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Investigating the Equity Imperative in High School Computer Science Curriculum for Latinx Students

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ABSTRACT

The goal of this qualitative research is to understand equitable teaching practices of computer science classrooms in the Chicago Public Schools through the video analysis specifically for the Latinx students. Data was collected through video recording from 10 different CPS classrooms. The videos were analyzed qualitative to determine the inquiry driven equitable practices. Though the equitable practices were identified based on the classroom video analysis, literature review on equitable practices and core ECS philosophy informed us to recognize and group the themes and their indicators of equity. This research plays a crucial role in terms of informing the current equitable teaching practices based on the videos in ECS classrooms in Chicago, also the research identifies a need to study further cultural references in terms of teaching computer science curriculum. This research has significance for designing professional development for marginalized population in computer science and possibly for other STEM areas.

KEYWORDS

Latinx students; equitable pedagogy; latinx education; computer science education; STEM education; research practice partnership in CS

Introduction

With President Obama's announcement of the Computer Science for All Initiative in 2016, there has been a surge in the number of districts offering Computer Science (CS) at their schools. Since the beginning of the standardized time (National Commission on Excellence in Education, 1983), this is the first time a content area has been gaining much national attention as a core subject. Many districts were at the beginning phases of implementing CS as an elective course back in 2016 (CPS, 2016). They did not yet face many hurdles they must surmount in creating equal opportunities for all students. However, the case for Chicago Public Schools (CPS) is unique as the CPS district has surmounted many of these initial challenges and has mandated CS as a graduation requirement for all students for the graduation year 2020. The foundation for the Chicago Alliance for Equity in Computer Science (CAFÉCS), a Research Practice Partnership (RPP) was laid in 2011 when an informal alliance was formed among CPS high school CS teachers, CPS administrators, and three university computer scientists to implement CS education in CPS. CAFÉCS was formalized in 2017 to ensure that CPS continues to provide schools with sufficient support and holds them accountable that the quality of this access is equitable across the entire district. The annual aim of CAFÉCS was to empower at least 20,000 Chicago high school students with foundational computer science practices.

The alliance members focused on high-quality CS experience to all CPS high school students. The Exploring Computer Science (ECS) curriculum is composed of activities that are designed to engage students in CS inquiry around meaningful projects, and ECS was embraced by CPS for CS education. The primary course that fulfills the graduation requirement of CPS is ECS (Goode & Chapman, 2012), an introductory computer science course designed to foster deep engagement through equitable inquiry around CS concepts. Exploring Computer Science is a year-long

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research-centric high school preparatory computer science curriculum that includes teacher professional development plan that is focused on broadening participation in computing. ECS is committed to providing meaningful educational opportunities to teachers and students with issues accessing quality education. ECS hosts summer professional development for teachers every year, and they also have quarterly professional development. ECS consists of six units. The ECS curriculum is composed of activities that are designed to engage students in CS inquiry around meaningful projects. The ECS professional development program is designed to prepare teachers to implement these inquiry-based activities while also guiding teachers in building a classroom culture that is culturally relevant and inclusive of all students. The ECS curriculum is designed to provide teachers with significant latitude for adapting the learning activities for the needs of their students.

In the alliance's first eight years, ECS has been taught in 85 CPS high schools to over 45,000 students. Of these participating students, 47% have been Latinx, and 37% have been African American, which is consistent with the overall CPS demographics; 44% of the students have been female. The alliance has also contributed to the literature on the impact of the ECS course on students' computer science outcomes (McGee et al., 2018) as well as students' choices about future CS coursework (McGee et al., 2018). The results in Chicago have shown that students of all races, ethnicities, and genders are achieving equivalent learning outcomes from the course, as measured by pre- and post-assessments of computational thinking (McGee et al., 2018). However, differences by race emerged when examining both performance within the course and the impact of the course on future CS course taking. Latinx students were less likely to pass the ECS course (McGee et al., 2018), less likely to take additional CS coursework in the future (McGee et al., 2018), and have lower positive attitudes toward CS (McGee et al., 2018) according to the prior analysis. The underrepresentation of ECS teachers of Latinx descent in Chicago is a dilemma underlying these results. Less than 15% of teachers participating in the professional development have been Latinx, whereas close to half of the ECS students have been Latinx. Therefore, there is a need to investigate the pedagogical practices in computer science classrooms and analyze if they are equitable for marginalized students, especially Latinx students. Also, it is imperative that modern computer science teaching should become more equitable. For example, Vakil (2018) that current pedagogies must simultaneously attend to at least three features of CS education: the content of the curriculum, the design of the learning climate, and finally, the politics and purposes of CS education reform.

