BRIDGING CULTURES: CULTURALLY RESPONSIVE SCIENCE TEACHING IN UNITED STATES-BASED INTERNATIONAL SCHOOLS

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BRIDGING CULTURES: CULTURALLY RESPONSIVE SCIENCE TEACHING IN UNITED STATES-BASED INTERNATIONAL SCHOOLS (220 pp.)

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Science education is essential for all students and should ideally be taught in a way that is responsive and connects students' culture and background experiences to their science learning. A current challenge that many science teachers encounter is a highly diverse classroom comprised of students with varied cultural backgrounds. The purpose of this dissertation was to investigate culturally responsive teaching within diverse international school science classrooms. The study was parsed into three research questions examining how the international school science teachers planned, taught, and reflected on their culturally responsive teaching.

This qualitative study employed an interpretive multiple-case study design. Three international school science teachers, who self-identified as culturally responsive teachers, participated in this study. Another distinctive feature of this research was the use of the Culturally Responsive Instruction Observation Protocol framework as a data analysis tool, adding rigor and depth to the study.

Significant findings from this study highlight the organic way teachers approached planning for culturally responsive teaching. Their own cultural identities played a substantial role in shaping their instructional plans. In terms of teaching strategies, educators applied effective science pedagogies, such as inquiry-based lessons, while also fostering diverse language and discourse practices, all while demonstrating a strong sense of cultural competence. Teachers' reflections on their culturally responsive teaching were influenced by the international school

environment in which they worked, as well as factors like small class sizes. These findings have important implications for both preservice and in-service teacher development, as well as broader school policies.

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ABBREVIATIONS

Abbreviation	Meaning
CRP	Culturally Relevant Pedagogy
CRT	Culturally Responsive Teaching
CRST	Culturally Responsive Science Teaching
CSP	Culturally Sustaining Pedagogy
FOK	Funds of Knowledge
IB	International Baccalaureate
IST	International School Teacher
MYP	Middle Years Programme (IB)
PST	Preservice Teacher
SES	Socio-Economic Status
STE	Student-Teacher Educator
STEM	Science, Technology, Engineering & Mathematics
TCK	Third Culture Kid

CHAPTER I

INTRODUCTION

."..children—born with a zest for knowledge, aware that they must live in a future molded by science, but so often convinced by their culture that science is not for them."

~Carl Sagan, *With Science by Our Side*

As I looked out at a sea of faces from all over the world, I quickly realized that these students had very different backgrounds and experiences from mine. Many of them lived in multiple countries and spoke multiple languages. The colloquialisms and jokes I previously used did not resonate with all my students. I realized that teaching at an international school would require a different approach.

International schools can be private schools, for-profit schools, or state-funded schools that were set up to serve the children of diplomats or expatriates seeking a comparable K–12 education similar to their national system but located in different countries throughout the world (Hayden & Thompson, 1995; Hughes, 2020). Like me, many of the students were also from the United States (US); some were living in a foreign country for the first time, while others had lived all over the world for most of their lives. Some students had multiple passports and came from families with parents from different countries. In contrast, others attended an international school in their native country where they had lived their entire lives.

Looking back, I appreciate the rich diversity of those international schools and their students and have realized that this combination of cultures, languages, and experiences makes for a stimulating learning environment. However, I am also astutely aware that teaching in this type of environment is more of a learning wave than a learning curve, as just when one thinks they have mastered the language and culture of a place, one learns something new. This was the

case in my first year at an international school in South America when a student walked into my classroom, altering my view of how I perceived and understood students and their cultural backgrounds. I was a little trepidatious at the start of school as everything was new, and many students and faculty spoke Spanish, which I was intensely trying to learn, but my high school Spanish was rusty. Kevin (pseudonym) was a sixth grader, and physically he looked as if he was of Asian descent. He seemed to have had the first days of school jitters just like I did but seemed keen to be starting middle school. We were waiting for the class to start and for other students to arrive, so we talked about the school and his friends. He wanted to do well in science and was already asking about extra work that he could do. Finally, other students started to arrive, and when Kevin greeted them in perfectly fluent Spanish, I was taken aback and quite surprised. I quickly realized that I had made certain assumptions about this student based on his physical appearance and our brief interaction. Even though I had lived on four different continents at this point and worked with students from all over the world, my human brain automatically wanted to categorize this student with other students who looked and spoke as he did. This experience left an indelible mark and not only made me reflect on my own biases but also made me question how teachers recognize and use the cultural and linguistic assets of our students.

By its very nature, science is an intellectual pursuit connected to society and the cultures that exist within societal bounds. The interaction of scientific practices and content with social needs and values is dynamic and interdependent (Longino, 1990). This interdependence also penetrates science learning and has to be considered when pursuing science education. A sociocultural approach to learning combines students' knowledge and experiences with science knowledge in meaningful, lasting ways (Fleming et al., 2015; Lemke, 2001; Upadhyay et al., 2017). Furthermore, a sociocultural lens allows science education to look beyond the Western

perspectives on science (Hodson, 2003; Lemke, 2001). Combining culture with teaching not only promotes the attainment of scientific knowledge but also encourages the success of diverse students while developing cultural competence and sociopolitical consciousness (Ladson-Billings, 2014). This chapter outlines why cultural integration is needed in science education and includes a description of how this study addresses culturally responsive science teaching (CRST) with diverse populations in international schools.

Problem Statement

For citizens to share in the advancements of science and technology, there must be a level of science learning that has occurred in education. Learning about science and its advances is a necessary survival attribute for citizens within modern society. Access to quality science education is a human right (Barton & Upadhyay, 2010; Chapman, 2009). The United Nations set this precedent in 1970 when addressing the intersection of human rights with scientific and technological developments. This human rights document addressed humans' physical and mental protection but also aimed to strike a balance "between scientific and technological progress and the intellectual, spiritual, cultural, and moral advancement of humanity" (United Nations, 1970, p. 563). The United Nations may have been attempting to stop or curb previous atrocities that occurred in the name of science, such as Nazi experimentations (Spitz, 2005) or the creation and use of atomic bombs (Schweber, 2013). Nonetheless, addressing the overlap of human rights with science provides evidence of the intertwined nature of science, society, and humanity. Science education is essential for reasons beyond the protection of human rights.

For instance, the authors of a report on science education in Europe stated that science education is essential because of the ability to explain the processes of the material world and allow individuals to face the issues of contemporary society (Osborne & Dillon, 2008).

Additionally, the authors cited that the history of science in European cultural heritage makes science education important. In the United States, the *National Science Education Standards* (National Research Council [NRC], 1996, 2012) also agree that science education is necessary for public discourse and allows people to make daily decisions regarding scientific information. The NRC (1996) also states that everyone deserves to understand and learn about the natural world and that science education is necessary to keep pace with global markets. To meet the demands of 21st century science education, the NRC developed the Next Generation Science Standards (NGSS) in April 2013. The NGSS fact sheet states that "We can't successfully prepare students for college, careers, and citizenship unless we set the right expectations and goals" (NGSS, 2013, p. 1). These standards were developed to serve as the foundation for science learning but have been left open for school districts and states to implement as they see fit.

Science education has historically struggled with whether its mission is creating better scientists or making science a tool available and accessible to every citizen. Science education came into existence within the United States because there was a need for a different type of education from that which traditionally served a small, rich portion of society (DeBoer, 1991). Even though science education started serving a larger and more significant portion of society, science education does not always follow that trend of inclusivity. A form of intellectual apartheid exists within our schools for groups based on race, ethnicity, and sociopolitical status (Hammond, 2014). For science education, this is evident in the increasing achievement gap between specific groups that belong to certain racial, ethnic, or low socioeconomic classifications (National Science Board [NSB], 2018). According to the National Center for Education Statistics, students at the school-age population are becoming more racially and ethnically diverse while disparities continue to exist in learning outcomes (NCES, 2019).

Not facing the challenges of teaching ethnically and racially diverse students can impact students' future career opportunities. Low achievement in science means opportunity gaps exist for access to Science, Technology, Engineering, and Mathematics (STEM) related careers leading to underrepresentation in these fields (Saw et al., 2018; Xie et al., 2015). Furthermore, science education is essential for making sense of the natural world (Renner, 1982), being informed citizens (Jenkins, 1999; Ratcliffe & Grace, 2003; Shen, 1975), and possibly pursuing future career opportunities (Osborne & Dillon, 2008; Wang & Staver, 2001).

Achievement gaps in education are not unique to the United States. In countries throughout the world, these gaps are often attributed to financial disparities (Clark, 2013). There are also achievement gaps among immigrants and their native counterparts in science assessments throughout Organization for Economic Co-operation and Development (OECD) countries (Andon et al., 2014). While considering the causes (i.e., racial disparities, socio-economic status, gender, etc.) of these divides in science learning will vary depending on location, the achievement gaps need to be viewed as a global issue with potential solutions lying beyond geopolitical borders.

Education should be inclusive of everyone to support transformative pedagogy (hooks, 1994). When everyone can be heard and listened to, we can better understand how to proceed forward in education and society. Society will be stronger as a nation and a world if more people have become science literate on their terms, thereby building a more robust, lasting connection (NASEM, 2016). Education (especially science education) can help students practice freedom by navigating their reality critically and creatively to transform the world or be relegated to conformity within the current system (Freire, 1970). When students have developed critical thinking skills and have the confidence to make informed decisions, they are able to exercise

their rights to freedom and actively participate in democratic processes. In order to better understand and live cohesively on this planet, all citizens need a quality science education. Global issues such as climate change, disease eradication, access to clean water and food supply must be addressed by world leaders and citizens who are scientifically literate and globally minded. Therefore, science education should be taught through a lens that is responsive to each student but connects them with the world at large.

Literature

At its core, science is about learning how to make sense of the world and further progress in society through problem-solving and technological advancement. Access to science is a human right laid down by international law and is considered necessary for informed participation in society (Porsdam & Mann, 2021; Tajmel et al., 2021; Wyndham & Vitullo, 2018). The avenue for access to science is through science education within our schools. However, for science education to be relevant to students and their lives, it is essential to acknowledge the interrelatedness of science and culture. “Science and culture intertwine and overlap and contribute symbiotically to intellectual creativity and expression in complicated ways” (Shaheed & Mazibrada, 2021, p. 107). Since each of these areas informs and shapes the other, it stands to reason that we must utilize culture in the teaching of science in order to capitalize on the symbiotic relationship between science and culture. Science education needs to engage students and teachers critically in using culture and students’ funds of knowledge or experiences (Ladson-Billings, 2014; Moll et al., 1992). One way to navigate the symbiotic relationship between science and culture is through culturally responsive teaching (CRT; Gay, 2002).

Culturally responsive teaching emerged from earlier framings of culturally relevant pedagogy (CRP). Culturally relevant pedagogy was constructed with three broad concepts: student learning or academic success, cultural competence, and critical consciousness (Ladson-Billings, 1995a, 1995b). Culturally responsive teaching emerged from CRP by centering students' cultural identities and background experiences as assets to learning and promoting effective instruction through differentiated practices that integrate all aspects of student's culture. Both CRT and CRP frameworks are influential in working with students of diverse cultural and linguistic backgrounds in science education (J. C. Brown & Crippen, 2016; Johnson, 2011; Laughter & Adams, 2012; McKinley & Gan, 2014; Mensah, 2021).

While CRP preceded CRT, there are specific aspects of CRT that make it a more pertinent framework for this study. For instance, CRT is geared toward teaching to and through cultural diversity (Gay, 2013). In the book *Culturally Responsive Teaching: Theory, Research, and Practice*, Gay (2018) emphasized CRT is about culturally situated teaching and not other pedagogical paradigms. Another reason for using CRT as the primary framework for this study is that one of the selected data analysis tools, the Culturally Responsive Instruction Observation Protocol (CRIOP) framework, is predominantly based on CRT. CRT is proposed as the main framework with the understanding that there is a substantial overlap with CRP, and there are likely to be aspects of CRP that presented themselves in this study.

Objectives

This qualitative study aimed to examine international science teachers' approaches to culturally responsive teaching with diverse student populations. The following research questions guided this investigation:

1. How do international school science teachers (ISSTs) deliberate and plan for teaching culturally diverse student populations?
2. How do ISSTs teach in culturally responsive ways?
3. How do ISSTs reflect upon their culturally responsive teaching in science classrooms?

An interpretive multiple case study approach will allow for examining CRT in diverse science classes. To ensure that the participating teachers work with diverse student populations, the context of this study was in international schools. These schools are most often established with the purpose of providing an equitable education to internationally mobile students (Fitzsimons, 2019; Hayden & Thompson, 1995, 2008). Cultural diversity is a characteristic of international schools (Morales, 2015). The Culturally Responsive Teaching Self-Efficacy (CRTSE) and the Culturally Responsive Teaching Outcome Expectancy (CRTOE) surveys were used during the recruitment process to ensure culturally responsive science teaching (Siwatu, 2007). For participation and sample size, three international science teachers were involved in this study. This allowed for a thorough case-oriented analysis and data saturation, thereby ensuring research validity (Fusch & Ness, 2015; Sandelowski, 1995). Data collection instruments used in this study included interviews, documents and artifact collection, and observations.

International schools are uniquely situated to allow for the study of diverse cultural interactions in an educational setting. While one study looked at the preparedness of international schoolteachers to teach in these culturally diverse institutions (Deveney, 2007), there are no subject-specific studies, to the author's knowledge, that focus on international school teachers' CRT in science classes. While issues of equity and diversity have been addressed, implementation strategies for science teachers working with diverse audiences are lacking in the

literature (J. C. Brown & Livstrom, 2020; Rodriguez, 2015). Teachers are becoming more aware of the need for ideological and pedagogical change but need to understand how to implement the practices of CRP (Underwood & Mensah, 2018). Finally, this study will answer the calls for further research in the area of CRT (Codrington, 2014; Gay, 2015).

Perspective

To position myself and communicate perspective, I must recognize and reflect on my race, ethnicity, and cultural background in order to fully situate myself as a teacher and researcher. I am a White, European American female who grew up in a large, diverse metropolitan area. While I was exposed to many languages and cultures, my home was monolingual, with the English language. My family's socioeconomic status would have been considered lower middle class. I am a first-generation college student. While I realize these details do not define me, I am aware of particular affordances and opportunities that were and are available to me due to my Whiteness and demographic details. Professionally, I have taught in the United States but spent the majority of my career teaching in international schools located throughout the globe. Internationally I taught in Russia, Pakistan, Kenya, and Argentina. Another aspect of positionality that I must acknowledge is that while every attempt was made to seek out international perspectives, much of the cited research is based out of the United States and may be a result of the author's background and experiences.

It is also noteworthy to point out that in this dissertation, I use the term *marginalized* to describe certain groups that have experienced exclusion or discrimination based on social or economic factors. Unfortunately, these groups are often based on race or ethnicity and have been relegated to a position of inferiority by systemic racism prevalent in the United States (Feagin, 2013). I intentionally will not use words such as *minority* or *non-White* to describe these groups

as I believe it contributes to the dominant White narrative prevalent throughout the United States. Words are shaped by historical and cultural context (Berg et al., 2014) and I elected to use my words wisely to not continue the cycle of repression and marginalization.

Conclusion

This introduction provided an overview of the intended study and pointed to the necessity of studying CRST in an international school setting. The literature briefly introduced CRT and other supporting theoretical and analytical framings. The objectives section outlined the study's purpose, research questions, and intended procedure. International schools were introduced as a viable option for studying the interaction of culturally responsive teaching and science with diverse student populations.

CHAPTER II

REVIEW OF LITERATURE

Quite often, people think of science as an objective subject that is built on cold hard facts. However, science is a human endeavor and, as such, is subject to the opinions and biases of the people doing and interpreting science. This statement is not meant to undercut the rigor of science but rather to come to terms with science as a human pursuit that is socially situated. In her book on *Science as a Social Knowledge*, Longino (1990) said that "scientific practices and content on the one hand and social needs and values on the other are in dynamic interaction but that the logical and cognitive structures of scientific inquiry require such interaction" (p. 5). In other words, for the learning and performance of science, there is a social component that cannot be ignored by educators.

For the teaching of science, it is important to recognize the lens and perspective of those striving to understand the world through science. One way to accomplish this is through continued and improved culturally responsive teaching (CRT) in science education. In her argument for CRT, Gay (2002) said that "Culturally responsive teachers help students to understand that knowledge has moral and political elements and consequences, which obligate them to take social action to promote freedom, equality, and justice for everyone" (p. 110). Therefore, science educators should look to instill these concepts through CRT in their classrooms.

This literature review investigates CRT in science education and identifies international schools as a resource for studying the teaching of diverse student populations. This is a *coverage* literature review with purposive sampling of central articles on CRT in science education (H. M. Cooper, 1988; Randolph, 2009). Specific criteria were used in this literature review to establish

the need for study in this area. The criteria started broadly and then became specific during the literature review process. For example, the broad search term *culturally responsive teaching* was one of the first terms used, and then more specifically, *culturally responsive teaching in international schools*. The research process was iterative when there was a need to revisit certain topics or research terms to attain more information related to certain lines of inquiry. During the literature review process, pertinent articles or resources were slotted into a literature review matrix that identified methods, methodology, purpose, findings, and whether they were theoretical or empirical. Another criterion set was the time of publication within this millennium unless the citation was for leading or foundational work. These criteria helped establish relevant and timely gaps in the literature for further research along this line of inquiry.

Defining the Problem

Students come to class with a variety of experiences and cultural backgrounds, including but not limited to their family culture. The learning of science by students in school can be greatly enhanced by tapping into their cultures and background experiences. This collection of knowledge, experiences, and cultural ways of knowing is called funds of knowledge (FOK; Gonzalez et al., 2006; Moll et al., 1992). Taking it further toward a Vygotskian perspective is the idea of *funds of identity*, which is when people use their FOKs to define themselves (Esteban-Guitart & Moll, 2014). The problem that teachers face is that their classrooms are often filled with a diverse range of students from different cultural backgrounds, and even students from the same culture may have had very different experiences. Therefore, it is imperative that teachers understand how to connect science learning with students' lives.

The science classroom can be an intimidating, foreign experience for students, especially those with little exposure to the culture of science. Aikenhead (1996) considered the science

classroom a subculture and a cross-cultural event for students wherein students are “border crossing” into science. Learning, in general, does not happen in a vacuum that is void of influences from society and individual experiences. A sociocultural theory of learning recognizes that learning happens within a network of influences from the environment, such as interaction with parents, peers, and culture (Bandura & Walters, 1977; Vygotsky, 1978).

If science education is viewed through this sociocultural perspective, then what this looks like must be defined. Lemke (2001) stated “Most basically it means viewing science, science education, and research on science education as human social activities conducted within institutional and cultural frameworks” (p. 296). There is no denying that students bring their background experiences to science class and, in turn, make sense of science through the social and collaborative processes found in classroom discourse and interactions (O’Loughlin, 1992). In order to address the importance of culture and society in science education, educators must investigate and reflect on how best to connect students’ sociocultural attributes within science education.

There is increasing concern over the achievement gap in science education between specific groups of students based on gender, race, and socioeconomic status (SES). In a congressionally mandated report, the National Science Board (NSB) reported data that revealed achievement and opportunity gaps in K–12 STEM education in the United States (NSB, 2018). These gaps were consistently attributed to students having a low SES or belonging to specific racial or ethnic groups. Besides race, ethnicity, and SES, other factors in the achievement gap that have historically existed are gender and culture (Baker, 2013; Dee, 2007; Garcia, 2002; Johnson, 2009; Johnson et al., 2016). Additionally, students who are English language learners (ELL) must contend with learning science and being held to the same testing standards as

students whose first language is English (Jackson & Ash, 2012; Johnson et al., 2016). While the Next Generation Science Standards (NGSS) have addressed issues of equity and diversity, they still need to provide examples or exact strategies for teachers to use (Rodriguez, 2015). The problem then becomes that many students need to take advantage of the opportunities and resources that come along with a science education that is authentic and relatable.

Suppose one of the purposes of science education is to guide students into discovering, investigating, and processing the natural world (Renner, 1982). In that case, science education is essential for mere existence. Science education can also be crucial for informed citizenship or future career opportunities (Shen, 1975). Equitable education is necessary to prepare students and future leaders for a diverse workforce (Aghazadeh, 2004). Systemic racism exists throughout our society and is being reinforced through our education system.

An additional problem is the 'Othering' of students who belong to or are descended from the non-dominant group (i.e., African, Asian, Latino, and Native American). In an analysis of 'Othering,' Brons (2015) stated, "Othering thus sets up a superior self/in-group in contrast to an inferior other/out-group, but this superiority/inferiority is nearly always left implicit" (p. 71). To be explicit and reduce confusion, within the United States education system, the identified "in-group" would be White Americans, and the "out-group" would be people of color and others marginalized based on race, ethnicity, or gender. This grouping through identities sets up an unequal relationship and is the definition of othering (Crang, 1998).

Science teacher preparation does little to prepare teachers for addressing the culturally responsive teaching of 'Other' students (Atwater et al., 2010). Cultural difference theory makes the assumption that the dominant culture is the one that is predominantly reflected in the culture of schools (Carlone & Johnson, 2012). The trends in racial demographics are that the teaching

force will remain predominantly White or European American while students' race and ethnicity will continue to diversify (Spiegelman, 2020). Therefore, teachers must be aware of how to teach and work with students whose cultural backgrounds are different from their own. One arena that you find teachers teaching students from different cultural backgrounds is in international schools. International schools are a potential source or gateway to developing teachers' intercultural competence (Savva, 2013).

