Examining Equity in Computing-Infused Lessons Made by Novices

Amy Isvik, Veronica Cateté, Erynn Elmore, and Tiffany Barnes

Department of Computer Science
North Carolina State University, Raleigh, NC, 27695
Email: aaisvik@ncsu.edu
Email: vmcatete@ncsu.edu

Abstract—In this study, we examine 10 computing-infused lessons with high equity scores created by high school interns. These projects were part of a larger corpus of 90+ projects made in summer 2020 for middle school and high school classrooms and the projects were evaluated using the Teacher Accessibility, Equity, and Content (TEC) rubric. This article examines the observed extensive evidence for equity in these 10 projects to determine how meaningful these equity scores are, what themes are present across projects, and to provide curriculum developers with strategies for ensuring their activities utilize equitable practices to be intentionally inclusive of all students.

Keywords—equity, curriculum design, equity analysis

I. Introduction

Numerous curriculum developers and community contributors have been developing Computer Science (CS) education materials for specific groups such as women, Blacks/African Americans, Latinx, and Indigenous peoples [1]–[3]. However, there has been little evaluation into the quality of curricula created for integrated settings regarding the ability to provide equitable and inclusive participation in learning computing. Programs such as Exploring Computer Science and Culturally Situated Design Tools were developed intentionally with culturally responsive pedagogy and inquiry-based learning in mind [2], [4]; however, K-12 teachers and other creators who are not professionally trained in curriculum development do not have the expertise to naturally include a high number of equitable practices into their own coding activities [5], [6].

In this study, each computing activity was created for middle or high school non-computing classes by novice curriculum developers. The activities examined are all single instance, light-weight activities meant to complement an existing curriculum or unit. In our prior work, we aligned with research in formal education [7], [8] to hypothesize that as fellow youth, our developers would excel at including concepts or themes relevant to their own youth culture such as games, social media, and other trending topics that would appear more authentic to K-12 students [9], [10]. However, this is only one facet of equitable computing curricula and overall, our novice youth creators struggled to meet additional Equity targets.

To address this gap, we use a case study approach to help understand *how novice curriculum creators incorporate equitable activities into their projects, specifically regarding projects that appear to be highly equitable*. Specifically, we seek to answer the following research questions: 1) what are simple strategies for adding equity into these projects, 2) where do novice curriculum developers need additional support, and 3) what strategies do novice creators target? As we review the selected coding activities and their accompanying supporting documentation, we also seek to evaluate if there is a meaningful inclusion of equity beyond simple presence.

II. Literature Review

Goode et al. suggest a supportive and inclusive learning environment, coupled with culturally responsive pedagogy and engaging curriculum facilitates equitable CS education [11]. The CSforAll campaign launched to ensure that CS education programs support not only students with preparatory privilege [12] but also students with disabilities, or from low-income, racially diverse, and rural backgrounds [13]. To help make a more inclusive curriculum, researchers use materials, topics, teaching and learning strategies that are culturally relevant to the learners [14]. Culturally responsive pedagogy emphasises the student being a stakeholder in their education to meet the needs of the student and local community [15]. Having a computing curriculum that provides the opportunity for students to see and celebrate both their culture and their personal identities can provide an avenue for inclusivity [16].

A strong example of computing curricula created with culture and equity in mind are the Culturally Situated Design Tools by Eglash et al. [17]. Culturally Situated Design Tools (CSDT) combine the "constructionist" learning style with the depth and care of cultural artifacts [18], [19]. The CSDT team has been developing culturally entwined activities for over a decade, with such rich examples as discovering mathematical principles through African American hair braiding or Native American loom weaving [20]. The intent of the work is for teachers to have tools that support equitable pedagogical practices that support the students such as ties to students' culture and perspectives [21]. In a controlled study of learning fractals with and without the cultural emphasis, results showed statistically significant advantages in performance and CS career attitudes in the culturally responsive group [22].

Equity is an essential theme in curriculum development, challenging content developers to create educational resources

TABLE I: Equity subcategories and indicator items examined in each computing activity.