Our previous research outcome of less positive attitude and higher failure rates of Latinx students in Chicago led us to ask the following questions: How did the ECS teachers implement equitable and inquiry-driven teaching practices? And what are the culturally responsive teaching practices adapted by the ECS teachers, especially for the Latinx students?

We predominantly seek to make a methodological contribution to equity pedagogies in Computer Science classrooms for culturally, linguistically, and racially diverse students. In addition, the empirical purpose of the paper was to explore equity practices that exist in the classrooms and identify the already established previous research in equity and the ECS curriculum.

Literature review

While conducting a thorough literature review on Latinx students in STEM and supporting them better we found that Latinx Students need more encouragement to learn Computer Science or to use computer on everyday basis than students from other culture. The literature review informed us that social barriers could hinder participation of *Latinx* groups in CS, including exposure to CS stereotypes in the media, lack of encouragement to learn CS from adults, and finally parents' and educators' belief that ethnic minorities are not as interested in pursuing CS which gets manifested in their actions (Nguyen & Riegle-Crumb, 2021). A study by Pak (2018) revealed that use of Spanish language inside classrooms enhanced sense of Belonging for Latinx students. It also provided an opportunity for the students to validate and value their identities.

Chisholm (1998) suggested to include three cultural elements in classroom to overcome those barriers; cultural awareness, cultural relevance and culturally supported environment. Chisholm (1998) suggested to include equitable access, instructional flexibility and instructional integration to support the need of marginalized students. Cultural awareness indicated instruction and learning activities that explain to support differences in learning styles, language. Cultural awareness meant to cultural literacy and cultural competence. Cultural relevance highlighted making teaching more relevant, drawing sources from one's culture to promote reading and writing. Similarly, Eglash et al. (2013) recommended using two different spectrums of culture. They recommended to blend students' social network and pop culture with their heritage culture. Young et al. (2018) showed ways to include the pop culture like hip-hop in mathematics and CS curriculum which can be embraced by CS teachers while teaching computer science. Brown (2002) suggested that educators should encourage cooperation over competition as it conflicts Latinx values. Wilson-Lopez et al. (2016) researched on Latinx engineering students and recommended to include funds of knowledge in engineering curriculum. Therefore, in the field of other disciplines like high school CS there is an opportunity to embrace one's culture and identity in classrooms.

There are a few articles that expanded the STEM identity and community of cultural wealth among LatinX students (Rodriguez et al., 2020). Also, Rincón et al. (2020) found that Latinx students draw on familial capital and resources to develop their STEM interests. They also center their families in decisions to pursue STEM majors and careers, considering familial obligations, family health issues, or a desire to improve their family's economic situation.

Methodology

The modes of inquiry are qualitative. The first author used open coding, axial coding, and selective coding as part of the data analysis. Those processes are borrowed from grounded theory as suggested by Corbin and Strauss (2008) and Saldana (2014). The first author took a bottom-up coding approach and started to code the data. Starting with open coding seemed to be the best fit in this research context as our goal was to understand the equitable teaching practices, therefore clustering the data provided us in details insight. The first step involved identifying open coding and self-reflection on first four video transcripts by the first author. Simultaneously, a literature review was on identifying equitable practices which informed our coding decision. Also, the first author attended summer professional development (2018) conducted by Exploring Computer Science to be able to understand the goals of ECS program. After the professional development and completion of the Charlotte Danielson training process, first author went back to the transcripts and identified the themes and built the codebook based on all the 10 videos. The team identified the recurring themes and highlighted compelling sections of all 10 transcripts to identity patterns. Once, the team identified key constructs, the next step was to introduce a composite codebook. The last step was to apply pattern coding or grouping the similarly coded chunk of data for each video transcript, which involved re-reading and coding each transcript. Some of the previously identified themes were removed, and some new themes were added. This time the coding framework was different from the previous one because of the volume data. Some codes were re-assessed, and they were condensed into other codes. The child codes or the sub-codes are referred as indicators and the selective codes (final themes) were referred as the themes. Member check-in method was followed a few times to ensure consistency in coding process.

