities of the youth who developed the curriculum and the students in the classrooms where the curriculum was implemented. All eight of the youth design partners identified as Black, and 99 percent of students in the implementing school identified as having a minoritized racial identity (including 86 percent of students who identified as Black). This centered the work on youth most impacted by Threats to Techquity and amplified their voices and experiences within the curriculum, ensuring that the conceptualizations of Threats to Techquity in which the curriculum was grounded were likely to be aligned with those of the students who used the curriculum in the classroom implementation.

Not only was the Talking Techquity curriculum grounded in constructivism and designed to allow for constructivist learning, but the process of creating it also provided a constructivist learning opportunity for both the youth and teacher co-designers. Working as design partners allowed both groups to construct their own new knowledge about Techquity through conversations and the development of designs. As previously mentioned, youth developed knowledge of Threats to Techquity during the design sessions, and their participation provided opportunities to make visible previously invisible Threats to Techquity. Similarly, while the teacher design partners were familiar with the idea of Threats to Techquity and could name some examples (e.g., varied pricing in online shopping), they were not aware of the extent of the Threats to Techquity that exist within society. By designing together, youth and teacher design partners constructed new knowledge and designs that shared that knowledge. The small nature of the design groups allowed that new knowledge to be constructed based on the needs of the designers and provided opportunities for the designers to learn while creating the curriculum.

When designing, the youth designers and teachers expressed instructional priorities aligned with those of constructivism, with a particular focus on developing active learning opportunities (Bada, 2015; Hoover, 1996; Piaget, 1964). Not only is active learning an essential aspect of constructivism, but the importance of active learning was also echoed by the youth designers: they focused on immersive learning experiences and their desire to be active discussion participants instead of passive listeners to a teacher's lecture. The teachers also focused on students having active learning experiences, including by having them take on the roles of marketers, collect data about their classmates, and develop their Scratch projects using this data. Additionally, both groups of designers focused on relevance to students' lives and making connections between their known and lived experiences and the curriculum. Together, this understanding of youth conceptualizations and the interests and ideas of both the teachers and the youth was important from both a constructivist perspective (Bada, 2015) and the perspective of creating more culturally sustaining and responsive classrooms (Kapor Center, 2021).

Age Appropriateness of Techquity

A question that remains unanswered within critical computing opportunities is at what age students should be introduced to Threats to Techquity. Many existing critical computing opportunities (e.g., those that surface and highlight broad societal critiques, not just those related to technology) focus on high school students (C. H. Lee & Soep, 2016, 2018; Proctor & Blikstein, 2019). Similar opportunities to consider Threats to Techquity in artificial intelligence curricula are aimed at high school students (Clarke, 2019). That said, some opportunities are now being offered to students in middle school (MIT Media Lab Personal Robots Group & MIT STEP Lab, 2021; Payne, 2019), and critical computing opportunities have been designed for students as young as elementary school (*#CSforSocialJustice Lesson Resources*, 2020). This trend toward giving opportunities to younger students and building students' critical consciousness in elementary school aligns with culturally relevant pedagogy, which was developed based on elementary classrooms and holds critical consciousness-building as a central tenet (Ladson-Billings, 2009).

Within this work, I specifically chose to focus on middle grades students (5th through 8th grades, ages 10 to 14) in recognition of the Threats to Techquity to which they are already being exposed and must handle. While middle school students are largely still under the direct care of adults and rely on caregivers or family members for their transportation and other needs, they have an increasing presence on social media; this is particularly true because privacy laws in the United States permit youth to have social media accounts beginning at age 13 (*Children's Online Privacy Protection Rule ("COPPA")*, 1998), although many create accounts at younger ages. The designs of the youth designers, who were between the ages of eight and 13 when the design sessions started, demonstrated youth awareness of Threats to Techquity and their exposure to these threats through their own technology and that of their family members. While some designs differed slightly by the age of the designers creating them, youth of all ages could describe good and bad aspects of technology and hold conversations about Threats to Techquity, particularly once more invisible threats were made visible to them. Their initial conceptualizations and abilities to develop knowledge demonstrated that youth do not need to be in high school before critically examining technology and the Threats to Techquity that permeate their lives and society. With this work, particularly the youths' conceptualizations of Techquity and Threats to Techquity presented in chapter 2, as a foundation, future research should investigate what Techquity education looks like in schools, particularly in K-8 spaces.

While some people believe that critical computing opportunities are best left for high school, when students have become more mature and can have deeper discussions, this work shows that younger youth already have an awareness of Threats to Techquity and are able to participate in activities centered around algorithmic bias and critiquing the technologies they use. Although in the K-12 Computer Science Framework these more critical opportunities are left for later in students' examination of the impacts of computing (*K-12 Computer Science Framework*, 2016), waiting to offer these critical opportunities could be detrimental given youth's access to technology and exposure to Threats to Techquity,. Youth need an awareness of Threats to Techquity to protect themselves and advocate for their communities. This research demonstrated that they are capable of taking part in, and can add to, such conversations and lessons centered around Threats to Techquity.

Techquity and Computer Science

This work sought to teach Threats to Techquity simultaneously with computer science. By connecting these topics, this curriculum ensured that students understood the technical aspects of and programming behind Threats to Techquity as they came to understand the threats themselves. This helped make invisible Threats to Techquity visible to students by ensuring that they could conceptualize the technical causes for the threats. While most curricula that teach about Threats to Techquity intertwine learning about Techquity with computing opportunities specifically around artificial intelligence, the current work integrated into computer science more generally and used Scratch (Maloney et al., 2010; Resnick et al., 2009) as an introductory environment. This choice was fueled by efforts to broaden participation in computing through topics relevant to students and the need for earlier introductory experiences that not only provide short exposure to coding, but also teach computer science principles. As such, this curriculum taught about Threats to Techquity alongside lessons about animation through looping, conditional loops, and one-way synchronization with message passing.

The thematic framing of computer science skills with Threats to Techquity provided opportunities to showcase the threats, but the introductory nature of the covered computer science skills did not provide a synergistic alignment between computer science content and Threats to Techquity. While these are important computing skills, creating algorithms that use basic loops, conditional loops, or message passing within the Scratch programming environment did not introduce the Threats to Techquity covered in the curriculum, nor did it have the potential for the same algorithmic biases discussed because of the simplicity of the algorithms. Simplistically, algorithmic bias is caused by what the creator chooses to include in the algorithm (O'Neil, 2016) and bias in data sets (Buolamwini & Gebru, 2018). Most algorithms written to execute short programs in Scratch do not have these elements and, therefore, are not susceptible to the same types of biases. Although students learned about algorithms and created computer programs while working on these introductory topics in Scratch, without introducing more complex computer science skills, those programs did not meet the goal of having students better understand the technical components of Threats to Techquity.

This lack of synergy between the basic computer science skills in Talking Techquity and the level or type of skills required to gain a deeper understanding of

Threats to Techquity raises the question of whether an introductory computer science environment, rather than a more advanced course in artificial intelligence, is the most synergistic place to teach youth about Threats to Techquity. In courses that connect artificial intelligence and Threats to Techquity (e.g., Clarke, 2019; MIT Media Lab Personal Robots Group & MIT STEP Lab, 2021; Payne, 2019), students are introduced to artificial intelligence and machine learning and the interplay between algorithms and data through training sets and feedback, after which they create or manipulate artificial intelligence and machine learning themselves. This knowledge more specifically aligns with technical knowledge that can support making invisible Threats to Techquity visible. In Talking Techquity, the lessons can adopt the theme of a Threat to Techquity, but the algorithms created at this level do not provide opportunities for students to grapple with Threats to Techquity as creators or within the context of potentially biased algorithms. This research surfaced the importance of Threats to Techquity, as evidenced by the youth design sessions, and an openness to including it in the curriculum from a teacher perspective. However, the current work did not provide sufficient evidence of the utility of the combination of introductory computer science and Threats to Techquity. The exact context that would be best for students to learn about Threats to Techquity is an open question that warrants further research and investigation.

Differences in Learning through Co-Design and in the Classroom

As previously mentioned, the design process acted as a constructivist learning environment for the youth designers. As they took part in the design sessions, the youth were introduced to Threats to Techquity, had the opportunity to develop new knowledge about them, and connected the Threats to Techquity to their lives during design activities and conversations with each other and adult co-designers. As described in Chapter 2, youth conceptualizations of Threats to Techquity changed over time and they gained new understandings of Threats to Techquity, understandings which they were able to connect to their own lives and designs.

While the youth designers who participated in the design sessions demonstrated new knowledge, the teacher's perception of changes in student understanding during the classroom implementation was not as substantial. As described in chapter 4, Mr. Johnson and Mr. Sanchez made various adaptations to the curriculum to support student learning in the classroom environment to overcome difficulties and struggles faced by the students within their classroom. Although many similarities existed between the environments (e.g., both the youth design sessions and the classroom implementation occurred in an online context; class sizes were small and, therefore, only slightly larger than KidsTeam), there appear to be differences in the depth of learning that occurred for youth designers as compared to students in the classroom implementation. While these differences are anecdotal based on the teachers' perceptions since examination of student data from the classroom implementation is outside the scope of the current work and no formal learning data was gathered for the youth designers, the potential discrepancies between the two groups raise questions about differences in learning between the two environments and how, if at all, the successful learning which occurred during the youth design sessions could be replicated within the classroom. Learning through co-design is different than learning through materials created through co-design, but examining the differences in the learning environments as potential reasons for learning differences could shed light on strategies for the classroom that could support greater engagement with and learning about Threats to Techquity.

One significant difference between the youth design sessions and the classroom implementation of Talking Techquity was the amount of material covered within the time. The youth designers were introduced to ten common Threats to Techquity and were invited to discuss additional Threats to Techquity as they identified them. This gave the youth designers a greater breadth of understanding, but only an introduction to each individual threat. Conversely, the students in the classroom implementation were only introduced to two Threats to Techquity, one in each unit, but were introduced to each Threat with greater depth than occurred in the design sessions. This was designed to allow for a deeper investigation of the Threats to Techquity that were elevated as salient by the youth designers, but by focusing on fewer Threats to Techquity, it is possible that the students in the classroom implementation were not able to make personal connections to the topics or did not have prior conceptualizations on which they could draw. This could possibly have led to them needing more time and scaffolding to build new knowledge and fewer spontaneous conversations about how the Threats to Techquity connect to their everyday lived realities.

Additionally, the students in the classroom implementation received lessons not only on Threats to Techquity, but also on the focal computer science concept within each unit. In contrast, the youth designers used Scratch to create their PSAs, but they did not receive formal computer science instruction and did not need to use specific skills within their designs or when using design techniques that did not require programming. The difference in understanding of Threats to Techquity could be, at least in part, due to the greater demand on the classroom students to learn new things as they were introduced to Threats to Techquity and computer science simultaneously. Added content means that the focus of the students within the classroom was split between the two topics (particularly given the challenges discussed above regarding aligning learning about Techquity to computer science). The difficulty of learning the two topics simultaneously might have been exacerbated by learning online and the limited ability for Mr. Johnson and Mr. Sanchez to give just-in-time support due to the online context.

While there were similarities in the contexts between the youth design team and classroom implementation, the differences between these contexts (in addition to the differences in content discussed previously) are also important and could provide insights into how to better support students in the classroom to learn about Threats to Techquity, particularly in an online environment. A core area of knowledge development for the youth designers was in their small design groups. Even though they were first introduced to Threats to Techquity as a full group, after the introduction youth went into small groups to design with an adult and other youth. Here they were able to ask questions, the adult designers utilized questioning to learn more about their experiences, and the design group iteratively and collaboratively built ideas. While it is not possible for the teacher to facilitate many small groups simultaneously within the classroom, breakout groups (for online learning) and talking to peers seated near them (for in-person classrooms) could provide opportunities for students to take part in the same idea elaboration. During these small groups, the teacher could rotate between groups to ask probing questions and encourage deeper conversation, as was seen in the youth design sessions. While not an exact duplication of the small-group work that occurred during the youth design sessions, these small group conversations could provide opportunities for more individualized learning or conversations. Additionally, classroom discussions already included in the Talking Techquity curriculum could be modified to have students first discuss answers with a partner or in small groups to provide all students with opportunities to converse before sharing out. This could decrease the pressure on students when answering in the full group and allow them to develop their ideas in a smaller setting.

Another important contextual element of the youth design sessions is the building of relationships through informal times such as snack time. Youth designers are invited to discuss their hobbies and interests during this time and shared projects or things they have been working on outside of the design sessions (e.g., games they were playing, Lego creations). While snack time is designed specifically as a buffer between school and KidsTeam to equalize power between the youth and adult designers, having a similar informal time could help support students to be more open about their experiences in conversations about Threats to Techquity and to get to know their peers more. While informal time together happens naturally in the school building, students learning at home do not have this same unstructured time with their peers. Having such a time during class could, over time, support students to feel more comfortable sharing in discussions, particularly sharing examples from their own lives or at times when they do not know if they are correct or not.

