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Leveraging Local Resources and Contexts for Inclusive Computer Science Classrooms: Reflections from Experienced High School Teachers Implementing Electronic Textiles

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Leveraging Local Resources and Contexts for Inclusive Computer Science Classrooms: Reflections from Experienced High School Teachers Implementing Electronic Textiles

Background and context: Promoting open-ended projects presents new opportunities and challenges for inclusive teaching in CS classrooms. While efforts have been made to develop inclusive curricula, little research has focused on ways teachers apply curricula in their classrooms to promote inclusion.

Objective: To understand the challenges faced in facilitating an open-ended unit and the pedagogical strategies enacted to address those challenges, we analyze the self-reported teaching practices that experienced teachers developed in their implementation of a constructionist electronic textiles unit in *Exploring Computer Science*.

Method: We inductively analyzed and coded 17 experienced teachers' weekly surveys and post-interviews.

Findings: Teachers leveraged local resources and contexts to adapt classroom activities as well as developed new perspectives on computing as ways to foster inclusivity.

Implications: We propose further opportunities for CS teachers to consciously reflect and draw upon the assets and funds of knowledge of their students' communities when facilitating open-ended, inclusive activities.

Keywords: computer science; inclusive; equity; electronic textiles; teachers

Introduction

Many efforts in computer science (CS) K-12 education are now focused on designing inclusive learning activities in schools (Eglash, Gilbert, & Foster, 2013; Guzdial, 2016). These efforts are in response to the social, historical and cultural norms and practices of computing that have resulted in the underrepresentation of women and people of color in the field (e.g., Margolis, Estrella, Goode, Jellison Holme, & Nao, 2008; Ensmenger, 2010). Yet while these efforts have supported an increase in CS learning opportunities for girls and students of color (e.g., Goode, 2008), providing access and different curricular activities are not enough. Equally important is the role teachers play in promoting (or hindering) inclusion in computing classrooms. Computer science teachers' perspectives on the barriers to diversity in CS can impact their teaching practices and the computing culture of the classroom (Gretter, Yadav, Sands, & Hambrusch, 2019). But there are only few studies that describe what engaging, equity-oriented pedagogies look like in formal CS classrooms, leaving teachers with fewer resources for sharing their classroom practices (e.g., Ryoo, 2019). In order to bring inclusive CS education to life, teachers must be aware of and have models for how their pedagogies, learning activities, and classroom structures resist—or further foster—marginalization of their students, as well as develop strategies that engage a diverse range of students.

One of the most longstanding national efforts to provide inclusive CS learning opportunities to underrepresented students is the *Exploring Computer Science* (ECS) initiative. Begun in 2008, ECS consists of a year-long, equity-focused, introductory CS curriculum paired with a two-year teacher professional development (PD) program that, as of this time, reaches over 2,500 teachers across the United States (Goode, Chapman, & Margolis, 2012). The PD equips teachers with knowledge about the institutional barriers that limit their students' participation in CS, the opportunity to examine inequities in computing, and the skills needed to challenge those barriers in their classrooms (Goode, Margolis, & Chapman, 2014). To date, ECS has expanded to 34 states and Puerto Rico, serving over 55,000 students nationwide during the 2018-2019 year as they engage in curricular units ranging from Human Computer Interaction to Robotics (Exploring Computer Science, n.d.).

Yet while the ECS curriculum and PD training have been successful at broadening participation in school districts (McGee et al., 2019), there are opportunities to improve student creativity and personalization, which can connect with a diverse range of students—particularly those who may disconnect from computing. For instance, although the ECS curriculum provides inquiry- and equity-oriented instruction with an emphasis on algorithms, abstraction, and problem solving, opportunities for students to create and express themselves personally are limited. A newly developed electronic textiles (e-textiles) unit can bring greater creativity and personalization into ECS by giving students the opportunity to design interest-driven, personally-meaningful projects with sewn, electronic crafts (Kafai et al., 2019). Electronic textiles combine the technical aspects of coding and circuitry with the aesthetic dimensions of crafting through the creation of physical, programmable artifacts, thereby providing multiple entry points for a diverse range of students and disrupting preconceptions about who can do computing (Kafai, Fields & Searle, 2014).

The e-textiles unit draws upon constructionism by combining open-ended, interest-driven projects with physical computing. This approach adopts a student-centered approach based on the idea that people build knowledge by creating tangible artifacts or projects to share with others (Papert, 1991). For each of the four projects in the unit, students begin with aesthetic sketches to promote personalization and have large degrees of freedom in what to create within design constraints that support learning core programming and engineering concepts and practices (Kafai & Fields, 2018). However, such open-ended projects come with their own sets of challenges, as teachers and students must share responsibility for the learning process and continuously negotiate with each other (Hertzog, 1998).

In initial pilots of the e-textiles unit with three experienced ECS practitioners, the teachers suggested that the open-ended nature of the unit, the wide opportunities for personalization, and the introduction of physical crafting supplies and techniques challenged them to restructure their existing teaching practices (Fields, et al., 2018). With the integration of cultural practices like crafting, e-textiles also situates computation within a context that can be familiar and meaningful for students and their families. Furthermore, e-textiles have supported teachers in shifting their perspectives "towards a more culturally aware vision of [their] students" and their learning capabilities (Tofel-Grehl & Searle, 2017). Considering e-textile can engage a diverse range of students in computing, this suggests that when facilitating the e-textiles unit, ECS teachers utilized pedagogies that not only changed the participation structures of their classroom but also promoted inclusion in their CS classrooms. Moreover, considering that ECS teachers are knowledgeable about equity-oriented teaching practices, this highlights an opportunity to understand how they facilitate such open-ended, student-driven curricula.

In this paper we explore more fully the kinds of challenges a group of experienced ECS teachers faced when implementing the e-textiles unit and how these obstacles shaped their perspectives about equity and inclusion. Building on a prior study that examined their teaching practices through the lens of culturally-responsive pedagogy (Nakajima & Goode, 2019b; Ladson-Billings, 1992 and 1995), in this study we inductively assessed the experiences of 17 teachers at 13 schools, all of whom implemented the e-textiles unit. As a way to illuminate the potential "in-the-moment" decisions that further supported inclusion, we collected and analyzed weekly surveys as well as post-unit interviews about their classroom implementation. Considering that teachers had already completed at least two years of equity-based PD using ECS, we sought to understand how the e-textiles unit restructured their classroom teaching and whether (and how) their perspectives on students changed, asking:

(1) What *challenges* did CS teachers face in building inclusion while implementing a project-based, open-ended unit and how did they approach those challenges?