Figure 1 explains the process of video analysis (identifying the main themes)-codebook development.

Data sources

Data sources consisted of 10 observational video recordings from 10 different ECS classrooms. Two of the teachers were teaching Scratch programming from Unit 4 of ECS, and the other seven videos contained muddy city activity, robotics, introduce to wait time, web-design,

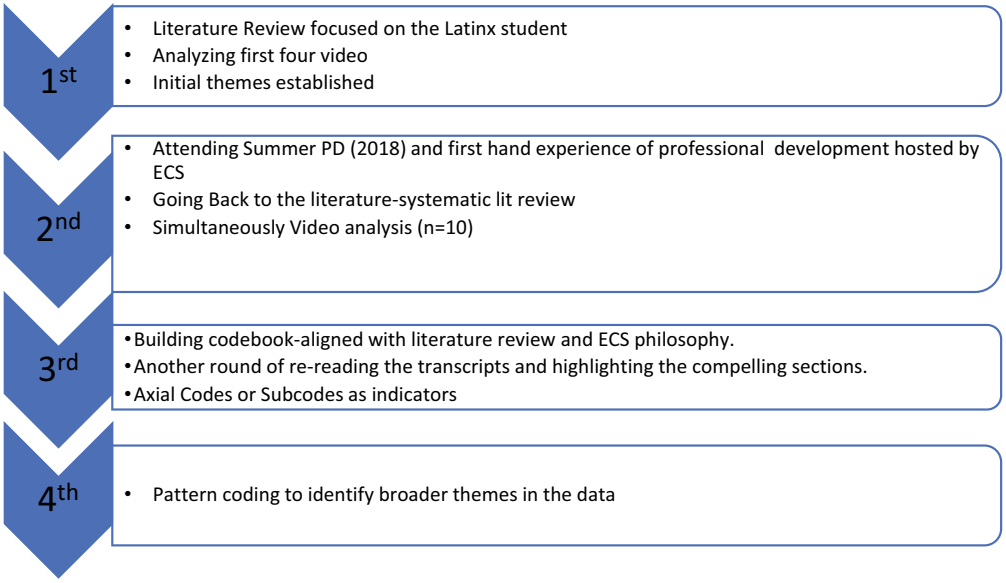

Figure 1. Data analysis cycle.

representation of data; univariate data vs multivariate data, class presentations on operating systems and web 2.0 application reflection from the ECS curriculum. We did not collect the demographic information of the teachers for this particular study. However, there was no teacher from Latinx background for this particular analysis. Some of the classes were taught in block periods, and some were taught through a single period. We analyzed recordings of the whole class. All the videos were transcribed and analyzed. Those 10 classes were chosen because the Latinx enrollment were high for all those schools or those schools were predominantly Latinx serving high schools. Therefore, first author chose to analyze those videos because they were most appropriate considering the goal of this study. The study is part of a larger NSF funded study, and we are reporting data from 10 classrooms focused on the Latinx students in Chicago Public Schools. Those all data were collected between 2017 fall and 2018 fall.

Findings: Equity in computer science classrooms

The following recurring themes were identified from the videos: instructional clarity (feedback, guidance, instructions, scaffolding, probing, questions, content area, and connecting to other disciplines, paying attention to individual student were sub themes), letting students explore (giving students choices, negotiating with students about a task-sub themes), making sure every student participates (accepting multiple answers, asking for student participation, asking questions from student participation, assigning group, classroom activity, facilitating group discussion, group work, humor, journaling, management of group activity, pair share, student presentation-sub themes), meeting the need of each student (individual instruction, checking student understanding and assessment, student–teacher interaction, supervising and meeting students-sub themes), respect and acknowledgment (calling each student, connecting classroom with outside world, encouragement, explaining the purpose of the research to make students comfortable, sharing teacher's view, welcoming students-sub themes), and using students' language (greetings in Spanish, instruction in Spanish-sub themes). Those practices were prevalent in the ECS classrooms in Chicago, and we identified them with the indicators.