Another argument for equity in science education is that most careers in the future will involve some aspects of STEM-related skills (Navy et al., 2021; NSF, 2014), and therefore, students require education in these science fields. Part of breaking down the barriers that exist for marginalized students must be to give them a chance to enter college and the opportunity to pursue science or STEM-related careers. There are still substantial equity gaps in STEM education for students of certain races, SES, and gender (Xie et al., 2015). The National Science Board reported that Advanced Placement classes, vital for college entrance, are predominantly entered into by White students (NSB, 2018).

STEM has been seen as key to economic prosperity and, in the educational realm, can be thought of as intellectual property (Bullock, 2017). On a global scale, STEM education has increasingly been recognized as "fundamental to national development and productivity, economic competitiveness and societal well-being" (Freeman et al., 2019, p. 350). Science education is vital for everyone because the more technologically advanced our world becomes, the more people will need some level of science and technology literacy to function in their everyday lives. This study does not perpetuate to solve the equity issues that exist within all of science education but rather hopes to give insight into teaching diverse student populations with cultural responsiveness.

International Schools

A potential resource for addressing issues of cultural integration in science education is international schools; however, it is important to consider their history and origins. There are different interpretations as to what constitutes an international school. According to Walker (2000), one of the first recognized international schools was the International School of Geneva which was founded for the children of parents working at the League of Nations and the International Labour Office. The school was set up to provide an education based on the international values of the League of Nations as well as to ensure that the children would be able to return to their own countries one day with minimal difficulty. Oftentimes, international schools are set up to serve the children of expatriates or diplomats who were seeking a compatible education outside of their national system (Fitzsimons, 2019; Hayden & Thompson, 1995, 2008). Most international schools are separate entities from each other and are set up all over the world.

The structure of international schools and the reasons for establishing them can differ significantly. Depending on the host country and the structure of the international school, students from the host country may attend the international school as well. Many of these schools provide services for families who are living outside of their country of nationality. International schools typically have a diverse population with students from all over the world, and cultural integration is common practice at these institutions. The reason for starting different international schools is most often based on educational philosophy or a mission of global mindedness leading to an enrollment of diverse students. In describing factors that affect students in international schools, Morales (2015) stated, “Diversity is an inherent characteristic of international schools, not only in learning styles but in cultural identification” (p. 52). The blending of several cultures

within an educational setting creates a unique opportunity to investigate how teachers address cultural diversity within their classrooms. As globalization has increased, so too has the number of international schools worldwide (Hayden & Thompson, 2008; Savva, 2013).

International schools, in and amongst themselves, operate in diverse manners. Hayden and Thompson (2008) indicated that international schools differ from national schools in four areas: curriculum, students, teachers and administrators, and management, leadership, and governance. For curriculum, they state that international schools offer a curriculum outside that of the host country. The International Baccalaureate (IB) Diploma Programme was originally created as a curriculum specifically for international secondary schools (Hill, 2007; International Baccalaureate Organization, 2023). However, it is important to note that different international schools and even different subjects (i.e., math, science, social studies) within these schools may use different standards or curriculums. Examples of these curricula are the IB, Next Generation Science Standards (NGSS), or Common Core State Standards (CCSS), and are based on the needs of their students and the subscribed curriculum of the school.

International school students are often non-nationals of the host country, but there are increasing numbers of children from affluent host country families attending international schools (Fail, 2011; Hayden & Thompson, 2008). The typical international schoolteacher (IST) or administrator tends to be staffed by many expatriates (Hayden & Thompson, 2008). Merriam-Webster's dictionary defines the noun form of expatriate as "a person who lives in a foreign country" (Merriam-Webster, n.d.). However, a practical definition of expatriate is difficult to define and often specifically refers to the corporate or business expatriate (McNulty & Brewster, 2017). It can be said that some international schools were established and serve to

educate the children of said business expatriates in order to allow the children of these families to return to their country of origin unhindered by a lack of comparable education.

International schools are often independent institutions that belong to organizations, such as the European Council of International Schools (ECIS), that connect and support the schools with professional development or governance training (Odland & Ruzicka, 2009). It is also important to note that since international schools are tuition-based and for the most part, serve a wealthy clientele, they are "often immune to the issues that accompany poverty and urbanicity in US schools" (Mancuso et al., 2010, p. 308). While many international schools are accredited by institutions within the United States and many even have "American" in their title, it is important to note that these schools and their students are different and are not necessarily subject to the same disparities (i.e., socioeconomic) as the typical school in the United States. However, the unique settings and composition of international schools will allow for understanding culture in a highly diverse context.

International schools are often confused with international education research, comparative education, or cross-national studies (Dolby & Rahman, 2008). Clearly, establishing the difference between *international schools* and *international education* is vital to understanding the position of international schools, their teachers, and their clientele. The international schools referred to in this study are K–12 institutions that have diverse citizenship and national origin in their student populations. International schools are considered valuable sites for research on national and international identity because of their "representation of the increasing diversification of many schools around the world" (Fitzsimons, 2019, p. 274). This diversification makes international schools interesting sites for research in other areas of education as well. For example, in a mixed methods case study, Belal (2017) found that the

diversity of the students was considered a more important factor in developing international mindedness than curriculum or engagement with the local community. Belal (2017) used Allport's social contact theory, which states that interpersonal contact with a diverse group of people is effective in reducing discrimination and prejudice, to suss out their findings about the importance of diversity.

Some research on international schools has focused on the teachers and their experiences in international settings. In a study at an international school in Thailand, Deveney (2007) found three areas (induction, mentoring, and professional development) to which the new staff members needed access in order to facilitate culturally responsive teaching. Focus groups and questionnaires were used in this research with teachers self-reporting their culturally responsive training experiences. The research also found the whole school culture played an important role in the teacher being able to conduct a culturally responsive classroom. In another study focused on ISTs, Roskell (2013) looked at the cross-cultural transition that 12 ISTs went through in their first year of teaching at a school in Southeast Asia. The research found that they experience 'double culture shock' as they adjust to living in a new country and working in different work cultures. These teachers are adjusting to living life in a country but also working at a school that is more than likely different from schools they attended unless they were at international schools.

International schools are not immune to the issues and challenges of national education systems. For instance, in a study on students' identities wherein the curricula and the culture of the two international schools were found to promote Anglo-Western identities as the highest in a hierarchy of identities, Tanu (2017) suggested that even though international schools claim an ideology of being international, they are often Eurocentric. International schools by their very designation are institutions that operate within their own 'bubble' or sphere of influence thereby

creating a tension of identity. Curricula and school culture can influence national and (inter)national identities and perceptions of self-worth (Fitzsimons, 2019). By not belonging to the nation where they exist or truly belonging to one educational system, international schools must constantly evaluate their educational path and its impact on their students.

A primary reason international schools are viable resources for studying the intersection of culture and education is their potential position as a 'third space.' From cultural studies, the third space is considered an ambiguous area that is developed when two or more cultures or individuals interact, thereby emphasizing the hybridity of cultures and identities open to discursive events and displacing dominant narratives (Bhabha, 2012). For educational studies, "the third space in learning environments refers to a place where two scripts or two normative patterns of interaction intersect, creating the potential for authentic interaction and learning to occur" (Gutiérrez et al., 1997, p. 372). Fitzsimons (2019) found that international students have to negotiate this third space on their own and through the lens of their individual identities.

The study of third space, sometimes referred to as hybrid space, is certainly not new in education, especially in science education (Barton & Tan, 2009; Moje et al., 2001, Seiler, 2013). In some of the earliest work on third spaces in science education, Moje et al. (2001) looked at language, literacy and capital "D" Discourse, which refers to a combination of language and social context wherein meaning is socially constructed within Discourse communities. Moje et al. (2001) found that building third spaces that brought together the classroom and students' lives enhanced science learning. Using a design experiment and targeting low-income urban middle school students, Barton and Tan (2009) found that hybrid spaces created in the science classroom were beneficial to students when they had ownership in creating those hybrid spaces through co-planning with the teacher and researchers. Barton and Tan (2009) stated that other areas for

research were “to explore the factors that help mitigate the creation of hybrid spaces” (p. 71) and “to identify more teaching practices and pedagogies that foster the creation of hybrid spaces” (p. 71). These hybrid spaces are all the more important when many of the students come with a plethora of background experiences and knowledge.

International schools are also ideal locations for research when looking at dialogue and education that reaches beyond geopolitical boundaries. International schools often claim to strive for developing internationally or globally minded students. The IB programme that many schools adhere to promotes international mindedness in its curriculum and favors intercultural dialogue (Hill, 2012). The emphasis of international schools to look beyond national identity and create a diverse and intercultural environment for education is what makes them suitable locations for research on culturally responsive teaching.

The International Student

To better comprehend international schools, one needs to look at the students who attend these schools. These international mobile students are often labeled third culture kids (TCKs) or global nomads because they spend a large part of their childhood in a culture different from their parent’s native culture or their own (Langford, 2012; Pollock et al., 2010; Schaetti, 1998). The reason it is labeled as ‘third’ is that they do not necessarily belong to their native culture or that of the host country in which they reside. The term *third culture* was first coined by Ruth Hill Useem in an attempt to describe the lifestyle of people living outside their own culture and TCKs denoted those children who accompanied their parents to other societies (Useem & Cottrell, 1996). Growing up as a TCK can afford many unique and positive experiences; however, it can also prove to be stressful for children (Morales, 2015). Perhaps the most famous TCK is former President Barack Obama, who spent time in Indonesia as a child (Pollock & Van Reken, 2009).

Third culture kids identify with and through their culture in many ways just as their counterparts who are educated in schools of their national system.

The International Teacher

As previously noted, ISTs are often expatriates living outside their country of origin (Hayden & Thompson, 2008). Most international schools employ a number of *local hire* teachers who are not expatriates but rather originate from the host country where the international school is located. Another category of local hire teachers may be people who were not specifically recruited but rather hired from within the country. This could include trailing spouses of businesspeople or diplomats who want to teach while living abroad. The number of expatriate teachers in international schools is growing rapidly but as a group are often neglected in the realm of expatriate research (Bunnell, 2017). The tension that exists for expatriates and expatriate international teachers alike is how much to adjust to the local culture without losing their own cultural background (Gertsen, 1990). Much of the research on expatriates has been done from a business perspective, however; expatriate teachers in international schools are growing rapidly and can be considered "a neglected community of non-corporate expatriates" (Bunnell, 2017, p. 194) that should be researched.

ISTs must navigate a variety of educational settings outside of their home country while adjusting to life in a different culture, sometimes resulting in double culture shock (Roskell, 2013). Historically and pedagogically, ISTs in international schools perceived their internationally mobile students to have different ideas and experiences from students in the context of the national schooling system (Hill, 2007). Just as the student population is transient in international schools, so too are the ISTs. To the author's knowledge, there is limited research on the characteristics of ISTs and what makes them choose to live and work in an international

school setting. Bunnell (2017) stated that “international schoolteachers, a heretofore understudied and rarely acknowledged population of expatriates whose professional life exists only when they live and work abroad” (p. 194). Therefore, the motivation of ISTs for teaching in international schools is unknown.

Culturally Responsive Teaching

Geneva Gay introduced and developed the idea of culturally responsive teaching and defines it as “using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them” (Gay, 2010, p. 31). In writing about cultural diversity, Gay (2013) indicated that her writing about CRT has developed through the years to center more on the teaching aspect versus the curricula. In *Preparing for Culturally Responsive Teaching,* Gay (2002) took a closer look at teachers’ strategies and introduced an asset-based view of “students who are not part of the U.S. ethnic, racial, and cultural mainstream” (p. 114). She placed teachers as caring individuals who could use cultural knowledge to redesign teaching and work in partnership with students. Additionally, the concept of CRT progressed to include attaining cultural competence and the use of cultural resources to promote teaching and learning (Gay 2013).

Other similar scholars or proponents promote ideas and frameworks similar to CRT. One would be remiss to not include the foundational work of Gloria Ladson-Billings with culturally relevant pedagogy (CRP). Ladson-Billings (1995b) first introduced CRP in her call to challenge ideas about culture and teaching with research into teachers’ pedagogical practices with African American students. She took the work of Shulman (1987) that centered around knowledge of educational context and knowledge of learners to add the cultural aspect of teaching. She cited

three important criteria for CRP:

- develop students academically,
- willingness to nurture and develop cultural competence,
- and development of sociopolitical and critical consciousness.

Before Ladson-Billing's work, there had been an anthropological progression of culture within education research. Much of this work evolved from and overlapped with multicultural education, wherein tenets of prejudice reduction, equity pedagogy, and knowledge construction are similar (Banks, 1993). The basis for much of that multicultural work lies in constructivist theories of education that promote the questioning and building of knowledge through the individual learner's lens (Byrd, 2016; Kier & Johnson, 2021). Later came the work of Django Paris, who offers the term *culturally sustaining pedagogy* (CSP) that takes into account how learners' identities and cultures evolve. Paris (2012) explained the requirements of this term in the following quotation:

> The term *culturally sustaining* requires that our pedagogies be more than responsive of or relevant to the cultural experiences and practices of young people-it requires that they support young people in sustaining the cultural and linguistic competence of their communities while simultaneously offering access to dominant cultural competence. (p. 95)

The individual and group work of these scholars has evolved and continues to change with the primary goal of achieving equitable educational outcomes. From praxis to theory, all of these lines of inquiry are pedagogically sound and highly relevant to science learning. Additionally, these preeminent pieces of work in education research stand to benefit not only marginalized students but those that live in a diverse society with a range of cultures and beliefs.

Teaching is a human endeavor that involves teachers' attitudes and beliefs. In an effort to understand the interplay between CRT and teacher beliefs about cultural diversity and their own teaching practices, Civitillo et al. (2019) found the relationships to be highly congruent. This multiple case study focused on four ethnic German teachers from the same school teaching two curricular subjects: German and Science. In the thematic analysis portion of the study, researchers categorized teacher cultural diversity beliefs into two categories: *color evasion* and *multiculturalism.* Wherein color evasion implicitly and explicitly avoids talking about race, and multiculturalism recognizes and supports culturally diverse groups. Among other findings, it was reported that teachers with a multicultural orientation had a high observation of CRT. In contrast, those with color-evasive beliefs had a low observation of CRT in their lessons. It is also important to note that a distinction should be made between culturally responsive pedagogy and multicultural education, as the first is responding to cultures within the classroom and the latter is about delivering content that reflects different cultures (Rychly & Graves, 2012). While much of CRT educational strategies and research are still developing, there are many examples of how it works and how these approaches can benefit all students.

When teachers are looking through this lens of CRT, they can figure out how to proceed in establishing themselves as culturally relevant and responsive educators. In a quantitative study from the students' perspectives in all classes, Byrd (2016) found that elements of CRP were significantly associated with academic and ethnic-racial identity development across all subjects. Thereby unequivocally stating, "In sum, when asking whether culturally relevant teaching works, the answer from the current study is a qualified *yes*" (Byrd, 2016, p. 7). The researchers made the following three primary recommendations for teachers:

1. Get to know students, including cultural background.

2. Teach about cultural diversity even when the class is not diverse.
3. Encourage appreciation for diversity while recognizing inequities.

Returning to the work of Gay, it is noticed that CRT has strong ties to sociocultural theory, which explains how culture influences social development (Vygotsky, 1978). Culture is a concept that Gay (2013) found powerful and useful in conceptualizing and communicating CRT. However, Gay (2013) also explained that it is important for educators to engage with diversity through their own priorities. She elaborated on her own priorities as being race, culture, and ethnicity but suggested other priorities may be gender, sexual orientation, social class, or linguistic diversity (Gay, 2013). There are numerous benefits to CRT for both students and educators (Gay, 2002; Hollie, 2017; Villegas & Lucas, 2002). The words of Gay (2013) better summarize the benefits and necessity of CRT; she stated:

> My intention is to remove the veil of threat and untouchability that often surrounds culture, race, and difference, and help teachers to genuinely see and accept them as potentially empowering factors for educating students. At the heart of these arguments is my belief that teaching to and through cultural diversity is a humanistic, realistic, normative, and transformative endeavor. (p. 61)

Gay (2015) extended this idea to articulate that the benefits of CRT are not only applicable to the United States, but also to international contexts. From multicultural competencies that help students learn about their culture and that of preparing students for participation in their community, the many facets of CRT provide the opportunity for equity in schools. Additionally, CRT stresses a plurality mandate wherein cultural socialization is emphasized along with recognition of the individual. One of the major principles of CRT is contextual specificity that prioritizes instructional strategies that are based on the specific needs

of the students (Gay, 2015). Gay (2015) called for more research in different nations that explores different domains of learning in accordance with CRT.

A number of tools have been developed based on the theoretical work of culturally responsive teaching and culturally relevant pedagogy. One such tool is the Culturally Responsive Instruction Observation Protocol (CRIOP) developed by Powell and Cantrell (2021) which is based on cultural responsiveness and has its foundation in linguistically responsive instruction. The CRIOP instrument was developed as a tool to guide teachers in culturally responsive instruction and consists of six elements: classroom relationships, family collaboration, assessment practices, instructional practices, discourse, and critical consciousness. Indicators were developed for each element to serve as descriptors and to clarify the identified culturally responsive practices. Powell and Cantrell (2021) stated, "Classrooms that are rich with racial, ethnic, and linguistic diversity provide greater opportunities for students to develop and learn in ways that leave them better prepared to participate in a vibrant democracy and global economy" (p. xiv). Building on this idea of enhancing educational experiences through culturally responsive teaching the CRIOP instrument can be used for analyzing teaching practices.

In Chapters 3 and 4, the CRIOP tool is further discussed as it was utilized in this research as a framework for analyzing teaching practices. Other tools that have been developed to measure culturally responsive teaching primarily with preservice teachers are the Culturally Responsive Teaching Self-Efficacy (CRTSE) and the Culturally Responsive Teaching Outcome Expectancy (CRTOE) developed by Dr. Kamau Siwatu (2007). Both of these validated surveys were utilized in the recruitment of culturally responsive teachers and are further discussed in Chapter 3.

Culturally Responsive Science Teaching

There is a need for culturally responsive science teaching (CRST) in order to engage students into the world of science and fulfill a call for a science literate society. Students from around the world do not find their science classes engaging and will need science and technology to function as literate citizens (Hofstein et al., 2011). A science-literate society is important as science and technology progress in hopes that everyone can fully participate and understand the role of science in society. Science education needs to anchor science content in real-world phenomena thereby helping students to see the relevance and authenticity (Hofstein et al., 2011; Windschitl et al., 2018). Authentic learning is vital for populations of students that do not have a vast number of resources, especially pertaining to science. Longino (1990) proposed that science is social knowledge and that societies that have a dominant race or sex (i.e., White males) will distribute resources disproportionately. This imbalance is perpetuated when science education does not rectify exclusionary practices along with making resources and the learning of science possible for culturally diverse students. CRST has the "transformative potential for eliminating disparities" (Gay, 2015, p. 136) and can benefit everyone in society. However, science teachers must be made aware of how to teach in culturally responsive ways that meet the needs of all students.

To address the need of meeting all students, Atwater et al. (2010) conducted an explanatory case study of two science teacher candidates to better understand culturally responsive teaching of 'Other' students. The study was a longitudinal qualitative research design framed by critical theory. The researchers found that the teacher candidates could not recognize culturally responsive teaching from their mentor teachers and were not prepared and/or not willing to successfully teach 'Other' students.

Inquiry-based science instruction uses an approach that encourages students to be active, questioning, and critical in their learning. Anderson (2002) stated, “Inquiry has a decades-long and persistent history as the central word used to characterize good science teaching and learning” (p. 1). It stands to reason that if inquiry-based science teaching and culturally responsive teaching are student-centric and considered best practices, the two will complement each other. As revealed in a meta synthesis of culturally responsive teaching and inquiry-based science education, there is some degree of overlap between these two practices (J. C. Brown, 2017). J. C. Brown (2017) found that overall, there was a complementary relationship between these two phenomena but discovered specific areas (e.g., using mathematics and computational thinking) that were infrequently utilized when facilitating culturally responsive science instruction. J. C. Brown (2017) used the CRIOP (Powell et al., 2012) framework in data analysis to identify culturally responsive elements, requiring that at least two CRIOP pillars be identified to qualify as CRST. Findings from this study indicated that teachers are knowledgeable about inquiry-based teaching but need more guidance on enacting CRST. Additionally, this study revealed that not all areas of science and engineering practices should be implemented in conjunction with CRST. For instance, scientific argumentation is not congruent with CRST in the sense that it may undermine dialogue across cultural groups (Gallard Martínez, 2011).

Examples of CRST

Valuing students’ ideas and perspectives and what they bring to class builds bridges between the students, home life, and school life (Barton & Tan, 2009; González et al., 1995; Moll et al., 1992; Windschitl et al., 2018). However, crossing these ‘bridges’ for students can be intimidating. Science as a domain can be considered a subculture in which students must crossover between their personal lives into school science through a cultural border crossing

(Aikenhead, 1996; Aikenhead & Jegede, 1999). Another similar approach that is based on FOK is the funds of identity approach which Esteban-Guitart and Moll (2014) explained as "historically accumulated, culturally developed, and socially distributed resources that are essential for people's self-definition, self-expression, and self-understanding" (p. 37). This intermingling of culture and identity provides further evidence for the necessity of CRST in student learning.