While it is not possible to completely replicate the co-design environment within the classroom, it is possible that making adjustments such as those suggested above could support students within the classroom as they supported the youth designers.

Learning about Techquity in Formal Verses Informal Spaces

Building on the previous discussion, it is also of note that while the youth designers were aware that their designs would lead to a school-based curriculum to teach about Threats to Techquity, none of their designs included a teacher or a classroom. As discussed in Chapter 2, the youth designers tended to use a knowledgeable other to teach about Threats to Techquity, but this person took the form of an intelligent robot or computer in their learning scenarios and, often, a non-human character in their PSAs. This creates both a tension when translating the youth designs into a classroom space and opens a conversation about the best spaces for conversations about Threats to Techquity.

First, the tension of translating designs. As is common with designs created by youth designers during cooperative inquiry, the youth designs included advanced, slightly futuristic technologies. While current technological capabilities would allow for some of the ideas shared by the youth (e.g., an adaptive computer game), other designs would be harder (although not impossible) to achieve (e.g., a robot that can identify the age of the user to provide relevant information and answer user questions). Additionally, these designs do not align completely with current classroom practices and what is possible given the infrastructures of schools; they are more informal learning opportunities. When designing the curriculum, design features and ideas were extracted from these designs to determine youth instructional priorities (see chapter 3). But this process of translation creates a tension in alignment with design ideas. This was alleviated, in part, by having the youth designers critique the lessons developed from their ideas, but it is notable that some translation occurred and more research is needed to fully understand the impacts of these translations and whether the youth designers feel their ideas are accurately translated into the materials. While adult researchers can trace the alignment, biases of the researchers and teacher design partners during the curriculum development process inevitably affected that translation.

Secondly, the youth designs open a question of the best place to teach about Threats to Techquity. Previously in this chapter I have discussed whether computer science is the most productive subject in which to teach Techquity. Additionally, I have discussed potential differences in learning between the youth designers and students in the classroom implementation. Given these points as well as the fact that the youth designed exclusively non-classroom learning environments, the question of the affordances of informal learning spaces as opposed to formal ones emerges. Within this work, I specifically chose a formal learning environment to ensure that all students had the opportunity to learn about Threats to Techquity (since informal learning environments require the youth and their parents to opt into the opportunity). But, since Black and Hispanic youth are less likely to have dedicated computer science classes in school and are more likely to learn computer science outside of school than their white peers (Google Inc. & Gallup Inc., 2016a) and Threats to Techquity disproportionately affect youth of color, out of school contexts could be a productive place to educate youth about Techquity. These spaces allow for different relationships to form as well as are not constrained by curricular standards or set schedules. There is an opportunity within informal spaces to have a greater number of adults or older youth as knowledgeable individuals to support youth who are just being introduced to Threats to Techquity. Additionally, depending on where the learning environment is developed, an informal space might not have the same history of marginalization that schools do and the learning environment could be developed within the youths’ community (e.g., at a local church, a neighborhood library, or a recreation center). Given these affordances, informal spaces could be strong learning environments for youth to be introduced to Threats to Techquity. Future research could consider these spaces and the impacts they have on student knowledge.

Implications

A central goal of this study was to provide design evidence for effective practices to teach students about Techquity and Threats to Techquity. In the following section, I provide recommendations for researchers, designers, and educators looking to develop lessons around Threats to Techquity that provide students with opportunities to critically examine and critique technological biases within their lives.

Implications for Researchers and Designers

When developing lessons about Threats to Techquity, researchers and designers should carefully consider the computing experience of the students they are teaching to determine the appropriate context in which to teach the lessons. For students with less computing experience, Threats to Techquity could be taught in a social science context with a focus on the impacts to society and less technical context. Since social studies and civics teachers likely already have conversations with students about bias and discrimination within society, they could be more prepared than technology teachers to lead these discussions and support students as they build critical consciousness. When introducing students to computing and providing opportunities to explore computer science is a goal, consider whether an artificial intelligence context or a more advanced computer science class might be the appropriate place for students to make connections between Threats to Techquity and the technical causes of the biases technology and technological systems can create or perpetuate.

For researchers utilizing participatory design to develop curricula, this research surfaced necessary considerations regarding who participates and how. As past research has pointed out, it is important to carefully consider the stakeholders involved in the design process and ensure that the ways they are included do not introduce or exacerbate power differences between adults and youth (Coenraad, Palmer, et al., 2021). As such, consider how youth and teachers design together and separately to ensure that youth ideas are welcomed and celebrated and that youth share their genuine ideas (Druin, 2002). This might include having multiple types of design sessions so that teachers and students can work in heterogeneous or homogeneous groupings by role or providing opportunities for each group to present their work to the other to influence and inform the other's designs.

Implications for Educators

Teachers and other educators need to be aware of the social justice and equity impacts of computing and technology on our society to teach students about these impacts. I recommend that educators explore these impacts more deeply, going beyond what is included within standards and frameworks (e.g., *K-12 Computer Science Framework*, 2016) and incorporating discussions of Threats to Techquity within their lessons. Awareness of Threats to Techquity and teaching about them is particularly important in the present moment given the increasingly technological lives that youth are living because of the COVID-19 pandemic, social distancing, and the current sociopolitical realities within the United States. The pandemic has led to an increase in technology in schools and in students' social lives. Additionally, technology is becoming an increasing part of all sectors of life, particularly for communities with minoritized identities who are already over-surveilled (Benjamin, 2019; Eubanks, 2018). The examples given by youth designers and the discussions they prompted and participated in during the design sessions demonstrated an awareness of technology as not always being good and of the negative impacts it can have on youths' lives. It is clear from this data that youth are attuned to at least some Threats to Techquity within their lives; with lessons about Threats to Techquity, they can become even more attuned to the ways technology can negatively impact their lives. There is space and a need for these conversations within K-12 classrooms, but they are largely absent from current conversations.

When having conversations about Threats to Techquity, I recommend that teachers begin with understanding their students' current conceptualizations of

Threats to Techquity and of the impacts of technology on them and their families, both positive and negative. By asking students for examples and their understandings, teachers can provide further instruction that relates to the technologies students use and with which they are familiar, builds off of what they already know, and counters misconceptions they might have developed. This also provides students with the opportunity to make connections to their lives and see the relevance of Threats to Techquity to them and their communities.

Limitations

This work was affected by three major limitations: the effects of the COVID-19 pandemic, the lack of student data within the classroom implementation, and the small scale of the work. Foremost, this work was significantly affected and adapted due to the need to social distance during the COVID-19 pandemic. The design sessions with youth began in April 2020, a month after social distancing due to the pandemic began; the classroom implementation occurred in spring 2021, when students within the participating school district were still participating in online learning. As such, no design sessions with youth or teachers occurred in person, and the classroom setting in which the Talking Techquity curriculum was piloted was significantly different than a typical classroom environment. While efforts were taken to limit the effects of online design activities on the results of the youth design sessions, whether the results or youth participation would have differed is unknown. Additionally, participation in online learning introduced other factors into the school hours for students that could have affected their ability to participate in class and complete assignments. While in both cases the youth (designers and students) were accustomed to the online environment, having participated in design sessions or classes in a similar environment before, it likely affected the outcomes and data.

Secondly, this work was affected by not having student data from the classroom implementation. While students and their caregivers were invited to be part of the research and consent forms were sent to all caregivers with students in the class, no students and caregivers consented to be part of the work. Therefore, no student work or student-level data was collected to determine the impacts of the curriculum on the students. This limited the conclusions that could be made about student impressions of the curriculum, changes in student knowledge about Threats to Techquity, and the extent to which students learned computer science skills due to being taught using the curriculum.

Finally, this work was completed at a small scale with participants in a relatively small geographic region. While this was intentional due to the commitment to co-design and the goal of developing a curriculum relevant to the students, this affected the overall generalizability of findings and could limit the relevance of the Talking Techquity curriculum for students in a wider geographic area. While I do not believe this to be true due to the universality of examples used, such as YouTube, it is, nonetheless, a potentially notable limitation.

Future Work

Possibilities for future work related to this dissertation pertain to the process of co-designing, further piloting of the Talking Techquity lessons, and shedding further light on the best environment in which to teach youth about Threats to Techquity.

First, as mentioned previously, future work should consider how to bring teachers and students together to co-design curricula in ways that do not affect the designs due to power imbalances. This could include having a mixture of design sessions that are homogeneous and heterogeneous by age for collaboration at key moments within the design. Future work could also consider having teachers design curriculum with their own students rather than having separate groups. This future work could also introduce design sessions with community members (e.g., families, business owners, etc.) to include their voices and opinions in design efforts and new curricula. Additionally, time constraints limited the extent to which the teachers participated in the design and development process. Future work could consider the timescale, incentives, or structures necessary to have teachers take an even bigger role in the co-design process, particularly because current literature on participatory design presents mixed levels of teacher involvement (see Introduction).

Second, to address the limitations of the effects of online learning due to the COVID-19 pandemic and the lack of student data, future piloting of the Talking Techquity curriculum should focus on two areas: implementation of the lessons in a more typical, non-virtual classroom and collecting student data on the implementation to learn more about the reactions and experiences of students. Given that the curriculum was simultaneously designed for a more traditional classroom setting and for online teaching, the Talking Techquity curriculum should be evaluated in the former context. Research could compare the curriculum in the two environments, determine how teachers adapt the curriculum in the classroom, and consider the impact of Talking Techquity in an in-person classroom setting. This research would be particularly impactful with student and caregiver consent to examine student data and consider how, if at all, youths' conceptualizations of Threats to Techquity change following the lessons and whether students demonstrate new computer science knowledge.

Finally, as discussed earlier, it is unclear whether an introductory computer science class is the most synergistic place to teach students about Threats to Techquity. More research is needed that compares teaching about Threats to Techquity within the context of artificial intelligence to teaching these same topics within the context of introductory computer science. Additionally, future research should consider whether a technology class is even the best place to teach students about Threats to Techquity and potentially introduce these topics within social science courses like civics or social studies. These settings could allow for an expanded focus on advocacy (a topic that surfaced during the youth design sessions) and opportunities for students to not only learn about Threats to Techquity, but also to work to combat them within their lives and their communities.

Conclusion

Threats to Techquity abound in the everyday lives of youth. With the number of visible and invisible ways that technologies perpetuate and exacerbate negative biases in society, it is important that youth are introduced to Threats to Techquity and understand how they are embedded into technological systems. Using a design study centered around co-design with youth and teachers, this dissertation investigated youth conceptualizations of Techquity and Threats to Techquity, developed a three-lesson curriculum integrating lessons on common Threats to Techquity, and studied the implementation of the curriculum within the classroom by one of the co-designing teachers. This work demonstrates the importance of involving both youth and teachers within the design process and allowing room for adaptations as novel curriculum are implemented within the classroom. It illuminates the pre-existing knowledge of youth about Threats to Techquity in their lives and the types of threats that need to be made visible to promote understanding. With the influence of technology on society only increasing, it is essential that youth have the opportunity to learn about Threats to Techquity so they have the knowledge to recognize technological bias and protect themselves and their communities.

Appendix: The Talking Techquity Curriculum

Talking Techquity

An introductory curriculum introducing students to computer science and the social justice and equity impacts of computing

Talking Techquity is a three-unit series focused on teaching introductory computer science and programming in Scratch while simultaneously introducing students to algorithmic and technological bias. Created in partnership between the District of Columbia Public Schools and the University of Maryland, this co-designed curriculum is designed for middle grades students (5th – 9th grades) and can be integrated into a variety of different courses. The curriculum is designed to build upon other computer science teaching opportunities and start conversations about technological bias in society.

<table>
<tr><th>Unit 1</th><th>Unit 2</th><th>Unit 3</th></tr>
<tr><td>Computing Focus: Animation with loops
Techquity Focus: Algorithmic bias in image search results</td><td>Computing Focus: One-way synchronization
Techquity Focus: Online data collection</td><td>Computing Focus: Conditional loops
Techquity Focus: Training machine learning algorithms</td></tr>
<tr><td colspan="3">Final Project (Project available for use after Unit 2 or after Unit 3)</td></tr>
<tr><td colspan="2">Computing Focus: Skills in Units 1 and 2
Techquity Focus: Students choose a Techquity topic or computer scientist who identifies with a group marginalized in computing</td><td>Computing Focus: Skills in Units 1, 2, and 3
Techquity Focus: Students choose a Techquity topic or computer scientist who identifies with a group marginalized in computing</td></tr>
</table>

Talking Techquity Materials

The Talking Techquity curriculum materials were created through co-design in partnership with the University of Maryland KidsTeam and teachers from the District of Columbia Public Schools. Each unit follows a four-lesson sequence. In Lesson 1, students are introduced to a Threat to Techquity, or a way technology can cause or perpetuate inequitable and harmful experiences for users due to their membership within a marginalized group. The remaining lessons follow the Use, Modify, Create pedagogical structure. In Lesson 2, students are led through a guided exploration (Use) of a Scratch project with the TIPP&SEE strategy and modify the project to practice the focal computer science skill. This project is themed based on the Threat to Techquity explored in Lesson 1. In Lesson 3, students create a project of their choice sharing what they have learned about Techquity. Finally, in Lesson 4, students present their work to their peers.