Instructional clarity

In all the videos, teachers set expectations from an assignment or classroom lesson, provided feedback to the students on a task, guided students in the process of accomplishing a task, and provided instructions to the students repeatedly (refer to Table 1 for more sub-codes).

This corroborated from the findings of Chapparo et al. (2015) as their research recommended that instructional clarity should be followed by teachers–student learning expectations and their teaching objectives clarified specially when teaching culturally diverse students. We witnessed that most teachers embraced instructional clarity. For example, a teacher stated that

> you need to do the program back to you own project. When you open the tutorial here will be a video, that will tell you what the robot should do when you open the program. So you run the video and then there is a button says open, when you open it, it actually shows you the code. So, all you have to do is to recreate that code. Alright?" In another example, another teacher said, make the graph, copy, paste, answered the question, and then there's four questions. Once you're completely done, you can re-post it as an assignment on the Google classroom and we'll be good to go. So, you might have questions once you see it, but before I post it are there any questions about what's expected of you quickly.

Table 1. Examples of main equitable practices and sub-themes (indicators).

Themes	Axial Codes-Sub codes
Instructional Clarity	• Clarification of Instruction for a task • Rationale Behind Classroom Expectation • Questions • Problem Solving Strategy • Probing and Scaffolding • Making Students Reflect • Introducing the Topic • Generating Inquiry • Expectation Set • Directing Students • Cue • Classroom instruction on student grouping
Letting Students Explore	• Giving students choice • Negotiating with students about task
Making Sure Every Student Participates	• Accepting multiple answer through asking different students • Student presentation • journal entry • Group work • Sharing with group • Asking question from student presentation to check their understanding • humor • pair share or elbow partner • assigning group • Managing group activity • Asking for student participation • facilitating classroom discussion • Classroom Activity
Meeting the Need of Each Student	• interaction between students and teacher • Individualized Instruction • Supervising and meeting students • checking students' understanding either individually or in group
Respect and Rapport	• Explaining the purpose of the research-making student comfortable • Encouragement from Teacher • connecting the classroom with outside lives • Sharing teacher's own view • Addressing students individually • Meeting the need of the students • Welcoming Students
Using Students' Language	• instruction in Spanish • Showing welcome power point at the beginning, written in spanish • Asking how are you in Spanish

This is a great example of probing and scaffolding and at the same time generating inquiry along with clarification of instruction for a task.

> Another example is described below where teacher scaffolded the student well to reach to the desired answer.
>
> Teacher: What's an internet service provider? Name one.
>
> Student: AT&T.
>
> Teacher: OK. Does AT&T have a cord that goes from AT&T directly to every AT&T customer's house?
>
> Student: Yeah.
>
> Teacher: The line doesn't necessarily go directly to each house but it like wraps around so that there's a way to access each customer's house. Yes?

This is a great example of problem-solving strategy and directing student to the answer before teaching the content on network.

Letting students explore

One of the concepts for ECS is that teachers should let the students explore and they also explore with the students, teachers don't take an authoritarian role like many other classrooms. One of the aims of the curriculum is that students and teacher learn together and that was reflected in the classroom videos as well.

The data highlighted that the students were in charge of their learning. In this category, concepts like giving students choices and negotiating with students emerged. For example, a teacher said

> so what you gonna basically do use at least 10 letters of the alphabet, you don't have to do all 36 10 letters of these, they don't have to be,A through Z, they don't have to be consecutive, ..." "did not ask him to do that, but it was an interesting way to play with the game, you know and make it its own. If you want extra credit, you add the title of the game as a slide. You add a slide as instructions and then going to the game.

Or another teacher stated "feel free to explore, by end of tomorrow I would like your frogger dine level 2 with your lives added on. How many lives we agree on?" Also, the same teacher mentioned while negotiating with students; "students you should have four sprites, two of my choices two of your choices."

Making sure every student participates

The strategies that teachers utilized in those classrooms were learned from ECS summer professional development, 2018. In this category, first author identified the strategies based on her experience of attending the week-long professional development that enhanced student participation and coded them accordingly, for example, teachers were encouraged to connect with students through humor during their professional development workshop. Teachers used methods like accepting multiple answer through asking different students, student presentation, journal entry, group work, asking questions, humor, through pair share or elbow partner, etc.