(2) What *resources and supports* did teachers recruit to create an inclusive environment? and

(3) What *insights* about inclusion did teachers report learning through this process of implementing a student-driven curriculum?

In the discussion, we consider the need for CS teacher preparation programs to shift from content to context wherein teachers have opportunities to reflect on the assets and funds of knowledge of their students' communities in order to develop and facilitate activities that are personally-meaningful and inclusive to a diverse group of students.

Background

Inclusion in Computer Science Education

Computer science education has not developed a unified definition of inclusion. In general, CS education researchers define inclusion as welcoming and attending to all students no matter their identities, backgrounds, and differences (Microsoft, 2019). Yet how to actually instantiate inclusion in CS teaching has been less well developed, particularly as CS is a relatively new academic discipline in K-12 instruction. Despite the recent adoption of CS into the core curriculum in schools across several countries, there have been pervasive racial and gender disparities in CS education within the United States specifically. Not only has CS education been criticized for the disproportionate participation of girls and students of color, but there have been several documented ways classrooms perpetuate exclusion among these and other underrepresented groups. For example, CS classrooms can reinforce stereotypical features and objects (Cheryan, Meltzoff, & Kim, 2011), create an impersonal and defensive communication climate (Garvin-Doxas & Barker, 2004), and perpetuate status hierarchies by positioning less experienced and less confident students as less capable of learning (Margolis, Estrella, Goode, Jellison Holme, & Nao, 2008). Therefore, broadening participation in computing is not enough; we must tend to the learning needs of all students by addressing the pedagogical practices that may inadvertently exclude students.

To teach CS equitably and inclusively, teachers must know (1) how students learn, (2) key computing content and its sociohistorical impacts on students, schools, and local communities, (3) pedagogical practices necessary to best engage all learners by building on students' cultural knowledge, and (4) an understanding of school structures and how they impact students' educational pathways (Goode & Ryoo, 2019). This includes designing learning environments where every student has access to not only material resources (e.g., rich content and quality instruction) but to non-material resources (e.g., identities as computer scientists and peer relationships) as well (Shah, et al., 2013). To counter exclusive teaching practices, researchers have developed several culturally-relevant education (CRE) computing programs as a strategy to make CS learning more inclusive to students from groups that have been historically marginalized (Morales-Chicas, Castillo, Bernal, Ramos, & Guzman, 2019; Searle, Tofel-Grehl, & Breitenstein, 2019). Through an emphasis on teacher practices and attitudes that are committed to social justice, these programs connect students' cultural assets to CS content and skills (Aronson & Laughter, 2016). In addition, they allow students to reflect on and challenge the status quo in computing using computational skills (Scott, Aist, & Zhang, 2014), as well as draw upon indigenous knowledge, heritage practices (Searle & Kafai, 2015a; Searle & Kafai, 2015b), and vernacular culture (Eglash, Gilbert, & Foster, 2013). Given how CS classroom structures can hinder students' feeling of belonging (Master, Cheryan, & Meltzoff, 2016) and given CS teachers can neglect their own role in such marginalization (Gretter, Yadav, Sands, & Hambrusch, 2019), it's imperative we explore how to bring elements of CRE computing in formal K-12 classrooms.

Exploring Computer Science Course and Professional Development

One model for developing inclusion through CRE in schools is *Exploring Computer Science* (ECS), an equity-focused and inquiry-based introductory CS course taught in public high school classrooms developed to broaden participation in computing (Goode, Chapman, & Margolis, 2012). Notably, ECS includes both a curriculum and a PD model. Over the past 11 years, approximately 2,500 teachers have learned inquiry-oriented and community-building teaching practices by participating in a two-year professional development program, on-going teacher mentoring, and CS teacher communities of practice (Margolis & Goode, 2016; Fields, Kafai, Nakajima, Goode & Margolis, 2018). Throughout the two-year PD program, ECS teachers engage in equitable teaching practices that support classroom inclusion, such as structuring activities so that all students are actively learning, collaborating, and engaged; drawing on students' cultural knowledge; using visuals and modifications to aid English language learners and students with special needs; and scaffolding the curriculum so that all students feel that they belong in the class and are able to participate (Goode, Margolis & Chapman, 2014). ECS teachers also engage in discussions about the structural disparities and negative belief systems that have contributed to the underrepresentation of female, Black, and Latinx students in CS (Ryoo, Goode, & Margolis, 2015). There is evidence that the longer teachers have participated in the ECS PD, the more they understand the role teachers and counsellors play in gatekeeping against underrepresented groups in computing (Goode, Runninghawk Johnson, & Sundstrom, 2020).

In addition to the two-year PD program, ECS provides a researcher-developed curriculum that is organized based on three strands: CS concepts, inquiry, and equity. The curriculum consists of six units that allow students to explore the ethical and social issues and careers in computing, including Human Computer Interaction, Problem Solving, Web Design, Programming, Computer Data Analysis, and Robotics. However, most of the activities throughout the ECS curriculum are relatively structured, providing little opportunity for student personalization (aside from students creating stories in Scratch during the Programming unit). Creating open-ended, personalized computational artifacts can provide opportunities for students to connect disciplinary (i.e., CS) practices with their everyday lives, thus promoting critical, culturally-connected awareness (Kafai, Fields & Searle, 2019). This further positions nondominant youth as creators and designers throughout their making and creating activities, thus promoting youth in developing STEM-linked interests and identities (e.g., Barron, Wise, & Martin, 2013; Pinkard, Erete, Martin & McKinney de Royston, 2017; Vossoughi & Bevan, 2014). This highlights an opportunity for ECS to provide more open-ended activities that not only support students in designing more interest-driven, creative projects but that also allow students to bring in more diverse forms of knowledge and practices to the CS classroom, thereby promoting inclusion. One way the e-textiles curricular unit addresses this is by centering the unit around interest-driven projects that allow for personalization with innovative materials in a way that is personally relevant, tangible, and creative for students (Kafai & Fields, 2018).

E-Textiles

In e-textiles students connect sewable Arduino-based microcontrollers with conductive thread to actuators such as LEDs and sound, light or touch sensors to make interactive craft projects (Buechley, Peppler, Eisenberg, & Kafai, 2013). Overall, e-textiles have been found successful in not only broadening perceptions of CS but also increasing participation in CS and students' knowledge of CS and engineering (Jayathirtha & Kafai, 2019). In addition to engaging more female designers than traditional Arduino microcontrollers (Buechley & Hill, 2010), research has demonstrated that making e-textiles can disrupt stereotypical notions of gender participation in computer science (Kafai, Fields & Searle, 2014). Furthermore, e-textiles can be used to create culturally-responsive educational environments in public school science classrooms (Tofel-Grehl et al., 2017) and for underrepresented populations, including American Indian youth (Searle & Kafai, 2015), and Black girls (Allen-Handy, Ifill, Rogers, & Schaar, 2018).