Another way to value students and their ideas is to encourage forms of expression that are empowering and culturally situated. For example, hip-hop science education allows students to have a voice, thereby connecting science to their lived realities (Adjapong & Emdin, 2015; Emdin et al., 2021). Adjapong and Emdin (2015) used pedagogical approaches based on Hip-Hop culture to support middle school students' science content acquisition, thereby connecting science to students' lives. In their focus on STEM education, Emdin et al. (2021) used *Reality Pedagogy* as an intervention for cultural agnosia, thereby empowering hip-hop youth to have a voice and connect to science learning. Both studies used localized contextual influences (Gay, 2015) and culturally rich instructional approaches to engage students who have otherwise been oppressed or excluded by traditional education approaches.

Culturally responsive materials can also have a positive impact on students' engagement which was shown with the use of a book of science essays by Puerto Rican scientists that contextualized science and provided cultural relevance (González-Espada et al., 2015). In this study, González-Espada et al. (2015) developed activities to accompany the book of science essays, titled *¡Ciencia Boricua! Ensayos y anécdotas del científico puertorro* (Puerto Rican Science! Essays and anecdotes of the Puerto Rican scientist) along with inviting scientists to be guest speakers. The combination of factors utilized in this study was found to increase Puerto

Rican students' positive perceptions of science. The generalization to all Puerto Rican schools from this study may be limited as it was conducted with students attending a Montessori school that may have had a positive perception of science, to begin with.

More recently, a framework by the name of *Ambitious Science Teaching* outlines and describes four sets of teaching practices: planning for engagement with big ideas, eliciting student thinking, supporting changes in student thinking, and pulling together evidence-based explanations (Windschitl et al., 2018). These teaching practices rely heavily on discourse with and among students but also make science instructions and learning more accessible to students from all backgrounds. Building on the Ambitious Science Teaching, Thompson et al. (2021) used a framework known as the Critical and Cultural Approaches to Ambitious Science (C2AST) that provided teachers and researchers with practical application for the science classroom. This work was founded on the following four principles:

1. Recognizing own world and other's worlds and developing critical consciousness.
2. Learning about and prioritizing students' communities and culture.
3. Designing for each student's full participation in the culture of science.
4. Challenging the culture of science through social and restorative justice.

Ideally, these principles help guide teachers to "create learning environments that develop students' identities as learners, scientists, and publicly engaged citizens (Thompson et al., 2021, p. 64). Another way to garner students' voices is to reposition the authority and power from the teacher to the students (J. C. Brown & Crippen, 2017; Ladson-Billings, 1995b). This shifting in power is not an easy strategy for many traditional educators.

Pilot Study

The author of this dissertation did an initial study on culture in science education (Heisler, 2021, 2022). The focus was on teacher use of student culture or students' FOK (Barton & Tan, 2009; Moll et al., 1992) in international school science classrooms. Four current or former international teachers were interviewed about their experiences with student culture. Middle school (grades 6–8) science teachers were the target participants. Semi-structured interviews were used with a wealth of information about how these four teachers utilized student culture in their science classes. After several rounds of descriptive coding (Saldaña & Omasta, 2018) and gerund or action coding (Charmaz, 2014), three overarching themes were developed.

The themes were student-teacher relationships, teacher culture, and strategies that teachers used. For the relationship theme, teachers expressed great importance for connecting to their students and valuing students' affective domain as well as their FOK. The teacher culture theme included awareness of their own ethnicity and cultural experiences as well as an awareness of a Western science perspective. Language was also found within this theme as only one of the teachers was bilingual, and the monolingual teachers viewed language as a potential barrier. The teacher's international experiences were viewed as an asset as their exposure to many cultures had opened their world views. One teacher commented on having lived "two lives of science teaching," one before their overseas experience and one life after. This theme's final area of interest was the teachers' science background and specialty. They felt that introducing students' culture was easier in subjects they were well-versed in (e.g., environmental science). However, whether this was because of the teacher's pedagogical content knowledge (PCK) (Magnusson et al., 1999; Shulman, 1986) or whether the social aspect of certain science subjects may facilitate ease of including students' culture remains beyond the purview of this study.

The final theme that was constructed from this study was that of teachers' strategies used in the integration of student culture. The first group of strategies was how teachers elicit students' FOK. These strategies were categorized as purposive or were done in a more informal manner through conversation and casual discourse. This supports Barton and Tan's (2009) study of FOK, discourse, and hybrid spaces wherein "Discourse mediates engagement in science, including not only what one learns but how and why one comes to participate in science-related communities of practice" (p. 52). The next group of strategies found had to do with community connection and how teachers built local partnerships. The final teacher strategy was product communication and how teachers used open-ended projects to facilitate students utilizing their FOK and giving students choices on how to communicate their learning.

This pilot study showed the potential for studying international teachers and several examples of culturally responsive science teaching. The science teachers in this study displayed culturally responsive teaching techniques (e.g., designing culturally relevant curricula, demonstrating cultural caring; Gay, 2002). While focusing on teacher implementation of students' FOK, this study brought about other questions concerning how ISTs use culture in helping international students to negotiate third space in science classes.

Benefits of CRST

The demonstrated practices of international school science teachers underscore the importance of integrating students' cultural backgrounds into teaching strategies, which resonates with both the work of culturally responsive teaching (Gay, 2002) and culturally relevant pedagogy (Ladson-Billings, 1995a). This connection suggests that while these teaching strategies offer techniques such as incorporating students' FOK, they must also align with a more significant shift that emphasizes a student-centered approach, which is pedagogical sound.

"Good Teaching"

Ladson-Billings (1995a) described CRP, the predecessor to CRT, in her titled work *But That's Just Good Teaching! The Case for Culturally Relevant Pedagogy.* The good news is that many, if not all, aspects of CRT are synonymous with good teaching practices in science. For instance, in the practice of teaching different types of learning (cognitive, physical, emotional), CRT is holistic in its approach versus the outdated discrete method of conventional teaching (Gay, 2002). Constructivist teaching methods are related to culturally relevant teaching and place the student at the center of classroom priorities (Byrd, 2016; Patchen & Cox-Petersen, 2008). The shift from the teacher having all the power in the classroom and allowing students to direct and lead some of their learning leads to an environment of CRP. A tendency to perpetuate conventional teaching practices such as direct instruction still exists within science, and this requires a shift in the culture of teaching and teaching preparation (Patchen & Cox-Petersen, 2008).

For inquiry-based science instruction, a complementary relationship has been found with CRT in a meta synthesis study previously discussed (J. C. Brown, 2017). Project-based science is another area that can bolster CRT and promote underrepresented students in the pursuit of science careers (Kanter & Konstantopoulos, 2010). When CRP is practiced by teachers, they establish a culture of learning in their classrooms rather than one of evaluation (Powell et al., 2013). The question then becomes how we support this shift in mindset and culture of currently practicing teachers.

Frameworks such as the C2AST provide a series of principles that will first allow teachers to reflect on their critical consciousness and way of thinking about science teaching in regard to CRP (Thompson et al., 2021). These types of frameworks promote community

collaboration and justice-oriented solutions. Another consideration is that teachers who do not share similar cultural backgrounds or experiences may need additional resources to make relevant connections (Mensah, 2011). Other instruments such as CRP toolkits with responsive instructional strategies and relevant science topics are viewed by teachers as a primary avenue for CRP instruction (J. C. Brown & Crippen, 2017). Teachers and teacher educators alike can benefit from practical tools for implementing CRST.

Language Connection

There is no denying that culture, language, and learning are interconnected. The relationship between language and culture is closely intertwined as each has an influence on the other (Jiang, 2000). Language and culture are studied through sociolinguistics, educational linguistics, and linguistic anthropology (Chambers, 2007; Duranti, 2009; Kramsch, 2014). The number of students with language challenges is on the rise. The National Center for Education Statistics reports that as of 2018, the percentage of ELL students was 10.2%, or 5.0 million students (USDE, 2020). The intersection of CRST and language comes when teachers utilize strategies such as connecting lessons to students' lives and guiding language acquisition (Hansen, 2006). Elmes (2013) stated that the issue happens when foreign language learners are functioning outside their own culture and are challenged with the task of not only learning a different language but also the cultural intricacies that are beyond the written language. Science is a subject with heavy vocabulary and often has scientific literacy as one of its major goals. There is also the issue of whether the language in the science classroom is meant to be a way of communicating information or whether language is used to make sense of science information (Lemke, 2001; Sutton, 1996). It is important to note that learning in science class "occurs through the oral and experiential contexts" (Carlisle et al., 2000, p. 2008). There is a strong

relationship between culturally responsive teaching and the use of language and discourse within the classroom. This relationship is highly apparent in the use of CRT in science classrooms. Powell et al. (2013) stated that "students acquire language when they use it in genuine interaction with others; thus, culturally responsive teachers provide explicit guidance in using language for authentic purposes and audiences" (p. 24).

Testing mandates and other pedagogical issues have left ELL students as one group that has been traditionally unattended in science education (Jackson & Ash, 2012; Johnson et al., 2016). Another dimension of learning to work with Hispanic or LatinX students is that teachers must consider the linguistic abilities of their students (Hernandez et al., 2013). Teachers must consider that many students in science classrooms are bilingual, multilingual, or ELLs. When teachers acknowledge or use other languages besides English, students who speak other languages can have their cultural identities affirmed (Dickson et al., 2016). Affirming cultural identity through language is one area for improvement, as encouraging students to use their native language has been found to be one of the lower item indicators of preservice teachers' self-efficacy and outcome expectancy beliefs in culturally responsive teaching (Siwatu, 2007).

The process of shifting or alternating between two languages is referred to as code-switching (Morrison, 2023). In multilingual classrooms, teachers use code-switching to bridge comprehension gaps and note salient information and instructions, which in turn facilitates science learning (Then & Ting, 2011). Allowing students to code-switch during science class has been shown to allow for the articulation of ideas, clarification of concepts, and formulation of new ideas (Rollnick & Rutherford, 1996). Furthermore, code-switching allows for exploratory talk and discourse-specific talk in math and science classes (Setati et al., 2002). Another linguistic practice that involves using multiple languages is called translanguaging. It allows

students to use multiple languages to create new meanings, thereby allowing multilingual students to use their linguistic resources in science learning in a culturally relevant manner (Karlsson et al., 2019; Suárez, 2020).

Connection to Community or Place

Another critical aspect of CRT in the science classroom is the connection to community or place for teachers to understand students' cultures and backgrounds fully. Community building is one of the strategies for preparing teachers on how to teach progressively and enact CRT (J. C. Brown & Crippen, 2017; Gruenewald & Smith, 2014; Smith, 2002). When teachers can connect science content to the local community, this connection can have a profound impact. Such was the case in an investigation that used virtual reality with fourth and fifth-grade students to teach in a culturally relevant manner (B. A. Brown et al., 2021). When students saw how the specific science subject mattered to their community, they were able to make connections "between the science, their community, and the large socio-political issues that frame these science issues" (B. A. Brown et al., 2021, p. 23). This connection can be made at all levels of education.

At the tertiary level, community connection can serve to disrupt privilege and power dynamics that exist within science education spaces (Ridgeway, 2019). The age of the child is not the only determining factor for community connection in CRT; it can also be addressed geographically. With regard to urban education, science education can and must take on a role in empowering youth through their communities (Emdin et al., 2021). Community connection is important for rural communities as well (Borgerding, 2017; Kier & Blanchard, 2021; Leonard et al., 2018). Whether elementary grades or higher, whether urban or rural, the point is that

community culture is an important influence for all students and a valuable aspect of CPR (Kier & Blanchard, 2021).

Social Justice

Culturally responsive science education can serve to empower students and allow them to think about the world critically and navigate it with finesse. Gay (2002) said, "Personal, moral, social, political, cultural, and academic knowledge and skills are taught simultaneously. For example, students are taught their cultural heritages and positive ethnic identity development along with math, science, reading, critical thinking, and social activism" (p. 110). As discussed in the last section, connecting to the local community in CRT can lead to an awareness of sociopolitical issues that can be addressed in science education (Tan et al., 2021). The relationship between teaching science through social justice and teaching science through CRT is highly interwoven. CRST can be instituted into teacher education programs through social justice action and awareness of social justice issues (B. A. Brown et al., 2019; Hancock et al., 2017). Many of the same premises for teaching science with social justice apply to CRT, such as connecting science to students' lives, integrating native language, and investing in the local community (Finkel, 2018; Mackenzie, 2020; Ridgeway, 2019; Rodriguez & Morrison, 2019). One could argue that teaching for social justice is CRST and vice versa.

One of the areas that social justice teaching and CRST are highly related to is environmental education. For instance, environmental injustices such as dumping industrial waste or limited access to clean water have been shown to occur in communities of marginalized persons and those in poverty (Borunda, 2021). Much of this has been allowed to happen because members of these communities do not have the power or voice to challenge these injustices. Furthermore, science curriculums have been hijacked by industries and corporations to push their

agendas and to maintain corporate power. Eaton and Day (2020) found that fossil fuel corporations were pushing *petro-pedagogy* that deterred students and teachers from questioning or challenging the role of the fossil fuel industry in the climate crisis. Climate injustices, such as climate change, occur when inequality exists regarding environmental effects on human beings (Borunda, 2021). For instance, Althor et al.'s (2016) research points to a global mismatch between countries that emit greenhouse gases and those that bear the burdens of climate change. Another inequity is that of the climate injustices experienced by indigenous people worldwide as they face heightened climate change impacts (Whyte, 2016).

CRST can link science education to the inequities that are occurring within our society and do so on a global scale. While the importance of CRST in battling climate injustices is beyond the purview of this paper, there is a tremendous amount of potential and success with this strategy. As seen in *Ambitious Science Teaching* and the C2AST approaches, science teaching can use social and restorative justice to challenge the culture of science and societal norms (Thompson et al., 2021; Windschitl et al., 2018). However, Ridgeway (2019) rightly pointed out that more studies are needed that explicitly state ways to leverage diversity and equity towards social justice goals.

For the social justice aspect of CRST to happen, teachers must first realize that they cannot remain neutral in providing the best education for their students. Indeed, educators have the duty of not being neutral (Horton & Freire, 1990). However, science teachers and science education researchers must be cognizant of thinking that more science is not the stand-alone solution, or else we risk assimilation and the very problems that created these inequities in the first place (Dawson, 2017). All members of the science learning and teaching community must figure out how to best practice relational and redistributive justice (Dawson, 2017).

Conclusion

In summary, this literature review has shown CRT as a credible framework for science education and science education research. While Gay's (2002) original concept has evolved and continues to be adapted for specific use in subjects such as science, a need still exists to explore the growth of this phenomenon in its many forms and many contexts (J. C. Brown & Crippen, 2017). This literature review has shown CRT in science education through three primary paths. These three paths were international schools and relevant players, CRT history and development, and finally, CRT in science education or CRST.

International schools were introduced as a potential resource for culturally responsive teaching to diverse student populations. Dolby and Rahman (2008) summed this up best by stating, "In a world of educational research that is dominated by conversations about the split between theory and practice, research on international schools provides a model of engaged practitioner research" (p. 693). To further contextualize the social justice rationale for pursuing this study within international schools is the idea that while these students and teachers in international schools are uniquely situated to understanding highly diverse student populations, they may not face some of the same problems that plague schools from a socioeconomic point. However, the financial state of these schools and their clientele does not make them immune to other social justice issues based on racism and sexism. International schools are also situated to understand social justice issues from a global perspective. Furthermore, these international schools are highly diverse settings that may serve as research sites for understanding the limits of teachers attending to cultural and linguistic needs of students in the science classroom.

Many scholars have addressed the challenges of implementing culturally relevant or responsive learning experiences within the science classroom (Atwater et al., 2010; J. C. Brown,

2017; J. C. Brown & Crippen, 2017; Hernandez et al., 2013; Underwood & Mensah, 2018). However, potential gaps in literature exist, such as implementation strategies for highly diverse communities with international schoolteachers that practice CRST being virtually untapped in the research community. Another gap that exists is how CRSTs at international schools connect science learning to the local community or global social justice issues. Other potential areas of research include how science teachers plan for CRT and then subsequently reflect on those experiences for improvement. Two other gaps found that exist from doing this literature review are using ISTs as a sample for this study and the methodology of using the CRIOP (Powell & Cantrell, 2021) to establish an analytical framework.

Calls for further research on CRT in science education are abundant (Atwater et al., 2010; B. A. Brown et al., 2019; J. C. Brown & Crippen, 2016; Codrington, 2014; Hernandez et al., 2013) with the founder of CRT stating, “The body of validating research and practice is not as extensive and comprehensive as it need to be” (Gay, 2015, p. 136). Further research is needed as science teacher educators are aware of the need for pedagogical and ideological changes but are inconsistent with the understanding and implementation of CRP (Underwood & Mensah, 2018). Additionally, this literature review points out the need for studying highly diverse populations in a somewhat neutral or third space as much of the research concerning CRST deals with marginalized populations within the United States (Codrington, 2014; Hernandez et al., 2013). While this research and advocacy for these marginalized groups is needed it would also benefit an increasingly diverse population of students both within the United States and internationally. A growing phenomenon to contend with is that many of the students in the future will have to contend with biracial and multiracial identity development (Renn, 2008), which provides yet another point for researching CRT within international schools.

CHAPTER III

METHODOLOGY

Science was traditionally thought of as a domain focused on facts to understand how the world works. However, the teaching and learning of science also include culture and other sociological factors within social constructivism (A. C. Barton & Yang, 2000; Cobern & Aikenhead, 1998). Students come from a variety of backgrounds and are equipped with a diverse set of life experiences often referred to as funds of knowledge (González et al., 2006; Moll et al., 1992). Effective science classrooms are student-centered and have teachers who engage pupils on a multitude of levels (Hammond, 2014; Mensah, 2021; Windschitl et al., 2018).

At the foundation of students' knowledge is culture. Some ways to include culture in science classrooms is through culturally relevant pedagogy and culturally responsive teaching (J. C. Brown & Crippen, 2017; Dodo Seriki, 2018; Patchen & Cox-Peterson, 2008). This study used a qualitative case study approach to ascertain science teachers' experiences with culturally responsive teaching (CRT) in an international school setting. International school settings afford the opportunity to study teacher practices with highly diverse students from all over the world.

In order to study the phenomena of international science teachers' (ISTs) cultural approaches to teaching diverse student populations, the following research questions guided this study:

1. How do international school science teachers (ISSTs) deliberate and plan for teaching culturally diverse student populations?
2. How do ISSTs teach in culturally responsive ways?
3. How do ISSTs reflect upon their culturally responsive teaching in science classrooms?

Research Design

This study followed an interpretive multiple case study design. Qualitative research has been used extensively in science education research even though it was not the traditional approach (Taylor, 2014). Interpretivism is the philosophical belief that reality and knowledge are socially constructed by humans; this idea has been used extensively in social science research to better understand the contemporary social world (Chowdhury, 2014). Interpretive research depends heavily on the observer defining and construing meaning from what they perceive (Stake, 2010).

The interpretivist qualitative approach is well suited to studies on teaching (Erickson, 1985; Thanh & Thanh, 2015). The interpretive approach allows for understanding the world while taking the cultural interpretation of teachers into consideration (Bhattacharya, 2017), making it the ideal method for this study. This study aims to understand the thoughts, behavior and experiences of culturally responsive science educators in an international setting. The research questions are structured with the cognitive processes of planning, teaching, and reflecting in order to take a holistic approach to studying the teachers and their environment (Hall & Smith, 2006). Within an interpretivist lens, the qualitative case study approach will allow for a deep exploration of teachers' authentic experiences with CRT in the science classroom.

An interpretive multiple case study method that is descriptive in nature was used in this study. The case or "single unit," as Merriam (1998) described it; is the culturally responsive science teacher in international schools, which is the bounded system under study. Using multiple cases will allow for in-depth exploration and provide a strategy for external validity (Merriam, 1998; Yin, 2009). According to Gustafsson (2017), multiple case studies versus single

case studies allow for "a wider discovering of theoretical evolution and research questions" (p. 9). Case studies have been used to study CRT in science education (e.g., Atwater et al., 2010; J. C. Brown & Livstrom, 2020; Kier & Johnson, 2021; Patchen & Cox-Peterson, 2008).

Participants and Sampling

Participants were selected through purposive sampling. Purposive sampling is a type of nonprobability sampling as it does not aim to generalize but rather chooses cases that are rich with information (Etikan et al., 2016). Participants are purposefully selected rather than randomly and situated in a context so they can best reveal the phenomenon being studied (Creswell, 2014). In an effort to recruit teachers, random purposive sampling was used with snowball sampling methods (Goodman, 1961) to better cast a net throughout the international school community.

Due to the restrictions of the Institutional Review Board (IRB) on research in other countries, it was only feasible to contact and use international schools located within the United States and surrounding territories. The screening criteria for international schools were that they identified as international schools, used a curriculum with international recognition (e.g., International Baccalaureate), and had a multinational/multilingual student population. International schools were identified through the https://www.internationalschoolsearch.com/ website. A total of seven international schools that fit within the parameters were contacted, with four responses and three participants from three different schools responding for participation in the study. The international schools in this study are located within the continental U.S. and vary in size from 600 to over 1,700 students.