Previous research by Petraki and Nguyen (2016), Wagner and Urios-Aparisi (2011), and Miller et al. (2017) suggested that humor is a great way to increase student participation in the classroom. Teachers used humor inside the classroom, for example, one of the teachers said "I know you have not consented so you won't be able to, you missed your chance of becoming a movie star." This is an example of teacher including humor so that students participate more in the research study and teacher was referring to the consent of participating in the study.

Other example was activity or team effort drive that included everyone, for example, one of the teachers said "decide in your partnership who is going to be the driver and who is the navigator" and that means teacher insisted on everyone participating but based on their interests. Teachers embraced different methods to ensure participation from everyone, in another example the teacher stated-

> "all right, ladies and gentlemen, I want you to take one minute and share in your groups. share, I want each person to share one way you've used the internet and how it would have been done before internet. Each person shares one of their responses."

This way teacher probed everyone to think and take part in group discussion.

Meeting the need of each Student

Data showed that the ECS teachers met the need of each student that ensured equity. They provided individualized instruction to each student, they checked and assessed each student and finally supervised and directed them as they learned from the professional development. Teachers embraced different pedagogical styles to accomplish this, for example, by providing individualized instruction, supervising and meeting students, checking students' understanding either individually or in group.

An example where teacher called student by their names and instructed them individually to address them-

> two pairs instead of a group of four. But hold on to that. We're going to look at it more. They're collecting maps, blocks, cards. Gisele. Miguel. Devon. Miguel, will you make sure there's only one there. Christian, will you pass that to Yaira? Nathaniel. Yes, hold on to that when we'll come back to it. Tyler. Frankie. Yes. Just have them on.

In another classroom, a teacher was following up on a student during the class who missed tutoring for a week.

> Could you not come to tutoring on every Tuesday or? That's a nice tractor what are you talking about, and your frog. the fact that you are concerned about the tractor, the frogs look like a square, c'mon. it's a square.

The student replied, "It was only last Tuesday cause my mama need me come help with laundry and stuff." Teacher asked and

> did you just forget yesterday? So come next Tuesday, if you send me a specific question and your code, I can also look at that, ok? just wanted to let you know, just don't just turn in any missing assignment to your I knew, I have seen your scary mace but not completed, if you are turning anything, please make sure you email it to me, so that I know to go and look at it. So if you upload here, I don't get any notification that let me know about the submission, ok?

Here, teacher not only provided individualized instruction and made sure to meet the student personally too to make sure the students have a grasp on the missed classes.

Respect and acknowledgement

The next noticeable component of each ECS classroom is shared respect and acknowledgment. Each teacher called their students individually and acknowledged them in the classrooms. They encouraged students, connected students' lives with classroom, welcome students in the classroom and made them comfortable with the camera by explaining the research purpose.

In an example, a teacher allowed cell phone time to the students and admitted that he does not do lot of things with phone that his students may do. This is an example of connecting students' lives inside the classroom.

> I am giving you permission to take out your phone right now and look at it. Well, I am giving you permission to take out your phone and look at it. Talking to students, inaudible. I was thinking that you normally do with your phone that I never do. I was thinking where we are headed were scratch? (7:47). We finished stories that's where we were headed.

This was before the actual lesson started.

In all the classrooms, students were free to express their thoughts and teacher often encouraged them to speak. In another example, the teacher explained the purpose of video recording, where he explained the purpose of the research and the reason why they should participate by consenting to the recording.

Also, we observed in another video- the classroom culture was a cognitively busy place, and the teacher conveyed high expectations for learning for all students and insists on hard work. He stressed on "I know you guys can solve this now. We just need practice" when the student was not assertive on a problem. The teacher said to the student regarding a problem, "It's not confusing" after the student complaint about a problem. The teacher also replied, "you got this."

Using students' language

There are examples in the data that teacher used Spanish language to greet, and welcome students. Occasionally the teacher also used Spanish for conversation and classroom instruction. Only one teacher addressed students in their home language as she was bi-lingual. However, we saw limited example of using home language in the CS classroom; only one teacher actively used Spanish to connect with students. For example, she welcomed students in Spanish and she displayed "Bienvenido" on the screen. She started basic conversational Spanish to connect with her students and then switched to her lesson for that day.