However, such interest-driven, open-ended, student-centered curricula brings with it their own set of challenges. Compared to more traditional CS classrooms, within the e-textiles unit, students not only work in groups but also have increased choices throughout the design of their projects, including choices in their circuit designs, their programming, and their projects themselves. Because personalized learning involves a consideration of how classroom elements—the pace of learning, the complexity of the content, and instructional methods—will vary from student to student, it requires that teachers are able to differentiate instruction (Heacox, 2018). Effective differentiation of both curriculum and instruction involves being proactive to students' readiness, interests, and learning needs; using a wide range of instructional approaches to scaffold learning; equipping students with key concepts and skills; and using variable pacing (Tomlinson, Brighton, Hertberg, Callahan, Moon, Brimijoin, Conover, & Reynolds, 2003). Considering that ECS teachers are knowledgeable about teaching practices that are both equitable and culturally-responsive, understanding how they facilitate e-textiles in such an open-ended, student-driven manner will be advantageous.

That being said, little is known about teachers' perspectives on implementing e-textiles in their classrooms. One option for examining how CS teachers foster inclusion is through their own reflections about their access and engagement with equity-focused content and PD training, specifically through their implementation of the ECS e-textile curriculum. Below we analyze the reflections of 17 experienced CS teachers regarding their approaches toward creating an inclusive environment while facilitating the e-textiles unit within the existing ECS curriculum. In Spring 2018, the third year of the curriculum implementation, 17 teachers implemented the unit with over 350 students. In this study, we inductively explore 17 teachers' perspectives on their experience facilitating the e-textiles unit, specifically the challenges they reported in implementing such equity-oriented practices and the solutions they enacted to address those challenges; the resources and supports they recruited; and their perspectives on what they learned about fostering inclusion after implementing the unit. We then discuss the implications of learning from and supporting experienced ECS teachers who apply inclusive approaches to CS curricula based on open-ended, interest-driven projects.

Context & Methods

E-textiles Curricular Unit

The e-textiles unit took place over 8-12 weeks and consisted of a series of four projects: 1) a paper greeting card with a single LED using a simple circuit; 2) a wristband with three LEDs in parallel; 3) a classroom-wide mural project in which students pairs created individual sections that incorporated two switches to computationally create four lighting patterns, and 4) a "human sensor" project that used two aluminum foil conductive patches that when squeezed generated a range of data to be used as conditions for lighting effects (for more details, see Kafai & Fields, 2018). Each project allowed increasing flexibility in design and personalization, reflected in the diversity of students' choices for the final human sensor projects, which included, amongst other artifacts: stuffed animals, paper cranes, wearable shirts or hoodies, handbags, projects featuring students' names or pop culture icons, and also gifts for family members. The unit culminated in the creation of a process-based portfolio where students shared and reflected on changes and challenges they faced in their final project and reflected on their learning in the unit (Lui, Fields, & Kafai, 2019).

ECS coaches and e-textiles experts (including the second and third authors) co-developed the curricular unit to be taught as one of the final units of the year-long, multi-unit ECS course, replacing either the Data or Robotics units. The resulting e-textiles activities follow the ECS model (Goode & Margolis, 2011), containing big ideas and recommended lesson plans, with much room for teachers to interpret and integrate their own approaches in their classrooms. In the design of the four e-textiles projects, we prioritized helping students learn challenging concepts in computing, electronics, and crafting while also supporting personal expression and design (for design principles of the unit, see Kafai & Fields (2018); for descriptions of all projects, see Fields, et al., 2018). In addition, the e-textiles projects were designed to support the equity-minded teaching practices and community-building practices teachers had already established in their ECS classrooms, thereby providing them ownership with implementing the unit based on the unique needs of their students.

Participants and Setting

In Spring 2017, the ECS-school district liaison in a large metropolitan area in California sent an invitation to the ECS-teacher listserv for educators to participate in the third and final year of the e-textiles curriculum implementation study. All teachers worked in public schools in one of two large, metropolitan school districts; all of the schools served predominantly Latinx students, with the majority of schools (11 out of 14) providing free and reduced lunch for students (see Table 1 in Appendix). Teachers and school sites were chosen by the liaison for their diverse teaching styles, to maximize the variety of feedback on the curriculum. The liaison, an experienced ECS teacher, also decided to participate in the study. Three teachers had previously taught the unit in one of two prior years of the study. Lastly, when two teachers announced their need to take maternity leave mid-pilot, the replacement teachers were selected through snowball sampling.

The final number of participating educators was 17 with teaching experience ranging from 3 and 37 years; most but not all also had taught ECS for several years (4 teachers had only taught for 1 year and 1 co-teacher—one of the replacement teachers chosen to take over for someone going on maternity leave mid-unit—was new to ECS). As Table 1 illustrates (Appendix), the diversity of the teachers varied across gender (9 female, 8 male), ethnicity (9 Hispanic/Latinx, 5 Caucasian, 2 Asian, and 1 mixed race), years of teaching in the classroom, (3-20 years) years teaching ECS (1-7 years except for one teacher who was co-teaching ECS for the first time), and the grade levels of their students in their ECS course (grades 9-12).

In Spring 2018, these 17 teachers implemented the e-textile unit in their 16 ECS classrooms (Julia and Amber co-taught in the same class before Amber left for maternity leave); classes ranged from 20-42 students. The unit lasted between 8 and 13 weeks, depending on the classroom. All teachers engaged in four days of e-textile professional development over a period of four months, with two of the teachers who had implemented the unit in two prior years (Ben and Angela) co-leading the PD with curriculum creators (including the second author). Teachers became familiar with the curriculum by creating the projects from the unit and reflecting on the pedagogy used during professional development in preparation for implementing the unit in their own ECS classes. Ten teachers, including the three teachers who had piloted the unit previously (Ben, Jose, and Angela), were able to complete the entire unit while the remaining seven teachers ended the unit after the third (mural) project. In the findings section, we share more about the modifications and changes teachers made in their local classroom contexts.

