



A Longitudinal Case Study of Middle School Teachers' Concept Development of Culturally Responsive Pedagogy in Teaching Computer Science

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ABSTRACT

This work-in-progress paper reports a case study that investigates middle school teachers' conceptual development of culturally responsive pedagogy (CRP) in teaching computer science (CS). The study includes four teachers who are participating in a five-year ongoing professional learning (PL) program named CS Pathways. The project aims to build the capacity of middle school teachers in teaching its computer science and digital literacy (CSDL) curriculum and eventually engaging culturally diverse students in creating apps for community and social good.

Through the lens of conceptual change, the study will explore how teachers build their concept of CRP throughout the project by using both qualitative and quantitative data. We are seeking the answers to two research questions: 1) What are teachers' understandings of CRP before and after attending the project's PL and teaching computer science? 2) How do teachers develop their concepts of CRP for teaching CS? Findings of this study will provide a deeper understanding of different CRP conceptual development pathways that teachers experience. Findings of this study can provide insights for the design of PL programs to help teachers update and reorganize their understandings and eventually improve their CRP classroom practices in teaching CS.

CCS CONCEPTS

• Social and professional topics • Computing education • K-12 education

KEYWORDS

Culturally responsive pedagogy, Conceptual change, Computer science, Teacher professional learning

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1 INTRODUCTION

With the mission to improve historically marginalized students' engagement and participation in learning computer science (CS), CS education has been evolving to include equity-focused pedagogy in classrooms. Culturally responsive pedagogy (CRP) has been recognized as an effective approach to achieve that goal, as CRP occurs in a multi-cultural setting that can enable students to make meaningful connections between learning and their culture [5], bring their culture into learning space [5,10], and empower students to be a change agent in their community [2].

Teachers acquire the concept of cultural responsiveness from various resources, such as their school culture, community, and professional learning. These prior understandings may not be sufficient to their CS classrooms, and their understandings need to be rearranged accordingly. To equip teachers with stronger capacity of CRP, teacher professional learning (PL) has been found effective in building their capacity and knowledge [6, 8].

In this current research in progress, we are conducting a longitudinal study to investigate the conceptual change of teachers' CRP knowledge through a learning science theory – *Conceptual Change Theory*. The study is based on four middle school teachers who have participated in the CS Pathways teacher PL program. This study seeks the answers to the following research questions:

- 1) What are teachers' understandings of CRP before and after attending the project's PL?
- 2) How do teachers' CRP concept develop through their PL?

2 THEORETICAL FRAMEWORK

Posner and colleagues first outlined the framework of Conceptual Change Theory, which suggests core conditions that need to be present for learners to acquire new concept [9]. Those conditions include dissatisfaction with their existing conceptions, the need for

a new conception that is both understandable and logically plausible, as well as the potential to extend into “fruitful” new areas.

Conceptual change research has made significant theoretical contributions regarding knowledge structure coherence, embracing two prominent, albeit competing, theoretical perspectives: knowledge-as-theory and knowledge-as-elements [1]. These perspectives describe the arrangements of learners’ naïve knowledge and the patterns which occur when that knowledge is replaced with new learning. The first framework, knowledge-as-theory, posits that learners’ naïve knowledge is logically organized, and then replaced with new knowledge, in what they cite as an “overwrite process”, and as a result, there is a broader focus on a “revolutionary” change in understanding as learners acquire new theories to ground their understanding.

In contrast, the knowledge-as-elements framework shows a more gradual and evolutionary change in learners’ understanding. Learners’ naïve knowledge exists as a natural collection of quasi-independent elements, rather than being arranged into highly organized theories. Learners gradually refine and reorganize their knowledge rather than replacing it one theory at a time. Logically, Özdemir and Clark conclude that the knowledge-as-elements framework is more relevant to real-world learning, particularly for learners beyond their young childhood age [1]. As learners age, their understandings become more transitional and fragmented. Both perspectives offer similar commentary about learners’ resistance to changing naïve knowledge, but the knowledge-as-elements framework offers a better explanation of the complex process of knowledge acquisition.