All three schools in the study use the IB diploma program with one of the schools also utilizing the Middle Years Programme (MYP). The IB Diploma Programme (DP) is an assessed

program with six subject groups (one of which is the Sciences) and three required components for students ages 16 through 19 (www.ibo.org). The three required components are a Theory of Knowledge (TOK) class, a number of Creativity, Activity, Service (CAS) hours, and a 4,000-word Extended Essay (EE) on a topic of their choice. Preceding the IB curriculum is the MYP, which is an educational program for students 11 to 16 years of age. The MYP program consists of eight subject groups, an interdisciplinary unit that involves two subject groups, and students are required to complete a long-term project (www.ibo.org). The MYP assessments are school based except for the final year of the program when there is an external assessment in the form of a personal project. Further information on each school and their specific curriculum use is available within the teacher participants' case studies in Chapter 4.

In qualitative research, sampling is the selection of specific data sources with the intent of collecting data to fulfill research objectives (Gentles et al., 2015). Since this study aimed to explore culturally responsive science teaching, science teachers from international schools were sampled based on whether they considered themselves culturally responsive practitioners. Besides the verbal confirmation of this practice, teachers were also given the Culturally Responsive Teaching Self-Efficacy (CRTSE) and the Culturally Responsive Teaching Outcome Expectancy (CRTOE) surveys developed by Siwatu (2007). Graciously, Dr. Kamau Oginga Siwatu has granted permission for the use of these surveys.

These surveys were distributed in the recruiting process and used to confirm teachers' views of themselves as culturally responsive educators. These validated instruments target teacher self-efficacy and teaching outcome expectancy of preservice teachers' culturally responsive teaching. Both scales are comprised of Likert-type items in which ISTs will rate themselves on a sliding scale from 0 to 100. The CRTSE consists of 41 statements wherein

respondents rate their abilities for culturally responsive teaching from 0 (no confidence at all) to 100 (completely confident). Meanwhile, the CRTOE has 26 statements that ISTs will rate the outcome of culturally responsive teaching practices from 0 (entirely uncertain) to 100 (entirely certain). The responses on both scales are summed to produce a total score. These total scores were used to confirm that those teachers believe in the positive outcomes of culturally responsive teaching and who consider themselves to be culturally responsive educators. While not solely designed for science education, the CRTSE does have an item that explicitly addresses science education and cultural contributions to science (Item #17—Teach students about their cultures' contributions to science; Siwatu, 2007, p. 1093). Additionally, both instruments have been cited or directly used in a substantial amount of research explicitly targeting science education. The Siwatu (2007) article has 617 citations in Google Scholar, and upon a refined search using the term 'science education,' 464 citations of those 617 citations were found to involve science education. The purpose of using these surveys is to identify teachers who are efficacious in their approach to utilizing culture in science learning.

In the interest of equity and inclusion, the researcher endeavored to represent a variety of people from different ethnic, racial, linguistic, and gender groups. The possibility of contending with new teachers to the profession is not a factor, as most international schools require at least two years of teaching experience. The target sample included those teachers in secondary level education, which is usually from grade six to grade 12. The reason for this is that the aim is to find out how science teachers implement CRT practices in their classrooms, and secondary grade teachers usually specialize in subjects such as science. The following is a list of criteria that was used as a guide for inclusion in the study:

- Science teachers at international schools (Hayden & Thompson, 1995)

- Secondary level (Grades 6–12) teachers (Lannegrand-Willems & Bosma, 2006; Verhoeven et al., 2019)
- High scores on CRTSE and CRTOE scales (Siwatu, 2007)
- High correlational relationship between the CRSTE and CROTE scales (Siwatu, 2007)
- A variety of teachers based on teaching experience, science-specific subjects (i.e., physics, biology), ethnicity, race, linguistic abilities, and gender

After the IRB approval for this study was granted, the three teachers who indicated interest were asked to participate. All three signed the consent form and completed the aforementioned surveys. The participants all worked at international schools located throughout the United States. As seen in Table 1, all three participants have advanced degrees and over 15 years of teaching experience. Pseudonyms were assigned to the participants in order to safeguard their privacy and anonymity.

Table 1

Demographic Information of Participants

Pseudonym	Nationality	Years of teaching experience	Degree	Courses currently teaching
Helen	USA	25	B.S. Biology M.A. Education	Grade 9 Science Grade 10 Science
Irene	French	22	*Bac +3/4 Biochemistry M.A. Counseling	Biotechnology
Isabella	USA	19	B.S. Natural Science M.Ed. Educational Leadership	Grade 6 Science Grade 7 Science

*Bac +3/4 French equivalent to a bachelor's degree

Data Collection

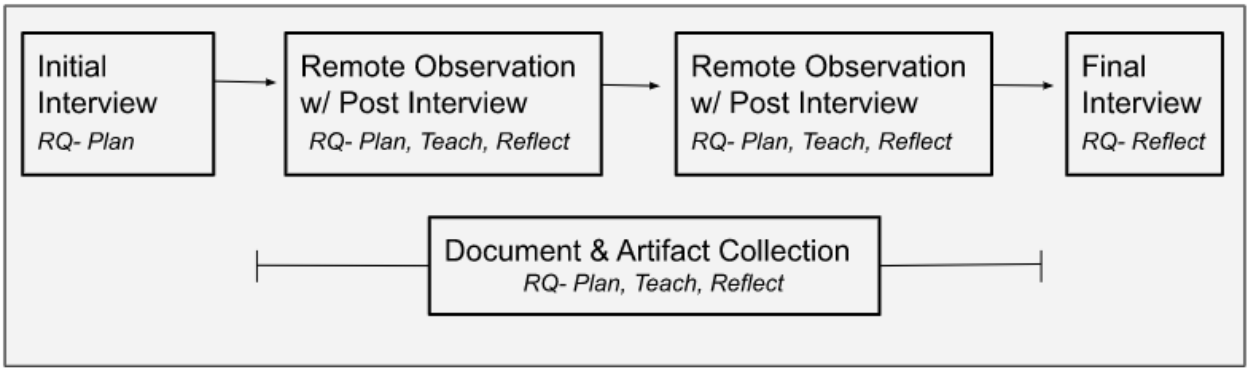
The procedure was meticulously planned for the data collection phase to ensure valid results and adhere to ethical guidelines. Detailed steps for the procedure are outlined in the following section, ensuring transparency and replicability for future studies.

Procedure

Data collection is centered around a cycle of instruction that includes planning, teaching, and reflection (Zembal-Saul et al., 2002). Figure 1 provides an overview and flow of participant phases with addressed research questions.

Figure 1

Participant Phases



After recruitment and when the necessary consent forms were signed, the initial interviews were scheduled. Document and artifact collection was identified during the initial interview, throughout observations, and was gathered throughout the research process until the final interview. A form was created to share and keep track of resources, but then follow-up or clarification questions were asked throughout the other phases of the project. Observations were scheduled and coordinated via email communication in order to coordinate technology and such

details for the observation. Post-observation interviews or debriefs were conducted as soon as possible after the observations occurred. The last and final phase of this data collection was the final interview with an emphasis on teacher reflection on culturally responsive teaching. An overview of the data collection and corresponding analysis can be seen in Appendix A—Data Collection/Analysis Matrix.

Data Collection Instruments

One of the key components of qualitative research is figuring out which data is to be collected and how to collect said data in order to best answer the research questions. For this study, the best-suited instruments were interviews, observations, and document analysis. It is essential to point out that the researcher plays a key role in qualitative research and cannot separate themselves from being an instrument in data collection. Hatch (2002) stated that "researchers are a part of the world they study: the knower and the known are taken to be inseparable" (p. 10).

Interviews

Interviews allowed the researcher to ask participants directly about their experiences (Saldaña & Omasta, 2018) and were used at different phases of this study. Interviews lasted from 14 minutes (post-observation interview) to one hour and 8 minutes (initial interview). The interviews were semi-structured for the most part, with clarification on the magnitude of structure in the description of each interview below. Semi-structured interviews are a verbal interchange where the interviewer prepares a list of predetermined questions, but the conversation is informal in a manner, thereby eliciting interviewees to explore issues they feel are important (Longhurst, 2003).

At the beginning of the initial interviews, the following definition of culturally responsive teaching was introduced in order to clarify the topic matter: Culturally Responsive Teaching: a pedagogy that uses students' customs, characteristics experiences, and perspectives as tools for classroom instruction (Appendix B). When discussing the term *culturally responsive teaching*, the interviewer took steps to be clear about the meaning of CRT and, just as Gay (2013) did, attempted to "shift between using the term itself and its equivalent meanings" (p. 52). The use of these equivalent terms (i.e., values, attitudes, customs, traditions, experiences, and perspectives) promoted conversation and understanding while minimizing encoding vocabulary that may be difficult for interviewees to understand.

Due to the varied locations of participants, an online video conferencing tool was used for most of the interviews, apart from one in-person interview after an observation. Online video conferencing allows for interviews to happen in real-time and was a viable option for this qualitative research (Nehls et al., 2015). The interviews were video and audio recorded with transcription being done with otter.Ai.

The first type of interview was an initial interview. A full list of interview questions can be found in Appendix B—Initial Interview Questions. In the interest of time, participants were asked to fill out a Demographic Information Form (Appendix C) beforehand, which helped to alleviate time constraints during the initial interview. The purpose of this interview was to establish a rapport with the participants and to set the foundation for research. The initial interview primarily served to answer research questions one and two, with the overriding questions aiming to look at planning and teaching. For instance, one interview question that addressed the first research question was, "How do you plan to work with students from diverse cultural backgrounds?" Another example that helped answer the second research question, which

focuses on teaching in culturally responsive ways, is “Do you connect science content to your students’ lives? If so, in what ways?” A document titled Mapping of Initial Interview (Appendix D) shows how interview questions connect to research questions and frameworks. Other examples of interview questions are as follows

- Do you address linguistic diversity in your classroom? If so, in what ways?
- What role do you think social justice (e.g., civil rights, social inequities, environmental justice) plays in the science classroom?

Participants were sent questions ahead of time to aid in participants feeling comfortable with the interview process (Rubin & Rubin, 2012).

Post-observation interviews were conducted following each remote observation and were aimed at answering the second research question of how teachers actually teach in culturally responsive ways. The intent of these interviews was to reflect on the remote observation and to clarify questions or occurrences that happened during the lesson. The interviews lasted approximately 30 minutes. The format for these interviews was somewhat responsive in nature, as the goal was to ascertain the teacher’s experience and interpretation of a culturally responsive lesson. However, there are a list of primary and secondary questions found in Appendix H that kept the focus on culturally responsive teaching. Examples of primary guiding questions used were:

- How do you think the lesson went overall? What went well? What could have been better?
- To what degree do you feel the lesson was culturally responsive?
- What obstacles/successes did you encounter in engaging students in a culturally responsive way?

Examples of secondary guiding questions are in a table in Appendix H that are linked directly to CRIOP categories to ascertain culturally responsive moments that may have occurred during the observation. This type of interviewing requires flexibility and may require the interviewer to change questions depending on the response from the interviewee (Rubin & Rubin, 2012).

The post-observation interviews consisted of broad primary questions that asked teachers to share key moments from the lesson. Teachers were prompted to share information on specific occurrences that the researcher observed during the lesson. An example prompt was "I noticed that you chose to draw a diagram for a particular group of students. Can you say a little more about what you were thinking there?" or "I noticed that you were talking with a group of students in French at one point, can you tell me more about that interaction and your rational for using French?" Some prompts targeted more specific moments related to the CRIOP pillars (e.g., Science Culture, Classroom Relationships, etc.) and how those occurrences played out in the classroom. The researcher also used the post-observation interviews to clarify any questions that arose during the observation.

The third type of interview was an end-of-study interview conducted with participants at the conclusion of their participation. The primary purpose of this interview was to have teachers reflect on their CRT as a whole, which is the third research question, and to answer any outstanding questions that the researcher or participant still had. Moreover, the final interview served to member check by the researcher sharing any broad assertions at this time with the potential for further evidence being shared for member checking after the interview. The format of this interview was primarily responsive in structure, with main questions, follow-up questions, and probes to keep the discussion on the topic (Rubin & Rubin, 2012).

The goal of the final interviews was two-fold. As previously stated, the primary purpose of this interview was to have ISTs reflect on their CRT over the past semester. However, the interview also served as a follow-up with participants to fill in missing pieces or clarify previous statements, generalizations, and contradictions (Rubin & Rubin, 2012). It was necessary to prepare in advance by identifying areas that needed clarification and further in depth of understanding. For example, one participant was asked to elaborate on what an "affinity group" meant at her school. Another example clarification was about the meaning of a statement that a teacher said to her students during the observation ("Don't yuck someone else's yum"). After general reflection questions were put forth to encourage conversation, more in-depth and specific questions were asked depending on the identified areas. The structure for the final interview can be found in Appendix E—Final Interview, which has the three main guiding questions along with a table to identify areas for specific follow-up.

While attempting to extrapolate the teacher's experiences, it is also essential to acknowledge the role of a researcher and co-constructor of knowledge (Ahern, 1999). After each interview, the researcher took thorough notes to debrief, and this served as a bracketing measure to acknowledge the role as an instrument in the process, make a note of personal interpretations, and record any thoughts or insights made during and after each interview (Ahern, 1999; Saldaña & Omasta, 2018). These memos and other bracketing measures will be more thoroughly addressed in the data analysis section.

Documents and Artifacts

After interviews and observations, participants were asked to share relevant documents and artifacts that may pertain to CRT in science. The purpose of collecting documents is that document collection and subsequent analysis can be considered a data source in qualitative

research (Bowen, 2009; Creswell, 2014). Documents consisted of texts and images; artifacts, on the other hand, cast a broader net and included more subtle or elusive objects that can symbolically represent the narrative of one or a group of people (Pahl, 2004). Therefore, the documents and artifacts in this study were relevant to the participants and the meaning that they attached to said objects. Participants shared handouts from the class that they thought represented culturally responsive projects that were conducted in their classes. One participant shared a food insecurity video project that the students completed, and another participant shared the students' climate change worksheet packet. Another participant shared artifacts from her classroom that were cut outs of hands with drawings and culturally relevant depictions from her students. The participants selected which documents and artifacts to share. Student work was de-identified before the participant shared the work. Artifact and document collection was documented for each participant through the Artifact and Document Sharing document found in Appendix F.

The researcher collected specific documents and artifacts that were relevant to culturally responsive teaching. The collection of materials included typical documentation such as lesson plans, curriculum materials, and worksheets. Observing and recording artifacts from within the physical environment can help qualitative researchers learn more about the participants (Saldaña & Omasta, 2018). The researcher also collected information on school mission statements, school descriptions, and demographic information to help place the international school into context.

Observation

The purpose of observations was to triangulate data and to study culturally responsive teaching in action. The researcher was merely there as an observer and not a participant. Most but not all of the data collected during observations served to answer the second research

question, which focuses on the teaching aspect of CRT. For the most part, observations were done remotely; however, one was done in person.

During the observations, the researcher recorded all remote observations with a voice memo and used otter.Ai transcription when possible. Each observation followed a general observation protocol that involved documenting the demographic information (e.g., time, place), description of the physical setting, descriptive notes that described the lesson, and accounts of particular events or discussions (Creswell, 2009). The researcher took extensive field notes throughout the study but especially during the observations in order to provide rich context (Phillippi & Lauderdale, 2018).

Remote or online observations required the organizing of many logistical issues, which mostly pertained to the technological hurdles that needed to be overcome but were viable tools for this research (Nehls et al., 2015). Appendix G is an example of the scheduling table that was sent to participants after the initial interview to set up the observation. For choosing a lesson to be observed, ISTs were instructed to consider lessons that would have culturally responsive elements or that they consider containing culturally responsive teaching as a whole. However, it was explicitly stated that teachers were not to prepare a special lesson for this observation in order to not disturb the teaching and learning cycle. One teacher was able to do two remote observations, and the other two teachers completed one observation, one of which was an in-person observation.

All school protocols were followed, and student identities were protected. Students and their parents were informed about the research, but since this study was focused on the teacher and did not manipulate the classroom environment, no waivers or permission slips were obtained

from students. However, if students did not want to be present during the observation, they were allowed to opt-out. No students took this option and were present during the observations.

Data Analysis

In qualitative research, data analysis is a highly inductive and deductive process that involves approaching the data with an open mindset (Merriam, 1998; Saldaña & Omasta, 2018). However, the ideal qualitative data analysis is, in the end, inductive and moves from specifics to general analytical conclusions (Lincoln & Guba, 1985). In order to ensure a level of rigor in qualitative research, this study used a structured coding system with three phases of analysis. As can be seen in Table 2, the three phases of data analysis are (a) in vivo coding, (b), descriptive coding, and (c) framework coding.

Table 2

Data Analysis Phases

DESCRIPTION	INDUCTIVE/DEDUCTIVE	
In Vivo Coding- highlighting or bolding salient words or phrases (Saldaña & Omasta, 2018)	Primarily Inductive "informant-centric" (Linneberg & Korsgaard, 2019)	Analytic Memos
Descriptive Coding	Both deductive and inductive (Azungah, 2018)	
Framework Coding- CRIOP	Primarily Deductive "researcher-centric" (Linneberg & Korsgaard, 2019)	

During the in vivo portion of the coding process, highlighting and bolding key terms or phrases (Saldaña & Omasta, 2018) was used to inductively explore the data and to decipher meaning. *In vivo* coding directly uses the words and phrases of the participant. At this stage, the

analysis draws on researcher knowledge but is *informant-centric* (Linneberg & Korsgaard, 2019). Using both inductive and deductive approaches (Azungah, 2018), descriptive coding was used in this data analysis to condense the data into main points and topics. All three phases of the data analysis were iterative in nature and did not necessarily follow one after the other. Additionally, as can be seen in Table 2, analytic memos were used, and they are posted on the side of the table to show that they were used throughout the data analysis process.

The framework coding part of the analysis was based on elements from the *Culturally Responsive Instruction Observation Protocol* or CRIOP (Powell & Cantrell, 2021), whose authors graciously gave permission for its use. The CRIOP protocol is a validated instrument and has been used for science education research (Barron et al., 2021; J. C. Brown, 2017; Upadhyay et al., 2021). The codebook in Table 3 was created using the CRIOP pillars and indicators and was a basis for this *researcher-centric* deductive coding (Linneberg & Korsgaard, 2019). In other words, this means that the framework helped to organize the data into categories of culturally responsive science teaching and assisted in identifying patterns among the data. The "pillars" of the CRIOP can be considered categories of culturally responsive teaching that were used in this phase of data analysis.

Table 3

Codebook

Code	Pillars	Definitions based on CRIOP (Powell & Cantrell, 2021)
CR	Classroom Relationships	The teacher demonstrates an ethic of caring for all students, communicates high expectations for all students, creates a classroom environment that promotes respect, and encourages students to work collaboratively.
FC	Family Collaboration	The teacher takes time to learn about and prioritize students' families, communities, and cultures. The teacher encourages parent/family involvement in science learning and reaches out to establish genuine partnerships with parents/caregivers. The teacher intentionally learns about families' linguistic/cultural knowledge and expertise to support student learning.
AP	Assessment Practices	The teacher designs assessments to make space for expansive science sense-making and opportunities for student self-assessment of science learning. The teacher makes sure that students can demonstrate learning in a variety of ways and that authentic assessments are used to determine competence in academic language and science content.
IP	Instructional Practices	The teacher contextualizes instruction in students' lives, experiences, and individual abilities. The teacher uses instructional techniques that scaffold student learning while developing students' science literacy and academic language. The teacher creates opportunities for students to have ownership in their learning through choices that are based on their interests and engage them through inquiry-based learning.
D	Discourse	The teacher promotes student engagement through discourse practices that affirm cultural and linguistic identities. The teacher provides opportunities to develop linguistic competence and promotes culturally responsive conversation about science matters.
CC	Critical Consciousness/ Social Justice	The teacher provides opportunities for the inclusion of issues important to the classroom and community at large while allowing for the expression of diverse perspectives. The teacher recognizes and revisits their positionality and biases through self-reflection to further develop and maintain critical consciousness. The teacher creates emotionally and intellectually safe spaces for students to question social injustices in science and science classrooms.

Those pillars consist of classroom relationships, family collaboration, assessment practices, instructional practices, discourse, and critical consciousness. Social justice is not one of the CRIOP pillars but was blended with the critical consciousness pillar in order to include the valuable data that came from discussing this topic area and has a warranted position in science

education (Thompson et al., 2021). The codebook was used to analyze all three data points (i.e., interviews, observations, documents, and artifacts). The precise use of the codebook with each data point is described in the specific sections in the instrument analysis section below.

Data Analysis Tools

In order to provide a comprehensive analysis of the qualitative data and to provide an effective analytic framework three types of coding were utilized. In vivo coding captured the participants exact words which ensured that participants voices and perspectives were prioritized (Saldaña & Omasta, 2018). Descriptive coding allowed for the categorization of data based concepts related to culturally responsive science teaching in relation to the research questions. The final part of the analytical framework was framework coding which allowed for a structured approach that compared data across cases and through the lens of the CRIOP framework. This multifaceted approach enriched the data analysis and enhanced the rigor and validity of the findings.

Interviews

Three different types of interviews were used with each participant at various times throughout this research study. They were the initial interview, the post-observation interview, and the final interview. The initial interview was primarily used to answer the first research question about IST planning for CRT in science. The post-observation interviews were used primarily to answer the second research question about ISTs' actual culturally responsive teaching. Finally, the third research question about IST reflection was mostly answered during the final interview.

