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Introducing Preservice STEM Teachers to Computer Science: A Narrative of Theoretically Oriented Design

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This paper narrates the process of designing a curricular unit that serves to introduce preservice science, technology, engineering, and mathematics (STEM) teachers to computer science (CS) education. Unlike most literature that focuses on results and findings, this paper explains how a justice-centered approach to CS education informed decisions about the theoretical underpinnings of curricular design choices. Situated in issues related to the gentrification of Austin, Texas, the described curricular unit explores how the increased use of CS and growth of the technology sector are having a direct impact on the historically marginalized residents of East Austin. Connected by a theme that maps are both a form of data visualization and political artifact, the described curricular unit uses CS as a tool to: critique the macro-ethics of politics and society; provide a CS learning environment that can be responsive to the multiple social identities of students; and connect CS to larger struggles for justice and liberation.

Keywords: case, computer science, design, equity, justice-centered approach, preservice

Computer science (CS) and the technologies enabled by it have become central to how we communicate, find information, and conduct our lives. Yet, limited access to CS education in K-12 public schools remains a persistent problem across the state of Texas (Fletcher, 2014) and throughout the United States (e.g., Google & Gallup, 2015, 2016; Wilson, Sudol, Stephenson, & Stehlik, 2010). In recent years, "Computer Science for All" (CS4All) has become the rallying cry of parents, educators, business leaders, and politicians who seek expand access to CS in K-12 education (Smith, 2016). Gaining national attention as an initiative under the administration of former President Obama, CS4All seeks to empower students with skills in computational thinking, address workforce development needs, provide academically rigorous CS experiences, and expand CS access to underrepresented groups (National Science Foundation [NSF], 2017). Unlike many other initiatives that are vulnerable to partisan politics, expanding access to CS education in K-12 schools has maintained bipartisan support as a funded priority under the administration of President Trump (White House, 2017), allowing for continuity of the K-12 CS education movement.

While CS education as a movement is barreling forward, there is also an emerging dialogue that is raising important questions regarding the underlying values, purposes, and ideological commitments of CS education; CS learning for what, for whom, and towards what ends? (Vossoughi & Vakil, 2018). These kinds of questions are rarely posed in the CS education community, including within equity-focused efforts to broaden participation and access for girls and historically underrepresented students of color (cf., Goode, 2008; Margolis & Fisher, 2002). In a recent paper, Vakil (2018) offers a critical review of CS education research, and presents a framework to draw attention to features of CS education including questions around how ethics are addressed in the curriculum, how student identity is incorporated in the design of learning environments, and how the collective political vision of CS education can be tied to discourses of justice and liberation. Rather than accepting the status quo of the dominant approach to CS education, which focuses on developing students' knowledge, skills, and understanding of CS in the context of career-readiness, this paper takes the view that CS can be used as a tool for emancipatory learning (Freire, 2000), where students are empowered with agency to engage in critical thought about the world around them.

In recent years, a growing number of scholars have been taking an interest in how CS is taught at the K-12 level, specifically in the context of both project- and problem-based designs for learning (e.g., Grover & Pea, 2013; Vakil, 2014, 2018; Veletsianos, Beth, Lin, & Russell, 2016). As CS education begins to emerge from its nascent roots, what counts as good CS curriculum has yet to be normalized. Due to this instability, it is crucial that designers of CS curriculum make informed decisions and provide transparent justifications about the theoretical underpinnings of their design choices (Kelly, 2009). In this paper, the process of curriculum design is narrated, making visible how a theoretical orientation towards justice informed the structure and epistemology of specific learning objectives and activities. First, however, an overview is provided of the framework for a justice-centered approach (JCA) to CS education.

A Justice-Centered Approach to CS Education

Drawing on critical pedagogy and learning sciences perspectives, Vakil (2018) argues that centering justice in CS education requires a radical rethinking of curriculum, the design of learning environments, and our collective political vision for CS education. A JCA to equity in CS education recognizes that technology and computing have sociopolitical implications. For example, often times when ethics are brought up in CS education the individual is asked to make the right or wrong choice, such as whether or not to obey copyright laws. Rather than focusing on the "microethics" of the individual, Vakil argues that the *motus operendi* is shifted to the "macroethics" of engineering (Herkert, 2005). This includes discussion about how advanced technologies impact the sustainability of global systems, and how those technologies are shaped by the complex sociopolitical systems in which they are embedded (Conlon & Zandvoort, 2011). The framework builds from sociocultural perspectives in CS and STEM education, which have emphasized the deeply interrelated processes of learning and identity development. The justice-centered CS classroom "honors and leverages students' racial, cultural, and gendered identities in service of consequential learning and positive CS and STEM identity development" (Vakil, 2018). Unlike the dominant approach, which paves a pathway both to and from Silicon Valley, a JCA is rooted in culturally relevant pedagogy (Ladson-Billings, 1995), viewing the culture, communities, and daily lives of students as an asset that they bring to the classroom. Vakil argues that "students' political identities are uniquely powerful and typically untapped resources for transformative learning and therefore should be welcomed, respected, and leveraged by CS educators motivated by justice and equity" (Vakil, 2018). As such, the justice-based CS classroom is a place where those who have been underrepresented have a voice, where the social and economic welfare of historically non-dominant students and their communities is emphasized, and where discourses are tied to liberation, as seen in Table 1, reproduced here from Vakil (2018).