We believe that learning is a process of inquiry, which is the result of interaction between what is taught and people’s current understanding. Instead of merely focusing on preexisting misconceptions and replacing the knowledge, the focus of this study is to investigate the inquiry processes of the teacher participants regarding the CRP concept throughout the project’s PL.

3 CONTEXT OF STUDY

The CS Pathways project is a five-year researcher-practitioner partnership (RPP). The project aims to support the partner middle schools to create and implement a computer science and digital literacy (CSDL) curriculum embedded with CRP, which can engage middle school students in learning CS as they create mobile apps for social and community good [7]. Over five years, our project enrolled 21 middle school teachers from various subject areas. We designed a series of PL activities to help teachers build their CS content knowledge and CRP knowledge in teaching the project curriculum. Below is a summary of the PL activities organized by each year.

3.1 Teacher Professional Learning

In the first year (2019-2020 school year), the project focused on building teachers’ CSDL knowledge, therefore, no CRP knowledge was introduced. We planned 52 hours of PL in this year, where teachers first gained hands-on training on coding and making mobile apps through professional development (PD). We then organized monthly professional learning community (PLC) meetings during the school year involving all the RPP members

(teachers, school administrators, and researchers) to address issues regarding the challenges teachers faced [7].

In the second year (2020-2021 school year), the project shifted its focus to co-designing the project’s CSDL curriculum with all the RPP members. In this year, the project PL was centered around three activities: 1) Through a summer workshop, all RPP members collaboratively identified the curriculum standards and learning objectives. 2) We organized curriculum co-development meetings during the school year led by teachers who created materials for each unit (5 units in total). In each unit, we integrated a culturally responsive module. Teachers discussed and contributed CRP resources that fit in each unit. 3) Researcher-teacher one-on-one meetings provided individual and timely support while teachers implemented the curriculum in their individual classrooms. In general, teachers who participated in year 2 PL developed their CRP capacity through collaboratively co-designing and piloting the curricular resources that directly supported culturally responsive pedagogy [8].

For the third year (2021-2022 school year) and the fourth year (2022-2023 school year), the project ran a similar PL model. Besides building newly enrolled teachers’ CS teaching capacity, the project put focus on helping teachers implement the project CSDL curriculum into their subject areas. In general, the project PL activities were divided into three major parts: 1) new teacher PD trainings, 2) teacher PLC meetings, 3) optional in-classroom support and one-on-one support meetings with project researchers to help teachers with any challenges encountered while implementing the curriculum. Feedback from the meetings prompted the project researchers collaborated with civics teachers in expanding the project curriculum to specifically support civics teachers. The project now is in our fifth year, following the same PL model.

3.2 Positionality Statement

The authors of this paper are university-based researchers, one assistant professor (project PI) and two doctoral students. The authors are all females. Two of us are Asian and one of the doctoral students is a White/Caucasian. All of us participated in the project teacher PL activities. For instance, the third author of this paper is an instructor of our teacher PD programs. She is a full-time high school CS teacher with almost 20 years of teaching experience. The first author also gave presentations to teachers during the PD sessions regarding CRP knowledge as using CRP teaching CS is the author’s research focus. All authors participated in data collection (e.g. interview teachers) and research instrument design (e.g. survey, interview protocol). The project members hold shared belief about CRP that it is an approach aimed at engaging students with diverse cultures and eventually closing educational gaps.

4 RESEARCH METHOD

4.1 Participants

The participants are four teachers who attended two or more years of the project PL, and they implemented the project curriculum every semester. All four teachers are White-Caucasians, including three females and one male. Among the four teachers, two of them are technology and computer teachers; the other two are civics

teachers. They implemented the project curriculum into 7th and 8th grades. All four teachers worked with substantial student population who are identified as underrepresented minorities. In terms of their prior CS teaching experience and CRP knowledge, none of the four teachers had prior experience in coding or teaching coding, except for one of the civics teachers, who attended a formal teacher PD on CRP.