Each unit contains:

- Unit plan covering 4 lessons
- Scratch projects for the Use/Modify portion of the lessons
- Student worksheets for in-person and virtual distribution
- Answer keys

The curriculum also includes a final project to be used after Unit 2 or Unit 3. The project provides students with the opportunity to showcase their computer science knowledge while learning more about a Techquity topic of their choice or a computer scientist who identifies with a group that is marginalized in computing (e.g., Black, Indigenous, People of Color; women).

To support teachers to learn about Threats to Techquity, the curriculum includes Getting Started with Techquity, a guide with readings, podcasts, and videos about a variety of Techquity topics.

Need more computer science lessons?

If you are looking for other computer science materials to support students before the Talking Techquity lessons or to provide them with opportunities to keep learning, check out the Scratch Encore curriculum developed by Canon Lab. Lessons 2 and 3 of each unit were adapted from the Scratch Encore curriculum. We recommend considering the following integrations:

- Teach modules 1 and 2 of Scratch Encore before beginning the Talking Techquity units if students are not familiar with Scratch or programming

- Teach additional modules after the Talking Techquity units. Use the following guide to determine what concepts have already been taught:
    - Talking Techquity Unit 1 is adapted from Scratch Encore Module 3
    - Talking Techquity Unit 2 is adapted from Scratch Encore Module 6
    - Talking Techquity Unit 3 is adapted from Scratch Encore Module 4

For more information or questions:
Download Talking Techquity at https://go.umd.edu/TalkingTechquity or contact Merijke Coenraad, lead designer, at mcoenraa@umd.edu.

Suggested Citation:
Coenraad, M. (2021). *Talking Techquity* [Curriculum]. https://go.umd.edu/TalkingTechquity

Talking Techquity Getting Started Guide

Definitions

Techquity = Technology + Equity

Threats to Techquity: The aspects of computing and technologies that cause or could cause inequalities, especially inequality based on membership within a marginalized population (e.g., race, immigration status, gender, sexual orientation, ability).

Bias is how someone perceives things are or should be, including when the perception is not correct.

Algorithmic bias is when the programs controlling computers and technology have been programmed with the biases of society and don't treat everyone fairly because of their identity. This results in prejudice or lack of fairness in the results of a computer system output.

Techquity Resources

Start here

- The Truth About Algorithms, Cathy O'Neil - https://www.youtube.com/watch?v=heQzqX35c9A
- Even Kids Can Understand That Algorithms Can Be Biased, Scientific American: https://blogs.scientificamerican.com/roots-of-unity/even-kids-can-understand-that-algorithms-can-be-biased/
- The Comb: Racist AI - https://www.bbc.co.uk/sounds/play/p08psmq0

Videos, Webinars, and Podcasts

- Ted Talk: How I'm fighting bias in algorithms, Joy Buolamwini - https://www.youtube.com/watch?v=UG_X_7g63rY
- Lecture: Are Robots Racist?, Ruha Benjamin - https://www.dropbox.com/s/j80s8kjm63erf70/Ruha%20Benjamin%20Guest%20Lecture.mp4?dl=0
- Challenging the Algorithms of Oppression, Safiya Noble - https://www.youtube.com/watch?v=iRVZozEEWlE
- Spoken Word Video: AI, Ain't I A Woman?, Joy Buolamwini - https://www.youtube.com/watch?v=QxuyfWoVV98
- Research Overview: Gender Shades, Joy Buolamwini - https://www.youtube.com/watch?v=TWWsW1w-BVo
- Research Overview; The Coded Gaze: Unmasking Algorithmic Bias, Joy Buolamwini - https://www.youtube.com/watch?v=162VzSzzoPs

- Ted Talk: The era of blind faith in big data must end, Cathy O'Neil - https://www.youtube.com/watch?v=_2u_eHHzRto
- Explainer: Algorithmic Bias and Fairness, Crash Course - https://youtu.be/gV0_raKR2UQ
- Explainer: Bias in Search Algorithms, Algorithms and Society - https://youtu.be/7SVin0_ePGQ

Blogs and News Articles

- Is Facial Recognition Racist? Yes. And Detroit is Using It, YR Media: https://yr.media/tech/video-is-facial-recognition-racist-yes-and-detroit-is-using-it/
- Amazon's Face Recognition Falsely Matched 28 Members of Congress With Mugshots: https://www.aclu.org/blog/privacy-technology/surveillance-technologies/amazons-face-recognition-falsely-matched-28
- How Big Data is Unfair: https://medium.com/@mrtz/how-big-data-is-unfair-9aa544d739de
- Amazon Scraps Secret AI Recruiting Tool that Showed Bias against Women: https://www.reuters.com/article/us-amazon-com-jobs-automation-insight/amazon-scraps-secret-ai-recruiting-tool-that-showed-bias-against-women-idUSKCN1MK08G
- Unable to Avoid Bias, Gmail Stops Using Gender in its Automated Replies: https://nymag.com/intelligencer/2018/11/unable-to-stop-bias-gmail-avoids-gender-in-ai-replies.html
- 'Alexa, Are You Invading My Privacy?' – The Dark Side of Our Voice Assistants: https://www.theguardian.com/technology/2019/oct/09/alexa-are-you-invading-my-privacy-the-dark-side-of-our-voice-assistants
- 'Significant Racial Bias' Found in National Healthcare Algorithm Affecting Millions of People: https://www.vice.com/en/article/ne859z/significant-racial-bias-found-in-national-healthcare-algorithm-affecting-millions-of-people
- The Algorithmic Justice League: https://medium.com/mit-media-lab/the-algorithmic-justice-league-3cc4131c5148
- Artificial Intelligence Has a Problem With Gender and Racial Bias. Here's How to Solve It: https://time.com/5520558/artificial-intelligence-racial-gender-bias/
- Machine Bias, ProPublica: https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing

Existing Curricula

- MIT AI Ethics Education Curriculum: https://docs.google.com/document/d/1e9wx9oBg7CR0s5O7YnYHVmX7H7pnITfoDxNdrSGkp60/edit#heading=h.ictx1ljsx0z4

- You are the Product, Teaching Tolerance: https://www.tolerance.org/classroom-resources/tolerance-lessons/you-are-the-product
- Code.org and Microsoft AI Curriculum: https://code.org/ai

Experiment

- YR Media, Erase your Face: https://interactive.yr.media/erase-your-face/

Techquity Unit 1:
Animation & Algorithmic Bias in Image Search

Computer Science Topic: Loops to create animation
Techquity Topic: Algorithmic bias in image searches

Unit Summary

Students learn about animating a sprite by repeating a set of blocks that alternate between switching costumes or moving to the next costume with repeated step movement inside a loop and varying that animation through changes in wait time.

Unit Objectives

Students will be able to:

- animate a sprite in one location using a repeat loop and multiple costumes.
- animate a sprite with movement using a repeat loop.
- distinguish between the functionality of `switch costume` and `next costume` blocks.
- define algorithmic bias and give examples of algorithmic bias in everyday life.

Big Idea:
Loops are critical aspects of computing. It is simple to think of repeating a single block. However, most loops repeat a sequence of actions. Animation in Scratch is a fun, engaging way to practice this concept. An important aspect of animation is the wait block - controlling the speed of the animation.

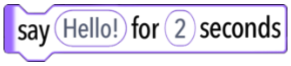
Unit Overview

Lesson 1: Examining Algorithmic Bias in Image Searches **60 minutes** Students learn about algorithmic bias through readings and experimenting with Google Image searches.	Lesson 2: Exploring Animation **60 minutes** Students are introduced to the concepts of animation and initialization. They modify a Scratch project to animate a sprite and initialize the project.
Lesson 3: Creating with Animation **120 minutes** Students create an animation about algorithmic bias in Image Search results in an open-ended, create project.	Lesson 4: Presentations **60 minutes** Students present the animation projects they created about algorithmic bias in Google Image Search results.

Materials adapted from Scratch Encore by CanonLab.org

Prior Knowledge

Looks

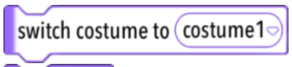


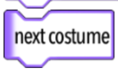
Events

Motion

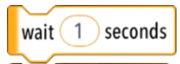
New Blocks

Looks

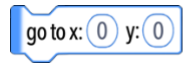




Control



Motion



Materials adapted from Scratch Encore by CanonLab.org

Lesson 1: Examining Algorithmic Bias in Image Searches

Lesson Overview	Lesson At-A-Glance
In this lesson, students learn about algorithmic bias through readings and experimenting with Google Image searches. The class discusses bias and how bias is present in image search algorithms.	Engage: 10 minutes Explore: 40 minutes Reflect: 10 minutes

Lesson Preparation	
Student Materials Engage • None Explore • Even Kids Can Understand that Algorithms Can Be Biased Article • Algorithmic Bias Quick Comprehension Check (optional) Doc PDF • Algorithmic Bias in Image Search Results Activity Doc PDF	**Teacher Materials** Engage • None Explore • Bias in Search Algorithms Video

Engage

Introductory Discussion (10 minutes)
Explain to students that for this term the class is going to focus on computer science and learning about ways that technology can be inequitable, or Threats to Techquity. To introduce the idea of bias, generally, and algorithmic bias, specifically, lead a class discussion about bias and the ways that it can be harmful.

What is bias? *[Bias is how someone perceives things are or should be, including when the perception is not correct.]*

Is bias always bad? *[No, there are biases that aren't harmful. For example, if you have a bias that chocolate is the best ice cream flavor no one is harmed by your preference.]*

When is bias bad? *[Bias is bad when the perceptions aren't true or when the bias means that people are treated differently or unfairly due to their identity or preference, such as being treated differently because you are a woman or because of your race.]*

In the ice cream example above, the bias can be harmful if chocolate ice cream is given away for free but people who eat vanilla ice cream must pay or if people who like chocolate ice cream were treated better than those who like vanilla ice cream by having chocolate ice cream served in clean bowls, but vanilla ice cream served on a paper towel. This example seems a little funny when we think about it based on ice cream preference, but negative biases are very common in our society.

Can anyone give an example of negative bias within our society? *[women and people from minoritized races earn less than men and white people, age bias that assumes younger people are more capable, etc.]*

Once students have discussed the term bias, introduce the idea of algorithmic bias. An **algorithm** is a set of instructions or steps that are used to solve a problem. Make sure students are aware that algorithms are everywhere in their lives, particularly when they are using technology. Explain that algorithms use data to make inferences, or educated guesses, about something like what video someone might want to watch. One example of this is the suggested videos that come up on YouTube.

What other platforms do you know of that might use algorithms? *[Amazon (product suggestions), Netfix, Hulu, Disney+ (suggested shows and content), Tik Tok, Instagram (Ordering of content and suggested content)]*

On all these platforms, what you see differs depending on what the algorithm has selected for you. For example, if you spend a lot of time on YouTube watching music videos, the algorithm is going to suggest new music videos for you, but if you tend to watch screencasts of people gaming those videos are going to be recommended.

Explain to students that while it might seem like algorithms are neutral because the decisions are being made by a computer, these algorithms are actually biased because the humans that create the algorithms can write their own biases into the programs based on decisions they make about the algorithm. A lot of algorithms also use data from the past. Since we know that the past and present include many continuing examples of structural racism, this data can encode negative biases. This results in **Algorithmic Bias**.

Algorithmic bias is an example of a Threat to Techquity because it is a technology that can cause inequality within our society.

Introduce today's activities: learning more about algorithmic bias by reading some background information and investigating algorithmic bias in image search results.

Explore

Algorithmic Bias in Image Search Results (40 minutes)

As a class, watch Bias in Search Algorithms. Then, explain to students that they are going to learn more about algorithmic bias through a reading. Distribute either Even Kids Can Understand that Algorithms Can Be Biased or Racial bias can impact the formulas doctors use to decide how to treat their patients (Newsela) to students to read independently. If time permits, once students have completed their reading, have them complete the algorithmic bias quick comprehension check or comprehension questions on Newela.

To further explore the algorithmic bias the students have read about, students complete the Algorithmic Bias in Image Search Results activity. Students can work individually or with a partner.

Note: Due to the pushback about image searches that Google has received, there are improvements made to specific searches. Before assigning this task, check to ensure the bias is still visible within these specific search terms and adjust the terms as necessary to depict searches where the bias is prevalent.

Reflect and Discuss

Reflect (10 minutes)

Debrief the activity by discussing what students observed in the image results.