Data Collection and Analysis

In order to capture the teachers' experiences with learning how to teach open-ended, student-centered e-textile projects in their ECS classrooms, we focused our analysis on the following data: weekly open-ended survey reflections by the teachers focusing on changes they made to the curriculum as well as challenges and successes they faced in their implementation and one-time post-interviews with the teachers following the completion of the e-textiles unit (30-60 minutes long). During the interviews, teachers were asked to reflect on (1) their professional development experiences, (2) the implementation of the unit (particularly any new instructional practices they enacted while teaching the unit), (3) their students' experiences, and (4) any adaptations they may have made to the curriculum. Weekly surveys asked teachers to reflect on a list of possible activities (e.g., programming) and practices (e.g., checked in with all of the students and their progress) they engaged in, as well as curriculum modifications, challenges/successes, and ways they addressed particular students' needs. The interviews were transcribed using an outside transcription company, edited for accuracy, then labeled and organized in a secure online database. Concurrently, the survey responses were also consolidated and organized into a spreadsheet.

Our intention for this study was to develop a framework with which we could analyze how teachers described the challenges they faced in promoting inclusion and the pedagogical strategies they enacted to address those challenges while facilitating the e-textiles unit in their CS classrooms. We chose a ground-up approach to analyze the data, in large part because of a lack of literature on pedagogy promoting inclusion in CS classrooms and on pedagogy supporting physical computing in classrooms analyzed all data using a grounded theory approach (Charmaz, 2006). Although others have taken a more specific theory-driven approach to studying teachers' inclusive CS pedagogy (for instance with culturally responsive pedagogy, see Nakajima & Goode, 2019), we chose not to apply a specific, top-down theoretical lens on the data. Applying a ground-up approach allowed us to understand what might be creative or original in what teachers reported about their teaching, and later compare with other known theories of inclusive pedagogy (as we do throughout the findings). During the initial reading and editing of ten teachers' interviews, the first author, a doctoral student, created a memo listing out the challenges and successes teachers shared, which were cross-referenced with the survey responses (including modifications teachers made to the curriculum) by the second author. The goal of this memo was to consolidate the shared challenges, successes, and strategies teachers identified in both the interviews and surveys in order to generate themes. For example, initial themes that emerged from the data included shifts teachers noted in their classroom culture (e.g., the distribution of roles and expertise), management of time and materials, and opportunities to reflect on teaching practice and attitudes.

From these themes, a detailed list of emergent codes was created and applied to two teacher interviews in order to discuss differences in our understanding of the codes and develop consensus. These codes included Content Knowledge, Differentiation, Classroom Management, Supports, Changes (to curriculum), and Perceptions. Noting how robust the examples were becoming for each of these codes, we generated subcodes for the codes, allowing us to highlight the related challenges, successes, and strategies and refine their definitions and examples. However, we noticed how extensive and descriptive these codes still were becoming, necessitating the anticipation for higher level (more focused) codes. The first author wrote a narrative memo as a way to thread together the story connecting these codes and shared it with the research team (including the second and third authors) in order to elicit feedback. Once we agreed upon a revised coding scheme and coded 10% of the interviews together to reach agreement and consistency, the first author applied the codes to the interviews while the second author applied the codes to the surveys. For a detailed list of the codebook, see Table 2 in the Appendix.

Findings

In the following sections, we synthesize reflections from 17 teachers on their experiences implementing the e-textiles unit in response to the following three research questions: (1) What *challenges* did CS teachers face in building inclusion while implementing a project-based, open-ended unit and how did they approach those challenges? (2) What *resources and supports* did teachers recruit to create an inclusive environment? and (3) What *insights* about inclusion did teachers report learning through this process of implementing a student-driven curriculum? We found that throughout the implementation of the unit, teachers adapted to the challenges of facilitating an open-ended, student-driven curriculum based on their knowledge of their students' needs, recruited a wide array of resources to address these challenges, and adopted new teaching mindsets that reflected more creative, inclusive and relational ideals.

Teachers Addressed Differentiation Challenges Through Flexible Adaptation of Curriculum

The ECS teachers expressed that one major challenge in implementing the unit was figuring out how to differentiate their pedagogical approaches in a way that not only promoted CS learning but was also proactive to every student's readiness, interests, strengths, and learning needs, and they identified two main challenges while trying to differentiate instruction: keeping track of students' progress and managing time. Given that the e-textiles unit was designed for students to complete multiple open-ended, constructionist-based projects, the teachers described the dilemma of how many elements they needed to monitor, making it difficult to anticipate what students would create and the challenges they would face. For example, students completed projects at different paces, some accelerating through project design, others taking more time for crafting, and others struggling to decide what to make or running into problems along the way. In addition, students had unique interests that they brought to each project, whether they were trying to embed the technology into their graduation cap or settle on a class-wide mural theme based on pop culture references. Adding to this challenge was the unique needs of students with special needs or limited English proficiency as well as varying prior expertise with sewing, electronics, CS, and artistic design.

In response to these challenges, teachers developed multiple strategies to assist students with completing their projects at their own pace and still feel accomplished, despite whether or not they finished. First, all teachers in the study made class-wide modifications of the curriculum while maintaining student learning by actively *adding* or *changing* elements of the curriculum in their implementation. As the curriculum provides much room for teachers to interpret and bring in their own teaching approaches (Fields et al., 2018), teachers made adaptations based on the needs of their students. For instance, some teachers created additional journal reflections for the unit as a means of promoting reflection on particular concepts or to track students' understanding of a challenging concept introduced the prior day. Others reordered lessons to build excitement and anticipation for a particular project or because of institutional interruptions of time that would have otherwise disrupted a set of activities. Based on an understanding of their students' prior knowledge, some teachers also skipped certain activities, such as storyboarding the code for a project, feeling that it was not needed, or provided additional time and supports for certain parts of projects, like when a coding concept was particularly difficult for students in a specific classroom. Lastly, some teachers modified the requirements of the projects, changing the number of lights or switches students had to include in the projects or making the mural the final project as opposed to the human sensor project when they faced a lack of time at the end of the semester. When facilitating open-ended projects, Hertzog (1998) found that teachers who struggled with taking pedagogical risks tended to increase the structure of learning activities. Because constructionist activities prioritize student inquiry over didactic instruction, it is not surprising that the ECS teachers would draw from more traditional methods of instruction (e.g. worksheets and journal reflections) when encountering facilitation challenges. The flexibility of the e-textiles curriculum allowed teachers to not only utilize a diverse range of pedagogical approaches based on their individual contexts but to also adapt the curriculum in a way that ensures their students still learn content and skills.