Based on the framework, I now describe how a JCA to equity in CS education has been applied in the creation of a curricular unit. In the section below, I provide the context of the preservice STEM program in which a week-long curricular intervention was designed using the framework.

Context

The curricular unit described here was designed for use in the Classroom Interactions course as part of the *UTeach Natural Sciences Program* at The University of Texas at Austin (UTeach, n.d.). Students enroll in Classroom Interactions during the third year of their undergraduate mathematics or science degree. The course serves to present students with multiple frameworks and strategies for addressing equity issues in the classroom and teaching students with diverse cultural backgrounds. Students design and implement STEM activities in high school classrooms that are related to either their mathematics or science concentration. Throughout the semester, Classroom Interaction students are provided with multiple opportunities to observe teachers at a local high school, receive feedback on the implementation of their own lessons, and perform video analysis as a method for self-reflection. Classroom Interactions has a history of serving as an active research site for studies involving STEM preservice teachers (Petrosino & Dickinson, 2003).

Table 1
Dominant vs. Justice-Centered Approach to Equity in Computer Science Education

	Representations of ethics in curriculum	**Identity in CS learning environments**	**Political vision**
Dominant approach	Technology and computing have social implications. Learning activities focus on individual and student choices. (e.g., piracy, cyber-bullying, obeying copyright laws, responsible social media use). Students are encouraged to be responsible digital citizens.	Learning environments focus on developing students' knowledge, skills, and understanding of CS concepts and practices. Research examines cognition and computational thinking. Role of student identity in learning process undertheorized, resulting in deficit lens on girls and students of color.	CS learning framed as important for global economic competitiveness and national security. Students are encouraged to pursue CS through potential career opportunities in technology companies.
Justice-centered approach	Technology and computing have social and **political** implications. Learning activities focus on individual **rights** and **freedoms**, and corporate and government responsibilities. Students engage in critique of unethical abuses of technological **power** (e.g., U.S. surveillance state and privacy vs. security debates), and explore the role technology can play toward reaching social justice goals.	Learning environments focus on developing students' knowledge, skills, understanding, and **disciplinary identities**. Research explores how to **design learning environments** that are responsive to students' multiple social identities, **including their civic and political identities**.	CS learning framed as important for the **social and economic welfare of historically non-dominant students and their communities** (including but not limited to students and communities of the United States). Students are encouraged to pursue CS as part of and connected to **larger struggles for justice and liberation**.

Note: Table reproduced from *Ethics, identity, and political vision: Toward a justice-centered approach to equity in computer science education*, by Vakil (2018).

I, the author, have been the teaching assistant for Classroom Interactions for six consecutive semesters. In prior semesters, pedagogical design for project-based inquiry was modeled through an engineering design challenge where students constructed a pinhole camera during the first few days of the course (Berland, 2013; Marshall & Berland, 2012). The learning activities from the pinhole camera included engaging students in inquiry-based learning from day one, contextualizing student work within a STEM-design challenge, and modeling an exemplar project-based activity to draw from pedagogically throughout the semester. This CS curricular unit sought to fulfill the learning activities from the pinhole camera unit while also introducing students to computing from a prospective that aligned with a justice-based theoretical commitment. In the next section, I describe the aims and epistemological framing of the CS curricular unit.

Explorations into Culture, Politics and Computing

Explorations into Culture, Politics and Computing (ECPC) is a curricular unit with a key pedagogical goal of presenting an alternative view about what CS is and what it could be.[1] This is accomplished by providing preservice STEM teachers with a more expansive epistemological framing of how CS knowledge is capable of beyond computational concepts and practices. The one-week curricular unit aims to allow preservice STEM teachers to explore the intersections of ethics, politics, and technology in the city of Austin, Texas and provide a theoretical framing of computer and data science grounded in social justice. Rather than presenting CS as a detached, neutral discipline based on a mysterious body of knowledge of 1s and 0s that can be used to create gadgets and gizmos, our curricular unit aimed to assist students in uncovering that CS is also a critical set of practices and body of knowledge based on a set of undergirding tools and artifacts that are socially and politically value-laden. Critically, these tools shape the systems and contexts in which they are embedded. By blurring the artificial barriers between the domains of CS and politics, we can pursue important questions about the inequities of society while also contextualizing CS learning.

To develop specific activities based on the critical and sociocultural theories of learning described in the justice-centered framework, the designers (Harron and Vakil) drew on the idea of consequential learning as a mediating concept (Hall & Jurow, 2015). Consequential learning recognizes that what is valued as knowledge is historically contingent on the views of the social world at that particular moment of time. For example, efforts to teach computing in K-12 education have existed for almost 40 years (e.g., Papert, 1980; Papert & Harel, 1991), yet the importance of teaching CS skills and thought processes to all children was not broadly recognized as valuable until recently (e.g., Grover & Pea, 2013; Wing, 2006). Second, learning becomes consequential when activities are recognized as bridging one or more cultural activities. For instance, in ECPC as students learn to program they may not see the connection between the data visualizations they explored at the beginning of the unit and the need to understanding how variables, arrays, and functions work. But, those programming concepts take on new meaning as students enact them in the context of creating their own data visualizations for the final presentations. Finally, consequential learning depends on the temporal, spatial, and social scales of the learning activities. With respect to ECPC, this meant grounding the curriculum in a contemporary local issue that is of social importance.