Table 1. Pre- and post-survey items regarding CRP capacity

CRP Capacity	Survey Item
CRP1 Understanding and connecting to students' culture and community:	Obtain information about my students' home life.
	Obtain information about my students' cultural background.
	Obtain information regarding my students' academic interests.
	Help students feel like important members of the classroom.
CRP2 Making use of students' prior knowledge, culture and interest to make sense of CS:	Use the interests of my students to make CS concepts meaningful for them.
	Use my students' prior knowledge to help them make sense of CS concepts.
	Use CS examples that are familiar to students from diverse cultural backgrounds.
	Teach students about their cultures' contributions to computer science.
CRP3 Integrating CRP into teaching:	Explain new CS concepts using examples that are taken from my students' everyday lives.
	Revise instructional materials to include a better representation of cultural groups.
	Design CS-integrated lessons that show how other cultural groups have made use of computer science.
CRP4 Facilitating student learning:	Design a classroom environment using displays that reflect a variety of cultures.
	Helping students find ideas and real-world examples on their own that can be solved by CS.
	Engaging students in critical thinking discussions around controversial or present-day topics to challenge them and foster their empowerment as a change agent.
CRP5 Encouraging collaboration of students from diverse culture:	Helping students eventually make their own apps for social good.
	Develop a community of learners when my class consists of students from diverse backgrounds.
	Implement cooperative learning activities for those students who like to work in groups.

4.2 Data Collection

The data were collected through multiple sources at several points throughout the project to provide in-depth profiles of the cases. The set of data are both qualitative and quantitative, as follows:

Teacher pre- and post-surveys. The teacher pre- and post-surveys contain 17 items designed to assess teachers' perceived capabilities in facilitating their diverse students' learning needs through using CRP. The CRP capacity items were adapted from the CRT survey designed by Leonard et al. [3, 4]. The survey items selected from the validated instrument are mainly employed to understand five major aspects: 1) teachers' abilities to understand and connect to their students' culture and community; 2) their abilities to use students' culture to make sense of CS; 3) their abilities to design and integrate CRP into their own teaching; 4) their abilities to facilitate student learning through various CRP approaches; 5) their abilities to encourage collaboration of students from diverse backgrounds. Table 1 shows the corresponding aspects the items intend to measure. The teachers' CRP capacities are evaluated on a five-Likert scale (1 = strongly disagree, 5 = strongly agree). Both pre- and post-survey were distributed through Qualtrics before teachers' first PD meeting and after they completed teaching the curriculum each semester, respectively.

End-of-year semi-structured interviews. The project conducted yearly end-of-year interviews as teachers conclude the project year. The year 1 interviews are not used in this study since the objective of that year was on building teachers' CS content knowledge, and no CRP related questions were asked during the interview. We designed the year 2 interview to understand teachers' CRP knowledge and enactments. The year 2 interview preliminary results also informed the year 3 interview design. The interview protocol included questions on teachers' understanding of CRP (e.g., "How would you define culturally responsive pedagogy?"), curriculum implementation (e.g., "Please describe how you implemented culturally responsive pedagogy this year.") and the support they received from the project (e.g., "How has the project prepared or supported you in teaching the CSDL curriculum?"). In year 4, we modified the interview protocol based on the Kapor Centers' Culturally Responsive Sustaining Pedagogy Framework to dive deeper into teachers' enactments and justice-oriented instruction [11]. The interviews were conducted online and lasted around 60 minutes per teacher. All interview recordings were transcribed verbatim for data analysis.

Teacher reflections during professional learning. Throughout the multiple-year PL, teachers reflected on assigned readings regarding CRP theories and practices, and shared their CRP understandings, practices and resources during PLC meetings. Those reflection documents were captured and collected. They are used as complimentary data to provide more comprehensive results.