Second, nearly all (14 of 17) teachers created structures for keeping track of students' differential progress on projects and managing time. For instance, Alana reported, "I usually use stamps to keep them on track, keep them going. I have my clipboard and I'll mark/check them off, what phase they're on." Such strategies allowed teachers to note where each student was in their project and to provide additional support wherever needed. In addition, many teachers expressed finding ways for students to become more aware of managing their own projects, promoting project- and time-management skills as well as lessening the burden on teachers to keep track of everything. For example, when they realized students needed more time to complete their projects, several teachers provided additional opportunities outside of class for students to work on their projects. These sessions were organized during lunch periods (Angela), other class periods (Jaime), after school (Jose), or students were allowed to take their projects home to work on (Sergio). When facilitating open-ended projects, teachers and students must negotiate quickly and often as students share more responsibility for their learning (Hertzog, 1998). By valuing students at different paces and supporting their progress at their own pace, teachers resisted classroom structures and negative belief systems that can leave students with different needs behind (Shah et al., 2013). As Ben expressed, individual students "are deciding for themselves what they want to do, where they are and their capabilities," making judgments about what they can do now and reflecting on what they can do next. Ben felt that supporting this type of thinking, personalization, and planning "is the most inclusive way to educate that I have ever seen" and framed students as highly capable in their different progressions through projects. Thus, teachers demonstrated a flexible, adaptive stance in implementing the unit based on the needs of their local contexts, from minor changes in the curriculum to supporting students working at different paces.

Teachers Relied On Local Resources As Support Systems

In addition to the challenges discussed while implementing the e-textiles unit, teachers also described the various resources they drew support from that allowed them to address those challenges, including professional learning communities, prior content knowledge, and students' families. For example, with regards to professional learning communities, thirteen teachers reflected on how the four-day, e-textiles PD provided them with resources that benefited their instruction. For example, the PD provided opportunities for teachers to learn content by creating their own projects, which allowed them to anticipate where students might get stuck (Sergio) or demonstrate what the projects' expectations were (Alana). According to Jose, the PDs helped him "transmit the work to the students," providing him with instructional strategies for conveying content.

Furthermore, nine teachers drew support from other school personnel, such as aides or fellow teachers. Teachers like Sergio, Claudia, and Jaime utilized aides who assisted with managing and prepping materials, including time-intensive tasks such as testing batteries (Claudia). Two groups of teachers also worked at the same schools, and here teachers within each of the schools leaned on the expertise of one another. As one of the developers of the unit, Joey was able to provide additional assistance to Julia and Amber with troubleshooting students' issues. Furthermore, because Alana was ahead of schedule from Yonatan's class, both teachers frequently met and discussed what Yonatan could learn from Alana's implementation. Drawing on professional learning communities—including their fellow ECS colleagues and school staff—is especially important for CS teachers since they often feel isolated within their schools due to lacking a department of colleagues (Ryoo, Goode, & Margolis, 2015; Yadav, Gretter, Hambrusch, & Sands, 2016).

In terms of a second resource, fourteen teachers discussed how they drew upon their own or their students' prior content knowledge to assist them in teaching the unit. Having taught this unit before, Ben, Angela, and Jose made connections to previous implementations to inform their instruction or assessment of student learning. Jose in particular felt more confident this year with the content, allowing him to focus less on worksheets and scaffolds and more on students' aesthetic designs of their projects. "I was able to remember or touch on things that I had some problems or issues last time," he added, illustrating how his prior experience helped him correct challenges he faced the previous year. Teachers' prior knowledge also included experience with crafting (Paulina and Jesse), graduate-level computing courses (Claudia), and computing-related PDs (Michael and Candace), which provided them deeper familiarity with various aspects of the content. This also included bringing in additional materials to assist students in their projects not listed in the curriculum, such as voltmeters (Jesse) and paints (Alana).

Furthermore, six teachers drew support from students' prior experience with sewing in their families by having them assist other students who were struggling. According to Alana, "If they had a little experience in any of it, sewing or designing, drawing, they felt like they were able to do it." The physical, interdisciplinary nature of the e-textiles projects, with their incorporation of "soft" materials like fabric and threading, allowed teachers to bridge the connection between students' homes and the CS classroom. In addition, integrating traditional crafting practices like sewing gave some students different entry points, when they might otherwise struggle or feel disconnected from CS activities. These connections came in different forms: in some instances, students **"**had a background in sewing because of their culture or their parents; they knew how to do that, so they brought those skills (Sergio)" while in other instances they might have simply observed relatives engaged in crafting or coding. Furthermore, students sometimes took e-textile projects home to show them to their family or seek advice from experienced relatives In these ways teachers were able to leverage students' prior content experience as a resource to further decentralize expertise in the classroom, thereby reflecting the ideals of culturally relevant computing (Scott, Sheridan, & Clark, 2014).

Another resource teachers drew support from were students' families. Teachers like Claudia, Sergio, and Jose encouraged students to reach out to family members to assist them with their sewing. "I tell them, reach out to your grandparents, reach out to your aunts, your moms," Claudia shared, "and their parents have actually [come] to me and told me thank you." Other teachers reached out to family members directly when students were disengaged with the unit

(Angela) or needed students to bring their projects back to school (Candace). Further, when a group of students were struggling with their projects and stopped working, Jaime invited their mothers to join the class and assist their children. “This was something they could actually help with,” Jaime reflected, “I think it was good for the kids to have them there and do that.” By reaching out to families or allowing students to lean on family members for assistance with their projects, the teachers further strengthened the connection between students’ homes and the classroom, drawing on families’ expertise in expanding the learning community to not only be inclusive to students but their families as well.

Lastly, one particularly interesting classroom adaptation that almost all (15) teachers implemented included structures to support *peer pedagogy*, or peers teaching peers. In the e-textiles unit where students bring different prior expertise in various domains (from crafting to coding) and where students are making highly personalized projects, unique needs arise, and teachers found they could not be the sole source of expertise in the classroom. Instead, teachers created a number of means to support peer pedagogy, both formally and informally. For instance, Jose moved from table to table of students, teaching a particular strategy (for instance, sewing techniques specific to conductive thread) and chose one student at the table to make sure that all the others learned it, in case they did not catch on the first time. Other teachers provided explicit encouragement for students to learn from each other as Jesse did when he told students, working at tables of four, to “help each other because you’re going to need this when you’re flying solo for the next project,” reporting that “some students adopted that right away.”