ECPC explores the ethical issues surrounding the role of the local technology industry in driving gentrification, specifically how the influx of more affluent residents has lead to the displacement of communities of color in East Austin (Tang & Ren, 2014). The choice of topic was a design decision informed by knowledge of how prevalent a social issue gentrification is in Austin and amongst students at UT Austin, as well as an understanding of how the rapid growth of the tech-

[1] The curriculum described in this paper was co-designed with Sepehr Vakil and is part of an ongoing research project.

nology sector is raising complex questions around race, inequality, and power in the city. While most people may associate learning how to program with bootcamps and hackathons, learning to program in this context intertwines CS with macro-ethical social and political issues. CS as a discipline and way of knowing is not traditionally seen as a way to understand or act on social and political issues. Neither is CS itself seen as socially or politically value-laden. In intertwining CS with the social and political in the exploration of a locally relevant ethical issue (of gentrification), this curricular unit represents a significant epistemological shift from the status quo in CS education.

Curriculum

In the section below, six activities are described that were central to ECPC. Using the a JCA to equity in CS education, we explain how: our design decisions embed macro-ethical issues in the curriculum; welcome multiple student identities in the learning environment; and frame CS learning as politically connected to issues of historically nondominant members of the community.

What is Computer Science?

As an opening activity, students engage in a class discussion about how CS and the technologies enabled by it are having a direct impact on their lives. Framed in the context of Austin, Texas, discussion is based around visible transformations that have been taking place throughout the city. These transformations include the rapidly changing downtown skyline from construction of new buildings, urban sprawl in cities that surround Austin, and the expansion of local transportation networks in an attempt to alleviate traffic congestion. As the discussion progresses, students are asked to isolate possible causes of these changes including the desire for residents to live closer to downtown for work and entertainment, the influx of new residents moving to Austin for high paying technology jobs, and the consequences of maintaining an "if we don't build it, they won't come" mentality for decades as a municipal no-growth strategy (Goodwyn, 2013).

The instructors help students unpack that Austin's transformation is being fueled by the growth of the technology sector, which in turn is both a result of and driver for the increased impact that CS is having on society. As more companies in the technology sector move to Austin, there is an increased demand for developers/programmers, web designers, network administrators, and other highly skilled CS jobs. Although students may or may not currently be interested in CS, as a class they discuss how CS is becoming an increasingly essential part of almost every 21^{st} century profession. Doctors, scientists, engineers, artists, designers, and activists use computing in increasingly sophisticated ways. Students are given five-minutes to write a reflection using the following questions:

1. What is computer science?
2. What is the role of computer science in society?
3. What is your experience and comfort level with computer science?

In line with the justice-centered framework, students are welcomed and encouraged to bring their professional, social and political identities to the learning process by drawing on their own conception of the meaning of CS. Some students may only associate CS with the practice of coding. Yet, choices such as the operating system of their smartphone, whether to engage or disengage in social media, and the curation and regulation of online identities all demonstrate that CS has been infused in their lives. Students are provided with time and space to engage in small group discussion about the impact of computing and then invite volunteers to share out their current beliefs about CS and the ethics surrounding the role of CS in society.

Austin: A Tale of Two Cities

The second activity is designed using case-based instruction (Bonney, 2015), where students are provided with an in-depth examination of documents related to the social and political context of historical racial segregation of the city of Austin, Texas. Although commonly viewed as a liberal enclave, colloquially referred to as the "blue dot" in a sea of conservative red, Austin is the most segregated metropolitan area in the United States (Florida & Mellander, 2015). By watching interviews as part of *Austin Revealed: A Tale of Two Cities* (KLRU, 2014), students are provided with context about how the residents of East Austin are being affected by gentrification. In most CS curriculum, students are introduced to content by learning how to write their first program to display the text "hello world." Instead, ECPC is designed to introduce students to CS by using it as powerful tool for managing data structures and producing visualizations that can help them question the world in which they live. Throughout ECPC, both pre-rendered and student generated maps are used as a form of data visualization. To begin the case, students explore the *History of Austin's Racial Divide in Maps* (Zehr, Villalpando, Tretter, & Sounny-Slitine, 2014) as a means of uncovering the social and political drivers that lead to the historical segregation of Austin. This exploration of the ethics and politics rooted in racist practices highlight the historical labeling of African-American and Latino/a neighborhoods as "hazardous" (Hiller, 2003) and reveals how political decisions of the past continue to have social and economic repercussions for the historically marginalized residents of the community. Based on the evidence that students gather in this case study, they are asked to reflect on:

1. What was useful about this data?
2. What was limiting about the data?
3. What additional data would you like to see in these visualizations?