Otter.ai (https://otter.ai/), an artificial intelligence (AI) voice recognition technology, was used to transcribe all the audio recordings. This type of technology has been used to enhance

qualitative research (Gray et al., 2020). Afterward, the transcriptions were checked for accuracy and cleaned up for suitable presentation. Following the transcription process, the interviews were sent to participants to check for accuracy as one form of member checking (Lincoln & Guba, 1985). The software NVivo was used during data analysis to organize and visualize data. Transcribed interviews were imported into NVivo and then coded and annotated by the researcher. Memos were utilized to identify patterns and insights throughout data analysis. Interviews were used to answer all three research questions depending on the type of interview and whether it addressed the research question.

In the first phase of coding interviews, in vivo coding was used wherein salient or important words or phrases within the participant text were highlighted or bolded. This helped the researcher to organize the data and its relevance to the research questions while using the exact words of the participants. For instance, when referring to planning for assessments, one teacher said, “We’ve been really big into differentiation and giving students choice.” Differentiation and student choice were highlighted as pertinent text. During the in vivo coding, every attempt to stay open-minded and let the data speak for itself was made, as this is an informant-centric part of the process (Linneberg & Korsgaard, 2019). After in vivo coding, descriptive coding was used, which involves summarizing the main topics of a passage into a word or short phrase (Saldaña & Omasta, 2018). Using the previous example from in vivo coding, the phrase ‘Student choice in assessment’ was assigned to this piece of data. Recurring or highly relevant text was assigned new “nodes” or codes in NVivo. Once again, this process was used to organize the data but also started identifying themes related to CRT. In another part of the analysis, the interviews were coded using the analytical framework that further organized the data into categories based on the CRIOP.

Documents and Artifacts Analysis

Unlike the interview analysis, document and artifact analysis had two phases. First, descriptive coding was used to summarize in a word or short phrase the basic topic of qualitative data, which was found with material objects and physical environments (Saldaña & Omasta, 2018). For example, in one of the syllabi that was provided by teachers phrases such as “enriched by differences” and “We speak in the language of inclusion for the people present” were coded as “valuing diversity and inclusion.” Secondly, documents and artifacts were coded to the codebook to establish connections to the CRIOP framework. For example, if a teacher shared a test or quiz as a document of culturally responsive teaching, then it was coded for “Assessment Practices,” and precise CRT aspects or indicators were documented. Additionally, when necessary, the researcher and participating teachers co-constructed ideas about the documents and artifacts (Saldaña & Omasta, 2018). For example, one teacher explained how their summative assessment was culturally responsive when the student document outlined how students would reflect on the impacts of science in analyzing a neurological condition through one of seven factors (economic, environmental, ethical, cultural, political, social or moral). Document and artifacts analysis was used to essentially answer any of the three research questions but was primarily found to answer the first two research questions on planning and teaching.

Observation Analysis

As previously mentioned, all observations except for one were done remotely. Most of the research on remote observations has been done with preservice teachers (Hager et al., 2012; Pickering & Walsh, 2011; Quezada et al., 2020). However, there are applicable lessons learned from this research that apply to this study. For instance, Hager et al. (2012) referred to the

frustration of preservice teachers when observing a classroom. This frustration stemmed from not being able to experience the entire classroom as a whole and having limited views. Nevertheless, the study found technology-based remote observations to be an effective measure (Hager et al., 2012). All three schools insisted that students not be recorded on video, so only the audio portion was recorded during the observations. The audio recordings from the remote observations were also transcribed with otter.Ai. One teacher was able to screen share with the researcher, and it allowed the researcher to see the screen that the students were seeing. Screenshots from this observation were utilized in the document and artifact analysis. The researcher took extensive field notes on the physical space and its setup for each of the classrooms. Once again, screenshots and photos were taken for documentation. Analytic memos were recorded at the conclusion of each lesson so that the researcher could recall specific thoughts and ideas about each observation.

The observation data were analyzed using the data analysis phases of coding (i.e., in vivo, description, and framework). For example, during one observation students read different eyewitness accounts about the effects of climate change on communities throughout the world. The teacher and students worked together to make a mind map of all the different scenarios that students read about and shared. During the in vivo phase the teacher's words "working together" were highlighted and coded for the mind map. Then in the description phase this part was coded as collaboration and instructional technique. Finally, in the framework part of coding the mind map was coded in the categories of classroom relationships for the learning atmosphere and students working together. For the entire mind map activity there were also framework codes for instructional practices, discourse, and critical consciousness.

Post-observation interviews were analyzed using all three phases of the data analysis. For instance, in one post-observation interview one teacher was asked to elaborate on how she was connecting the content to students' lives. For in vivo coding the phrase "understanding how their own body systems work" was highlighted and for the descriptive coding this was labeled as "relating to students' lives." In the framework coding it was coded as an instructional practice as the teacher was using techniques to connect the learning to life outside of school and to contextualize the learning into students' lives.

The post-observation interviews consisted of broad primary questions that asked teachers to share key moments from the lesson. Teachers were prompted to share information on specific occurrences that the researcher observed during the lesson. An example prompt was "I noticed that you chose to draw a diagram for a particular group of students. Can you say a little more about what you were thinking there?" or "I noticed that you were talking with a group of students in French at one point, can you tell me more about that interaction and your rational for using French?" Some prompts targeted more specific moments related to the CRIOP pillars (e.g., Science Culture, Classroom Relationships, etc.) and how those occurrences played out in the classroom. The research also used post-observation interviews to clarify any questions that arose during the observation.

Analytic Memos

Analytic memos were used throughout the data collection and analysis phase of this research study. Saldaña (2011) refers to analytic memos as "think pieces" (Saldaña, 2011, p. 98). This is an appropriate term and allows the researcher to start thinking about the data and how it will fit into the storyline. One example of an analytic memo is as follows:

> I deliberated on whether to code this as planning or teaching. I went with planning because Isabella mentioned the mission statement of the school and preparing students to be global citizens. This indicates a degree of deliberation and forethought for achieving the school mission statement.

More importantly, analytic memos allowed the researcher to keep track of thoughts and ideas that occurred during the study and were used to make conceptual leaps from raw data to the research phenomena (Birks et al., 2008). An example of this is found in the following excerpt from the researcher; "This type of reflection by Helen makes me rethink how the 3rd RQ will be answered. Reflection can also happen before and just as a part of thinking about their role in being a culturally responsive educator." Another example of an analytic memo is from the rereading and subsequent analysis of field notes taken during the in-person observation. The researcher wrote the following memo

> Time was definitely a factor in this lab. The teacher seemed slightly stressed about getting done with the lab. Problem: I don't always know what dialogue was about in French. Q: Does the teacher find switching languages mentally exhausting?

All of these examples show how analytic memos were used to think through the data and how the researcher made conceptual leaps in the data analysis phase.

Trustworthiness

It is essential to establish yourself as a researcher with honesty and integrity (Saldaña, 2011). Using a multiple case study approach allows for a point of rigor in that it gives more than one perspective on the phenomena being studied (Merriam, 1998). Additionally, by utilizing several research methodologies, the study lent itself to triangulation both in the validity sense and systematic exploration of CRT science teaching (Denzin, 2007; Flick, 2004). Other measures

that were taken to ensure reliability were member checks, peer debriefing, and thick descriptions (Morse, 2015). In terms of thick descriptions, the aim is to provide plenty of data, which causes data to overlap and contribute to internal reliability (Morse, 2015). For member checking, a copy of the transcribed interviews were sent to make sure that interviewees' thoughts and experiences are properly conveyed. Lincoln and Guba (1985) stated that member checking is a crucial technique for researchers to establish credibility. The researcher also communicated with constant "check-ins" throughout the study to ensure that teachers were satisfied with the research process and that their thoughts, ideas, and experiences were being properly conveyed when broad assertions are made. Besides a few changes in sentiment or meaning from statements during interviews these check-ins did not change the trajectory of the data analysis. This check-in process assisted in making sure the study remained ethical and valid (Lincoln & Guba, 1985). There were potential pitfalls to avoid with member checks that can compromise the researcher and participants' relationship, but every effort was made to curtail these pitfalls (Birt et al., 2016; Carlson, 2010).

Peer debriefing was used intermittently throughout the data collection and data analysis phases of this study. The meetings served as debriefing sessions to confirm findings and discuss issues that may arise during the research process. The impartial peers were fellow doctoral students who understood the stresses accompanied with research fieldwork and the peer debriefing served to aid stress management (Lincoln & Guba, 1985). Peer debriefers were shared the study's methodology and codebooks along with interview excerpts. Sharing the study's methodology helped to evaluate and critique for methodological flaws in the study. Some of the outcomes of these peer debriefing sessions during data analysis were improved clarity and identification of biases made on the part of the researcher. For instance, an initial codebook was

shared with one peer that allowed for streamlining of the parent codes that led to improved clarity. For identification of biases, one peer meeting led to a recognition of assumptions being made by the researcher about a teacher that had no foundation in the data. Memos of the meetings were kept by the researcher and aided in the process of reflection, facilitated ideas and aided in accountability. Additionally, the researcher checked in with their mentors and used those opportunities for debriefing and reflection.

The researcher's perspective in qualitative research is one of submersion to the point that even they are considered an instrument (Stake, 2010). Therefore, it was essential to position myself as a researcher and thoroughly outline data collection and analysis methods. As the primary researcher for this study has direct knowledge of the subject matter, it was essential to bracket biases and preconceptions (Tufford & Newman, 2012) with the use of analytic memos. Addressing issues with analytic memos (Saldaña, 2011) of personal connection at this phase of the research better developed an awareness of preconceptions throughout the research process (Glaser, 1978, 1992).

Ethics

Kvale and Brinkmann (2009) suggested following four guidelines for ethical pursuit in interview research. The four guidelines are as follows: (a) getting informed consent, (b) abiding by confidentiality, (c) thinking through the consequences, and (d) considering the role of the researcher. Part of teacher recruitment was accessing informed consent from the participants. For confidentiality, the anonymity of the participants was protected in this study, and every effort was made to ensure that the participants are comfortable and satisfied with the research process. Participants were informed of their right to withdraw from the study at any point.

Additionally, this study occurred in commonly accepted educational settings. Saldaña stated that “researchers need heightened attunement during all stages of a study to ensure that no harm and minimal discomfort come to anyone” (Saldaña, 2011, p. 25). The goal was to make sure that the participants were comfortable with the research process; this was especially pertinent as the participants are practicing educators and work with children. The researcher was acutely aware that qualitative research and inquiries into people’s lives were an exercise in ethics (Agee, 2009). To further ensure participant protection, all guidelines set down by the Internal Review Board when dealing with human subjects were followed. Continual reflection was done as self-reflexivity deals with the researcher examining their influence on the scene and other people (Tracy, 2010). Throughout the entire research process, the researcher was introspective about the potential impact on the outcome of this research and documented personal connections and potential biases in analytic memos. One way to establish honesty and integrity is to have an in-depth audit trail that provides clear evidence of decisions and actions taken during the research process (Creswell, 2009).

The overall aim of this research was to understand the experience of international schoolteachers teaching with aspects of culturally responsive science teaching. The gaps that this research aimed to fill were as follows:

1. The use of a unique sample with science teachers in international schools.
2. Research within the unique ‘third space’ that international schools occupy.
3. Focusing on CRT science teachers with highly diverse populations versus specific ethnic and racial groups.
4. Methodologically, the CRIOP was used as an analytical framework for other purposes (i.e., interviews and document analysis) besides observation.

Additionally, this study showed that international schools can provide a lens into working with highly diverse classrooms and contribute to the knowledge base surrounding culturally responsive science teaching.

CHAPTER IV

FINDINGS

The purpose of this qualitative case study was to examine ISST's approaches to culturally responsive teaching with diverse student populations. The research questions for this study are: (a) How do international school science teachers (ISSTs) deliberate and plan for teaching culturally diverse student populations? (b) How do ISSTs teach in culturally responsive ways? (c) How do ISSTs reflect on their culturally responsive teaching in science classrooms? This chapter includes a presentation of findings from each case study in relation to the research questions and a cross-case analysis.

Each case study begins with an introduction to the participants and their background, followed by a general description of the school in which they work to give context to the situation. Subsequently, the findings for each participant are presented with three subsections that address each research question. The subsection for research question number one first discusses how the teachers plan and deliberate to teach science to culturally diverse students. The second subsection addresses teaching strategies and practices for culturally responsive science teaching in international schools. The final subsection examines how the teachers reflect on their work and roles as culturally responsive science educators within international schools. Each case study ends with a data summary table that has examples of culturally responsive teaching organized by the CRIOP pillar and indicators with evidence and sources. In an effort to emphasize the findings, the researcher opted to use bolding words or phrases that are directly linked to coding categories based on the CRIOP analytical framework. During the individual case studies, bolded terms or phrases are directly linked to at least one of the CRIOP categories.

Finally, a cross-case analysis compares commonalities and differences between the case studies. The analysis includes a breakdown of the major categories used in data analysis (e.g., classroom relationships and instructional practices) and how each participant is represented in these categories. In order to compare the three case studies further, the subcategories or indicators of the CRIOP are identified by the italicized words. Each major category ends with an indicators comparison table that thoroughly represents how each participant compares and contrasts with the others in regard to that specific category in relation to planning, teaching, or reflecting.

Helen: A Global Nomad's Perspectives on Culturally Responsive Science Teaching

Helen is originally from the United States but spent several years teaching and living in other countries, such as Bulgaria and Argentina. At the time of this study, she had 25 years of teaching experience with subjects such as High School Biology and Chemistry. She has a Bachelor's degree in Biology and a Master of Art in Education. Helen graduated from a prestigious university on the West Coast and does interviews for potential students who are applying to her alma mater. These interviews were conducted with students from outside of the school where she teaches. Helen's current teaching position is in the International Baccalaureate (IB) Middle Years Programme (MYP), Grade 9 and 10 Biology. The MYP is part of the IB program that is designed for students ages 11 to 16. The MYP is a whole school curriculum framework comprised of eight subject areas that schools must purchase in order to have access to the materials and the program in its entirety (https://www.ibo.org/myp). Ideally, the MYP program is meant to prepare students for the rigorous undertaking of the IB Diploma Programme. Helen has extensive training in the IB and MYP. Helen identifies as White and

Caucasian, speaks English fluently, and has advanced conversational Spanish. She is married and has three children.

Currently, Helen teaches at an international school located in the Midwest United States. School documents state that there are 50 nationalities represented in their community, with the school offering immersion and dual language learning in Mandarin, French, English, and Spanish. Language immersion is primarily done in the lower elementary grades (Kindergarten through Grade 3), with dual language happening in upper elementary (Grades 4 and 5), middle school (Grades 6–8), and high school (Grades 9–12). The school is accredited by the Independent Schools Association of the Central States and the Spanish Ministry of Education International Spanish Academy. “The World Within Reach” is the motto found on the school website.

Helen says that many of her students are from dual-nation households where the parents are from two different countries. She stated that quite a few families from outside the United States have come specifically to this area for work and that many parents are employed in the medical community. Overall, the socioeconomic status of the schools’ students is relatively high, with the school offering a voucher program for low-income students. As for other faculty, Helen stated that many teachers are from outside of the United States and come to work for the international school, specifically the language immersion programs.

Planning

In response to the question from the initial interview (Initial Interview) that directly asked, “How do you plan to work with students from diverse cultural backgrounds?” Helen had a multi-layered response. She first prefaced her answer by saying that if she were still working outside of the United States, her country of origin, her answer would be different. She attributed

this to having moved back to her country of origin and being somewhat familiar with the culture. However, she also mentioned cultural differences within different regions of the United States. Specifically, living in the mid-western part of the United States also made her feel less culturally adept. She said, "I'm also a little bit foreign because the Midwest is very different than the West Coast" (Initial Interview), where she grew up. Another layer of Helen's response to this question was how culturally responsive teaching often comes about organically due to the diverse atmosphere at her school. She said

> I don't really think about applying that diversity to my teaching because a lot of the conversations that we have, like, for example, the World Cup, we're all from everywhere, and, you know, just things come up naturally in the class. And so I don't make, you know, a concerted effort to try and do that [plan for CRST]. (Initial Interview)

Helen also mentioned that her background in the international system prepared her to be more understanding of different cultures. For instance, she shared a story about the parents of a student who were writing to ask if their son or daughter could be excused from taking the test. The reason was that the family was out all night because of their grandma's birthday, and this particular student could not prepare for the test. Helen said that when she first arrived in that country, she thought it was crazy to excuse students for prioritizing a party. However, she grew to understand that **family** is critical in that culture and that staying up all night for a party was not out of the norm. She recognized that "every culture is different," which helped steer her to "not make judgments" about other cultures (Initial interview).

Helen observed that in teaching students from different cultures, you had to recognize that they have many parts to their story and that the "story is kind of like an iceberg" (Initial interview). She said that on the top of that iceberg, you see the typical parts of being a teenager.

She said, “You see their 16-year-olds, and they’re busy, and they’re stressed out, and they’re doing sports, and maybe they’ve got some emotional issues going on because they’re teenagers” (Initial interview). For the lower part of the iceberg, Helen said,

> And then underneath that, like an iceberg in the sea, there’s all the other stuff going on, like, you know, parents and relationships, and, you know, it was grandma’s birthday, or they struggle with reading, and you don’t see that. And so they’re covering it up, and they’re not doing their homework because they really just don’t understand what the question is. And they don’t have strong communication skills because they are teenagers, or they just would rather not confront it. So, you know, trying to dig a little bit into that, to get an understanding of what’s going on, and I think culture plays a role in that. (Initial interview)

Helen uses this insight about students and teenagers to help plan her teaching.

Helen believes that a large part of being a culturally responsive teacher is establishing **relationships** with the students. She does this through talking to students in the hallway or getting to know them through small conversations in class. In response to a question about how she gets to know students from the initial interview, Helen said, “I think it’s that kind of building the relationship over time and having chances to talk to students in class or in the hallway.” Her role as a mother is blended with her role as a teacher since her own children attend the school where she teaches. She knows when certain students were at a swim meet until 10:00 o’clock the night before as she was there cheering for her daughter. Additionally, she takes the opportunity on less formal occasions, such as Spirit Day, where she can joke and continue conversations that allow her to establish rapport with the students. She says, “They’re kind of open and vulnerable

and not thinking like they're being judged in the classroom" (Initial Interview). Helen uses this type of informal **discourse** to further her knowledge and understanding of her students.

Besides building relationships with students, Helen also values the importance of **collaborating with parents and families**. Her role as a fellow parent helps her understand the families and establish **genuine partnerships**. However, Helen is cognizant of maintaining professional boundaries. "I stay very professional, and don't bring anything into the classroom where, like, even though their parents are my friends, I don't discuss that in class. So, I feel like I keep boundaries" (Initial Interview).

Helen recognized that students' and families' cultures impacted how she would address potential issues in science class. She also mentioned that potentially controversial topics can arise in the science classroom. She said that when planning to teach biology, she has to expect that students will want to discuss issues like sex determination, and she feels that teaching in the Midwest, she has to be careful of parents who are very conservative and think that she may be pushing a certain agenda. However, when she taught on the West Coast of the United States, they could talk about these issues even many years ago. Helen demonstrates culturally responsive teaching through the CRIOP pillar of **family collaboration** when she makes an effort to **understand families and respect their cultural traditions**. Interestingly, even though Helen considered the school she currently teaches to be "a liberal school relative to the area" (Initial Interview), she still had concerns about certain content. Another controversial topic that Helen mentioned was evolution, but she said she had limited direct experience with that topic because it was primarily addressed in middle school grades (Initial Interview).

When planning for assessments, Helen communicated that she based much of her assessment work, both **formative** and summative, on the MYP curriculum. In regards to working with ELL students and making the **language accessible,** she said:

> So that might have been taking one of my tests and just changing the language so that it's easier to understand or changing an assessment from maybe a video to a poster where they can more readily represent their learning. (Interview)

Students in Helen's class are also given choices on what topic they will choose for their final product, thereby displaying another component of CRST.

Teaching

There were two days of online observation of Helen's science classes. On the first day of her Grade 10 Biology class, Helen began one lesson with a 10th-grade class by reviewing material and employing an open discourse with students. She asked them to help remind each other of the particular aspects of the nervous system they had been studying the past few days. Students responded with points about neural pathways, the brain, and the autonomic nervous system (Observation). In her review of the previous lesson, Helen encouraged students to participate in open dialogue about what they had covered in the previous class. She used prompts such as "Anything you remember about the fight or flight response?" (Observation). Rather than telling students what they had studied, Helen expected them to drive the conversation, and then she acknowledged and thanked the students for their contributions. One strategy she used to engage students was to have them toss a stuffed hedgehog toy to each other to indicate who would be talking or leading the discussion. Students readily contributed to the conversation and were actively engaged in the dialogue. As can be seen in Table 4 (Helen's Summary Data Table), having students **work together** in this fashion is an example of the culturally responsive

classroom relationships that exist in Helen's classroom. She encouraged **discourse** from her students by thanking them for their contributions and encouraging others to contribute. Additionally, when asked how she helps to develop student language, she referred to a word wall that helped develop **key academic vocabulary**.

It was evident during Helen's classroom observations that she embraced a multicultural approach to education. Her classroom space had several indicators supporting this approach. For example, even though the space was used primarily for science instruction, there were student-created hands with different cultural components (flags, food, languages, etc.) from Helen's advisory. Helen was very proud of what the students had produced, and she celebrated the diversity of the students.