Table 1 explains the themes and their subcodes. This table explains how the main codes are related to the sub codes or child nodes.

We often noticed equity centered pedagogy and inquiry driven model co-existed in most of the classes while exploring our first research question more in-depth.

For example, one teacher said,

> diagonal would be quicker but it's more efficient just to keep the rectangular routes – rectangular streets. Yeah? OK. so you're good? OK. Can you guys count up how many pavers it took and I'm going to record it up there. And then you guys can look at our – have you thought about the strategies you used? Oh yeah, you did. You told me some stuff. So can you guys like make some notes of those strategies in your list and then flip it over and look at the extension on the back? Sounds good? So count first then make some notes and then the extension on the back.

Even though we coded this as instructional clarity category (under clarification of instruction) for a task, it involved group participation and the goal of this instruction is to make sure students understand it, and they take part in the lesson. This is an example that the goal of inquiry driven approaches are to ensure equal participation from all students. In another example, a teacher said, "Processor will be Intel Core – there's I think i3. I know we've seen i5 and i7. All right. So what was another operating system? Chrome OS. Chrome OS. What's another one"? A student replied "Apple." Then, the teacher said, "OK. What's the Apple operating system? This was coded as generating inquiry, however the end goal of this was to make sure most of the students speak in class, the teacher also called for participation from some of the quiet students by their names. Therefore, we report that often inquiry driven pedagogies supported equity in ECS classrooms.

Discussion

Other than, identifying the equitable teaching practices inside the ECS classrooms in Chicago, we also tried to identify the important findings that was aligned with literature review, and ECS philosophy to explicate what is missing and what is present in the current ECS classrooms. Encouragement, Spanish Language, role of culture and constructivist pedagogical approaches those four components were present in the classrooms, literature review and ECS philosophy, and that answered how can we improve the learning outcome of the Latinx students further in ECS classrooms in Chicago. However, none of them were really adapted at in-depth level by the CS teachers.

We observed some examples where teachers were encouraging their students, for example, one teacher was encouraging students to participate in a hackathon competition outside of their school to foster more awareness around coding. However, representation of Latinx role models in STEM inside the classroom could be a powerful tool to use, and we did not observe that. We recommend representing Latinx STEM role models inside the classrooms and ECS professional development team should present examples to the teachers during the PD.

Also, one teacher tried to embrace students home language while others did not. We recommend mono-lingual teachers to include google translator/other translation tool if they decide to use the Spanish inside the classroom. We noticed teachers' effort to step by step scaffolding, however teachers did not draw much inferences from Latinx culture for example, they never ask students to brainstorm any community driven problem that students are familiar with.

We recommend to include more examples and ideas of lesson plan for Latinx students like cornrow braiding which is relevant to the heritage culture of Black students. First author is currently involved with a project where she is facilitating a makerspace and that is based on local issues like building RANFLA cars or ways to purify water. Similar kinds of community problems can be used in Chicago as well while promoting computer science content. We also recognize the data collection for this particular project took place a few years ago, therefore, new video data analysis and current professional development delivery might have more addition.

Figure 2 explains the need of Latinx students-the need are defined from previous research, ECS philosophy and finally from the video data-all three components help us define the need of Latinx students. Then, from the video analysis, we list the equitable pedagogical practices that we observed in