What surprised you about the Google Image searches? *[Answers will vary, but could include discussions of search results omitting women and people of color]*

Were you more likely to see white people or people of color in the search results? *[White people]*

Materials adapted from Scratch Encore by CanonLab.org

When they were portrayed, how were people of color portrayed differently than white people in the search results? *[In a more negative context – example of the three Black teens]*

Were you more likely to see women or men in the search results? *[Men]*

What biases are present in the image search algorithms? *[Answers will vary, but could include discussions of search results omitting women and people of color]*

How might image search results maintain existing biases and racism within society? *[Answers will vary]*

Explain to students that Google has changed some results based on the research that has been done about image search bias. One example is the search for beautiful. Demonstrate the Google Image Search for "beautiful." Explain that about 5 years ago, people started to push back because the results for beautiful resulted in only images of white women. Now, the result for beautiful includes women of color as well as some landscapes. Demonstrate the Google Image Search for "handsome."

How are the results from handsome different than the results for beautiful? *[The results show mostly white men]*

The changes that Google has made haven't stopped the bias in all searches, just in some. As you saw today, there are many examples of bias that still exist within the image searches.

Conclude the lesson by explaining that for the next few weeks the students are going to explore computer science concepts while continuing to think about algorithmic bias in image searches. The class will continue talking about ways that technology can be biased this term.

Lesson 2: Exploring Animation

Lesson Overview	Lesson At-A-Glance
In this lesson, students animate sprites both in one location and then with movement by repeating sets of blocks in loops. Students modify the code of an existing project to animate sprites to wave and walk off stage using costume changes. **Vocabulary:** animation, loop, initialization	Engage: 15 minutes Explore: 35 minutes Reflect: 10 minutes

Lesson Preparation	
Student Materials Engage • None Explore • Animation: TIPP&SEE worksheet Doc PDF Slides Answer Key • Animation: L2 Student Sheet Doc PDF Slides	Teacher Materials and Scratch Projects Engage • Animation Engage Video Drive YouTube Explore • None Scratch Projects • Animation: Image Results

Engage

Introductory Discussion (15 minutes)

Use Question / Student Answer / Teacher Clarification to introduce animation through this sequence of questions.

What is animation? What are some examples of animation? *[Cartoons, flip books, animated movies]*

In an animation, what causes the characters to move? [*The animation cycles through pictures of the characters that look slightly different. As you move quickly through the pictures, it looks like the character is moving.]*

Animation in programming works the same way that we think of animation in real life. Using repeated changes to the sprites and movement at varying speeds, the actions of sprites become animated either in place or as they move on the screen.

Note: If students have seen or made flip books before or taken burst photos, that will help them to visualize how a set of slightly different pictures be used to create animation. Here is a fun YouTube video of a soccer flip book.

Can something be animated if it doesn't change location (or move across the screen)? *[Yes, a sprite can be animated by changing its appearance, but its location on the screen can stay the same. Some examples are a monkey juggling, someone waving their hands, etc.]*

In Scratch, a sprite can be animated through costume changes without changing locations using `wait` and `next costume` or `switch costume to __` blocks. In Scratch, a sprite's costume is more than the clothes that it is wearing, changing the costume in Scratch is most often used to change body positions, so a sprite can have his or her hand raised in one costume and down in another costume. This allows the use of costume changes to animate a sprite in one location. This animation can happen by using the series of blocks multiple times or by placing them in a repeat loop.

What is a loop? *[Something that keeps going for a long time.]*

In a programming, a **loop** is an action or series of actions that are repeated until a condition is determined to be true. Some loops happen a certain number of times and then stop while others run forever. All loops end at some point, but that ending time can be determined by completing the loop a set number of times or continuing the loop for as long as the program is running.

What are things that you do that are loops? *[Blinking, heart beating, jumping jacks, walking]*

Just like in real life, for these actions to occur in a computer program, animation is needed to show them happening.

Can there be more than one block, or instruction, in a loop? *[Yes, loops commonly contain more than one block. Some examples are `move` then `wait` and `next costume` then `wait`.]*

A loop can contain as many instructions as the programmer desires. The program will run through all of the instructions in order until it reaches the end and then begin at the top of the list again for as many times as the loop is run.

What block do we need to use to place a sprite at its starting location after it has moved across the screen? *[The `go to x:__y:__` block]*

In programming, when a sprite changes location and needs to start at a certain beginning location, commands are included in the program to set up the action. This is called **initialization.** Initialization is the assigning of a beginning value to a piece of data in a program. Initialization can set up a program right when it starts. When you initialize a program, it always starts in the same state.

Introduce to students that today, they are going to use TIPP&SEE to explore different types of blocks used for initialization and to initialize sprites in a project.

Animation Engage Video
Use the recorded Animation Engage Video to introduce content for students who miss class when the concept is introduced, when teaching online or asynchronously, or for students who benefit from multiple exposures to content.

Explore

Using TIPP&SEE (15 minutes)

Students open the Animation: Image Results student project (https://scratch.mit.edu/projects/471823921/) and complete the Animation: TIPP&SEE Worksheet to work use and explore the project with the TIPP&SEE strategy. Once students have completed the activity, debrief as a class.

Modify Project (20 minutes)

Pass out the Animation: L2 Student Sheet. Remind students to **R**oa**R** and hi**SS** (**R**eload, **R**emix, **S**hare, and +Add to **S**tudio) the Animation: Image Results student project (https://scratch.mit.edu/projects/471823921/). Remind students that they need to share the project so it is accessible to you and others.

In this activity, students program the project to:

- Animate the Kyle_Reality sprite to wave in place when the space key pressed
- Animate the Luca_Image sprite to walk off the stage when the right arrow is pressed.

Extensions

- Adjust the speeds that the Reality sprites wave at
- Add observations you made during the Google Image Search activity to what the Grandmother says

Materials adapted from Scratch Encore by CanonLab.org

- Make the Kyle_Image sprite grow to take up the entire "Image Results" section of the stage after Luca_Image and Noor_Image walk off.
- Make Luca_Image and Noor_Image hide when they walk off the stage (Hint: Make sure to initialize the sprites to show when you set up the project)

Reflect and Discuss

Reflect (10 minutes)
As students finish their modify project, they complete the journal questions and note the new blocks on their Animation: L2 Student Sheet.

New Blocks and Concepts

- `wait __ secs`
- `repeat ___`
- `next costume`
- `switch costume to ___`
- Animation
- Loop
- Initialization

Journal Questions

- How is animation in Scratch different than what you thought it was at the beginning of the lesson? How is it the same?
- What is the difference between the `next costume` and `switch costume to ___` blocks?

Share & Discuss (if time permits)
If there is additional time in the class, consider having students present their projects to the class (or make time for a walk around showcase where students run each other's projects on individual computers). If there is time, consider leading a discussion identifying examples of when students would use `next costume` vs. `switch costume to ___`.

Assessment
Student projects should be graded based on completion of all required elements.

Integration
Art – Animation and Drawing

Differentiation:

- Prepare block definition sheets for students. Options include: List the block name (students fill in the definitions), block names and definitions provided (students match block names to the definitions).
- Provide a list of the type and number of blocks needed to complete each activity.

Materials adapted from Scratch Encore by CanonLab.org

Lesson 3: Creating with Animation

<u>Lesson Overview</u>
Students create an animation about algorithmic bias in image search results in an open-ended, create project.

<u>Lesson At-A-Glance</u>
Engage: 15 minutes
Explore: 95 minutes
Reflect: 10 minutes

Lesson Preparation

<u>Student Materials</u>
Engage
- None

Explore
- Animation: L3 Student Sheet
  Doc PDF Slides

<u>Teacher Materials</u>
Engage
- None

Explore
- None

Scratch Projects
- None

Engage

<u>Introductory Discussion (15 minutes)</u>
Review algorithmic bias and the Google Image Search activity.

What is algorithmic bias? *[When the programs controlling computers and technology have been programmed with the biases of society and don't treat everyone fairly because of their identity.]*

What are some examples of algorithmic bias that we have read about or seen? *[Google image search, facial recognition, entry into medical school etc.]*

How did Google Image Searches demonstrate bias? *[They were likely to show men and people who are white. They tend to show the stereotypes of society like who is stereotypically believed to be a nurse.]*

Remind students that in the last lesson, they learned how to animate sprites in one place and with movement.

What methods did we use to animate sprites in the previous activity? *[Changed the sprite's costumes using the* `next costume` *or* `switch costume to ___` *blocks and, to create movement, used a* `repeat loop` *containing* `wait` *and* `move` *blocks.]*

Materials adapted from Scratch Encore by CanonLab.org

Open the Animation: Image Results project (https://scratch.mit.edu/projects/471823921/) and review with students the difference between animation without movement (the sprites on the reality side waving when the space key is pressed) and the animation with movement (the sprites on the image results side walking away when the right key is pressed).

Explore

Create Project (95 minutes)

Introduce today's activity: To create an animation of the students' choice. Pass out the Animation: L3 Student Sheet to give students guidance throughout the project.

To complete this task, students will:

- Create a new Scratch project
- Add a backdrop
- Add 3 sprites (with multiple costumes) to the project
- Animate at least 2 sprites in place
- Animate at least 1 sprite to move across the stage
- Animations should include:
    - Costume changes
    - Movement from left to right (at least 1 sprite)
    - Repeat loops
    - Speed control (with wait blocks)
- Test the code.

Explain to students that they are creating a project sharing about algorithmic bias and biased search results. The students can choose how to do this in a way that is interesting to them. Some ideas include:

- Have a sprite walk on stage and discuss a specific image search result including sharing how it is biased. Remember you can upload images as sprites and backdrops if you want to show the result.
- Animate a story of a sprite discovering image search bias

Remind students to run their project to test that it works as expected. Debug and re-test if necessary. Students should **S**hare and +Add to **S**tudio before exiting Scratch.

Extensions

- Add additional sprites and have them animated in place and/or moving across the screen.
- Experiment with different types of animation using `turn`, `move`, `point in direction`, `change x by`, and `change y by`.

Reflect and Discuss

Reflect (10 minutes)
As students finish their create project, they complete the journal questions and note the new blocks on their Animation: L3 Student Sheet.

Journal Questions
- What was challenging about this project?
- How did you work through the challenges you faced?

Assessment	Integration
• Student projects should be graded based on completion of all required elements.	Art – Animation and Drawing

Differentiation:
- Prepare block definition sheets for students. Options include: List the block name (students fill in the definitions), block names and definitions provided (students match block names to the definitions).
- Provide a list of the type and number of blocks needed to complete each activity.

Lesson 4: Presentations

Lesson Overview	Lesson At-A-Glance
Students present the animation projects they created about algorithmic bias in Google Image Search results.	Presentations: 60 minutes

Lesson Preparation	
Student Materials None	Teacher Materials None

Engage

Preparing for presentations (5 minutes)

Students pull up the projects that they have been working on. Each student spends 5 minutes brainstorming what they will share about their project. Students should be prepared to:

1. Introduce the topic and concept of their project
2. Explain why they chose to share this specific example of algorithmic bias

At this time, also have each student make sure their project has been shared to the correct studio so you can share their project without needing to load new screens.

Explore

Project Sharing (45 minutes)

Each student shares their create projects. Students should:

1. Give an introduction to their project
2. Share their project (Recommended that you play all projects from your screen)
3. Answer questions from you and classmates about the project

Reflect and Discuss

Reflect (10 minutes)

Hold a concluding reflection and discussion with students about both their projects and what they have learned about Techquity. Remind students that

Techquity is when technology is equitable. There are things that work against Techquity such as algorithmic bias as the class saw in the Google Image Search activity. Create an opportunity for students to ask final questions and share what they have learned in this unit.

Standards

CSTA Standards

1B-AP-10 Create programs that include sequences, events, loops, and conditionals. (P5.2)

1B-AP-12 Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features. (P5.3)

1B-AP-14 Observe intellectual property rights and give appropriate attribution when creating or remixing programs. (P5.2, P7.3)

1B-AP-15 Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended. (P6.1, P6.2)

1B-AP-17 Describe choices made during program development using code comments, presentations, and demonstrations. (P7.2)

2-AP-16 Incorporate existing code, media, and libraries into original programs, and give attribution. (P4.2, P5.2, P7.3)

1B-IC-18 Discuss computing technologies that have changed the world, and express how those technologies influence, and are influenced by, cultural practices.

1B-IC-20 Seek diverse perspectives for the purpose of improving computational artifacts. (P1.1)

1B-IC-21 Use public domain or creative commons media, and refrain from copying or using material created by others without permission. (P7.3)

2-IC-20 Compare tradeoffs associated with computing technologies that affect people's everyday activities and career options.

2-IC-21 Discuss issues of bias and accessibility in the design of existing technologies.

ISTE Standards

1. **Empowered Learner:** Students leverage technology to take an active role in choosing, achieving and demonstrating competency in their learning goals, informed by the learning sciences. Students:
    - c. use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.
    - d. understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

2. **Digital Citizen:** Students recognize the rights, responsibilities and opportunities of living, learning and working in an interconnected digital world, and they act and model in ways that are safe, legal and ethical. Students:

b. engage in positive, safe, legal and ethical behavior when using technology, including social interactions online or when using networked devices.