As the lesson began, Helen relayed the expectations for the upcoming lab and communicated the **high expectations** for the activity. She stated,

> We're going to look at the reflex arc today. And one of the things we're going to do after we look at the arc is you guys can measure your reaction time. Have you ever done the ruler drop lab? You might have done that, but we're going to make it more challenging, and what we're going to do is use a formula to calculate how fast your responses from the stimulus to your response, which is catching it. (Observation)

Additionally, she discussed how students would need to **work togethe**r to be successful. She mentioned, "This is a partner lab, and you must work together to be successful" (Observation). The lab was a **hands-on inquiry** into reaction time and the reflex arc. Students were given a ruler for one partner to hold and drop within a five-second time period while the other partner was expected to catch the ruler. Students then measured the distance that the ruler had traveled and were expected to convert the distance into reaction time. Immediately, students

partnered with one another and worked on completing the lab. Results were recorded in their science notebooks, and students worked steadily throughout the lesson, with Helen observing and walking around the room to give feedback and answer questions. Students seemed **engaged** by posing relevant questions about the task and the connection to the content. Later in the lesson, Helen shared a **personal experience** about being bitten by a dog. She said,

> I was training for a marathon with one of my friends; it just so happened that one of the dogs that were running by was off-leash, and it came up to me, and then it bit me in my back and tore my jacket off. And so, to this day, I'm scared of dogs, like 30 years later, and it goes back to the amygdala. But my stimulus is that of seeing a dog that's free roaming. (Observation)

She is still scared when she sees a dog off-leash because of her amygdala response. She then opened it up to the class, inviting students to share stories. Students engaged in the **discussion** and shared their **lived experiences**.

Helen also tied the lesson to all students' lives by using the example of how the music at movies evokes emotion and engages the autonomic nervous system. She relayed that there is a reason behind the music at scary movies and that many people are still afraid of the water because of the music in the movie Jaws. **Contextualizing the content** into students' lives and using real-world examples helps make the learning experience meaningful.

Helen also implemented a culturally responsive **instructional strategy** on the second day of the reflexes lab by **giving students choices**. Students were allowed to pick the variable that they wanted to test in relation to reaction time. She said, "Alright, guys, we have six minutes to decide the variable that you want to test against. We're looking at reaction time compared to another variable you can think of right now as your control" (Observation). Helen suggested a

few possibilities, such as age and height, but ultimately let students choose based on their interests. Additionally, Helen promoted **student collaboration** by asking one student during the experiment, “Do you need an assistant?” and then proceeded to ask another student to help them. Students were encouraged to **discuss** the process of finding the standard deviation when working with their data set.

From a curriculum standpoint, Helen is strictly held to the MYP standards. She stated, “I have **high expectations**; the diploma program, too, especially MYP, sets very high expectations” (Initial Interview). The MYP curriculum overview emphasizes inquiry in the sciences and ideally wants conceptual understandings developed through global contexts. In the MYP subject brief, the IB states that these global contexts are used “across the curriculum, supporting transfer and interdisciplinary learning” (International Baccalaureate Organization, 2015). Examples of these global concepts are as follows:

- Identities and relationships
- Orientation in space and time
- Personal and cultural expression
- Scientific and technical innovation
- Globalization and sustainability
- Fairness and development (taken directly from the MYP Subject Brief)

The MYP global concepts directly address the cultural aspect of CRST but also address **relationships and critical consciousness issues** (i.e., globalization, fairness, development, etc.) based on **real-world issues**. One part of the critical consciousness pillar is incorporating opportunities to confront negative stereotypes and biases. In the initial interview, Helen discussed how she does a lot by showing women in science. She said,

> I find I do a lot of women in science because we want to increase women in science, but then again, I'm a woman. I think I could do a better job of representing some of the other groups that are underrepresented that I'm not a part of . . . But bias, like negative bias, comes up a lot. But I think the program itself addresses that. And so, a lot of it just comes up naturally.

Helen utilizes the MYP program in her teaching to **confront negative biases** that may present themselves while teaching. She went on to say that her classes had been talking about Henrietta Lacks recently and that she wanted to focus more on groups that are underrepresented. Helen conveys to her students that "You have to let go of your biases. You have preconceived notions about certain groups, ethnicities, nationalities, and cultures, and you just have to let go of those because it's a stereotype" (Final Interview).

One of the assessment criteria in the MYP is Criterion D: Reflecting on the Impacts of Science. Helen explained that students needed to "explain how science can be used to overcome a condition or how does science solve a problem. And then, they have to assess the implications and limitations of that solution" (Post-Observation Interview). In the unit Helen's students were studying, potential examples Helen cited were "a student might talk about putting an electrode into the brain to stimulate the neural pathway for paralysis. Or they might choose a painkiller drug or a migraine drug treatment and talk about how it interacts in the synapse" (Post-Observation Interview). Giving **students choices** based on their interests and strengths is part of culturally responsive teaching in the CRIOP pillar of **instructional strategies**. Helen explained that another part of the MYP curriculum is to evaluate the implications of that solution through a social, political, environmental, or economic lens. For instance, if the student were studying the migraine treatment from the previous quote, they may also look at drug availability

in low-income areas locally and globally to incorporate the social, political, and economic lenses that the MYP requires. Having students explore **real-world issues** at a **local and global** level is a part of culturally responsive teaching through the CRIOP pillar of **critical consciousness**.

In dealing with a challenging MYP program, another CRST practice that Helen used was **scaffolding student learning**. With some students, she said, "they don't know where to begin to do some of the things they need to do with research-based or open-ended questions. So you try to support them and give them feedback" (Initial Interview). She went on to say that part of the MYP and IB program that she likes is the formative work and the highly specific feedback she can give students to help them identify what they need to work on. Helen mentioned that as her career progressed, she had to give more and more verbal feedback to students. She stated that

> I also find that as long as I teach longer and longer, kids change, and families change. I actually spend a good portion of my efforts telling them that what they're doing is actually really good. And even though they're not perfect scores, that's really good. And it's really hard to get as high as a seven in biology, that's the highest score. And telling them, like, actually, a five is really good. Yeah, you can't be so hard on yourself. (Initial Interview)

Once again, Helen demonstrated how to teach in a culturally responsive manner with an **ethic of care** while maintaining **high standards**.

Helen discussed several ways of how she assessed students that fit into the culturally responsive framework. She discussed using **formative assessment practices**. She said, "One of the things I appreciate is being able to give very specific feedback on what they need to do to improve that's part of the MYP IB program is that formative work . . ." Using authentic **task-embedded assessments** such as rubrics is a consistent practice in Helen's classroom. She

said, “So, I’m very clear that I’m really working towards the rubric” (Initial Interview). Furthermore, students have the opportunity for **self-assessment**. Helen said,

> I do a lot of that [self-assessment] with the diploma kids (students who are enrolled in the IB program), where it’s just really content heavy. And I’ll walk into class and give them one question, they write the answer. And then they assess where they’re at. I take a look at their scores, but I don’t write them down, or I might write them down, but they’re self-assessing. And then I ask them, what do you need to do to get the grade that you want to get? If you want the top mark? How much vocabulary do you need to study? What content are you missing to be able to write that much detail? (Initial Interview)

In the previous passage, Helen demonstrated culturally responsive teaching not only through her use of self-assessment but also task-embedded assessments and other formative assessment practices.

Reflecting

In reflecting on her role as a culturally responsive teacher, Helen recognized that teaching at an international school helped to make her a culturally responsive educator. “One of the ways it’s impacted me is just thinking of while we’re all here together at international school. We can use these different examples from outside the country so that we’re promoting a more worldly perspective to things” (Final Interview). Helen also mentioned that being at an international school tended to bring people together. These factors help her teach students from diverse backgrounds and utilize a curricular framework that obliges her to implement cultural, social, economic, and global perspectives.

As mentioned in her background information, Helen interviews students who are interested in attending her alma mater. These interviews give her the opportunity to hear whether students

from non-international schools are aware of the international perspective on issues. She said, “I really find that the public-school kids and the local community really don’t have that international factor; I think it has to do with we’re constantly bringing in these evaluation points and things like the United Nations sustainability goals” (Post-Observation Interview). She elaborated on the United Nations Sustainability Goals and said, “the United Nations sustainability goals are like a no-brainer. It creates a connection between the international program and life and social justice” (Post-Observation Interview). Thus, Helen provides opportunities for **critical consciousness** through the inclusion of issues important to the international community.

Helen also reflected on how, sometimes, **contextualizing content** into students’ lives and trying to frame it culturally at a local and international level creates a juxtaposition. For example, Helen relayed a story from the pandemic when she was teaching a unit on global health, specifically disease outbreaks. At the time, the local recommendation in her area was not to wear a mask as they were trying to conserve the masks for medical professionals. She said that she had a student from China in her class who was wearing a mask, which is common practice in China during cold and flu season. There was a local video that advocated for not wearing a mask, which she chose not to show because she felt like “I’m not going to put her on the spot” (Initial Interview). She took into account the **students’ perspective** that wearing a mask helps to keep the community healthy.

Helen also tries to bring in **diverse perspectives** through mock events and roundtable discussions about controversial subjects such as vaccine development. Students have a **choice** to take on **different roles,** such as an immunologist, a community member who is against vaccines, or a doctor. In looking back at some of the **classroom conversations**, Helen said they created “total paradigm shifts” (Final Interview) but also mandated respect for all sides of the discussion.

Another factor that both aids and impedes her teaching in a culturally responsive manner is the MYP curriculum that she must adhere to. In reflecting on the role of the MYP curriculum, she said

> So the curriculum itself, the assessments are based on the rubrics, one of which I set for criteria D in that particular rubric provides the opportunity for that cultural responsiveness because the students need to evaluate a scientific solution based on a factor, and that factor might be economic, political, social, etc. And those factors tend to lend themselves well to culture as well. (Final Interview)

This quote has two components of the CRIOP framework within it. First, the use of rubrics as an assessment tool provides **authentic assessments** to determine students' competence. Second, the necessity for students to evaluate factors of contemporary global science issues is an example of **critical consciousness** in the CRIOP framework. Furthermore, Helen went on to say

> And it gives them a **choice** as well. Students can choose which factor, and so if they identify more with maybe the social factor, then they might take a look at how society and all of the people within society respond to the benefits and drawbacks and solutions. (Final Interview)

She gives students choices based on their interests and background experiences, which are components of the **instructional practices** pillar in the CRIOP. Helen further elaborated on the MYP helping to advance culturally responsive teaching when she said, "The IB program kind of segues into some of the stuff that creates culture because I think just by nature, it brings in a lot of their identity and their culture because it's always this global perspective" (Post-Observation Interview). While Helen clearly feels that the IB and MYP programs promote culturally responsive

teaching, she also mentioned that the two programs have large amounts of content to cover, and this impedes her ability to do as much culturally responsive teaching as she could.

When asked about how teaching in international schools impacted her science teaching, Helen said, “One of the commonalities between me and the students is the fact that we are all at an international school. So, it’s one way that brings us together” (Final Interview). Once again, this shows how she valued the **relationship** aspect of culturally responsive teaching. Another part of teaching in international schools that has made Helen a CRST is her willingness to use **discourse practices** that promote students’ native languages. She referred to capitalizing on students using their knowledge of Latin roots in recognition of many science terms and encouraged students to share that knowledge (Final Interview). Helen also mentioned that she is aware that her students’ backgrounds are very different and that many are Third-Culture Kids (TCKs).

Teaching for a number of years outside of her home country and raising children while living overseas has given Helen an in-depth understanding of her international students. Her time in international teaching has given her great cultural competence that was not there before living and teaching outside of the United States. Helen considers her flexibility and adaptability as her most valuable skills as a CRST. In response to what she considers her most valuable skill as a CRST, she said, “And so that flexibility to slow down or adapt the curriculum to help diverse learners and just flexibility within a lab situation where understanding students and their age or where they’re coming from” (Final Interview).

A final area that Helen reflected upon in her role as a culturally responsive educator was the service-learning aspects of the class. For example, she said, “In chemistry, we’re studying batteries, and so we talk about let’s get a battery drive going and collecting batteries that people

don't need, and then we'll drop them off at the local hazardous waste place" (Final Interview). By encouraging students to **take action at a local level**, she provides learning experiences that help to **solve problems**.

Table 4 summarizes the data collected from Helen, organized by CRIOP pillar/category and whether it addressed the plan, teach, or reflect research questions. Each relevant CRIOP indicator or subcategory is noted with the evidence and source below it.

Table 4

Helen's Summary Data Table

CRIOP CATEGORIES	PLAN	TEACH	REFLECT
CLASSROOM RELATIONSHIPS	CRIOP Indicator: The teacher demonstrates an ethic of care.	CRIOP Indicator: Students work together productively.	CRIOP Indicator: The teacher creates a learning atmosphere that engenders respect for one another and toward diverse populations.
	"I think it's that kind of building the relationship over time and having chances to talk to students in class or in the hallway." (Initial Interview)	Students were encouraged to work together and have discussions. (Observation)	"One of the commonalities between me and the students is the fact that we are all at an international school. So it's one way that brings us together. (Final Interview)
FAMILY COLLABORATIONS	CRIOP Indicator: The teacher reaches out to meet parents in positive, non-traditional ways.	CRIOP Indicator: The teacher establishes genuine partnerships with parents/caregivers.	CRIOP Indicator: The teacher intentionally learns about families' linguistic/cultural knowledge and expertise to support student learning.
	Getting to know parents at swim meets or other school events. (Initial Interview)	Helen's efforts to understand families and their cultural traditions. (Initial Interview)	Understanding family and student culture ("every culture is different") and not jumping to judgment ("not make judgments"). (Initial Interview)

(*table continues*)

Table 4 (continued)

Helen's Summary Data Table

CRIOP CATEGORIES	PLAN	TEACH	REFLECT
ASSESSMENT PRACTICES	CRIOP Indicator: Students are able to demonstrate their learning in a variety of ways.	CRIOP Indicator: Formative assessment practices are used that provide information throughout the lesson on individual student understanding.	CRIOP Indicator: Authentic assessments are used frequently to determine students' competence in both language and content.
	In regards to working with ELL students "So that might have been taking one of my tests and just changing the language so that it's easier to understand or changing an assessment from maybe a video to a poster where they can more readily represent their learning" (Initial Interview).	Helen started the lesson with a review of nervous system knowledge. She continuously checked for student understanding throughout the lab and students voiced learning throughout (Observation).	Rubrics (Documents) "I do a lot of that [self-assessments]..." (Initial Interview)
INSTRUCTIONAL PRACTICES	CRIOP Indicator: Students engage in active, hands-on meaningful learning tasks, including inquiry-based learning.	CRIOP Indicator: The teacher focuses on developing students' academic language.	CRIOP Indicator: Students have choices based upon this experiences, interests and strengths
	Ruler Drop Lab (Observation)	Word Wall (Observation) Motor Neurone Handout, Coordination and Response Handout (Documents)	Students are given choice in major project. "...students need to evaluate a scientific solution based on a factor and that factor might be economic, political, social, etc. And it gives them a choice as well." (Final Interview)

(*table continues*)

Table 4 (continued)

Helen's Summary Data Table

CRIOP CATEGORIES	PLAN	TEACH	REFLECT
DISCOURSE	CRIOP Indicator: The teacher promotes active student engagement through discourse practices	CRIOP Indicator: The teacher provides structures that promote academic conversation.	CRIOP Indicator: The teacher promotes equitable and culturally sustaining discourse practices.
	The teacher planned to use a variety of prompts and strategies to promote student engagement through talk. (Observation)	The teacher shared her story about a dog bite and then encouraged students to share their experiences and stories. (Observation)	Encourages students to capitalize on knowledge of Latin-based words in their home language. (Final Interview)
CRITICAL CONSCIOUSNESS	CRIOP Indicator: The curriculum and planned learning experiences provide opportunities for the inclusion of issues important to the classroom, school, and community	CRIOP Indicator: The curriculum and planned learning experiences incorporate opportunities to confront negative stereotypes and biases.	CRIOP Indicator: The curriculum and planned learning experiences integrate and provide opportunities for the expression of diverse perspectives.
	Reflecting on the Impacts of Science- Criterion D- MYP (Document)	"But bias, like negative bias comes up a lot. But I think the program itself does that. And so a lot of it just comes up naturally. Okay. And like environmental justice. I have a lot of students that… have very strong passions about, like climate change and environmental justice." (Final Interview)	"We can use these different examples from outside the country so that we're promoting a more worldly perspective to things." (Final Interview)

Irene: Skills-Oriented Approaches in Culturally Responsive Science Teaching

Irene is originally from France and has lived and taught in the United States, the United Kingdom, and France. Her teaching assignment at the time of this study was a 10th-grade Biotechnology class, which was a science elective with students from the international program and French program. Previously, Irene taught biology, biotechnology, and French as a foreign

language. She considers herself to be of White or Caucasian race and has 22 years of teaching experience. Her educational background is a Bachelor's degree in biochemistry and a Master's in counseling. Irene is fluent in French and English. She is married and has one child.

The international school where Irene teaches is located in the southern part of the United States. It is a private day school with students ranging from preschool to 12th grade. The school offers an international program and a French program or French Baccalaur*é*at. The school is accredited by the Independent Schools Association of the Southwest, the French Ministry of Education, and the International Baccalaureate. It has over 1,700 students from more than 50 countries, with a third of its students holding citizenship from a nation other than the United States. The school website states that they offer a language immersion program in Spanish, English, and French. Students have the opportunity to study primary, secondary, and tertiary languages. The Middle School (grades 6–8) and Upper School (grades 9–12) offer other languages such as Arabic, Dutch, German, Mandarin Chinese, and Portuguese.

Planning

Irene believes that the school's climate facilitates the process of planning to teach a culturally diverse student population. She says

> It's normal for them [students] to be friends with someone from Russia, another kid from the Middle East, and another one from South America. So, to them, I think it's not a surprise to be in this kind of environment. (Initial Interview)

Irene finds that this type of environment means that they respect each other and value how they relate to one another, making her job that much easier. The Biotech class she teaches has students from both the international and French programs. Additionally, Irene values the

environment of international schools from a parent's perspective and has her daughter attend the international school where she works. She mentioned

> I think it's the philosophy of the school, and that's why the parents want the kids to come here. That's why I picked it for my daughter as well because this is what we're looking for. For the students to be in an environment with different cultures, to be tolerant, and to become citizens of the world. (Initial Interview)

Alongside the international aspect of the school, Irene communicates the high expectations that she has for her students. She said, "We are trying to provide academic excellence, and we want them in an international environment" (Initial Interview). The school website supports Irene's beliefs about the school in saying "In addition to a challenging curriculum, [blinded] school provides students with a kind and friendly environment, in which diverse cultures, nationalities, and languages are celebrated." Another characteristic of the school that Irene thinks facilitates the planning for culturally responsive teaching is small class sizes. The biotech class she teaches has a maximum of 18 students, and in the observation of Irene's class, there were 12 students. She believes that this helps with communication and says, "I think this is something particular about our school is that we really are here for the students, and we can take care of them because it's a small group" (Initial Interview). Being able to be there for students represents an **ethic of care** in Irene's culturally responsive teaching. She further elaborated on small groups by adding that not only did it help her connect to students but that they also connected with one another, thereby allowing them to know and appreciate each other's backgrounds and cultures.

An additional area where Irene sets the course for teaching science in a culturally responsive manner is in her communication with students regarding the **hands-on, meaningful learning** that is expected from them. She said that "the academic level here [at her school] is

kind of high" and that universities are "looking for not just academics, but also the hands-on part as well, you know, in students in STEM" (Initial Interview). They created the Biotechnology course in order to challenge students in a practical manner. In her course syllabus, Irene communicated the following expectations:

> As this course offers advanced laboratory techniques and equipment, students are expected to always adhere to strict safety guidelines, listen carefully, and follow oral and written instructions. Students should take care when using the laboratory equipment and ask for help from an instructor if they need it. Students should also be active members of the classroom and work cooperatively with their classmates.

Additionally, Irene listed the challenging major topics in her syllabus that would be covered in the class, which can be seen in Figure 2.

Figure 2

Major Topics Covered in Biotechnology Course

Major Topics Covered:

- DNA: genes to proteins, DNA sequencing, Gel Electrophoresis
- Proteins: Enzyme assays, ELISA, spectrophotometer
- Genetics: PCR, primers, restriction enzymes, GMO detection lab
- Invasive Species Identification: PCR, Gel Electrophoresis, DNA sequencing
- Tissue culture: animal and plant tissue culture, sterile technique, slide preparation, bacteria culture

Irene created and planned for this course to be challenging, and she communicated those **high expectations** in her syllabus. Besides communicating the hands-on learning with which her students would be challenged, Irene also set the classroom environment as one where **students work together productively**. Furthermore, the aforementioned syllabus was distributed in French and English, thereby promoting **multilingualism**.

Irene's course is primarily lab-based, and students are expected to utilize inquiry methods. Irene said, "I want them to be hands-on" (Initial Interview). Planning for this type of **hands-on, inquiry-based** teaching and learning is part of the **instructional practices** CRIOP pillar.