These questions are designed to help students think about how data visualizations are limited by the types of data that is available (Philip, Olivares-Pasillas, & Rocha, 2016). The limitation of data becomes apparent as students discover how a large portion of East Austin's African-American population has disappeared over the last twenty years. The maps used in this activity end at the edge of the Austin city limits, leaving nothing but white space with no data. This leads to the question: *Where did the African-American population go? And in what ways did the growth of the technology industry serve as a catalyst for the displacement of the African-American community?*

In order to expand upon the idea of using CS to create data visualizations, the activity begin to zoom out from the Austin city limits and explore *The Racial Dot Map*.[2] This map was created using a dataset from the U.S. 2010 Census (U.S. Census Bureau, 2012). Color-coded dots are digitally placed to signify both the race and residence for over 300 million participants in the census (see Figure 1). This is used as an opportunity to explore the ethical implications of both the social and political decisions about the types of information collected by the government and for what reasons. Furthermore, ethics and identity are brought into conversation with each other as the class discusses which colors of dots have been privileged with the name of a race and which dots have been "othered" (Borrero, Yeh, Cruz, & Suda, 2012). Through this activity students uncover that the African-American residents of East Austin have moved northeast to the suburban outskirts of the city. This activity was designed with student-centeredness in mind, giving students complete freedom about how they choose to explore the map. In the process, students may make a wide variety of observa-

[2] See https://demographics.virginia.edu/DotMap/

tions about the neighborhoods in which they reside, or about racial segregation patterns of other metropolitan areas.

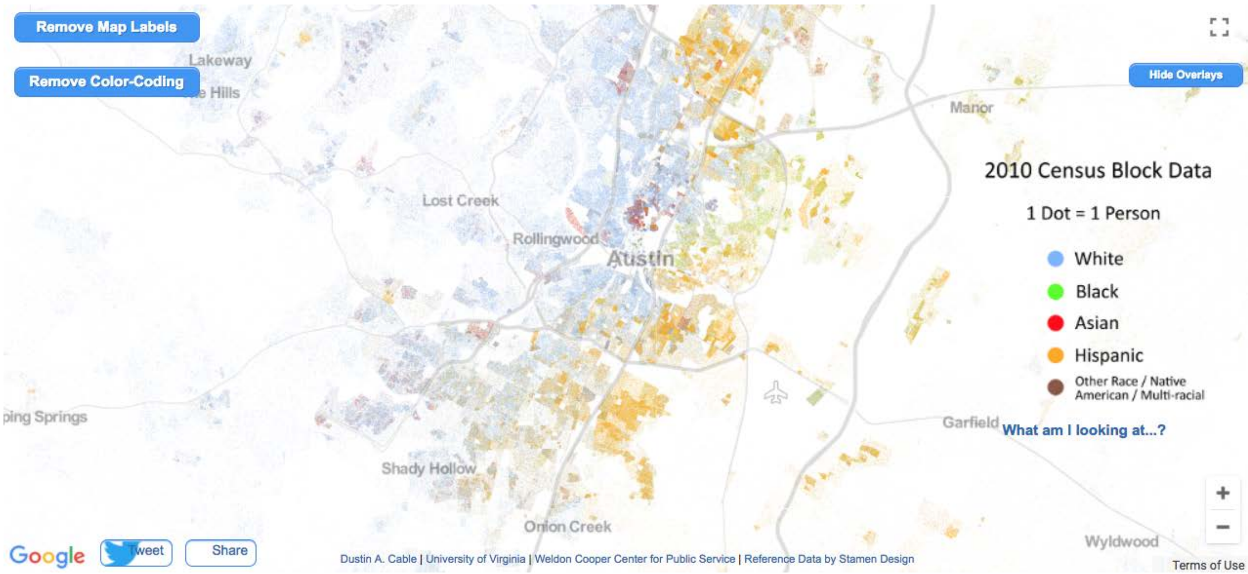

Figure 1. Racial Dot Map.

These activities help frame CS learning as politically connected to issues of historically non-dominant members of the community. This design leverages data visualizations as a powerful tool to both contextualize and critique the history of the city, while remaining grounded in the macro-ethical implications about what gentrification means in terms of individual rights, the responsibilities of government and industry, and the effect it has on members of the community. This activity concludes the first day of the lesson and students are assigned a reading as homework to provide context for day two.

Are Maps Political Artifacts?

The third activity starts the second day of the curricular unit and is called, *Are Maps Political Artifacts?* Prior to this lesson, students are assigned Langdon Winner's (1980) essay, *Do Artifacts have Politics?*, as a means of facilitating the discussion about whether the technical objects around us have political qualities. In this essay, Winner argues, "What matters is not technology itself, but the social or economic system in which it is embedded" (p. 122). Using the example of Robert Moses, Winner describes that the bridges of Long Island were purposely built too low for buses to clear as a means of keeping out the minorities who largely depended on public transportation. As a result, even after the death of their creator, these artifacts continue to have political implications.

Keeping with the theme of maps as a form of data visualization, the class continues to zoom out from the city of Austin until they arrive in outer space peering down on the Earth. Students are shown NASA's famous Apollo 17 "Blue Marble" photo, which depicts an image of the Earth taken by the crew of the final Apollo mission on their way to the moon (NASA, 2007). Rather than focusing on the human computers (McLennan & Gainer, 2012) and digital computers (Hall, 1996) that were fundamental in making space exploration possible, the instructors ask students to focus on the geographical features they recognize in the image (e.g., Madagascar off the coast of Africa.) Switching to a second image of "Blue Marble", but this time it shows the original orientation of the photo. The Apollo crewmember that captured the image was unable to tell geographic north from south while floating in zero gravity, resulting in Antarctica being oriented at the "top" of the world. This alternative representation is designed to open the door to discussion about our contradictory views of the world. Time is provided for students to discuss how this representation of the Earth may challenge what they identify as "normal". This leads to the question, *does the typical north-up publication of the "Blue Marble" photo make it a political artifact?*

Springboarding from this conversation, the instructors bring media into the lesson to catalyze the discussion about whether maps are political artifacts, using a clip from Larry Wilmore's monologue from the final episode of *The Nightly Show with Larry Wilmore*, (Comedy Central, 2016):

> Before each show I have a Q&A with the audience and the number one question I get is 'Why is your map upside down?' Right, well what I always say is 'I disagree with your premise.' You see upside is just an opinion. If you are floating in space the Earth can take on any orientation, but as a culture we have all agreed to the opinion that the world should be seen in a certain way.