4. **Innovative Designer:** Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions.

a. know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

d. exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.

5. **Computational Thinker:** Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.

a. Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.

d. Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

6. **Creative Communicator:** Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.

b. create original works or responsibly repurpose or remix digital resources into new creations.

c. Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.

Techquity Unit 2:
One-Way Synchronization & Online Data Collection and Use

Computer Science Topic: One-Way Synchronization with Message Passing
Techquity Topic: Online Data Collection and Use

Unit Summary

Synchronization is the coordination and timing of actions between sprites. Previously, events were all directly from the user. However, a single sprite is limited in what events it can sense. For example, a sprite cannot sense when a user clicks on a different sprite. In one-way synchronization, one sprite sends an invisible message to other sprites, thereby initiating an event. This is called message passing.

Unit Objectives

Students will be able to:

- create scripts that use message passing for one-way synchronization between two sprites.
- create scripts that use message passing for one-way synchronization that initiate simultaneous actions on multiple sprites.
- describe data collected about people and how it is used in online advertising.

Big Idea:
Users may start the action with an event, but many applications are working on multiple things at the same time. Those many independent tasks need to be able to cause events in each other. One way to do this is by sending and receiving messages. This is used in Scratch to coordinate actions between different sprites.

Unit Overview

Lesson 1: Examining Online Data	Lesson 2: Exploring One-Way Sync
60 minutes Students learn about online data collection and how data is used online. Then, they consider how they could use data as marketers.	120 minutes Students are introduced to the concept of one-way synchronization. They modify a Scratch project to pass messages with one-to-one and one-to-many synchronization.

Materials adapted from Scratch Encore by CanonLab.org

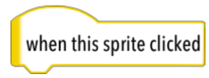
<u>Lesson 3: Creating with One-Way Sync</u> **120 minutes** Students develop a project about or using data utilizing one-to-many synchronization in an open-ended create project.	<u>Lesson 4: Presentations</u> **60 minutes** Students present the projects they created using one-way synchronization and data.

Prior Knowledge

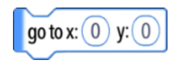
Looks

Control

Events

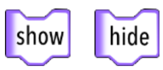


Motion

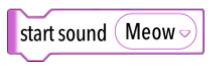


New Blocks

Looks



Sound



Events

Materials adapted from [Scratch Encore](#) by [CanonLab.org](#)

Lesson 1: Exploring Online Data Collection

<u>Lesson Overview</u> In this lesson, students learn about online data collection and consider data collection in their own online behaviors. Then, students consider how they would use data if they were in charge of online marketing.	<u>Lesson At-A-Glance</u> Engage: 10 minutes Explore: 40 minutes Reflect: 10 minutes

Lesson Preparation	
<u>Student Materials</u> Engage • None Explore • Product Marketing Plan Doc PDF	<u>Teacher Materials</u> Engage • A Visit to Chartmetric Video: https://www.youtube.com/watch?v=kBDplоPg35w Explore • Exploring Online Data Collection Kahoot: https://create.kahoot.it/share/exploring-online-data-collection/96613eff-32bc-4fd5-aa5f-c3c02e43e005

Engage

<u>Introductory Discussion (10 minutes)</u>
Preview for students that today the class Is going to be thinking about data, online data collection, and how companies use data to make decisions.

Show students A Visit to Chartmetric, a video about how a music company uses data. As students are watching, ask them to listen for how the people in the video discuss data and use data to make decisions for their company.

Debrief the video and discuss data and online data collection with students.

What is data? *[Data is pieces of information that are collected and brought together.]*

In computer science, individual points of data are combined into datasets and used in algorithms and decision making.

When have you used or looked at data before? *[Graphing in math class, running an experiment or analyzing data in science class.]*

Materials adapted from Scratch Encore by CanonLab.org

Just like you have collected and analyzed data, companies are doing the same.

In the video, how did the computer scientists describe using data at their music company? *[tracking 1.3 million artists and 1 million playlists, who buys music, when music is bought, and how it is bought, Instagram followers, Wikipedia views, etc.]*

What other types of data do you think would be helpful if you were trying to help a new musician to be successful? *[YouTube views, social media followers, visits to website, etc.]*

Introduce students to the idea of their data being collected and used with YouTube as an example. Explain that every time you make a decision online such as which video to watch, the websites track what you picked. This data is then used to try and get you to make more selections and stay on the website. One common example of this is YouTube.

How does YouTube personalize the content that you receive? *[Autoplay, suggested videos, creating personalized playlists)]*

The website can do this using the data it collects about what you have watched before. If you spend time watching videos of the latest video game, it will suggest similar gaming videos. But, if you watch exclusively music videos, it will suggest videos with music in the genre you like.

Introduce today's activities: Today, you are going to consider what data about you are collected online. Then, you are going to consider how you could use data if you were working in marketing for a company of your choice.

Explore

Online Data Collection (40 minutes)

As a class, complete the Online Data Collection Kahoot (https://create.kahoot.it/share/exploring-online-data-collection/96613eff-32bc-4fd5-aa5f-c3c02e43e005). This Kahoot starts with questions that have students consider how their own data might be collected online and different types of data collection and then collects some data about what students are interested in that they can use to plan how they would use data in marketing.

Use the summary slide after each question or the "Reports" page after the class has completed the entire Kahoot to go through the students' answers. As you go through each question, provide students with a bit more information about why the question is important and ask students for their thoughts, opinions, or experiences with getting targeted advertisements or suggestions. Below is some information about online data use related to each question. Share this as well as any other recent or relevant information you have. Some of these points pertain to multiple questions from the report.

9. Searches on Google (Q1): Google is designed mainly as an advertising tool. Google and other search engines use information about what you have searched to make suggestions for products or websites to visit.
10. Videos on YouTube (Q2): As we talked about before, YouTube uses information about the videos that you have watched previously to make suggestions about other videos you might like. The company's goal is to keep you on the website watching videos so they earn money through ads. To do this, they want to make sure you find content that you will find interesting.
11. Audio and Video Streaming Services (Q3, Q4): Like YouTube, both audio and video streaming services use information about what you have watched previously to suggest new content that you might like. They suggest content by compiling data about what everyone on the site has watched to determine trends.
12. Smartphone Location (Q5): Allowing apps to use your location means they can locate where you are. This is used by companies to identify when people are in their store, potentially providing coupons or ads for things relating to where you are located. Rideshare apps have also tracked where people go immediately after getting out of their ride.
13. Music and video suggestions (Q6, Q7): As discussed above, suggestions are used to help you find content that is relevant to you and help keep you on the website or service. Invite students to give examples of when suggestions have been relevant or not relevant to them.
14. Ads and Suggestions (Q8, Q9, Q10, Q11): Students have likely seen ads online or been suggested products. Invite them to share examples of when the ads have related to things they have done online. For example, a student looking up getting the newest Xbox and later receiving ads for Xbox games or accessories.
15. Should companies be allowed to collect data? (Q12): Based on the information you have provided and students' examples, discuss whether companies should be allowed to collect and use data. Invite students to share whether they think that companies should be able to collect the data online that they are currently or alterations that students would suggest to protect individuals who use technologies. Explain that sometimes companies use the data to make assumptions about the person and this can lead to offering different products based on presumed race or gender. Have student discuss when this is helpful and when it harms people. Companies also sell data to other companies to use. As a class, discuss whether companies should be allowed to sell data about you and your online activity to others without you knowing. *This is a focal discussion within this unit, so ensure*

all students can contribute and make connections between the first 11 questions on the Kahoot and this conversation.

16. What students do and look at online (Q13, Q14, Q15, Q16): The remainder of the questions are about what student do and look at online. This data will help students in the next activity, so review the results as a class. If students answered "Other" for any of the questions, ask them to share what else it is that they do online or other places they visit.

Now, have students imagine that they are working in marketing and want to sell products to middle school aged consumers. Have students complete the Product Marketing Plan thinking about how their classmates answered the questions about what they do online. Students select a product they are working to market and decide who to market to and how to best reach consumers who are their age. Finally, students consider how to do this in a way that does not discriminate against anyone. As students are considering how to market, encourage them to consider whether they thought the current data collection practices were fair and how they might act differently if they were in charge of marketing.

Reflect and Discuss

Reflect (10 minutes)

Debrief the activity by having students share what they chose to market and how they would market it to their peers. As students are sharing, allow other students to comment and provide feedback about any other data they would collect or other places online they would market the product.

Lesson 2: Exploring One-Way Synchronization

Lesson Overview	Lesson At-A-Glance
In this lesson, students are introduced to the concept of one-way synchronization with message passing between two sprites using `broadcast [message]` and `when I receive [message]` blocks. Students modify Scratch projects to use both one-to-one and one-to-many synchronization with message passing. **Vocabulary:** one-way synchronization, message passing	Engage: 10 minutes Explore:100 minutes Reflect: 10 minutes

Lesson Preparation

Student Materials	Teacher Materials and Scratch Projects
Engage • None Explore • One-Way Sync: TIPP&SEE worksheet Doc Slides PDF Answer Key • One-Way Sync: L2 Student Sheet Doc Slides PDF Answer Key	Engage • One-Way Synchronization Engage Video Drive YouTube Explore • None Scratch Projects • One-Way Sync: Online Data Collection

Engage

Introductory Discussion (10 minutes)

Start a discussion about **one-way synchronization** using message passing. Explain that a message is passed (sent) from a person or place and received by another person or place, but no response is sent back. The message is only passed in one direction. Give some examples such as someone giving instructions or leaving a note with chores for someone.

Use think-pair-share to have students brainstorm other real-life examples of one-way synchronization with message passing. Ask students to think about this question while they discuss, "Who sends the message, and what will the receiver do?" Ask a few people to share out their ideas.

Can the sender do an action at the same time the receiver is doing an action? Explain. *[Yes, the sender's action and the receiver's action are independent of each other. For example, in Musical Chairs the sender turns on the music, the receivers walk around the circle of chairs. While the receivers are walking, the sender can chew gum, bounce a ball, dance without it changing the action of the receivers; The sender can send another message (in this case turn off the music) and still continue their action (chewing gum) while the receivers stop and do a different action (find a chair).]*

In computer programs, messages need to be passed as well. This is called message passing - the sending and receiving of invisible messages that trigger specific scripts or actions.

	One-Way Synchronization Engage Video Use the recorded One-Way Synchronization Engage Video to introduce content for students who miss class when the concept is introduced, when teaching online or asynchronously, or for students who benefit from multiple exposures to content.

Explore

Using TIPP&SEE (50 minutes)

Students open the One-Way Sync: Online Data Collection (https://scratch.mit.edu/projects/490453259/) project. Remind students to use the TIPP&SEE strategy: Read the **Title**, **Instructions**, and **Purpose** of the project, **Play** it and notice what is happening. Pay particular attention to the actions that happen for each event. Click See Inside to show the **Sprites**, **Events**, and **Explore** the code. Students should pay particular attention to the blocks that are used for the events and actions inside the scripts.

Have students complete the One-Way Sync TIPP&SEE Worksheet. Explain that they will use the TIPP&SEE Strategy to preview and help them understand the program. They will Explore the project by making a set of modifications designed to reveal information that will be useful as they start to modify and create code.

Once students have finished, as a class, discuss the importance of sending and receiving the same message name in a project, and that the same message can be broadcast by one or more sprites - or received by one or more sprites. Discuss the Explore the project! tasks to uncover some of these ideas.

On the Buy Button sprite, you created a new message in the `broadcast` block, "Go". Did the Recommendation appear when you clicked the Buy Button? *[No, the Buy Button broadcasted "Go!" but the Recommendation didn't appear. The message "Go" was passed, but the Recommendation sprite was waiting for the message "Buy."]*

On the Buy Button sprite, you changed the receive message to "Go." Did the Recommendation appear when you clicked on the Buy Button? *[Yes. The Buy Button passes the message "Go" and the Recommendation receives it and appears.]*

When one sprite sends a message and another receives it and carries out an action - this is called **one-to-one synchronization**. A message is sent by one sprite and received by one sprite.

You created a new script for the Ads sprite that received the message "Go." What did the Ads do when you clicked on the Buy Button? *[When the Buy Button is clicked, the other sprite appears, too! Two sprites are receiving the same "Go" message.]*

When more than one sprite receives a message sent by another sprite, this is called **one-to-many synchronization**. A message is sent by one sprite and received by many other sprites.

You created a new script for the Search Button sprite that broadcasted the message "Go". What happened when you clicked on the Search Button? What happened when you clicked on the Buy Button? *[Now, the Ads will appear if either the Buy Button or the Search Button is clicked. The Recommendation does the same actions because both the Buy Button and Search Button send the same message.]*

Modify Project (50 minutes)

Pass out the [One-Way Sync: L2 Student Sheet](). Remind students to **R**oa**R** and h**iSS** (**R**eload, **R**emix, **S**hare and +Add to **S**tudio) the One-Way Sync: Online Data Collection project: https://scratch.mit.edu/projects/490453259/. Remind students that they need to share the project so it is accessible to you and others.