One-on-one interviews during the school year. These interviews were designed to provide real-time support for teachers during their curriculum implementation. Those interviews were organized in the form of a 15 to 30-minute semi-structured interviews between the researcher and the teacher by request. Videos regarding CRP were selected and used as one of the data sources.

4.3 Data Analysis Process

The analysis of the cases is built upon both qualitative and quantitative approaches to capture the conceptual changes. The processes are proposed as follows:

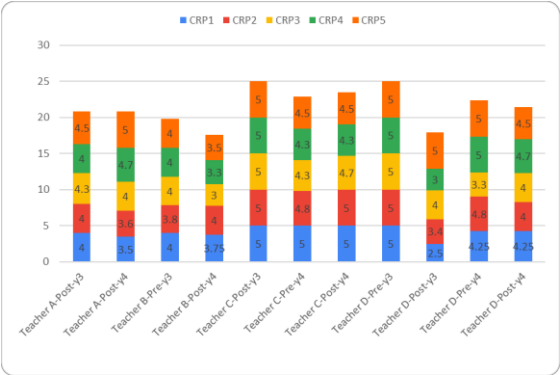


Figure 1: Teacher pre- and post-survey mean scores of the five CRP aspects by each teacher each year

Quantitative measurement of conceptual change. The teacher pre- and post- survey data were used to examine changes in teachers’ perceived ability in teaching CS using CRP before and after attending the project’s annual PL activities. The mean scores of the five aspects (as shown in Table 1) were calculated to indicate the teachers’ conceptual change. The descriptive statistics examined the most and least efficacious aspects of their ability when enacting CRP throughout the years.

Qualitative measurement of conceptual change. We use a deductive data analysis to capture teachers’ conceptual change of the five major CRP capacities. The end-of-year interviews and school year one-on-one interviews will be the primary data sources for the qualitative analysis. Teacher reflections will serve as complimentary data. The data will be analyzed using thematic analysis. Teachers’ responses to each of the five CRP aspects will be coded by two researchers. The initial codes will be discussed and developed.

5 PRELIMINARY RESULTS

We conducted a preliminary analysis on teacher surveys to get an overview of teachers’ conceptual changes. The results show the mean values of the five major aspects of teachers’ perceived ability of using CRP in teaching CS, as shown in Figure 1. The chart confirmed that as teachers proceed throughout the years, they showed changes in their perceived abilities.

We also conducted analysis on one of the end-of-year interview questions, which directly asked teachers to provide a definition of CRP. From year 2 to year 4, some teachers presented great changes in their understandings. For example, in year 2, Teacher A shared that CRP is a way to get all students access to CS and build their future career path. In year 3 and year 4, she acknowledged that the concept also embeds inclusion and equity, with a strong focus on gender equity in CS. Teacher C’s understanding of the CRP underwent a three-year evolution. She initially viewed CRP as classroom projects that connected to students lives, cultures, and

local communities. By the end of year 4, Teacher C’s view of CRP had expanded to include raising students’ awareness of different cultures around them and being respectful of those differences. Teacher D had formal training of CRP from her school PD, and as such, her understanding showed little change throughout the program. Her initial understanding involved cultural sensitivity, awareness, and engagement. Teacher B’s response in year 3 showed a complete misunderstanding of CRP. In year 4, he recognized that students’ life experiences should be part of the curriculum. And that concludes his understanding and improvement.

6 ASSUMPTIONS AND LIMITATIONS

This research study operates under the hypothesis that teachers of different subject matters and with various prior knowledge of CRP will develop different understandings and implementation methods of CRP into a CS classroom. Through the lens of Conceptual Change Theory, we intend to understand the trajectories of teachers’ CRP conceptual development. This paper intends to contribute to the empirical body of CRP research and serve as a reference for future PD programs that focus on teachers’ CRP development in teaching CS. One limitation of this study is that teachers are only able to provide feedback at limited time intervals, such as the beginning, middle, and end of the semesters, rather than through weekly teacher reflections. Similarly, the study relies solely on teachers’ self-evaluated data, as we have limited observational data, which is insufficient for a longitudinal study.

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