Following the video, students are shown an image of a south-up map of the world. The use of the image is designed to help students facilitate reflection of their own cultural and political identities. In small groups, students are asked to discuss the following questions:

1. How does this map make you feel?
2. How does the Earth seem different when viewed this way?
3. Is there a reason why we typically see the north-up version of the map?

The discussion is designed to provide opportunities to uncover how we all have different perspectives about the world. Some students may have a strong identity tied to the traditional representation of a north-up map, while other students may tie it to lingering political visions embedded in Eurocentric maps related to imperial domination and colonization. Similarly, some students may have already developed a strong personal and professional identity that does or does not include CS as part of who they are as a person. But, in line with the justice-centered framework, the learning environment is designed to be responsive to these identities.

After addressing issues related to normalized orientation of the global map, attention is turned to the proportions of the countries depicted. The majority of global maps use the Mercator projection, in which the size of objects that are closer to the poles are distorted due to the stretching of lines of latitude (Monmonier, 2010). This results in landmasses, such as Greenland, appearing much larger than objects that are closer to the Equator, such as Africa. Using *The True Size Of…*[3] students digitally manipulate the position of countries and states by translating them to different parts of the world (see Figure 2). Throughout this activity students leverage the power of computation to morph both the countries on the screen as well as their preconceived notions of size. This transformative use of computing goes beyond the limitations of traditional maps and shows that CS has the ability to challenge existing political boundaries.

[3] See https://thetruesize.com/

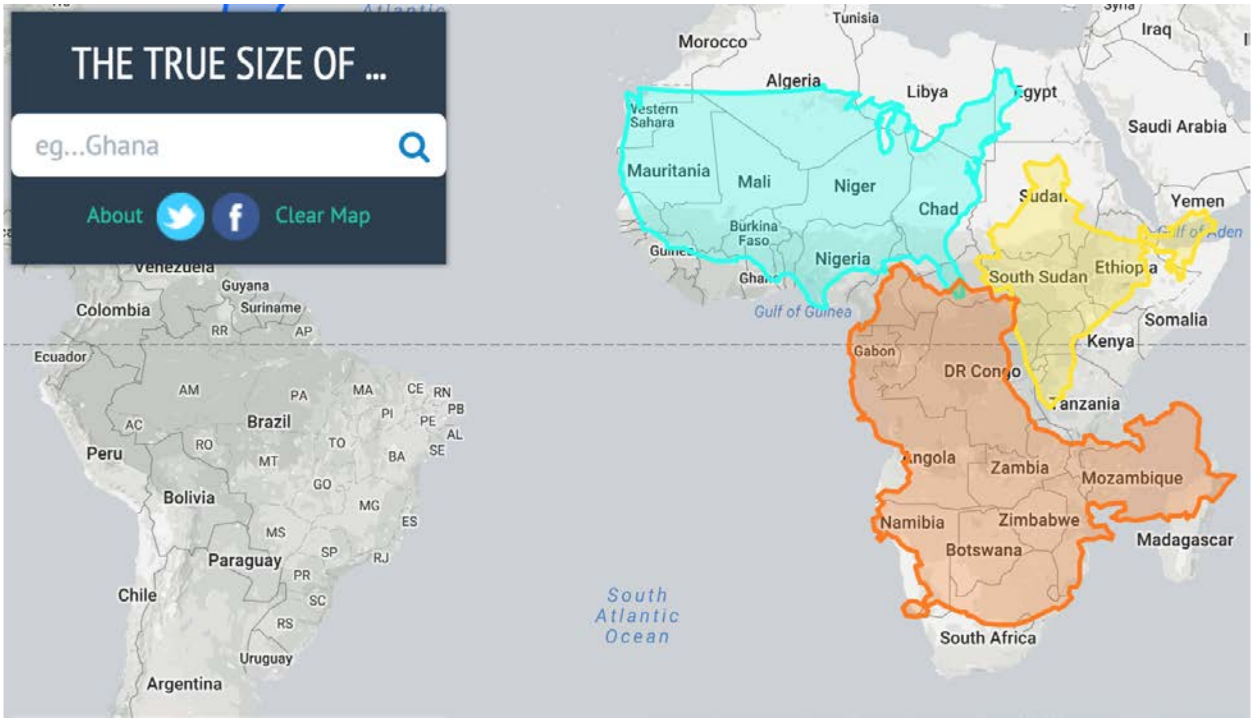

Figure 2. The True Size Of…

Just as the layperson may not see maps as a cultural or political artifact, most people do not recognize CS and related technologies as political. Connecting back to the idea that technical artifacts have political implications, students are asked, "Are computers a political artifact?" Students are asked to examine the familiar QWERTY pattern of their computer and tablet keyboards. There are several stories behind how the design of the QWERTY became our standard, ranging from purposefully being made inefficient so the typewriter hammers would not jam, to simply being a historical accident due to the standardization of market choices (Lewin, 2001). Yet, hidden in a single row of this computational artifact students find the word "typewriter", rumored to be placed there so typewriter salesmen could quickly type the name of the device (Vox, 2017). Much as maps are political artifacts, this activity was designed to help students uncover that our computational artifacts are not as neutral at they may at first seem. Rather, both CS and the technology enabled by it carry the sociocultural history of their creators.