In this activity, students will modify the project to do the following:

- Finish the costumes for the Search Button and Ads with something you would search for and ads that might appear.
- Make it so that when the Search Button is clicked: the Search Button changes costume and makes a sound AND the Ads appear on the stage.
- Make the Start sprite show and have it start all the sprites at once. When the Start Sprite is clicked: the Buy Button changes costume and makes a sound AND the Recommendation appears AND the Search Button changes costume and makes a sound AND the Ads appear on the stage.

Make sure students have tested their projects for correct functionality.

Scratch Skill: Painting a new sprite
In the Sprites pane, click on the paintbrush (to the right of New sprite:) to 'Paint new sprite.'

Explore using these tools to create your button sprite:
- Draw the shape: Use the rectangle (or other shape) tool.
- Add color: Use the paint bucket tool.
- Add text: Use the Text tool to add text to your button.
- Adjust the size: Click 'Convert to vector' (lower right corner), click on your button and adjust the size.

Extensions:
- Finish the costumes for the Search Button and Ads with something you would search for and ads that might appear.
- Make it so that when the Search Button is clicked: the Search Button changes costume and makes a sound AND the Ads appear on the stage.
- Make the Start sprite show and have it start all the sprites at once. When the Start Sprite is clicked: the Buy Button changes costume and makes a sound AND the Recommendation appears AND the Search Button changes costume and makes a sound AND the Ads appear on the stage.

Reflect and Discuss

Reflect (10 minutes)
New Blocks and Concepts and Reflection Questions are included on the [One-Way Sync: L2 Student Sheet].

New Blocks & Concepts:	Journal Questions:
• `broadcast [message]` • `when I receive [message]` • one-way synchronization • message passing	• Why is it important that the same message is received as was passed? • Why is using one-way synchronization to pass a message useful in programming projects? • In what other ways would you use one-way synchronization in a Scratch project?

Materials adapted from Scratch Encore by CanonLab.org

Share & Discuss (If time permits)
Consider having students present their projects to the class (or make time for a walk around showcase where students run each other's projects on individual computers). If there is time, lead a brief discussion about one-way synchronization in Scratch projects and other uses students can think of for this skill.

<table>
<tr><td>Assessment:
Student projects can be graded based on completion of all required elements.
The One-Way Sync TIPP&SEE and One-Way Sync: L2 Student Sheet worksheets can be graded for completion and/or correctness.</td><td>Integration:</td></tr>
<tr><td colspan="2">Differentiation:
Prepare block definition sheets to add to journals - block names listed (students fill in the definitions) or blocks and the definitions completed, students match block names to the definitions.
Provide a list of the type and number of blocks needed to complete each activity.</td></tr>
</table>

Lesson 3: Creating with One-Way Synchronization

Lesson Overview	Lesson At-A-Glance
Students develop a project about or using data and utilizing One-Way synchronization in an open-ended create project.	Engage: 10 minutes Explore: 100 minutes Reflect: 10 minutes

Lesson Preparation	
Student Materials Engage • None Explore • One-Way Sync: L3 Student Sheet Doc Slides PDF Answer Key	**Teacher Materials** Engage • Building Your Business Online Video • Marketing Video Explore • None Scratch Projects • None

Engage

Introductory Discussion (10 minutes)

Motivate students by showing one or two video clips about starting a business online and marketing. BizKids has videos for kids about Building Your Business Online and Marketing.

Then, review online data collection and the data the class collected during the first lesson.

What data do companies collect online? *[Views, links you follow, likes, things you search for, etc.]*

How do companies use the data they collect for marketing? *[Decide what you might like to see or buy, give personalized advertisements, etc.]*

What data did we collect about the class? *[The class' preferences about where they see ads, and products they would be most interested in buying.]*

If you worked in marketing, how would you use that information? *[To decide what people my age liked and how to sell products to them.]*

Brainstorm with students how they would sell things online. Then, ask students to brainstorm ideas for a project that uses one-to-many synchronization.

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Remind them that they used this type of synchronization in the previous lesson when they added a start button to the One-Way Sync: Online Data Collection Scratch project. Ask students to think-write-pair to discuss ideas for a new one-to-many project that talks about or uses the data they collected to explain online data collection.

Explore

Create Project (100 minutes)

Introduce today's activity: To create a new project that uses one-to-many synchronization to shares about using data collection or suggestions and advertising online. Students may choose a project of their choice. Pass out the One-Way Sync: L3 Student Sheet to give students guidance throughout the project.

To complete this task, students will:

- ❏ Plan the one-to-many interaction: what actions will the sprites carry out when another sprite is clicked?
- ❏ Complete the graphic organizer to plan their one-to-many synchronization.
- ❏ Add 5 sprites and a backdrop to a new Scratch project.
- ❏ Create a one-to-many interaction that includes 4 sprites that do something when another sprite is clicked - one sprite sends a message that is received by all the other sprites.

Explain to students that they can create any project that is interesting to them about online data collection, but some ideas are:

- Imagine that you are working for a marketing company. Use the data collected about what your class likes to create a project that demonstrates marketing to youth of your age. Think about what data you would collect and the resulting ads or suggestions.
- Think about online data collection in your life. Create a project that shows where you receive ads online or in apps based on choices you have made.
- A topic of students' choice!

Students can also look back at the Product Marketing Plan they created in lesson 1 for ideas.

Remind students to run their project to test that it works as expected. Remind students that they need to share the project so it is accessible to you and others.

Extensions:

- Think of another way to use one-to-many synchronization in your project, add it to your project by creating new scripts and messages.
- Animate your sprites or make them talk using say blocks. Consider having them talk about how the online data collection can be a Threat to Techquity.
- Think of a way to use one-to-one synchronization in your project.

Reflect and Discuss

Reflect (10 minutes)

As students finish their create project, they complete the journal questions and note the new blocks on their One-Way Sync: L3 Student Sheet.

Journal Questions

- What was challenging about this project?
- How did you work through the challenges you faced?

Assessment	Integration
• Student projects should be graded based on completion of all required elements.	

Differentiation:

- Prepare block definition sheets for students. Options include: List the block name (students fill in the definitions), block names and definitions provided (students match block names to the definitions).
- Provide a list of the type and number of blocks needed to complete each activity.

Lesson 4: Presentations

Lesson Overview	Lesson At-A-Glance
Students present the one-way sync projects they created about online data collection.	Presentations: 60 minutes

Lesson Preparation	
Student Materials None	Teacher Materials None

Engage

Preparing for presentations (5 minutes)

Students pull up the projects that they have been working on. Each student spends 5 minutes brainstorming what they will share about their project. Students should be prepared to:

3. Introduce the topic and concept of their project
4. Explain why they chose to share this example of the use of data collected online

At this time, also have each student make sure their project has been shared to the correct studio so you can share their project without needing to load new screens.

Explore

Project Sharing (45 minutes)

Each student shares their create projects. Students should:

4. Give an introduction to their project
5. Share their project (Recommended that you play all projects from your screen)
6. Answer questions from you and classmates about the project

Reflect and Discuss

Reflect (10 minutes)

Hold a concluding reflection and discussion with students about both their projects and what they have learned about Techquity. Remind students that Techquity is when technology is equitable. There are things that work against

Techquity such as using the data collected online to make assumptions about people and offer them different products or products at different prices. Create an opportunity for students to ask final questions and share what they have learned in this unit.

Standards

CSTA Standards

1B-AP-10 Create programs that include sequences, events, loops, and conditionals. (P5.2)

1B-AP-11 Decompose (break down) problems into smaller, manageable subproblems to facilitate the program development process. (P3.2)

1B-AP-12 Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features. (P5.3)

1B-AP-13 Use an iterative process to plan the development of a program by including others' perspectives and considering user preferences. (P1.1, P5.1)

1B-AP-14 Observe intellectual property rights and give appropriate attribution when creating or remixing programs. (P7.3)

1B-AP-15 Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended. (P6.1, P6.2)

1B-AP-17 Describe choices made during program development using code comments, presentations, and demonstrations. (P7.2)

2-AP-10 Use flowcharts and/or pseudocode to address complex problems as algorithms. (P4.4, P4.1)

2-AP-13 Decompose problems and subproblems into parts to facilitate the design, implementation, and review of programs. (P3.2)

2-AP-16 Incorporate existing code, media, and libraries into original programs, and give attribution. (P4.2, P5.2, P7.3)

2-AP-19 Document programs in order to make them easier to follow, test, and debug. (P7.2)

1B-IC-18 Discuss computing technologies that have changed the world, and express how those technologies influence, and are influenced by, cultural practices.

1B-IC-20 Seek diverse perspectives for the purpose of improving computational artifacts. (P1.1)

1B-IC-21 Use public domain or creative commons media, and refrain from copying or using material created by others without permission. (P7.3)

2-IC-20 Compare tradeoffs associated with computing technologies that affect people's everyday activities and career options.

2-IC-21 Discuss issues of bias and accessibility in the design of existing technologies.

ISTE Standards

1. **Empowered Learner:** Students leverage technology to take an active role in choosing, achieving and demonstrating competency in their learning goals, informed by the learning sciences. Students:

    c. use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.

    d. understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

2. **Digital Citizen**: Students recognize the rights, responsibilities and opportunities of living, learning and working in an interconnected digital world, and they act and model in ways that are safe, legal and ethical. Students:

    b. engage in positive, safe, legal and ethical behavior when using technology, including social interactions online or when using networked devices.

    d. Students manage their personal data to maintain digital privacy and security and are aware of data-collection technology used to track their navigation online.

4. **Innovative Designer:** Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions.

    a. know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

    c. develop, test and refine prototypes as part of a cyclical design process.

    d. exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.

5. **Computational Thinker:** Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.

    a. Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.

    d. Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

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6. **Creative Communicator:** Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.

   b. create original works or responsibly repurpose or remix digital resources into new creations.

   c. Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.

Techquity Unit 3:
Conditional Loops & Training Machine Learning Algorithms

Computer Science Topic: Conditional Loops
Techquity Topic: Training Machine Learning Algorithms

Unit Summary

Students learn about using conditional loops to have an action repeat until a specific condition becomes true. They implement conditional loops that control repeated actions in a vehicle, then create a project of their own that uses conditional loops and tells about Threats to Techquity in the training of machine learning algorithms.

Unit Objectives

Students will be able to:

- create an animation with one costume and repeated movement.
- write a script using a conditional loop that repeats an action until a condition is true.
- detail the process of and potential biases when training machine learning algorithms.

Big Idea:
It is very often that loops need to execute a number of times that cannot be predetermined, therefore simple repeat loops cannot be used. Programmers need to think about what will decide when the loop stops. Here we step through both the design and implementation of such loops in Scratch.

Unit Overview

Lesson 1: Examining Bias in the Training of Machine Learning Algorithms **60 minutes** Students learn about training machine learning algorithms using Google Teachable Machine and consider bias in the process.	Lesson 2: Exploring Conditional Loops **60 minutes** Students are introduced to the concept of conditional loops. They modify a Scratch project to stop the action when a condition becomes true using sensing blocks.
Lesson 3: Creating with Conditional Loops **120 minutes** Students use conditional loops to create a project that teaches	Lesson 4: Presentations **60 minutes** Students present the conditional loops projects they created about

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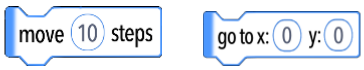
about training machine learning algorithms.	bias in the training of machine learning algorithms.

Prior Knowledge

Looks

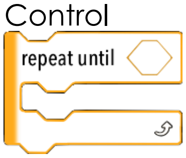
Motion



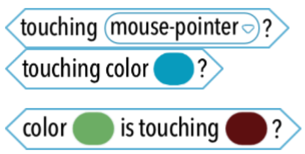
Events

New Blocks

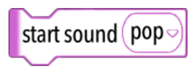
Control



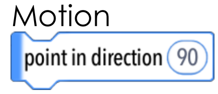
Sensing



Sound



Motion



Materials adapted from [Scratch Encore](#) by [CanonLab.org](#)

Lesson 1: Examining Bias in the Training of Machine Learning Algorithms

Lesson Overview	Lesson At-A-Glance
Students learn about training machine learning algorithms using Google Teachable Machine and consider bias in the process.	Engage: 10 minutes Explore: 40 minutes Reflect: 10 minutes

Lesson Preparation	
<u>Student Materials</u> Engage • None Explore • Machine Learning with Google Teachable Machine Doc PDF	<u>Teacher Materials</u> Engage • What is Machine Learning? video Explore • None Reflect • Inside Uber's Self-Driving Car video

Engage

Introductory Discussion (10 minutes)

Review the idea of algorithmic bias with students.