In planning for the assessment, Irene said that very few written assessments of their work were expected. Primarily, students are assessed on skills. The course syllabus listed the grades based on 75% biotechnology skills rubric and 25% lab reports. Irene said, "I have rubrics, so I give them rubrics with what's expected and with all the skills, and I work with my department on this" (Initial Interview). This use of rubrics shows that Irene primarily uses **task-embedded assessments,** which is part of the authentic assessment indicator.

Furthermore, Irene's Biotech administrative materials (e.g., syllabus, rubrics) are published in French and English. An excerpt of one of the biotechnology skills from her rubric, can be seen in Figure 3. This figure represents a **task-embedded assessment** that Irene used frequently in her class.

An example of the course descriptions from the syllabus for this class in both French and English can be found in Table 5.

Figure 3

Example From Biotechnology Skills Rubric

Lab Table Organization	My table is always clean and organized. All the chemicals and tools (including transferring tools) are labeled.	My table is usually overall organized/clean. Most of my tools are labeled	My table is somehow organized/clean. The lack of labeling/organization creates some confusion.	My table is not organized. I cannot safely and efficiently work. Nothing is labeled.
Organisation de la table de laboratoire	Ma table est toujours propre et organisée. Tous les produits chimiques et outils (y compris les outils de transfert) sont étiquetés	Ma table est généralement bien organisée / propre. La plupart de mes outils sont étiquetés	Ma table est partiellement organisée / propre. Le manque d'étiquetage / organisation crée une certaine confusion	Ma table n'est pas organisée. Je ne peux pas travailler efficacement et en toute sécurité. Rien n'est étiqueté

Table 5

Course Description in French and English

French Course Description	English Course Description
Description du cours : Ce cours s'articulera autour de travaux-pratiques visant à améliorer les compétences et les techniques de laboratoire des étudiants tout en approfondissant leur compréhension des applications concrètes de la recherche biologique.	Course Description: This course will be centered around practical labs that will improve student laboratory skills and techniques while deepening their understanding of real-world applications of biological research.

Teaching

The observation of Irene's teaching was done in a one-day in-person session. The Biotechnology class started promptly, and 12 students were in attendance. Irene began the class by explaining the task for the day which was a lab activity focused on plant cell cultures. The experiment objective was to "establish plant cell cultures from a plant tissue to generate whole plants" (Document). Students were learning how to prepare plant tissue for culture, practicing sterile techniques, and learning about the components of plant culture media. Irene introduced the lesson and emphasized that the students must work efficiently during class to get a viable

sample from the lab. She said, “We are limited on time, so you must work precisely in order to be successful. Don’t rush and take the time to bleach and rinse” (Observation). Students came in and immediately started to work. The students were obviously aware of the expectations and protocols of the class. Students were in previously assigned groups of two or three and **worked together productively**. There was limited conversation between the students unless they were talking about the lab. At one point, Irene called the entire class together in order to demonstrate how to use a specific piece of equipment. She **scaffolded the learning** by demonstrating the necessary skills. Moreover, Irene consistently used both French and English throughout the lesson. She **promoted student engagement** through her codeswitching and allowed students from the French and International programs to access the lesson.

To establish **classroom relationships**, Irene takes the time to get to know her students and their families. At the beginning of the year, she has her students introduce themselves and say where they come from (Initial Interview). Irene takes time during school functions, such as parent night, to establish **partnerships with parents**. She discussed the last parent night when she was talking to the parents of her Biotechnology class, and they all realized that they were not native speakers of English (Initial Interview). This bonded them as a community, strengthened their **partnerships**, and invited parents from diverse linguistic and cultural backgrounds to **share their experiences**. These types of events allowed Irene to **solicit information** about the students and their **families’ funds of knowledge**.

As previously mentioned, Irene is multilingual and able to switch between French and English with ease during her instruction. For example, during the observation of Irene’s class, she explained to one group in French how to do a specific part of the lab when another group asked a question. She immediately switched to English and answered a question about plant

cultures (Observation). This practice of code-switching or alternating between two languages seemed to come naturally. This was confirmed when I asked Irene whether this task of switching languages was a difficult one. Irene said, “No, it is just something I do” (Post-Observation Interview). Since Irene works in a bilingual environment, she does not consider it difficult to address language barriers. Additionally, she did point out that most students have a relatively high degree of proficiency in English. However, it was evident during the observation of Irene’s class that **multilingualism** is encouraged. Not only did Irene herself use code-switching to bridge comprehension gaps, but students also consistently code-switched throughout the class. This level of code-switching and multilingual atmosphere allowed for **discourse** about the science content and encouraged all students to participate.

Irene also uses **partner and group conversations** to promote academic discourse in her class. She relayed the following strategy:

> What I do in my class is when they do labs, I have a card game before they enter, I mix the cards together so they’re going to be matched together randomly. So I fold them, you know, and usually, I have one IB and one French student, so I have a group of three, sometimes four for lab, and I mix them together, so then they get a chance to interact together because they tend to separate themselves. (Initial Interview)

She said that she uses the card game to mix students together so they have the opportunity to work together, and it helps promote **classroom relationships** by working together **collaboratively**.

As far as assessment is concerned, the Biotechnology class that Irene teaches is a total skills-based class. They have little to no summative assessment of content. This is partially done because the course is a science elective and to counterbalance a large amount of content in the IB

program. Irene explained that the plan for the course was to keep it skill-based and for students to explore the field of Biotechnology. Initially, the course was designed and co-taught by an English teacher and a French teacher who translated everything into English or French, respectively. This gave IB and French Baccalaureate program students access to the content. However, the program switched to one instructor during the pandemic and has stayed that way since. Irene uses a self-designed Biotechnology skills rubric in her class. She publishes these rubrics in English and French. An example of a strand in the rubric can be seen in Figure 4.

Figure 4

Strand From Biotechnology Skills Rubric

Use of biotech equipment (PCR, Electrophoresis)	I am always careful while using the biotechnology equipment I always follow the teacher or equipment instructions	Overall, I am careful while using the biotechnology equipment, but I need to pay more attention to the teacher and equipment instructions.	I am often in need of a reminder and help to properly and efficiently use the biotechnology equipment.	I use the equipment in a way that poses a risk for continued functional use.
Utilisation d'équipements biotechnologiques (PCR, électrophorèse)	Je fais toujours attention en utilisant l'équipement de biotechnologieJe suis toujours les instructions de l'enseignant ou de l'équipement	Dans l'ensemble, je fais attention en utilisant l'équipement de biotechnologie, mais je dois faire plus attention aux instructions de l'enseignant et de l'équipement	J'ai souvent besoin d'un rappel et aide à utiliser correctement et efficacement l'équipement biotechnologique	J'utilise l'équipement d'une manière qui présente un risque d'utilisation fonctionnelle continue

Rubrics such as the one from Figure 4 above are **task-embedded** assessments that allow for **authentic** evaluation of a student's performance. Irene also stated that students have opportunities to **evaluate their own work** based on specific criteria. For example, after the labs that the classes conduct, Irene gives the students a rubric to self-assess what skills they worked on in the lab and how they could have done better (Document).

Much of what Irene tries to do in her Biotechnology class is to create **learning tasks** that allow them to **practice skills** that will benefit them in their other science classes. She explained that the IB and French Baccalaureate programs have a tremendous amount of research and conceptual work but also have challenging labs, and "this class is a really good foundation for later at that point" (Initial Interview). This **instructional practice** and course design allows science students to engage in exploratory learning using hands-on activities. Irene explained, "So I really want them to use their hands and use the equipment. That's, that's the point" (Initial Interview). She further explained that she really thinks this will benefit her students in the future as universities want to see more than academics; they also want students who are focused on STEM and have hands-on experience.

As far as critical consciousness is concerned, Irene discussed how they often talk about current and relevant issues that are linked to **real-world problems** for students. For instance, she said, "With the students we talk about, how often have you taken antibiotics in your life? Do you think it's good or bad? We talk about this kind of issue" (Final Interview). She further elaborated on how they also **discuss** world problems such as COVID and AIDS. They study the biotechnology behind these issues but also discuss them in class because Irene says, "It's really important to talk to them because it's something that's important nowadays" (Initial Interview).

Reflecting

Growing up outside of the US, Irene found she was stricter than her students were used to. However, she recognized this and adapted to the needs of her students, which can be seen in the following quote:

> I was more strict, I would say, but we learned from each other, and I think at some point, we tried to understand and get the best of each other, so I think that I've changed a lot in my teaching. (Final Interview).

Reflecting on her favorite part of working at an international school, Irene conveyed the story of the school's international festival. She explained that they have an international festival for two days that opens with a flag ceremony. She said, "I love it, it's super emotional!" (Initial Interview). She went on to explain that the seniors walk in carrying the flags of over 50 nationalities from the school, flags from all over. Irene explained

> Everybody is in the same room at the same time when everything else is happening to the world . . . I loved that moment! I think it's, you know, proof that everybody can be together in the same, you know, even with differences. (Initial Interview)

Irene continued to express how much she loved this event and how important it is for their students and families to celebrate their culture and diversity. This event also gives opportunities for teachers to **engage with parents** in a positive, non-traditional way.

When reflecting on the lesson that was observed about obtaining plant cell cultures, Irene stated that the goal of the lesson was to have students demonstrate the **inquiry process** with **hands-on activities** that they had been practicing. There was a high level of **student engagement** during this lab on plant cell cultures; students were focused on the task at hand, and small group conversations were held about the lab. When asked about how she communicates her high level of expectation for this lab, Irene said that students know the skills that she is looking for because of the **rubric** she gives and that she has **scaffolded** the various skills into lessons throughout the school year. This lab also had other culturally responsive moments in how it was assessed. Irene stated,

> After the lab, the next time we meet, I give them the paper, and they will assess themselves and see if they could have done better. And then I check back and say, I noticed you did that or didn't do that. (Post-Observation Interview)

Giving students the opportunity for **self-assessment** encourages students to reflect on their learning.

Regarding Irene's reflection on academic language and how it is promoted in her course, she said she tries to focus on **academic language** in French and English. In response to the question of whether the science elective she teaches is English or French academic language, she said, "We want it to be a combination of both" (Final Interview). By utilizing this strategy, Irene ensures that students are proficient in both languages, and she helps them to navigate academic norms and conventions of each language. Additionally, this strategy not only enriches their academic experience but also prepares them for a more global academic and professional environment.

She reflected back on how the course used to be taught. Irene said that she used to co-teach the class with another teacher so they could split the translation duties. She also said that it was better because the class used to be 90 minutes, and now it was split into 45-minute sessions, which were too short. She further elaborated and said that with the shorter sessions, she did not feel that students had time to go through a whole lab and reflect on it. Now, the students are rushed and have little time to think about what they are doing.

Irene reflected upon the value of her course in giving the students from the two different programs (IB & French Baccalaureate) a chance to interact with each other and see that even though they come from different programs, they are working on similar things. In response to the questions about her teaching a culturally responsive science class, she said

> I think it's good that we are mixing sections in this kind of elective to show them that the French Bac and the IB, it's kind of different. I mean, it's two different paths. But they show the students that actually, you know, we're working on the same thing. (Final Interview)

She also said that the skills they learn in her class are applicable to other courses and in **life**. "Yes, I think they need to know that they can use these skills in science but also in other classes and in life probably too" (Final Interview). In other words, the skills (e.g., analytical thinking, problem-solving, effective communication) they develop in her class have broad applicability. Having a combination of students from the French and International program shows the students that these skills are valuable in multiple contexts and cultural settings.

A summary of the data collected from Irene can be found below in Table 6. The table is organized by CRIOP pillar and how it was addressed through her planning, teaching, and reflection. The evidence and source can be found below the appropriate CRIOP indicator. Grayed-out boxes in the table indicate that that particular indicator and category were not found for that research question.

Table 6

Irene's Summary Data Table

CRIOP CATEGORIES	PLAN	TEACH	REFLECT
CLASSROOM RELATIONSHIPS	CRIOP Indicator: The teacher communicates high expectations for all students.	CRIOP Indicator: Students work together productively.	
	Document- Syllabus Interview- Communicating classroom expectations	Students were observed collaborating and discussing the lab. (Observation)	
FAMILY COLLABORATIONS	CRIOP Indicator: The teacher establishes genuine partnerships with parents/caregivers.	CRIOP Indicator: The teacher intentionally learns about families' linguistic/cultural knowledge and expertise to support student learning.	
	School events- International Day, Gala, etc… (Initial Interview)	"I like to know where they [parents] are from…I realized I had no parents from America…None of us were native speakers of English" (Initial Interview).	
ASSESSMENT PRACTICES	CRIOP Indicator: Authentic assessments are frequently used to determine students' competence in both language and content.		CRIOP Indicator: Students have opportunities for self-assessment.
	Teacher use of rubrics on labs and activities. (Document)		"But with the assessments, we've been really big into differentiation and giving students choice" (Post-Observation Interview).

(*table continues*)

Table 6 (continued)

Irene's Summary Data Table

CRIOP CATEGORIES	PLAN	TEACH	REFLECT
INSTRUCTIONAL PRACTICES	CRIOP Indicator: Students engage in active, hands-on, meaningful learning tasks, including inquiry-based learning.	CRIOP Indicator: The teacher uses instructional techniques that scaffold student learning	CRIOP Indicator: Instruction is contextualized in students' lives, experiences, and individual abilities.
	"I want them to be hands-on" (Interview).	Observation- Modeling skills	"How often have you taken antibiotics in your life? Do you think it's good or bad? We talk about these kind of issues." (Final Interview).
DISCOURSE	CRIOP Indicator: The teacher promotes equitable and culturally sustaining discourse practices.	CRIOP Indicator: The teacher promotes active student engagement through discourse practices.	CRIOP Indicator: The teacher promotes equitable and culturally sustaining discourse practices.
	Document: Syllabus in English and French	Observation: Codeswitching strategy	"We want it to be a combination of both." (Interview)
CRITICAL CONSCIOUSNESS	CRIOP Indicator: The curriculum and planned learning experiences provide opportunities for the inclusion of issues important to the classroom, school, and community.		
	I have talked about the COVID as well. I have a lab where we go to test and see the test for the COVID (Initial Interview).		

Isabella: Identity and Intuition: Foundations of Culturally Responsive Science Teaching

Isabella is Native Hawaiian, Japanese, and Chinese-American. She has 19 years of teaching experience with the following classes: Conceptual Physics, Biology, Anatomy & Physiology, Chemistry, and Biology at the High School level. At the middle school level (grades 6–8), Isabella has taught Biology and Integrated Science. Her educational background is a Bachelor's degree in Natural Science with a Post-Baccalaureate Certificate in Secondary Education. Additionally, Isabella has a Master of Education degree in Educational Leadership. She has lived and taught in the United Kingdom and the United States. Her teaching position is as a middle school science teacher. Isabella enjoys teaching at the middle school level and, at the time of this research, was teaching 6th- and 7th-grade science classes. Isabella speaks English and has beginner proficiency in Japanese, French, and Hawaiian. She is married and has one child. Another key background detail about Isabella is that she was an Olympic athlete and used to compete at an international level.

As a person of color, Isabella is acutely aware of how her race and ethnicity have given her a unique perspective on teaching. Additionally, Isabella feels that it is important to help students of color find their voice and sponsors an affinity group where students and teachers of color can meet to discuss and share their experiences.

The international school where Isabella teaches is located on the east coast of the United States. It is a not-for-profit independent school that serves students from Preschool through Grade 12. The school is comprised of families from 101 countries, with 48% of parents in households originally from outside the United States. For the year of this study, students' racial identity was 55% students of color, 41% students identifying only as White, and 4% preferring not to answer. The school's academic offerings include the IB Primary Years Program in grades

Preschool through Grade 5, Project Zero methods in middle school (Grades 6–8), and the IB Diploma program in 11th and 12th grade. The Project Zero program is a research group based in the Graduate School of Education at Harvard University (Harvard, 2022). Additionally, language learning is emphasized with French or Spanish language immersion in early elementary, and then students study at least two languages through graduation. Many of the families are from fairly affluent backgrounds, and 15% of students receive financial aid from the school. During the interviews, Isabella relayed that the school is highly diverse and embraces a culture of inclusion.

Planning

Isabella stated that her planning for culturally responsive science teaching is organic and also about being cognizant of who is in her classes. She spoke about the varied jobs and careers of the parents and how the varied demographics contribute to the school being international. In addition, Isabella recognizes her students' families as potential sources of expertise since so many of the parents hold high-profile jobs. Rather than shying away from this, Isabella knows who the parents are and **intentionally learns about the families** in an effort to better **collaborate** in their children's learning experiences. Additionally, Isabella knows specific information that the students might have been exposed to in their educational background. An example of this was whether students had knowledge of the metric system. She said,

> There are some students who are foreign but have grown up in the United States and are not used to the metric system. There are other students who grew up outside of the United States and are used to the metric system. (Initial Interview)

Then she explains that another layer of student comprehension of the metric system comes from students who have gone to her school since primary school but may have had a French or Spanish teacher in elementary school who used the metric system. She said, "So it's really

interesting, like just all that they come to the class with, and then you know, because of that, it's easier to teach the metric system" (Initial Interview).

When asked about how she finds out where students come from and what their background experiences might entail, she said that she does use a form at the beginning of the year, but it is more organic and also about how her longevity at the school has helped her to get to know the families. "I've been here long enough where I teach a lot of siblings and know the students" (Initial Interview). Isabella also attributed small class sizes to being able to **establish relationships** with her students and their families. In response to finding out about students, she said, "Most of the teachers do their homework; our class sizes are not so huge that you just get buried with students" (Initial Interview). Isabella also capitalizes on using her students' parents as a potential source of knowledge and expertise. From climate scientists coming into class to discuss climate change to another parent who owned a solar farm for a potential field trip, Isabella views and utilizes the **parents in her community as valuable resources** in teaching science.

Another method of planning that Isabella implements in her classroom is giving her **students choices**. In discussing an energy project that they do in 7th-grade science, Isabella gives students the opportunity to pick which country they would like to focus on. She said,

> Some students are like, oh, I want to do my home country, or, you know, or I like to get to know a little bit more about this. Or, you know, I'm Russian. So let me look at what Russia does as far as energy goes. (Initial Interview)

Isabella also attributed these **instructional practices** to the **global perspective** that lies within the mission of her school. "I think because part of our motto or mission statement is that we want global citizens. We're trying to build global citizens" (Initial Interview). Isabella's school sets up

an atmosphere that allows teachers to specifically address teaching in a culturally responsive manner by emphasizing the importance of the global or international program. She explains

> We're specifically trying to make sure that every unit has kind of some sort of aspect of IDI, so instead of DEI, which is diversity, equity, and inclusion, because this is an international school, we use internationalism, diversity, and inclusion, rather than equity, which is just a different acronym I guess. (Initial Interview)

This quote shows the emphasis that the school and, subsequently, Isabella place on the international aspect of education at their school.

Besides appreciating the international part of her teaching, Isabella also values establishing positive relationships with students. In response to a question about **building relationships** with students, she said, "I appreciate it. I definitely make it a point to show respect for wherever anybody's from, and we **talk** about it. Hey, what do you do in your home country?" (Initial Interview). She further elaborated on this part of her culturally responsive approach when she said, "So I think just setting that tone, like hey, everybody has something to bring to the table like, and just sharing what other people do that makes us more knowledgeable" (Initial Interview).

Since Isabella has taught in international schools for some time, she considers herself to be fairly culturally competent and is able to use examples from her time traveling and living abroad. She gave an example of her ability to do this in a unit on electricity, wherein she discussed different voltages throughout the world and gave examples of overloading circuits or the necessity for converters. She said,

> I tried to plug in my curling iron with the converter, and it blew out, you know? I was like, okay, so when that blew out the electricity, then what did that tell you? Oh, yeah, the circuit was overloaded and not everything is on the same voltage. (Initial Interview)

In regards to her ability to do this in class, she said, "You know, it's just like small things like that that you can bring in just informally" (Initial Interview). Her ability to **contextualize** science into students' lives is based on her cultural competence. Isabella attributes this high degree of cultural competence and knowledge to having taught students from all over the world.

For the curriculum, Isabella said that the school used to use the MYP curriculum but dropped it before she got there. However, they did inherit the units, and teachers were given the autonomy to develop their own curriculum. Since students who graduate from her school only have the option to do IB in their 11th- and 12th-grade years, Isabella does feel that students need to be prepared for the IB. As a Science Department, they have chosen to focus specifically on science skills.

When it comes to helping students navigate complex science discourse, Isabella says she uses **real-world** events that students want to talk about (**discourse**).

> I would like to think there's like a current event that has to do with science that we spend some time in class talking about, whether it's new images of faraway galaxies, the volcanic eruption in Tonga, or anything current, even like COVID or just things that they want to talk about. (Initial Interview)

By using current events and allowing the students to drive the conversation, Isabella incorporates several indicators of being a culturally responsive science teacher. When planning for science class, Isabella shows a degree of flexibility that allows for discussions on current events impacting the world. For instance, when Isabella's students participated in a worldwide school

strike for climate change walkout, they spent class time **talking** about the issue and **different perspectives**. She said

> I ask them what they think about no countries hit their targets that they set at this last conference [United Nations Climate Change Conference]. So, we spent time in class talking about that. Alright, so I guess that's how we help students navigate and access complex scientific discourse. (Initial Interview)

She promotes **student engagement** through **discourse practices** that include conversations about **meaningful science academic content**.