Using Computer Science to Model Segregation

After zooming out to view data visualizations at a global scale, the unit returns to our local context of Austin. While the prior activity was designed to challenge students' perspectives by turning the world upside down, instead the instructors turn Austin on its side and focus on changes that have taken place in the skyline over the past two decades. The examination of photos depicting the Austin skyline from 1997 and 2012 (Villalpando, n.d.) provide additional context about changes that have taken place in Austin during the lifetime of our students. Returning to our discussion from the first day, the instructors lead a discussion about how the influence from the growth of the technology sector has been driving much of this change in Austin. Conversations about who is benefiting from these changes and the lack of affordable downtown housing drive marco-ethical discussions about how CS related industries are impacting residents of the city, while also providing a segue to revisit discussions about the gentrification of East Austin.

Modeling and simulations are frequently used to investigate hypotheses in CS education (e.g., CSTA K-12 Computer Science Standards, 2017; Exploring Computer Science v7, 2017). Computer simulations can iteratively run mathematical models to simulate outcomes of events over time (e.g., the outcome of a hundred coin flips, or the generation of a normal distribution by dropping a thousand balls down a Plinko board.) Using NetLogo (Wilensky, 1997), students use the Schelling (1971) segregation model to explore behavior as an emergent phenomenon. By adjust a variable called "happiness", circles and squares move round a map until they are surrounded by a user defined minimum percentage of like-colored neighbors. Students are able to adjust the minimum percentage and run the model multiple times in order to test different hypotheses about how the preference for similarity may result in different segregation patterns (see Figure 3).

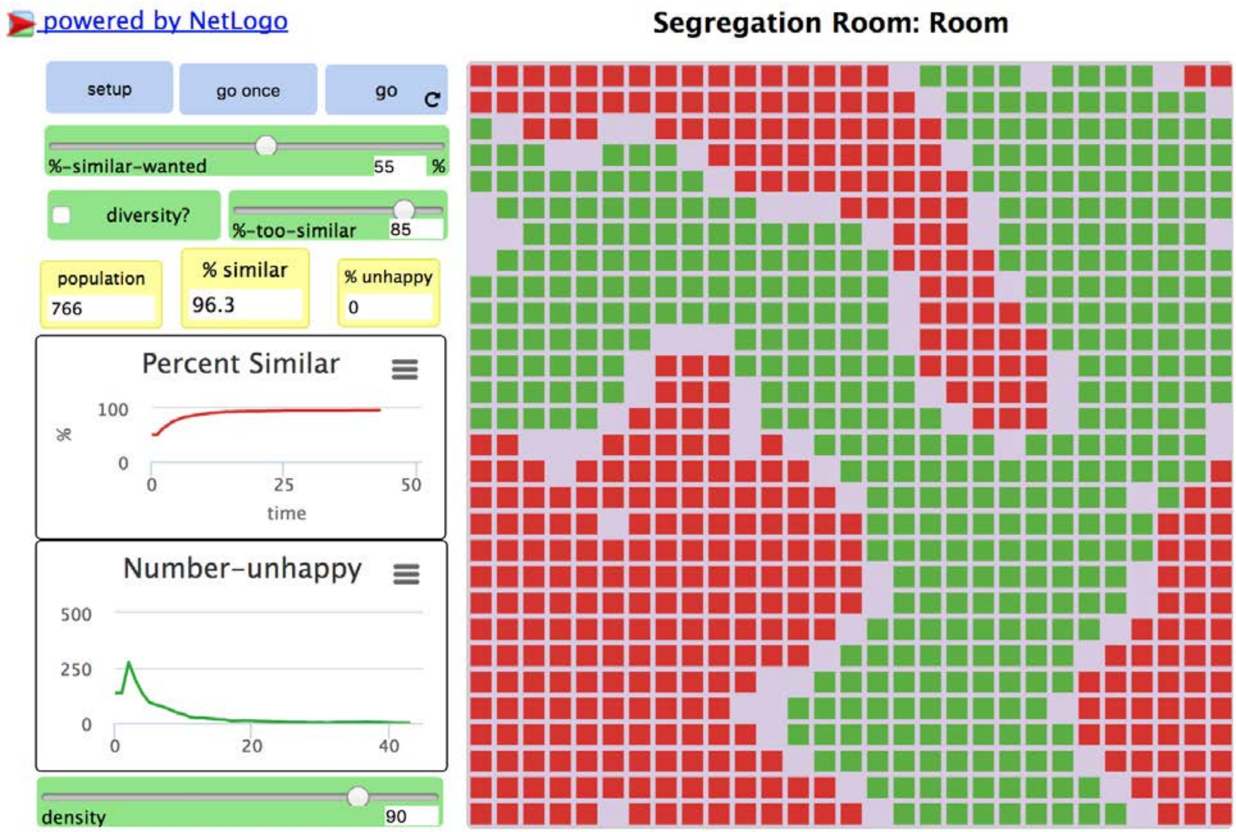

Figure 3. NetLogo Segregation Model.