Culture (community-level)	Identity (individual-level)	Exceptionalities (ELL, Sp. Ed, etc)
C1. Reflects and highlights the diverse cultures, perspectives, languages, and community values of students with regards to cultural heritage and/ or contemporary youth culture (e.g. popular video games or common student interests/actvities) C2. Gives students the opportunity to share their own culture and cultural heritage C3. Connects learning to students' homes, neighborhoods, and communities	I1. Context is meaningful and authentic to students and connects to students' interests I2. Students see themselves represented in the curriculum and classroom materials I3. Provides opportunities for students to contribute their knowledge and perspectives about a lesson's topic and share information about their life experiences I4. Provides opportunities for students to represent themselves in their projects	E1. Provides multiple representations within the lesson by adapting for a variety of different types of learners using alternatives to reading, writing, listening, and speaking such as translations, pictures, or graphic organizers E2. Provides extensions that allow a deeper understanding of topics for students who meet the performance expectations E3. Assessment methods are accessible to all students and do not penalize or reward students due to exceptionalities

that include materials to support student needs and provide every student with an opportunity to succeed. The research that follows explores equity design from the perspective of novice curriculum creators, focusing on presumably high equity projects and the specific traits those projects display in order to meet an exceptional evidence of equity.

III. CONTEXT

The study examines computing-infused lessons created for K-12 non-computing classrooms by high school interns participating in a 6-week summer virtual high school internship program [23]. Interns were able to work on an activity either alone or in pairs. The demographics for the internship program are shown in Table II; the participants were majoritively Asian females (19/29) and were rising juniors and seniors (typically ages 15-16). Each intern had prior coding experience either through formal high school courses or through summer camps and self-taught skills acquisition.

TABLE II: Demographic information of high school interns

Total	Gender			2019-2020 Grade Level				Multiracial, Black or Hispanic
	Female	Male	Other	9th	10th	11th	12th	
N=29	79%	21%	0%	10%	21%	59%	14%	14%

Before creating any curricular materials, interns were given a one-week, high-level introduction to curriculum development focusing on engagement strategies, differentiation, and understanding computational thinking [24]. This included a brief discussion (30 min) about culturally relevant pedagogy. As interns developed coding lessons, they also worked on developing supporting documentation such as topic slides, student instructions, and teacher guides including learning objectives and potential extension activities.

IV. METHODS & ANALYSIS

Authors 1 and 2 evaluated 67 intern projects using the Teacher Accessibility, Equity, and Content (TEC) Rubric for evaluating computing curricula by Weintrop et al. [16], [25], achieving inter-rater reliability ($k > .70$) on 15 projects before dividing the remaining 52 projects and tagging them accordingly. In this analysis we focus solely on 10 projects that scored extensively on the Equity dimension, meaning 80% of indicators were met in the following subcategories: Culture (community-level), Identity (individual-level), and Exceptionalities (English Language Learning, Special Ed, etc) [16]. The indicators for each equity subcategory are shown in Table I.

Prior research has evaluated the intern projects empirically, correlating TEC scores to author traits and lesson characteristics [9], [25]. This research uses case study-based methods [26] to analyze and explore equitable characteristics present in high scoring, novice-developed programming activities to better understand what factors contribute to the projects' success and if their evidence for equity is meaningful. Authors 1-3 reexamined the evidence of equity indicated on the initial TEC rubric evaluation for each project, using inductive coding to identify themes within the project features [27].

V. RESULTS

Table III shows a break down of Equity score for each of the highly-equitable projects analyzed. A series of independent samples t-tests on the various equity indicators, with nonparametric values when indicated necessary by Levene's Test of homoscedasticity, determined that our 10 exemplar 'equity' projects were significantly more equitable than the other projects in the original corpus. We also identified several themes that characterized these lessons and how the novice creators incorporated equitable practices, including: open-ended activities (10 projects), subject area correlation (8), youth culture (7), games (5), extensions & multiple representations (10), and adult avatars (4). After researcher discussion, three projects were chosen to highlight, demonstrating either positive or negative attributes that contribute to the meaningfulness of the assignment's equitability. We provide high level vignettes below.

Business Education
Themes: Open-ended activities, Youth Culture, Games, Extensions & Multiple Representations, Adult Avatars

Consisting of three gameplay modes: "spend, save, and invest", "make your own business plan", and "business terms & quiz", Business Education is a lesson focused on helping middle school students learn about finance and economics. When students start the program, they are greeted by a stereotypical white male in professional business attire. In the first section, students are given scenarios where they can select between three options for what to do with money they have received. The scenarios are geared towards youth circumstance, incorporating "contemporary youth culture" by mentioning common student interests such as skateboarding or AirPods. It is important to note, however, that some scenarios aren't relatable to students, often from lower-income families,

Activity/ Indicator	Business Education	Choose Your Own Adventure	Court Quest	Organizing Plot Structure	Palabras a La Luz	Presidents Memory Game	Salem Poor	Story Scenes	The Femme Mystique	Great Gatsby Visualizer	Total
C1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
C2	✓	✓		✓	✓	✓		✓	✓	✓	8
C3	✓		✓				✓				3
I1	✓	✓	✓	✓	✓	✓	✓	✓		✓	10
I2		✓		✓					✓	✓	4
I3	✓	✓	✓		✓	✓	✓	✓	✓		8
I4				✓	✓	✓	✓	✓		✓	8
E1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
E2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
E3											0

who would not have the ability to choose certain options in their real lives, such as buying a laptop or investing in stocks.