While facilitating peer pedagogy has come up in earlier implementations of the e-textile unit with just two teachers (Author et al., 2018), it is remarkable that nearly all teachers mentioned, without interview prompting, that they developed that as a pedagogical strategy in their classrooms. In most classrooms this also appeared to be a strategy teachers implemented in recognition of students’ different personal expertise with crafting or coding, like Sergio and Jaime who positioned students with sewing experience as experts for other students to ask for help. Teachers implementing these different forms of peer pedagogy created a supportive, inclusive environment where expertise was distributed across everyone in the classroom (Shah et al., 2013; Authors, 2018). Students taking up the role of teaching and supporting each other reflects constructionism's emphasis on learning as “a social activity where learners share ideas, collaborate on projects, and build on others’ work” (Davey, Thanapornsangsuth, & Holbert, 2018, p.562). Even Paulina felt that students as a whole were more helpful to one another compared to other ECS units.

E-textiles allow for diverse forms of making, like crafts, that can engage a broader range of students and allow them to draw on local and family knowledge. Students, their families and peers, and their prior content knowledge served as funds of knowledge (Gonzalez, Moll, & Amanti, 2005) that teachers viewed as legitimate resources to draw support from beyond their professional learning communities. Not only did teachers create a learning environment that allowed students to connect their personal interests and home communities with the CS classroom (Ito et al., 2013), but they were able to engage students by building on their cultural knowledge, thereby demonstrating equitable, inclusive teaching practices (Goode & Ryoo, 2019).

Teachers Adopted New Perspectives About Inclusive Computing

Beyond developing new pedagogical practices and drawing on a range of supports in implementing the unit, teachers also deeply reflected on what they were learning about their students and their teaching throughout the unit. These reflections went beyond whether and how much students learned essential CS content and practices. Instead, after implementing the unit, teachers realized new perspectives about computing that supported inclusive and enriching learning opportunities for students.

First, e-textiles offered novel ways for teachers to value CS learning and student engagement not experienced in other ECS units. For example, twelve teachers explicitly recognized students’ creative, personal expression in their projects, and fourteen teachers noted that the e-textiles unit was more inclusive to a diverse range of learners in their classes. For instance, Jesse expressed how the creative, personal nature of the projects fostered inclusivity amongst students, stating, “I think there’s more creativity. There’s more accessibility and there’s more equity because of that.” Stone identified the interdisciplinary nature of the e-textiles unit as allowing for creativity, expressing, “There's so many other pieces to it, that I think it makes it more creative, and more open, and more...just really, it's more interesting.” Furthermore, Angela reflected on how her class did not feel like a typical computer science class, recounting, “Most kids are actually, happy and proud of their projects. You don't really get that in any other class.” Similarly, teachers like Amber echoed the joy students felt creating their projects, particularly students who were not engaged in previous ECS classes or who struggled in other classes. Thus, teachers expressed that creative, personal expression within the e-textile unit opened up doors to greater inclusivity in their CS classrooms.

In addition to students being able to express themselves creatively and experience joy, teachers also acknowledged how the e-textiles unit was inclusive for students with special needs or English language learners (ELL). For example, Paulina discussed how two of her students with autism were able to better participate in the projects and understand computer science. She described one of the girls as “failing the class until we got to the e-textiles unit, and it really made her understand computer science, and computer coding,” she recounted “It kind of put everything in a nice little box, so she understood at the end what computer science is about.” In another example, Jose had two ELL students who were engaged by working in a group with other students who could help them. Through facilitating this unit, teachers adopted the understanding that CS can be engaging, creative, and collaborative for a wide range of students, illustrating how e-textiles situated in a constructionist-based curriculum can create a CS learning environment where almost any student belongs.

Second, teachers expressed how their own roles changed through facilitating the e-textiles unit, challenging familiar expectations and relations they had in teaching prior CS classes. Nearly all (16) teachers discussed how their relationships with and among students changed during the e-textiles unit. For example, teachers shared how e-textiles provided them with more one-on-one time to get to know their students more personally. This included students’ personal interests or skills, such as sewing or drawing, as well as hobbies and media interests. “You see when they're creating their projects, you're seeing, ‘Oh, you're interested in Batman,’” Angela remembered, “And, you get to talk about these things.” For teachers like Paulina, who sewed personal projects alongside her students, students expressed that they were able to see her in a familiar, more relatable light—like a family member. This is common in constructionist and open-ended projects, where teachers not only elicit students’ opinions, concerns, interests, and knowledge (Hertzog, 1998) but conversations that might be considered “off-task” in traditional classrooms become a source of connection between teachers and students.

Seven teachers also used different metaphors for how their roles felt less like teachers but more like “partners” (Ben) and “coaches” (Jose), helping students manage their own projects. This shift in teacher role was often accompanied by observations that students became more collaborative and encouraging to each other during the unit. Not only did almost all of the teachers (16) comment on how much students problem solved throughout the unit, but students with prior experience in different domains (especially students who were not usually considered top students) shared ideas and helped others. Furthermore, Joey, Candace, and Katie all noted how they did not have to be the sole expert in the classroom, that students and teachers could draw expertise from each other. Such shifts in relationships among teachers and students are common in constructionist learning environments (Blikstein, 2013), where teachers and students can be more collaborative and share expertise with each other, providing students with more ownership and feelings of empowerment over their learning.

Discussion

As CS education moves into K-12 schools, teachers like the ones we interviewed for this paper will play a critical role in making computing accessible and inclusive for all students. Given how little we know about how teachers are learning to navigate this complex and challenging territory, our findings contribute to the growing foundation in creating inclusive CS environments. Building on previous research on ECS teachers’ equity-oriented, culturally-responsive teaching practices (Ryoo, 2019; Madkins, Martin, Ryoo, Scott, Goode, Scott, & McAlear, 2019; Nakajima & Goode, 2019b), the responses in this study from the 17 teachers who implemented a new open-ended, constructionist curriculum demonstrate an entire repertoire of potential teaching practices that CS teachers can draw upon when facilitating computing activities that meet the needs of a diverse range of students—particularly students who have not traditionally been engaged in CS. Because no classroom observations were conducted during this study, the teaching practices and experiences discussed are limited to teachers' weekly and retrospective accounts of what happened in their classrooms. However, their reflections highlight the potential benefits of experienced teachers engaging with equity-focused, student-driven curricula as an opportunity to reflect on their own teaching practices and perspectives about inclusion. Our findings stress the importance of expanding experienced CS teachers' approaches to inclusivity in at least two ways, one that supports the development of asset-based views of students and their communities' funds of knowledge and another that supports teachers' professional development in reflecting on and learning about their own local resources and developing their ability to utilize those resources and adapt to local challenges.