NetLogo is an authorable environment, meaning that code can be modified and recompiled. By leveraging this feature, the curricular unit uses the segregation model as an introduction to programming. Students are shown how to modify a single line of code that determines the colors of the circles and squares in the model. Rather than accepting the default, this small change facilitates conversations about what else can be modified about the model. Although the emergent behavior of the Schelling model is an interesting phenomenon, it does not fully represent the political and social factors that lead to segregation. In order to critique the model, the class is asked to discuss:

1. What does this model do well?
2. If you could redesign this model, what other variables would you include?
3. Does this segregation model fairly represent how segregation takes place in Austin? Why or Why not?

This modeling and simulation activity was designed to situate knowledge about segregation in the context of authentic problem solving (Brown, Collins, & Duguid, 1989). In order to make learning consequential, the model is applied in an immediate local context rather than only focusing on the computational procedures that operate the model. As students are guided through problem-based inquiry (Kirschner, Sweller, & Clark, 2006) they generate additional variables that would like to see in the model such as wealth, income, and education-level. Based on our conversation about variables, the curricular unit uses this as a transition to begin introducing students to some of the key CS data structures that are needed to learn programming.

Introduction to Data Structures

Programming is a core concept that allows students to develop skills in CS while also engaging in many elements of computational thinking (e.g., Brennan & Resnick, 2012; Grover & Pea, 2013; Wing, 2006). During the segregation model activity, students had their first opportunity to modify code. In *Introduction to Data Structures* students begin to explore fundamental components of CS such as variables, arrays, and functions. Students "remix" a lesson where they modify JavaScript to learn about variables, logging to the console, posting alerts, calling individual elements of an array, and creating a function to call multiple commands. Throughout the activity there are multiple challenges designed to help students understand how variables, arrays, and functions can be used to represent parts of their own identity. For example, when defining an array called "scientist", students may choose to fill the array with words such as hypothesis, laboratory, goggles, scientific method, and replication. Although variables, arrays, and functions may seem isolated from the social and political themes of ECPC, learning these fundamental components of CS serve to bridge the activity of programming with the final activity of the curricular unit described below.

Choose Your Own Austin Adventure: A Data Visualization Design Activity

The culminating activity in the curriculum unit is *Choose Your Own Austin Adventure: A Data Visualization Design Activity*. This activity is designed to continue building upon their knowledge of CS by introducing students to open data sets from the city of Austin, while simultaneously raising their awareness about the availability of open data on the Internet. After exploring the data and variables of the 2014 Austin Housing Market Analysis (National Housing and Community Development, 2015), students are asked make social and political arguments rooted in evidence from the housing data set.

Working in groups of three, students choose and take on the identity of a fictional character (similar to "avatars" of virtual worlds) based in Austin. Groups construct an identity for their character that can include fictional and non-fictional elements, and may depart from their own identities. In addition to ascribing a set of identities to their character, the students also create a storyline that provides a sense of the character's goals, challenges, and concerns. Suggested roles include, (a) a school principal in a public school; (b) a community organization in Austin; (c) a community activist; (d) a CEO of a new technology company; (e) a concerned parent; and (f) a land developer.