Many of the remaining equity indicators come from the open-ended nature of the "make your own business plan" task. Students are able to incorporate aspects of their own cultural identity and life experiences when choosing the topic of their business. However, the lesson does not provide structure to help or encourage students to incorporate their culture into their business plan, e.g. example businesses like restaurants and hair salons that incorporate cultural heritage or example prompts inspiring students to draw upon their culture.

We showcased this lesson because it shows a weakness found in several lessons: scoring high on equity but not quite hitting the mark of meaningfully incorporating and providing support for equitable activities. This indicates that novice curriculum developers need assistance in incorporating equitable activities into their lessons. It's not enough to provide the opportunity to incorporate culture; intentional support structures should be included to help students realize this is something they can do.

(a) Business Education (b) Court Quest

Fig. 1: Screenshots of Equity Case Studies

Court Quest
Themes: Open-ended activities, Subject Area, Youth Culture, Extensions & Multiple Representations, Adult Avatars

Court Quest teaches students about how the federal court system works and by exploring four landmark Supreme Court Cases through plaintiff and attorney role-play. Characters used in the program are diverse, providing representation instead of portraying lawyers and judges solely as white men. Two cases are particularly relevant to students, focusing on freedom of expression in schools and segregation in schools, respectively (Tinker v. Des Moines and Brown v. Board of Education). Beyond showing the events of these cases from a lawyer's perspective, the lesson relates these cases to students' communities and discusses how they are relevant through in-program narration and questions on the student guide. After interacting with the program and learning about the cases, students have the opportunity, as an extension, to code a landmark Supreme Court Case of their choice. We selected this lesson to profile because it is a good example of intentionally including equitable practices through the use of relevant court cases, the effort put into providing structure to show how these cases are relevant, the use of diverse avatars, and allowing students to code a court case of their choice.

Story Scenes
Themes: Open-ended activities, Subject Area, Youth Culture, Extensions & Multiple Representations

In Story Scenes, students place events from *Harry Potter and the Sorcerer's Stone* in order, then see the impact these events have on the main character and his thoughts and reactions to the events. When plotting the Harry Potter events, students also have to undertake several coding tasks (i.e. fixing buggy code and solving a Parsons problem) before they make their own version of the activity using their favorite book. We selected this lesson because it is a good example of how popular youth culture can be incorporated to help spark students' interest and provide a base for understanding cause and effect in narrative plot. It is unfortunate that the book chosen for doing this is Harry Potter, given J.K. Rowling's transphobic, homophobic, racist, and antisemitic remarks [28] but changing this project to use another book common in youth culture would be extremely easy and we wanted to be able to discuss the structure and use of youth culture in this project.
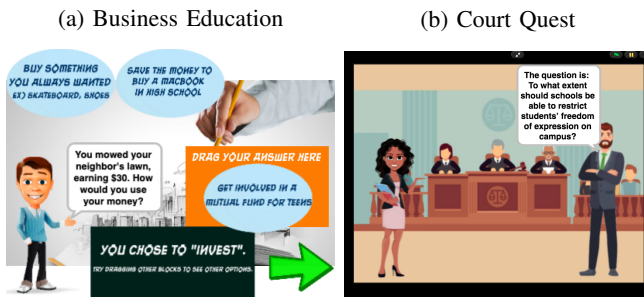
VI. Discussion

In this study, we considered 1) how novice-curriculum creators incorporate equitable activities into their projects, 2) what common strategies and areas for improvement exist and 3) what are simple and easily-adoptable modifications for intentionally supporting equitable practices.

Open-ended We found that higher equity projects included open-ended activities, allowing more freedom of expression for students in what they are able to incorporate into their final product (storyline, characters, graphics, etc.). Providing student choice had a large impact on equity scores, allowing students to have the opportunity to represent both themselves and their cultural heritage in their products. However, this

opportunity to represent oneself should be made intentional with appropriate support for doing so, something that is missing from the examined projects in general.