Expanding Teachers' Perspectives on Funds of Knowledge

While ECS is designed to promote equity, there still exists an opportunity for ECS teachers to grow in this area, specifically by generating inclusive practices while facilitating open-ended, constructionist activities. The 17 teachers in this study had at least two years of formal training in equity in CS but they revealed substantial new learning through their implementation of the e-textile unit. By putting students' interests and creativity at the center, connecting students' and families' prior experiences (e.g., with sewing) to their projects, and prioritizing the relationships between teachers, students, and their peers, these experienced ECS teachers challenged the culture and structures of CS classrooms that tend to make them inaccessible for many students, particularly students of color and girls. By doing so, they developed new bridges as connection points for students, thereby helping them find meaningful contexts to struggle through difficult CS content. While e-textiles provided that useful context for situating computation within cultural practices (e.g. crafting), future research can continue to explore the implementation of novel open-ended, constructionist activities based in other cultural practices (like quilting or grafitti) as a way to promote inclusion in formal CS classrooms. Here, experienced teachers actively drew upon their local knowledge in order to transform their CS classrooms into more inclusive learning environments. While a challenge to facilitate, the open-ended, flexible nature of the e-textile unit (e.g. students' increased choices throughout the design process or the decrease in curricular structures) encouraged curricular adaptations that were advantageous for their classrooms. For example, the teachers in this study were able to draw upon their experiences implementing the previous ECS units, which allowed them to better understand the pedagogical tools needed to personally engage their students in computing (particularly the students that struggled to engage previously). In working to support students' aesthetically and personally-relevant physical projects, teachers developed a deeper understanding of their students and their students' needs—including learning more about their students' unique interests, strengths, learning challenges, and motivations—which allowed them to provide support that was both contextualized and specific.

Creating Multiple Opportunities for Professional Development

Prior research has shown that experienced CS teachers search to learn beyond introductory content, seeking PD opportunities where they can address problems of practice within their classrooms and participate in collaborative, in-person learning communities (Qian, Hambrusch, Yadav, & Fetter, 2018; Nakajima & Goode, 2019a). Since ECS teachers want to promote equity in CS by authentically engaging their students in CS and addressing social inequities through teaching CS, future research should take into consideration the idea of teachers as learners themselves and explore the value of creating and facilitating connected learning opportunities for teachers. For example, during the four days of e-textiles PD training when teachers learned the e-textiles curriculum, the teachers grew existing relationships and developed new ones with each other. This continued development of a professional community, building on community created through their original ECS PD years prior, became a key resource for teachers as they implemented the e-textile unit. Such connected learning opportunities can provide teachers the space to learn from one another (e.g., their successes, challenges, and local resources) in developing inclusive CS classrooms.

In addition to fostering a professional learning community where teachers can support each other and share strategies for strengthening each other's teaching, the e-textiles PD embeds and models equitable practices, as experienced teachers facilitate the e-textile unit for ECS teachers who are new to the curriculum (building on the model by Goode, Margolis, & Chapman, 2014). What we see in this practice builds on successful traditions in other educational fields such as mathematics education which described the collective professional development of teacher communities as "polishing stones" (Stevenson & Stigler, 1994). Furthermore, throughout their reflections on implementing the unit, teachers expressed anticipation for teaching the e-textile unit again the following year, noting improvements they wanted to make based on their current implementation. This anticipatory view of reteaching activities in the unit also contributed to their practices and highlights that experienced CS teachers want to grow in developing richer content knowledge and learning how to engage more diverse groups of learners in their classrooms (Hubbard & D'Silva, 2018; Nakajima & Goode, 2019a). Thus, retrospective accounts also present an opportunity for future research to explore PD and curriculum implementation as a potential space for CS teachers to reflect on their own, their students' and their local communities' knowledge and expertise when considering ways to promote inclusivity in CS learning environments. As we continue to explore ways to increase participation, diversify representation, and deepen learning in CS, future research should consider the merits of designing teacher PD models and learning communities where experienced, equity-oriented teachers reflect on their practices and local resources that promote inclusivity in their classrooms. These kinds of teaching practices and learning environments will foster more inclusive learning environments and increase CS participation.

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Table 1. Demographics and Teaching Experience of Teachers.

ID (pseudonyms)	Gender	Ethnicity (Race)	Years Teaching	Years Teaching ECS	School Free & Reduced Lunch Students	School Ethnicity
Jessica	F	Asian	10	2	75.2%	B-14.3%, AI-0.2%, As-1.6%, Fi-20.5%, HL-54.9%, PI-5.2%, Wh-2.0%, 2+-1.4%
Claudia	F	Hispanic/Latinx	18	1	96.7%	AI-0.3%, As-0.5%, Fi-0.3%, HL-99.0%
Sergio	M	Hispanic/Latinx	12	2	90.3%	B-15.1%, AI-0.2%, As-0.3%, Fi-0.1%, HL-83.8%, PI-0.05%, Wh-0.3%, 2+-0.2%
Jose	M	Hispanic/Latinx	20	7	97.1%	B-7.6%, As-0.1%, Fi-0.05%, HL-91.6%, Wh-0.5%, 2+-0.05%, NR-0.05%
Julia	F	Hispanic/Latinx	17	0	47.3%	B-21.9%, As-7.8%, Fi-1.9%, HL-34.5%, Wh-26.3%, 2+-7.5%
Joey	M	Hispanic/Latinx	6	1	47.3%	B-21.9%, As-7.8%, Fi-1.9%, HL-34.5%, Wh-26.3%, 2+-7.5%
Amber	F	White	3	1	47.3%	B-21.9%, As-7.8%, Fi-1.9%, HL-34.5%, Wh-26.3%, 2+-7.5%
Ben	M	White	9	4	49.4%	B-3.6%, AI-0.4%, As-17.6%, Fi-9.7% HL-39.8%, PI-0.3%, Wh-25.5%, 2+-1.2%, NR-2.0%