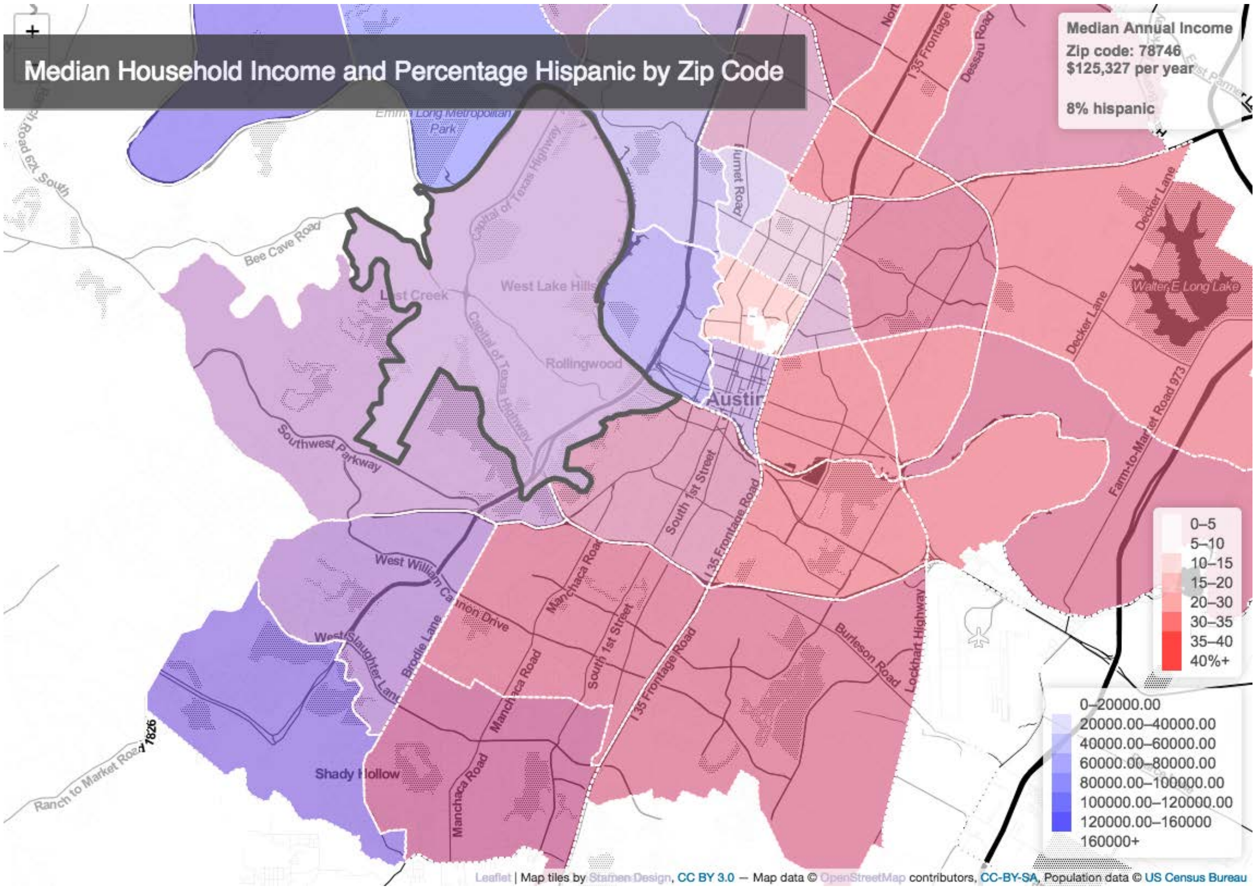

Figure 4. Data visualization based on 2014 Austin housing data.

Bringing elements from the theatrical arts into a STEM classroom, students design their own their "character" with a unique identity and backstory. Using the programming skills learned in the prior activity, students are asked to "remix" a web-based data visualization based on the zip codes of the city of Austin (see Figure 4). Students use functions to select variables from which they would like to generate a data visualization. The visualization separates the city of Austin by zip code and will shade each section to different colors intensities depending on the value of the variables in the array. Towards the objective of the character's goals, students create a data visualization by controlling the variable and color intensity for the minimum and maximum values. Based on the practices of Augusto Boal's (1979) *Theater of the Oppressed*, students present their character along with how, when, and where their character will use the data visualization to make an argument. The audience, consisting of their peers from the class, is asked to also become active participants in the performance. By taking on the dual role of the "spect-actor", members of the audience take on both the passive role of a *spectator* who is viewing the world around them and the active role as an *actor* who may speak-up at any point during the performance, using their voice to transform the reality in which they are living.

Throughout this activity students are never denied access to their identities. Unlike the dominant-approach to CS education, the activity described above permits students to engage in a macro-ethical critique of social and political issues, while also providing a liberating experience that is not found when only studying procedures and syntax. By providing space for students to exercise their identities as "spect-actors," there is room in the learning environment to explore how access to and knowledge of CS education is about much more than career-readiness, and how CS education can be a powerful tool to disrupt the inequities present in modern society.

Discussion

The aforementioned curricular unit represents only one possible vision about how to use a justice-centered approach to introduce STEM preservice teachers to CS education. This example was designed to be rooted in a local content, expose students to authentic problems affecting their university campus, and provide multiple opportunities to address the macro-ethics behind segregation and gentrification. The design of ECPC encourages students to bring their own social and political identities to the discussion, which in turn allows for students to reach their own conclusions about whether the changes were beneficial or detrimental to the community.

This project leverages the availability of large public datasets. As such, this curricular unit represents an exercise that could be replicated in multiple contexts where open data is available. While this curricular unit has students taking on the role of imagined characters in their community, future iterations of this project could include students engaging in fieldwork to learn about issues firsthand, and encourage students work in tandem with actual community members to create data visualizations that support authentic causes.

The curricular unit was designed with the idea that these preservice STEM teachers had limited experience with formal CS education. We anticipate that inservice STEM teachers may face the same professional development challenges due to their limited CS education backgrounds. As such, this curricular unit is a possible resource to help introduce inservice teachers to justice-based CS education. As CS becomes a standard literacy, it is important that preservice education programs infuse these topics into existing courses. Infusing CS into education programs should not be viewed as yet another burden that we are placing on classroom teachers. Rather, CS should be seen as a skillset that enables new ways of thinking, as a way for students to become more involved in their communities, and as a means of allowing students to be empowered by expressing their own identities in the classroom.

Concluding Thoughts

In this paper, the curricular design process was narrated with the aim of making visible how a theoretical orientation towards justice was used to inform the structure of specific CS learning objectives and activities. This design represents just one way to apply the framework and uses consequential learning as a mediating concept. Situated in the authentic problem of gentrification, this paper explored how the increased use of CS and growth of the technology sector has a direct impact on historically marginalized residents of East Austin. In an era where technology permeates our lives, it is important that all students are provided with the knowledge and skills needed to peel back the lid of the black box of computing. As such, this paper views CS as a tool to: critique the macro-ethics of politics and society; provide a CS learning environment that can be responsive to the multiple social identities of students; and connect CS to larger struggles for justice and liberation.

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