What is algorithmic bias? *[Prejudice or lack of fairness in the results of a computer system output.]*

What are examples of negative algorithmic bias that we have discussed? *[Image search results not showing images representative of society]*

What is data? *[Data is pieces of information that are collected and brought together.]*

In computer science, individual points of data are combined into datasets and is used in algorithms and decision making.

Explain to students that today the class is going to learn about a type of algorithm that uses a lot of data and often exhibits bias, machine learning algorithms.

Play the Oxford Sparks "What is Machine Learning?" video. As students watch, have them write 2 or 3 common machine learning algorithms they experience.

Use Question / Student Answer / Teacher Clarification to discuss the idea of machine learning through this sequence of questions.

What is machine learning? *[According to* Oxford Sparks in the video we just watched, "Machine learning brings together statistics and computer science to enable computer to learn how to do a different task without being programmed to do so."*]*

In the video, the machine was determining which images were cats and which were dogs. The programmer didn't tell the algorithm which characteristics to look for, instead they provided many different examples of cats and dogs and allowed the algorithm to figure out how to tell between them.

How do machine learning algorithms use data? *[The machine learning algorithm "learns" based on the data that it is given. This data is often called the training data. Based on that data, the algorithm figures out how to complete a task without a programmer telling it exactly what to do.]*

So, given thousands of images of dog and cats that a human has labeled correctly as a dog or cat, the algorithm can "learn" the difference between them. The more data that a machine learning algorithm has, the better the algorithm becomes. So, a machine learning algorithm that is given 1000 pictures of dogs and 1000 pictures of cats will be able to identify a new picture of cat or dog better than one that only received 10 images of each animal for training.

What are examples of machine learning algorithms? Can you think of any that weren't in the video? *[In video: facial recognition, text and speech recognition, spam filter, online shopping or viewing recommendation, identity theft detection; other examples: music or video recommendations, self-driving and smart cars, web search]*

Note: If you would like to learn more about how machine learning algorithms work or have a student who is interested in learning more, check out the video "How Machines Learn" or the blog "Children's Guide to Machine Learning."

Introduce today's activity: experimenting with training a machine learning algorithm using a tool called Google Teachable Machine.

Explore

Machine Learning with Google Teachable Machine (40 minutes)

Individually or in pairs, have students complete the Machine Learning with Google Teachable Machine activity. In this activity, students will use images of their right hand open and in a fist to train a machine learning algorithm to recognize these two hand positions. Then, students will experiment with what happens when they test with their left hand in these two positions or give the machine a thumbs up.

Reflect and Discuss

Reflect (10 minutes)

Debrief the activity by discussing what students observed when training and testing their machine learning algorithm.

What happened when the system didn't have data for your left hand or the thumbs up? *[The output certainty decreased. Sometimes it identified correctly, but other times it did not]*

Raise your hand if the algorithm identified your thumbs up with a higher percentage for open hand. Raise your hand if the algorithm identified your thumbs up with a higher percentage for fist. Why do you think this is? *[Answers will vary, but could have to do with where the hand was positioned on the screen, thumbs up being closest to a fist, thumb sticking out]*

The machine learning algorithm is trained to recognize patterns. It might have identified the thumbs up as a fist because most of your fingers are balled into a fist or it could have recognized it as an open hand because your thumb was sticking out. Since we only used 50 to 100 images, it also might have recognized it depending on where your hand was on the screen. If your training images don't have the hand all around the screen, it could associate open or fist based on where the hand is in the image, not the hand position. Remember, the computer doesn't know what open hand or fist is, it is looking for patterns in the images it takes, and those patterns might not be what you would expect.

Explain to students that one real-life example of machine learning that is being worked on right now is self-driving cars.

What do you know about self-driving cars? *[Answers will vary]*

Explain to students that Uber has been experimenting with self-driving cars in Pittsburgh and the class is going to watch a video to learn more about the technology. Show the video Inside Uber's Self-Driving Car.

What are your reactions to a self-driving car? Would you ride in it? *[Answers will vary]*

The self-driving cars use machine learning to help them drive. Their algorithms help them to recognize a stop sign, another car, a bicyclist, or a person crossing the street.

Why is it important that self-driving cars have enough training before they drive without an engineer behind the wheel to make corrections? *[If they don't have enough training, the car might not follow traffic laws or might hit another car or person]*

Since machine learning models look for patterns and make decisions based on those patterns, they rely on making decisions based on what they have seen. The danger with self-driving cars (and any machine learning algorithm) is that everything might not be in the dataset or might be underrepresented in the training data. For example, research has shown that the algorithms controlling autonomous vehicles are less likely to detect people with darker skin tones. There is also concern over whether they will reliably detect children or people in wheelchairs since most training data in predominantly able-bodied adults.

What do you think engineers and government regulators need to do to make sure self-driving cars are safe for everyone? *[Answers will vary]*

Conclude the lesson by explaining that students are going to share what they have learned about in the Scratch projects they create over the next few lessons. Encourage students to write down 3 things they learned, 2 things they found interesting, and 1 question they have as an exit ticket. Challenge them to talk to their families about machine learning and self-driving cars tonight and see if their caregiver would allow them to ride in a self-driving Uber.

Lesson 2: Exploring Conditional Loops

Lesson Overview	Lesson At-A-Glance
In this lesson, students learn how to stop an action when a condition becomes true by modifying a conditional loop using a `touching < >?` block. **Vocabulary:** conditional loop	Engage: 10 minutes Explore: 40 minutes Reflect: 10 minutes

Lesson Preparation	
Student Materials Engage • None Explore • Conditional Loops: TIPP&SEE worksheet Doc PDF Slides Answer Key • Conditional Loops: L2 Student Sheet Doc PDF Slides Answer Key	Teacher Materials and Scratch Projects Engage • Conditional Loops Engage Video: Drive YouTube Explore • None Scratch Projects • Conditional Loops: Self-Driving Cars

Engage

Introductory Discussion (10 minutes)

Use Question / Student Answer / Teacher Clarification to introduce conditional loops through this sequence of questions.

What is a repeated action? *[Something that happens over and over again]*

Do repeated actions happen forever? *[No, all loops end. In animation we used repeated actions that only repeat a certain number of times]*

Repeated actions within computer program exist within loops. Loops can have a set number of repetitions, as seen in the animation unit, can continue as long as the program is running, or can end based on a condition becoming true. In this unit, we will focus on loops that run until a condition is true, these are called conditional loops.

Introduce students to the concept of a **conditional loop**, a repeated action that continues until a specific end condition becomes true. Explain that with a conditional loop, the action repeats an undetermined number of times because the action will not stop until the end condition is true. An example of this is running until you cross the finish line, walking until you reach a locked door, or reading until the end of a book.

Ask students to brainstorm other repeated actions and write them on the board. If actions without conditions come up, write them on the board as well, they will be teachable moments later in the discussion. Collect 5-8 ideas depending on how much time you have.

When all of the ideas are on the board, ask the students to identify the actions and the end conditions (what causes the action to stop). For each example that is on the board, ask, "What are the actions and what are the end conditions?" As students answer, underline the actions and put a box around the end conditions. For example running until you cross the finish line and walking until you reach a locked door. If students have volunteered any actions that do not have conditions, point them out as you go and demonstrate that they do not have an end condition, showing the difference between action and actions with end conditions. After discussing these as a class, erase them from the list.

	Conditional Loops Engage Video Use the recorded Conditional Loops Engage Video to introduce content for students who miss class when the concept is introduced, when teaching online, or asynchronously, or for students who benefit from multiple exposures to content.

Explore

Using TIPP&SEE (20 minutes)

Tell students that today they are going to use **TIPP&SEE** on their own. Point out the **TIPP&SEE** classroom poster and remind students that they can look there if they forget a part of the strategy. Remind students that **TIPP&SEE** allows them to get their head in the game, focus on the project, and explore the code.

Students open the Conditional Loops: Self-Driving Cars project (https://scratch.mit.edu/projects/484495845) and complete the Conditional Loops: TIPP&SEE Worksheet to work through the **TIPP&SEE** strategy.

After they have finished, review with students what happened with each of the Explore: Modify questions.

Materials adapted from Scratch Encore by CanonLab.org

Modify Project (20 minutes)
Pass out the Conditional Loops: L2 Student Sheet. Remind students to **R**oa**R** and hi**SS** (**R**eload, **R**emix, **S**hare and +Add to **S**tudio) the Conditional Loops: Self-Driving Cars project (https://scratch.mit.edu/projects/484495845). Remind students that they need to share the project so it is accessible to you and others.

In this activity, students will modify the project to do the following:

- Modify the script to stop the car using a different condition.
- Personalize by choosing a costume, editing the text, and changing the speed of the car.

Extensions
• Add another sprite and have it stop at another sprite or a color. • Have a sprite go back to the start after it stops moving. • Add more information about machine learning to the project.

Reflect and Discuss

Reflect (10 minutes)
As students finish their modify project, they complete the journal questions and note the new blocks on their Conditional Loops: L2 Student Sheet.

New Blocks and Concepts	Journal Questions
• repeat until • touching <sprite>? • touching <color>? • color <color> is touching <color>? • Conditional Loop	• Why is a conditional loop a useful tool in programming? • How would you use sensing blocks in another project? • What other actions could you place inside a conditional loop? • How do you make a sprite look to the left?

Share & Discuss (if time permits)
Set up a gallery walk with projects on each computer and allow students to circulate around the room to visit their classmate's projects and view them. If there is time, consider leading a discussion about how conditional loops with sensing blocks could be used in their projects.

Assessment	Integration

Materials adapted from Scratch Encore by CanonLab.org

Student projects should be graded based on completion of all required elements.	Social Studies - societies

Differentiation:

- Prepare block definition sheets for students. Options include: List the block name (students fill in the definitions), block names and definitions provided (students match block names to the definitions).
- Provide a list of the type and number of blocks needed to complete each activity.

Lesson 3: Creating with Conditional Loops

Lesson Overview	Lesson At-A-Glance
In this lesson, students create a project that tells about machine learning by animating a sprite to move across the stage and use a conditional loop to stop the sprite when a condition becomes true using a sensing block.	Engage: 15 minutes Explore: 95 minutes Reflect: 10 minutes

Lesson Preparation

Student Materials	Teacher Materials
Engage • None Explore • Animation: L3 Student Sheet Doc PDF Slides	Engage • None Explore • None Scratch Projects • None

Engage

Introductory Discussion (15 minutes)

Use a discussion to review the blocks and concepts covered in the previous lesson.

What is algorithmic bias? *[When the programs controlling computers and technology have been programmed with the biases of society and don't treat everyone fairly because of their identity.]*

What is machine learning? *[Algorithms that use datasets to make predictions that allow them to complete a task without being explicitly programmed to do so.]*

Why is it important that self-driving cars have enough training before they drive without an engineer behind the wheel to make corrections? *[If they don't have enough training, the car might not follow traffic laws or might hit another car or person. With biased training data, the cars might be more likely to hit someone who has darker skin, is a child, or has a disability.]*

Remind students that in the last lesson, they learned about conditional loops.

What is a conditional loop? *[A loop that continues until a condition is determined to be true.]*

What block do you use in Scratch to create a conditional loop? *[*`repeat until`*]*

How does the `repeat until` **block work?** *[Anything inside the block will continue to happen until the condition is determined to be true]*

What do you use with `repeat until` **blocks?** *[sensing blocks - (*`touching <sprite>?, touching <color>?, color <color> is touching <color>?`*)]*

What did the `point in direction __` **block that we discovered during our exploration do?** *[pointed the sprite in the selected direction so that it would move the right way.]*

Based on what you learned in the previous lesson, how would you make a sprite move from right to left rather than from left to right? *[They could move backwards to the left by using negative numbers in the* `move_steps` *block or they could turn around and move forwards by using* `point in direction` *to turn around and positive numbers in the* `move__steps` *block.]*

> In Scratch, the `move __ steps` block moves the sprite depending on the direction that the sprite is facing. In order to have the sprite move from right to left rather than left to right, the `point in direction __` block is used to turn the sprite to face the other direction so that forward movement for that sprites goes right to left.

Explore

Create Project (95 minutes)

Introduce today's activity: To create a project using animation that moves across the screen and a conditional loop to stop when a condition becomes true. Pass out the Conditional Loops: L3 Student Sheet to give students guidance throughout the project.

To complete this task, students will:

- Select a backdrop and at least 3 sprites for their project.

- Move the people sprites to logical locations within the stage
- Build a script on their chosen sprite to make it move (including the go to x:__y:__ block to start at a specific location and a repeat until__ conditional). If students choose to make it move from right to left, they will need to use a point in direction block.
- Add a sensing block to stop their chosen transportation: either touching <sprite>?, color <color> is touching <color>?, or touching <color>? and identify the condition that will make the movement stop.
- Add a say or sound block to signal that the sprite has stopped.

Explain to students that they can create any project that is interesting to them and shares about machine learning, but some ideas are:
- An animal or object moves across the screen to be identified by machine learning
- A person moves across the screen to another person and discusses machine learning
- Facts about machine learning move across the screen with each giving more information about it
- A topic of their choice!