Paulina	F	Hispanic/Latinx	10	4	87.5%	B-2.7%, AI-0.3%, As-2.2%, Fi-3.5%, HL-86.9%, Wh-4.2%, 2+-0.3%
Angela	F	Asian	13	5	91.2%	B-42.1%, AI-0.3%, As-0.6%, Fi-0.06%, HL-55.7%, PI-0.06%, Wh-0.9%, 2+-0.2%, NR-0.1%
Jesse	M	Mixed Race	17	1	58.4%	B-19.4%, AI-0.3%, As-8.5%, Fi-4.8%, HL-45.8%, PI-2.8%, Wh-15.0%, 2+-1.9%, NR-1.6%
Jaime	M	Hispanic/Latinx	12	2	95.2%	B-0.2%, AI-0.08%, As-0.4%, Fi-0.2%, HL-98.4%, PI-0.08% Wh-0.7%
Candace	F	White	11	2	77.1%	B-3.6%, AI-0.3% As-7.8%, Fi-1.9%, HL-69.7%, PI-0.2%, Wh-15.6%, 2+-1.0%
Yonatan	M	Hispanic/Latinx	7	3	92.5%	B-1.7%, AI-0.3%, As-0.2%, Fi-0.4%, HL-95.3%, PI-0.05%, Wh-1.6%, 2+-0.1%, NR-0.3%
Alana	F	Hispanic/Latinx	5	4	92.5%	B-1.7%, AI-0.3%, As-0.2%, Fi-0.4%, HL-95.3%, PI-0.05%, Wh-1.6%, 2+-0.1%, NR-0.3%
Katie	F	White	8	2	98.8%	B-0.4%, As-6.2%, Fi-4.8%, HL-83.9%, PI-0.4%, Wh-3.9%, 2+-0.5%
Michael	M	White	37	7	77.2%	B-2.9%, AI-0.5%, As-3.2%, Fi-3.1%, HL-

						57.8%, PI-31.2%, 2+-1.2%

B=Black, AI=American Indian, As=Asian, Fi=Filipino, HL=Hispanic/Latinx, PI=Pacific Islander, 2+=two or more races.

Table 2. Finalized codebook depicting number of teachers (and occurrences) for whom codes were applied.

	Code		
	Name	Definition	Teacher number (occurrences)
CONTENT KNOWLEDGE	**Content knowledge:** Need for more (conscious inexpertise)	Teachers express an awareness that they need more content knowledge (i.e. coding, crafting, circuity) in order to help students with the essentials or extensions of the project	13 (31)
	Content knowledge: Utilizing peer pedagogy	Teachers explicitly structure peer learning by allowing students to contribute expertise to the class. Also includes occurrences where students implicitly help each other without initiation from the teacher.	15 (54)
	Content knowledge: Being open with students about own inexpertise/learning	Teachers relate to students by being open with them about their own content-related learning, knowledge and growth	7 (15)
DIFFERENTIATION	**Differentiation:** Tracking and assessing student progress	Teachers express difficulty with tracking and assessing students' progress on their projects.	5 (8)
	Differentiation: Supporting students at different paces	Teachers express difficulty with assisting students who are either struggling or who want extensions	14 (39)
	Differentiation: Time management	Teachers express difficulty with either themselves or students having enough time to complete curriculum/projects. This includes teachers providing students with additional time or less time.	16 (113)
	Differentiation: Adapting culminating projects	Teachers change the requirements for the final projects in order to help students finish the curriculum (due to time constraints, individualized needs, etc.)	11 (35)
	Differentiation: Supporting student's project management	Teachers provide opportunities or enact structures that support students in managing their own project progress. In other words, students have a choice whether or not to utilize the supports. This includes extra work sessions during lunch or after school. Could also include adding objectives that support project management (e.g., do ___ today).	14 (52)
	Differentiation: Valuing students at different paces	Teachers express how it is acceptable for students to be working at their own pace and with their own strengths and weaknesses	5 (10)
CLA	**Classroom management:** Organizing and managing materials (challenges)	Teachers express challenges related to organizing materials or managing materials distribution	14 (32)

SSROOM MANAGEMENT	**Classroom management**: Space management (challenges)	Teachers express how the physical classroom presents challenges for students to complete their projects	7 (8)
	Classroom management: Organizing and managing materials (solutions)	Teachers describes solutions they enacted for organizing materials or managing materials distribution	16 (34)
	Classroom management: Space management (solutions)	Teachers describe solutions to address the challenge of the physical classroom presenting challenges for students to complete their projects	5 (7)
SUPPORTS	**Supports:** Other school personnel (other teachers, aids, etc)	Teachers described instances where other school personnel provided them with assistance during the unit	9 (20)
	Supports: Professional development	Teachers described how the professional development sessions provided them with assistance for implementing the unit, whether it was takeaways from the PDs or artifacts that they made during the sessions.	7 (15)
	Supports: Out-of-school people: e.g., Family (potentially; there might not be enough examples across the board)	Teachers described instances where out-of-school people provided them or students with assistance during the unit	13 (43)
	Supports: Prior knowledge domains (i.e., crafting experience, computing courses, other knowledge)	Teachers described instances where they drew from their own or students' prior content knowledge when facilitating the unit	14 (24)
	Supports: Outside materials	Teachers described how they brought in and utilized outside materials/resources (physical and digital) to support them when facilitating the unit. Includes tools or the Internet.	11 (18)
CHANGES	**Changes:** Additions	Teachers describe additions they make to the curriculum, for instance adding journal questions or a lesson on pulse modulation or electricity. *Note that this is slightly different from "Outside Materials", which is technically an addition but focuses more so on resources and we are categorizing separately.*	15 (42)
	Changes: Subtractions	Teachers describe things they took away from the unit. Note that this does not include modification to project requirements (which would be under D-Adapting Culminating Projects)	5 (15)
	Changes: Other	Teachers describe other changes made that are not otherwise categorized elsewhere in this coding scheme. :) For instance, changing the order of lessons	15 (52)
PERCEP	**Perceptions:** Perceptions of their role in the classroom	Teachers describe the role they have taken on (or ways their role has changed) while facilitating the unit	7 (13)
	Perceptions: Things they want to improve upon for the following year	Teachers note ideas that emerge or changes they want to enact when facilitating the unit the following year.	12 (35)

T I O N S	**Perceptions:** Effect on classroom climate (e.g. teacher-student relationships, student-student relationship)	Teachers describe how the unit has positively changed the classroom climate, including relationships among teachers and students (including a leveling of expertise among students) and culture.	16 (41)
	Perceptions: Allowance for creative, personal expression	Teachers describe how the unit has afforded students the opportunity to express themselves creatively or to express their personal interests.	12 (27)
	Perceptions: Inclusivity	Teachers describe how the unit was inclusive and accessible for more diverse range of learners	14 (49)
	Perceptions: Student engagement	Teachers describe students as being engaged in class during the unit or excited about their projects or work. Could also include expressions of students' pride in their work.	16 (80)
	Perceptions: Problems Solving	Teachers describe students solving problems, usually in a celebratory way, perhaps on their own or with others. Students are framed as problem solvers and/or troubleshooters.	16 (44)
	Perceptions: Student struggles	Teachers observe that students struggle with specific things. Perhaps students get stuck, have an unresolved issue, quit, etc.)	17 (128)