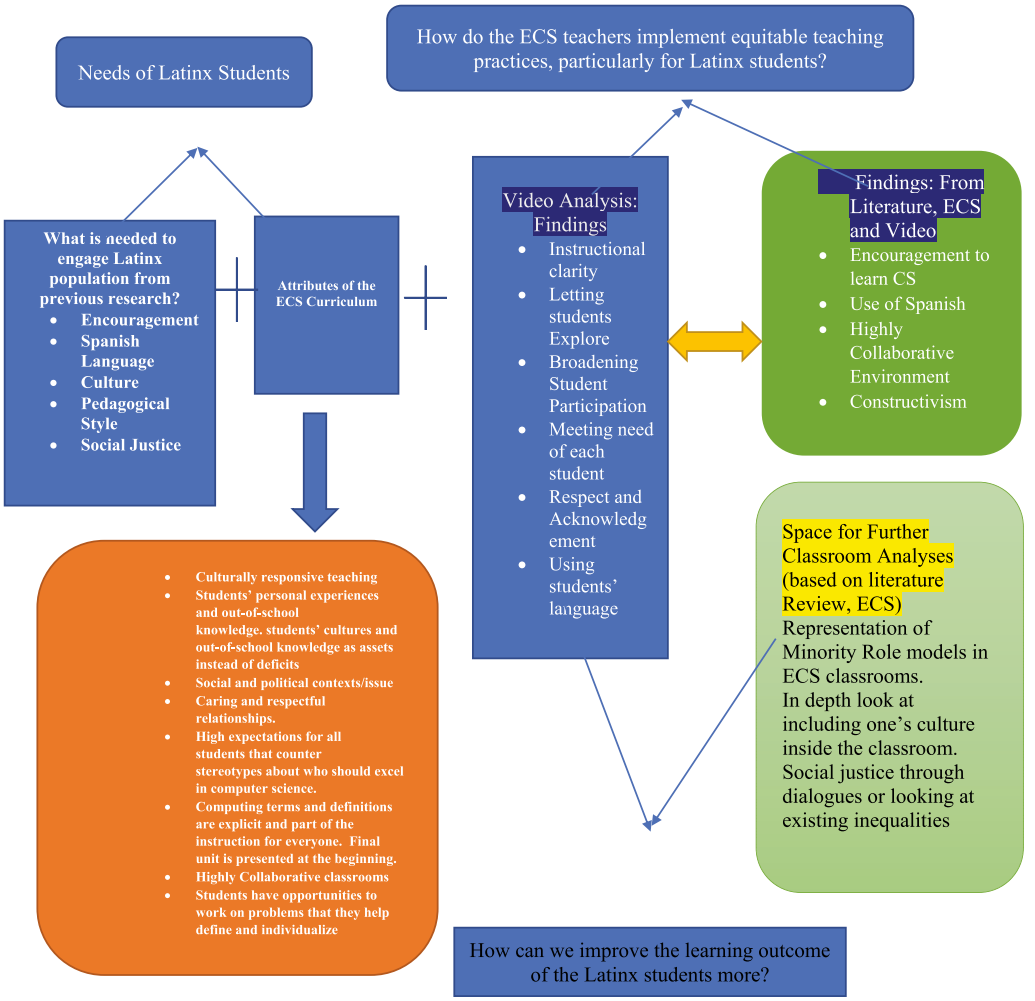

Figure 2. Construction of ECS classrooms through video analyses and space for further research.

the classrooms. We also compared and contrasted our findings with literature review and ECS philosophy to address the gap in current practices. Finally, from the gap, we draw inferences on the areas of improvement.

Further analyses

From the analyses, it is evident that there is a room to examine cultural reference as mentioned by Eglash et al. (2013), and Young et al. (2018), cultural awareness and culturally supported environment (Chisholm, 1998), direct reference between one's Funds of Knowledge and application of that in Computer Science classrooms as Wilson-Lopez et al. (2016) investigated Latina/o students' funds of knowledge and application of that in college-level engineering classroom, and social justice issues (Eglash et al., 2013; Terry, 2011). We observed a lot of examples of teachers willing to implement equity, however there are not enough examples of drawing inferences from students' home culture directly. ECS professional development were still at earlier phases of providing resources to teachers on how to incorporate students' home culture and everyday life. We encourage them to include local community issues while delivering PD at different regions, so that teachers have a guideline on how to utilize students' cultural capital.

Conclusion

This research plays a crucial role in professional development of ECS teachers in terms of informing the current equitable teaching practices based on the videos in ECS classrooms in Chicago. This research only captures the essence of equity in ECS classrooms, also bridges between the previous literature and ECS curriculum and identify the gap in the practice. Our analyses led us to investigate teachers' belief, understanding and attitude while enacting the ECS curriculum because ECS curriculum is exploratory and subjective to teachers' adaptation. Therefore, it is crucial to investigate what teachers think of equitable pedagogy. ECS philosophies are open ended; therefore, its upon teachers to use certain strategies in the classrooms. Our research also revealed that teachers used all the established equitable strategies to teach to students, however we did not observe in-depth use of culture-specific strategies.

Disclosure statement

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