Remind students to run their project to test that it works as expected. Debug and re-test if necessary. Students should **S**hare and +Add to **S**tudio before exiting Scratch.

Extensions
- Add repeat and move blocks to animate another sprite.
- Add a sprite from the sprite library (resize if needed) to be used in the sensing block as the condition that stops the sprite.
- Have the sprite stop in different places when it is triggered by different events.

Reflect and Discuss

Reflect (10 minutes)
As students finish their create project, they complete the journal questions and note the new blocks on their Conditional Loops: L3 Student Sheet.

New Blocks and Concepts	Journal Questions
• point in direction__	

Materials adapted from Scratch Encore by CanonLab.org

	• What was challenging about this project? • How did you work through the challenges you faced? • How did you choose which sensing block to use in your project? • How is moving a sprite from right to left different from moving the sprite from left to right?

If there is time, lead a discussion about challenges, questions, and new discoveries identified while completing their project.

Assessment	Integration
• Student projects should be graded based on completion of all required elements.	Social Studies - societies

Differentiation:

- Prepare block definition sheets for students. Options include: List the block name (students fill in the definitions), block names and definitions provided (students match block names to the definitions).
- Provide a list of the type and number of blocks needed to complete each activity.

Lesson 4: Presentations

Lesson Overview	Lesson At-A-Glance
Students present the conditional loops projects they created about bias in the training of machine learning algorithms.	Presentations: 60 minutes

Lesson Preparation	
Student Materials None	Teacher Materials None

Engage

Preparing for presentations (5 minutes)

Students pull up the projects that they have been working on. Each student spends 5 minutes brainstorming what they will share about their project. Students should be prepared to:

5. Introduce the topic and concept of their project
6. Explain why they chose to share this information about machine learning.

At this time, also have each student make sure their project has been shared to the correct studio so you can share their project without needing to load new screens.

Explore

Project Sharing (45 minutes)

Each student shares their create projects. Students should:

7. Give an introduction to their project
8. Share their project (Recommended that you play all projects from your screen)
9. Answer questions from you and classmates about the project

Reflect and Discuss

Reflect (10 minutes)

Hold a concluding reflection and discussion with students about both their projects and what they have learned about Threats to Techquity. Remind

Materials adapted from Scratch Encore by CanonLab.org students that Techquity is when technology is equitable and bias in machine learning algorithms is not equitable. Create an opportunity for students to ask final questions and share what they have learned in this unit.

Standards

CSTA Standards

1B-AP-10 Create programs that include sequences, events, loops, and conditionals. (P5.2)

1B-AP-12 Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features. (P5.3)

1B-AP-14 Observe intellectual property rights and give appropriate attribution when creating or remixing programs. (P7.3)

1B-AP-15 Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended. (P6.1, P6.2)

1B-AP-17 Describe choices made during program development using code comments, presentations, and demonstrations. (P7.2)

2-AP-16 Incorporate existing code, media, and libraries into original programs, and give attribution. (P4.2, P5.2, P7.3)

1B-IC-18 Discuss computing technologies that have changed the world, and express how those technologies influence, and are influenced by, cultural practices.

1B-IC-20 Seek diverse perspectives for the purpose of improving computational artifacts. (P1.1)

1B-IC-21 Use public domain or creative commons media, and refrain from copying or using material created by others without permission. (P7.3)

2-IC-20 Compare tradeoffs associated with computing technologies that affect people's everyday activities and career options.

2-IC-21 Discuss issues of bias and accessibility in the design of existing technologies.

ISTE Standards

1. **Empowered Learner:** Students leverage technology to take an active role in choosing, achieving and demonstrating competency in their learning goals, informed by the learning sciences. Students:

    c. use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.

    d. understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

2. **Digital Citizen**: Students recognize the rights, responsibilities and opportunities of living, learning and working in an interconnected digital

world, and they act and model in ways that are safe, legal and ethical. Students:

b. engage in positive, safe, legal and ethical behavior when using technology, including social interactions online or when using networked devices.

4. **Innovative Designer:** Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions.

a. know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

c. develop, test and refine prototypes as part of a cyclical design process.

d. exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.

5. **Computational Thinker:** Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions.

a. Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.

d. Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

6. **Creative Communicator:** Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.

b. create original works or responsibly repurpose or remix digital resources into new creations.

c. Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.

Techquity Unit Final Scratch Project

After Units 1, 2, and 3

Computer Science Topic:	Animation, One-Way Synchronization, and Conditional Loops
Techquity Topic:	Varies by Student

Project Summary

In this project, students create a final Scratch project combining what they learned in previous Techquity units. Students use animation, one-way synchronization, and conditional loops to present information about a Techquity topic of interest to them.

Project Objectives

Students will be able to:

- animate a sprite in one location using a repeat loop and multiple costumes.
- animate a sprite with movement using a repeat loop.
- create scripts that use message passing for one-way synchronization between two or more sprites
- utilize conditional loops to program a sprite to move across the screen until a condition becomes true.
- share information about a Techquity topic such as highlight a woman computer scientist or computer scientist of color or describing a Threat to Techquity

Unit Overview

Part 1: Topic and Research Students select a topic for their project and learn about their topic. They identify information that they want to include in their final project.	Part 2: Set-up and Initialization Students set up their Scratch projects and initialize their sprites.
Part 3: Animation and One-Way Sync Students use animation, one-way sync, and conditional loops to program their projects.	Part 4: Presentations Students present their final project.

Project Preparation

Student Handouts

- Part 1: Topic/Research
  Doc PDF
- Part 2: Setup/Initialize

Materials adapted from Scratch Encore by CanonLab.org

Doc PDF

- Part 3: Animation/One-Way Sync/Conditional Loops
  Doc PDF

Other Resources

- Annotated Sample Project: https://scratch.mit.edu/projects/553830673/
- Techquity Unit Final Scratch Project Rubric
  Doc PDF

Part 1: Topic and Research

Lesson Overview
Students select a topic for their project and learn about their topic. They identify information that they want to include in their final project.

Project Preparation

Student Handouts

- Part 1: Topic/Research
  Doc PDF

Other Resources

- Annotated Sample Project:
  https://scratch.mit.edu/projects/553830673/

Engage

Introducing the Project
Explain to students that they are going to be working on final projects that will allow them to practice and showcase what they have learned in the last few units. Students will create a project that uses animation, one-way synchronization, and conditional loops to share about a Techquity topic.

As is helpful for students, review key Techquity concepts and vocabulary such as bias, algorithmic bias, and online data collection.

Explore

Working on Final Projects
In this working session, students will pick a topic for their project and identify information to include. Students should:

10. Select a topic. Students can use the topics provided on the Part 1 handout or get another topic approved.
11. Read an article and research the topic.
12. Identify at least 5 facts to share about their topic.

Reflect

Exit Ticket

Materials adapted from Scratch Encore by CanonLab.org

At the end of the work session, have students complete the exit ticket questions at the bottom of their handout to reflect on the work they have done so far and what they plan to do the following day.

Part 2: Set-up and Initialization

Lesson Overview
Students set up their Scratch projects and initialize their sprites.

Project Preparation

Student Handouts

- Part 2: Setup/Initialization
  Doc PDF

Other Resources

- Annotated Sample Project:
  https://scratch.mit.edu/projects/553830673/

Engage

Introducing the Work Session
Explain to students that today they are going to start their Scratch projects about the topic they selected in the previous work session. Remind students that they need to be signed into Scratch and share their project before they begin working.

Explore

Working on Final Projects
In this working session, students will start a new Scratch project, share the project, add sprites and a backdrop, and initialize their sprites. Students should:

1. Start a new Scratch project
2. Share the project and add it to the class studio
3. Add 2 sprites and a backdrop to the project
4. Initialize the sprites

Reflect

Exit Ticket
At the end of the work session, have students complete the exit ticket questions at the bottom of their handout to reflect on the work they have done so far and what they plan to do the following day.

Materials adapted from Scratch Encore by CanonLab.org

Part 3: Animation and One-Way Sync

Lesson Overview
Students use animation, one -way sync, and conditional loops to program their projects.

Project Preparation

Student Handouts

- Part 3: Animation/One-Way Sync/Conditional Loops
  Doc PDF

Other Resources

- Annotated Sample Project:
  https://scratch.mit.edu/projects/553830673/

Engage

Introducing the Work Session
Explain to students that for the next few work sessions they are going add animation, one-way synchronization, and conditional loops to their projects. Students should focus on creating projects that share the information they gathered during the first work session. Encourage students to look back at their work from Part 1 to identify information to include in their project.

Explore

Working on Final Projects
In these working sessions, students will animate a sprite in place, animate a sprite with movement across the screen, use one-way synchronization, and move a sprite with a conditional loop to share about their Techquity topic. Students should:

1. Animate at least one sprite in place
2. Animate at least one sprite with movement
3. Pass at least one message between sprites to trigger an action
4. Program at least one sprite to move across the screen using a conditional loop to stop the motion when a condition becomes true
5. Include information about a Techquity topic in their project.

Reflect

Materials adapted from Scratch Encore by CanonLab.org

Exit Ticket

At the end of each work session, have students complete the exit ticket questions at the bottom of their handout to reflect on the work they have done so far and what they plan to do the following day.

Lesson 4: Presentations

Lesson Overview
Students present their final projects.

Project Preparation

Other Resources

- Techquity Unit Final Scratch Project Rubric
  Doc PDF

Engage

Preparing for presentations
Students pull up the projects that they have been working on. Each student spends 5 minutes brainstorming what they will share about their project. Students should be prepared to:

7. Introduce the topic and concept of their project
8. Explain why they chose to share this specific example of Techquity

At this time, also have each student make sure their project has been shared to the correct studio so you can share their project without needing to load new screens.

Explore

Project Sharing
Each student shares their project. Students should:

1. Give an introduction to their project
2. Share their project (Recommended that you play all projects from your screen)
3. Answer questions from you and classmates about the project

Reflect and Discuss

Reflect
Hold a concluding reflection and discussion with students about both their projects and what they have learned about Techquity. Remind students that Techquity is when technology is equitable. There are things that work against Techquity such as algorithmic bias and not having representation of women

or people of color in the computer science field. Create an opportunity for students to ask final questions and share what they have learned.

CSTA Standards

1B-AP-10 Create programs that include sequences, events, loops, and conditionals. (P5.2)

1B-AP-11 Decompose (break down) problems into smaller, manageable subproblems to facilitate the program development process. (P3.2)

1B-AP-12 Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features. (P5.3)

1B-AP-14 Observe intellectual property rights and give appropriate attribution when creating or remixing programs. (P7.3)

1B-AP-15 Test and debug (identify and fix errors) a program or algorithm to ensure it runs as intended. (P6.1, P6.2)

1B-AP-17 Describe choices made during program development using code comments, presentations, and demonstrations. (P7.2)

2-AP-13 Decompose problems and subproblems into parts to facilitate the design, implementation, and review of programs. (P3.2)

1B-IC-18 Discuss computing technologies that have changed the world, and express how those technologies influence, and are influenced by, cultural practices.

1B-IC-20 Seek diverse perspectives for the purpose of improving computational artifacts. (P1.1)

1B-IC-21 Use public domain or creative commons media, and refrain from copying or using material created by others without permission. (P7.3)

2-IC-20 Compare tradeoffs associated with computing technologies that affect people's everyday activities and career options.

2-IC-21 Discuss issues of bias and accessibility in the design of existing technologies.

ISTE Standards

1. **Empowered Learner:** Students leverage technology to take an active role in choosing, achieving and demonstrating competency in their learning goals, informed by the learning sciences. Students:
    a. Students articulate and set personal learning goals, develop strategies leveraging technology to achieve them and reflect on the learning process itself to improve learning outcomes.

c. use technology to seek feedback that informs and improves their practice and to demonstrate their learning in a variety of ways.
d. understand the fundamental concepts of technology operations, demonstrate the ability to choose, use and troubleshoot current technologies and are able to transfer their knowledge to explore emerging technologies.

2. **Digital Citizen**: Students recognize the rights, responsibilities and opportunities of living, learning and working in an interconnected digital world, and they act and model in ways that are safe, legal and ethical. Students:

b. engage in positive, safe, legal and ethical behavior when using technology, including social interactions online or when using networked devices.

3. **Knowledge Constructor:** Students critically curate a variety of resources using digital tools to construct knowledge, produce creative artifacts and make meaningful learning experiences for themselves and others.

c. Students curate information from digital resources using a variety of tools and methods to create collections of artifacts that demonstrate meaningful connections or conclusions.
d. Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories and pursuing answers and solutions.

4. **Innovative Designer:** Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions.

a. know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.
c. develop, test and refine prototypes as part of a cyclical design process.
d. exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems.

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a. Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.

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c. Students communicate complex ideas clearly and effectively by creating or using a variety of digital objects such as visualizations, models or simulations.

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