Subject area Aligning with previous research [25], our corpus of highly-equitable lessons were almost all from the Social Studies or English/Language Arts domain, which were shown to have significantly higher equity score than Math or Science. The subjects' nature may help boost equity scores because they often focus on "real world" situations which can more easily connect to students' communities and lives.

Youth culture We found that our interns incorporated youth culture into their projects but did not often incorporate cultural heritage themes into their projects. We speculate that our interns felt more comfortable incorporating youth culture because they have seen it more often in their classes. If they haven't seen many lessons that incorporate cultural themes and elements, then they might have felt uncomfortable or lacked inspiration to do so themselves. Alternatively, interns may focus on youth culture over cultural heritage as a way to try to make materials relevant for more students as they are designing for general use rather than a specific set of students.

Games One way our creators included youth culture was by including games or game-elements in their projects such as Hangman, memory matching game, or Choose Your Own Adventure gamebooks. Others projects included video game elements i.e. a medal system for quiz scores. We think games were popular because they are a fun, interactive, and engaging way to teach information [29].

Multiple representations & Extensions Since zero projects in our equity subset (and few in the original corpus) included assessment, evidence for both these indicators are required for these lessons to have a high equity score. We suggest that using a visual programming language afforded multiple representations of information. Our interns commonly included both graphical and textual representations of information, leading to many projects providing evidence for this indicator [25]. The provided teacher guide template also afforded a high rate extension inclusion [25]. Most of these extensions were potential additions/alterations with limited support present within the existing project. It is unknown how easily implementable these extensions may be in the classroom, therefore, additional guidance may be needed for novice curriculum developers.

Avatars Four out five avatar-containing projects included avatars of teachers or professionals who provided information about a topic and did not represent youth as experts. Beyond not having youth avatars, the adult avatars were not of the same demographics as the intern(s) who created the project. In fact, the most common demographic of avatars were white men. These high equity projects allow students to represent themselves and/or their communities, but their creators did not take that opportunity using avatars (though they may have represented themselves in other ways). This varies from patterns we observed in teachers creating computing-infused lessons, who often represent themselves with Bitmojis. We believe the interns' choices may be influenced by who they typically view as experts or persons of authority, corresponding with findings

that stereotypes are often reflected in drawings [30].

Limitations This work is based on program artifacts generated by high-performing high school summer interns. Interns self-selected to apply to the internship and demonstrated academic capacity for independent learning. Demographics are skewed to predominantly female and Asian participants. A replication study on different data may yield other results. We attempt to mitigate biases arising from statistical analysis by taking a case-study approach and focusing on generalizable trends applicable to a broader range of programming activities.

VII. CONCLUSIONS

Through an examination of 10 computing-infused lessons perceived to have high equity according to the TEC Rubric, we gained a better understanding of how novice curriculum developers incorporate equitable practices into their work. We identified themes characterizing this work, including youth culture, games, and open-ended opportunities. We also found that the extensive evidence for equitably, did not eliminate stereotyping or other limiting factors. However, we identified simple modifications curriculum developers can make to increase equity in projects in addition to areas that we can better support for training novice creators to design with intentional inclusivity. We offer these following recommendations for novice curriculum developers and those supporting them:

- Diverse avatars are a simple way to help students feel represented in the material. Giving students choice in what avatar teaches them can also combat stereotypes.
- Open-ended opportunities and student choice should be paired with scaffolding such as examples or guided questions to encourage student self-representation.
- Incorporating cultural heritage into lesson materials is an area in which novice curriculum developers continue to require more guidance and assistance.
- Further research into how teachers adapt lessons is required. It may be necessary for curriculum developers to provide additional support for extensions.

Overall, we feel that the TEC rubric is a valuable tool for teachers deciding what computing curricula to use and for curriculum developers to be more aware of teacher needs. We applaud how the use of the rubric helps teachers be more aware of equity-related concerns in their classrooms [31]. However, users of the rubric should be aware that there is a difference between having evidence for one of the equity indicators and intentionally incorporating that equity indicator into a lesson.

For this paper we specifically investigated high-equity ranking projects created by our cohort of high school interns. To further understand how curriculum creators incorporate equity in computing-infused lessons, we plan to investigate differences between high and low equity intern projects. We also plan to examine projects from by other types of creators (ex. teachers) as we are interested in understanding what different groups of curriculum creators bring to the table when it comes to creating culturally-responsive and equitable lessons and the types of support the groups may need.

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