When planning for assessment, Isabella indicates in her syllabus that she uses both **formative** and summative assessments. The use of formative assessments shows that Isabella is practicing CRST by gaining information on students throughout the lesson. She also uses check-ins or reflections to check for understanding, such as the Reflection Worksheet in her Climate Change Packet (Documents). This worksheet was completed after a cap and trade simulation activity about CO_2 emissions. Furthermore, in her course syllabus, she states ,"By providing a wide range of assessments, teachers will be able to see how students are able to demonstrate their understanding in more than one method" (Document). This indicates an assessment practice within culturally responsive teaching that allows students to demonstrate their **learning in multiple ways**. Finally, Isabella plans to assess in a culturally responsive way by using rubrics in her grading practices. Isabella stated that she utilized rubrics in assessments because it let "students know what is expected" (Initial Interview).

In regard to linguistic diversity, Isabella acknowledges that her students have a certain degree of fluency in English; otherwise, they would not be admitted to the school. However, for the few students who may struggle with English, she is not opposed to letting them use their

home language. With Isabella's school being a dual language program, most of the students are multilingual, which she views as an asset in planning for culturally responsive science instruction. She said, "Students that know five or six languages and speak in one way in school have to speak their second languages in several of their classes. And it might be different than their home language. So it's pretty cool" (Initial Interview). In conversation with the computer science teacher, Isabella also observed that her multilingual students are able to pick up new languages, including computer languages. She said,

> They [the students] will approach a new type of computer programming language in the same way that they would a new language. And because they have that system down, programming is a lot easier. They pick it up so quickly. (Initial Interview)

Isabella definitely views the **linguistic diversity** of her students as an asset. Other strategies that she uses for students struggling with language are to have students **work together** and **provide materials** in different languages, such as a Spanish version of the textbook. In reference to students working together, she stated "Usually, there's another student that speaks that language" (Initial Interview). Regarding access to materials, Isabella said

> We use textbooks to supplement what we learned in class. We don't really teach from the textbook, but our textbook is offered in Spanish, as well. So I know there are some students that sometimes use that and toggle back and forth between the electronic English and the electronic Spanish versions. (Initial Interview)

When planning for **linguistic diversity,** Isabella first and foremost embraces that aspect of her students but also has **strategies** in place that allow all students to access and participate in the language they use.

Before beginning a unit, Isabella distributes a packet of materials outlining what students can expect to find in the upcoming unit of study. This packet includes worksheets and activities that the students will complete, informational diagrams, and, most importantly, the driving questions (Big Unit-Long Questions) behind the unit. Table 7 shows an example of one set of Isabella's driving questions and how it was coded for the CRIOP indicators and pillars.

Table 7

Example Coding for Isabella's Climate Change Unit

Isabella's "Big Unit-Long Questions" for Climate Change	CRIOP Indicators (Example)	CRIOP PILLAR
What are greenhouse gases, and how do they contribute to global warming and climate change?	Students engage in active, hands-on, meaningful learning tasks, including inquiry-based learning. (Exploratory learning is encouraged.)	Instructional Practice
How is climate change affecting different people and places around the world?	The curriculum and planned learning experiences integrate and provide opportunities for the expression of diverse perspectives. (Students are encouraged to explore alternative viewpoints.)	Critical Consciousness
How can individuals or the government help reduce the effects of climate change? Is one more effective? How does the social and political atmosphere affect our actions?	Instruction is contextualized in students' lives, experiences, and individual abilities. (Materials and real-world examples are used that help students make connections to their lives.)	Instructional Practices
What are some existing or potential policies enacted by countries (or states)? How do these policies work, and what are the major challenges and successes relating to them?	The curriculum and planned learning experiences provide opportunities for the inclusion of issues important to the classroom, school, and community. (The teacher encourages students to investigate real-world issues related to a topic being studied and to become actively involved in solving problems at the local, state, national, and global levels.)	Critical Consciousness

When planning to teach science, Isabella draws on her indigenous science knowledge, which she learned while growing up in Hawai'i. One example she gave is that "in Hawai'i, the ecosystem goes from the mountain to the ocean, and it basically follows the water from the top

of the mountain all the way to the ocean . . . And it is all about taking care of the land" (Initial Interview). She went on to explain that Hawaiian science doesn't consider the land or water to be something that can be owned. When asked how she learned about the science of Hawai'i, Isabella replied,

> My background, I guess. Just growing up in Hawai'i, that's just how things were. And I was really interested in the science. I didn't study under anybody, but I did a lot of research and talked amongst my other native Hawaiian science teachers about medicines, navigation, farming, irrigation, all of these different things. And, you know, Hawai'i is a very unique place in the world. (Initial Interview)

Isabella brings a different perspective to the classroom, which, in turn, helps to facilitate **academic conversations** that are **genuine** and reflective of her **cultural identity**. By having **discussions** and sharing her Hawaiian culture, Isabella creates a **respectful** and welcoming **learning atmosphere**. Additionally, sharing her linguistic and cultural identity may encourage students from different backgrounds to do the same.

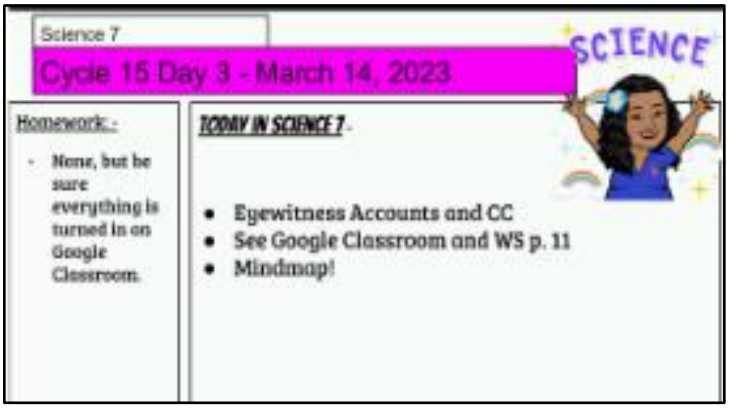
In planning and deliberating for culturally responsive science teaching, Isabella incorporates her background into her classes. While most of it may happen in an informal way, she incorporates stories and knowledge from her Native Hawaiian, Japanese, and Chinese-American heritage. She said, "That's what I bring; I talk about Hawai'i all the time" (Initial Interview). Being a teacher who brings a different perspective and intentionally uses that to facilitate discussion about human differences solidifies Isabella's standing as a culturally responsive science teacher.

Teaching

The teaching observation occurred in a 7th-grade science class. Isabella started the lesson by **greeting students by name** as they entered the classroom. This is an example of Isabella demonstrating an **ethic of care**. She then began the lesson with a Google slide (Figure 5) that had the homework and what they were going to be doing for the day.

Figure 5

Slide for Isabella's Class



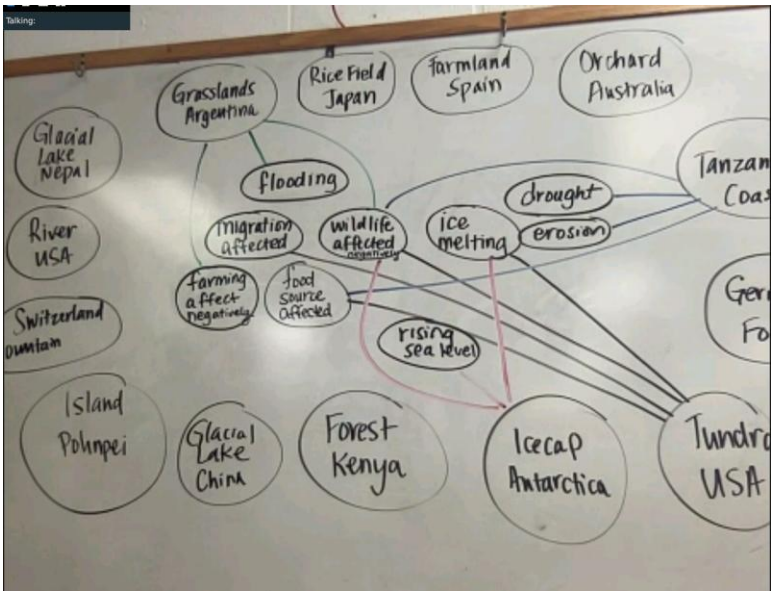
Students seemed excited to hear about some of the things they would be doing on the field trip, like catching and releasing fish to study the biodiversity of the area. One of the ways that Isabella teaches in a culturally responsive manner is by linking the content from field trips and other excursions outside of the school. These field trips are examples of **inquiry-based learning** that are relevant to their **local community**. Isabella explained that they would do water quality testing on a stream near the school and then compare it to the Potomac River, where they would take water samples on the excursion (Observation). Students are able to see water conservation in action as this area used to be a dead zone and now can support life.

After outlining the upcoming field trip, Isabella started the science lesson on climate change by sharing a document of eyewitness accounts. During this initial part of the lesson, Isabella gave **students the option** to pair up or work on their own but explained that they would have to **work cooperatively** to cover all the accounts in the lesson. Isabella also gave students ownership of their learning by allowing them to choose which part of the world their eyewitness account was from. Almost like an auctioneer, Isabella set about having students select which country or region they would like to cover. She said such phrases as "Who would like the Glacial Lake in Nepal?" "What about the Grasslands of Argentina?" and "So, Jimmy and Fred are going to both work on the forest of Kenya" (Observation). Once again, the students were **excited** and **engaged** with the lesson.

Additionally, the content of the lesson was itself an example of culturally responsive materials as the eyewitness accounts were stories from all over the world about people in different countries dealing with the effects of climate change (e.g., drought, severe weather, glacial melt, ocean temperatures). Not only did these accounts develop students' **academic language,** but also had a degree of **critical consciousness** as they read about real-world problems from all over the globe. This lesson also showed the development of **discourse** in Isabella's class. One student said, "The Tanzanian coastline is being affected by drought, erosion, and overfishing, and this affects the wildlife and food sources for humans" (Observation). This example shows how students are able to practice their **linguistic competence** through the use of scientific terminology. After students gave a quick synopsis of their person, country, and the effect of climate change, Isabella helped students build their mind maps by modeling one as a class. An example of the partially finished map can be seen in Figure 6.

Figure 6

Mind Map From Isabella's Class



Many of the countries used were countries that students were from or had visited. Isabella was intentional about her selection of these global locations and used her own cultural competence to navigate these various locations throughout the globe. For instance, at one point, a student said something about the wildlife being affected by climate change and specifically mentioned cranes. Isabella said, "Okay, yeah, that is definitely wildlife affected because the cranes are coming and leaving earlier. Right, and aren't cranes a sign of prosperity in that country?" (Observation). Isabella pulls in a bit of knowledge about a country, and students are able to realize a **different perspective** and participate in **culturally sustaining discourse**. Additionally, **respect for one another and other populations** was evident during the case scenario read aloud.

As a Native Hawaiian, Isabella often incorporates real-world issues that are situated in Hawai'i. For example, she talked about the controversial issue of scientists building a 30-meter

telescope on top of the dormant volcano Maunakea. She said, “Maunakea is a pretty sacred place to Native Hawaiians, except the state of Hawai’i allowed companies, universities, whatever research people to build telescopes up there, but there’s no oversight” (Initial Interview). Isabella brought the attention of her students to this issue so that they could question who benefits from this progress in science and whether it is worth desecrating sacred land. This is an ideal example of Isabella challenging her students to utilize their **critical consciousness**. She also utilizes other examples to **confront biases** and express **diverse perspectives,** such as the case of Henrietta Lacks. “We talked about Henrietta Lacks and how they got her tissues and how it has spearheaded a lot of medical breakthroughs. But did her family benefit from that? Absolutely not. So hopefully, there are reparations” (Initial Interview).

In regards to assessment, Isabella said that they often incorporate different aspects of Project Zero. Project Zero is an education research project out of the Harvard Graduate School of Education (Harvard, 2022). Isabella said,

> So with Project Zero, it’s all about feedback, or gallery walk, or, you know, there’s a lot of thinking routines that students are already well versed in. So, for example, we’re going to analyze or do a gallery walk, and you’re going to walk around and stick Post-It notes and ask questions about another student’s projects. (Initial Interview)

When students are able to **demonstrate their learning in different ways** and give each other **feedback,** these are all examples of culturally responsive assessment practices. Isabella went on to say,

> But with the assessments, we’ve been really big into differentiation and giving students choice. I think when we give students a choice on what either their project is on, or how

> their product is done, and how they show their understanding, I think it helps with the diversity piece. (Initial Interview)

Students are given parameters to work within, which embeds some **authentic tasks** within their projects.

Reflecting

When reflecting on her experiences with culturally responsive teaching, Isabella said, “So I think yes, culturally responsive teaching is something that I just do. I don’t think it’s intentional. Like, oh, let me throw some culturally responsive teaching in; I think it’s just instinctual” (Final Interview). On further reflecting on why she became an international educator who values culturally responsive teaching, Isabella attributes much of her influence to her diverse background. She said,

> I think because I come from a diverse background, not necessarily international, even though I’ve taught internationally and traveled internationally. I mean, it has a lot of influence on why I teach at an international school and why I teach abroad. Because from when I was a junior national athlete, I was traveling and training, you know, like various places in the world, like Japan or France. (Final Interview)

Isabella was referring to her time as an Olympic athlete in Judo. She said that she loved traveling, and her experience in the Olympics made her want to continue learning about new places and cultures.

> When you go through things like that, you meet a lot of people from all over the world, you get to go to a lot of different places, and you just kind of see how, you know, it’s not the same as where you’re from. And that’s okay. That’s how other people do things. Not everybody does the same thing you do. (Final Interview)

Isabella went on to say, “That’s what kind of fueled my love for being an international educator” (Final Interview). She is also very humble in her reflection and values her own background experiences, which was evident when she said

> It’s been pretty cool, that part of my life. I would probably still be in Hawai’i, and that wouldn’t be a bad thing. But I was lucky enough to kind of get to experience, you know, things outside of my small little island in the middle of the Pacific. (Final Interview)

As previously mentioned, Isabella utilizes her own culture and background in the classroom. She is an ambassador for Native Hawaiian values and knowledge. Isabella values this role and appreciates the culturally sustaining relationships that she has built. “Yeah, there are so many things that kids ask me about Hawai’i. I think it’s, it’s kind of cool because, like, you know, they’re interested” (Final Interview).

An indicator of Isabella’s ability to promote **linguistic diversity** and **discourse** with her students came from sharing at an assembly. The middle school has a theme during the year through which teachers are encouraged to connect their learning. Isabella said that last year, the theme was water, and students were encouraged to share the word for water in their mother tongue. Isabella said the students were proud of sharing their culture. She went on to say, “Having students be a part of that assembly and what you’re teaching, even when it’s language. I think it helps them connect” (Final Interview).

When reflecting on her instructional practices in science, Isabella felt that teachers have to be able to adapt and keep the **content relevant** to students. She said, “I think that the biggest part of being a teacher is just being able to adapt to what’s happening. In your classroom, what’s happening with your content, especially with science? You’re not going to be able to teach the

same, you know, exact lesson from twenty years ago" (Final Interview). Isabella elaborated on this point and said

> Science is dynamic, and it's constantly changing, and science teachers want to keep it relevant, like what is happening in real life. And that's, I think what draws students in is what's actually happening now. And how is this relevant to what I need to know as a person and individual? (Final Interview)

These reflections show Isabella's abilities to contextualize science into students' lives and to base their learning on what is relevant and of interest to them.

Isabella referred to teaching in international schools and the spaces where she and her students' ideas came together in a third space outside of the normal teacher-student communion. "It's like a third culture, right? It gives students **knowledge about other places** in the world that they wouldn't be exposed to if they were at your typical American public school" (Final Interview). It is clear that working at an international school encourages teachers to be culturally responsive educators.

Isabella commented on how the school encourages teachers to reflect by looking back at unit plans and asking, "When did you take into account **other perspectives**?" (Initial Interview). Rather than always reflecting on the lessons from a dominant group perspective, teachers are encouraged to reflect on other viewpoints and experiences thereby targeting students who would otherwise not be included in the learning of science. This approach to education allows all students and teachers to feel validated and culturally respected.

During the post-observation interview, Isabella reflected on how she hadn't ever truly defined what culturally responsive teaching looked like in her classroom until she was given the opportunity to think about it for this study. She said,

> Until I had to talk about this, I didn't really know, and it's hard to define what it is. The value that is added to your lessons when we [students and teachers] share [experiences]. It kind of snowballs. I think it helps students kind of get a perspective other than the American perspective. (Interview)

Showing understanding and appreciation for her students' **background experiences** allows Isabella to build on those experiences. Additionally, she is able to connect the learning to **global perspectives** and base it on **real-world situations,** such as the climate change case scenarios from all over the world.

In Isabella's final interview, she spoke extensively and excitedly about the work she does with her middle school science students. The school had just taken mini-trips in the area, and Isabella could concentrate on climate change issues in the news. When asked about strengths and weaknesses in dealing with students from diverse backgrounds, Isabella responded

> Yeah, I'm never the center of the conversation or the kind of the default, right? Because whiteness is centered or the mainstream is centered in a lot of the conversations when we talk about science, but I guess just being a person from a diverse background myself, I think I didn't really think of it this way, but I think that adds to kind of a strength of mine to just be able to empathize or understand where other people are coming from. (Final Interview)

Besides recognizing her cultural identity as a strength, Isabella also saw her background experiences of travel and living abroad as contributing to her being open-minded and flexible in her thinking. She said, "My mindset is important to understand other perspectives" (Final Interview). Additionally, she commented that it was essential to help students develop a similar mindset in their progression into becoming global citizens.

A summary of Isabella's data can be found in Table 8. The table is organized by CRIOP pillar and whether it addressed the plan, teach, or reflect research questions with the evidence and source found below the appropriate CRIOP indicator.

Table 8

Isabella's Summary Data Table

CRIOP PILLARS	PLAN	TEACH	REFLECT
CLASSROOM RELATIONSHIPS	CRIOP Indicator: The teacher demonstrates an ethic of care (e.g., equitable relationships, bonding).	CRIOP Indicator: Students work together productively.	CRIOP Indicator: The teacher creates a learning atmosphere that engenders respect for one another and toward diverse populations.
	"...everybody has something to bring to the table like, and just sharing what other people do that makes us more knowledgeable." (Initial Interview)	Throughout climate change discussion and mind-mapping, students were encouraged to work together and view each other as resources. (Observation)	The teacher affirms students' language and cultural knowledge by integrating it into classroom conversations. (Observation)
FAMILY COLLABORATIONS	CRIOP Indicator: The teacher intentionally learns about families' linguistic/cultural knowledge and expertise to support student learning.	CRIOP Indicator: The teacher encourages parent/family involvement.	CRIOP Indicator: The teacher establishes genuine partnerships with parents/caregivers.
	"Because of where I am at [blinded] school, sometimes I have [blinded] parents, parents that work at the University and are scientists." (Initial Interview)	"I have a unit in seventh grade on that [climate science] and we would love to have you [parent climate scientist] in" (Initial Interview)	"I've been here long enough where I teach a lot of siblings and know the families." (Initial Interview)

(*table continues*)

Table 8 (continued)

Isabella's Summary Data Table

CRIOP PILLARS	PLAN	TEACH	REFLECT
ASSESSMENT PRACTICES	CRIOP Indicator: Students are able to demonstrate their learning in a variety of ways	CRIOP Indicator: Formative assessment practices are used that provide information throughout the lesson on individual student understanding.	CRIOP Indicator: Students are able to demonstrate their learning in a variety of ways
	"By providing a wide range of assessments, teachers will be able to see how students are able to demonstrate their understanding in more than one method" (Document)	Students voiced learning throughout the lesson. The teacher utilized Google Docs to assess student learning. (Observation)	I think when we give students a choice on what either their project is on, or how their product is done, and how they show their understanding…" (Interview).
INSTRUCTIONAL PRACTICES	CRIOP Indicator: Students have choices based upon their experiences, interests, and strengths.	CRIOP Indicator: The teacher creates a learning atmosphere that engenders respect for one another and toward diverse populations.	CRIOP Indicator: Instruction is contextualized in students' lives, experiences, and individual abilities.
	"We do country energy projects, where we look at what are the main sources of energy, renewable and non renewable energy, that different countries use. And then some students are like, oh, I want to do my home country, or, you know, or I like to get to know a little bit more about this. (Initial Interview)	Teacher modeling and reinforcing effective interactions. (Observation)	"Science is dynamic, and it's constantly changing, and science teachers want to keep it relevant, like what is happening in real life. And that's, I think what draws students in is what's actually happening now. And how is this relevant to what I need to know as a person and individual?" (Final Interview)
DISCOURSE	CRIOP Indicator: The teacher promotes equitable and culturally sustaining discourse practices.	CRIOP Indicator: The teacher promotes active student engagement through discourse practices.	CRIOP Indicator: The teacher provides structures that promote academic conversation.

(*table continues*)

Table 8 (continued)

Isabella's Summary Data Table

CRIOP PILLARS	PLAN	TEACH	REFLECT
	Wait time and turn-taking during observation (Observation).	The teacher employed a read-aloud and discussion during the climate change scenarios. (Observation)	Teacher prompted students to elicit different viewpoints. (Observation) "Everybody should have a seat at the table…" (Final Interview)
CRITICAL CONSCIOUSNESS	CRIOP Indicator: The curriculum and planned learning experiences integrate and provide opportunities for the expression of diverse perspectives.	CRIOP Indicator: The curriculum and planned learning experiences provide opportunities for the inclusion of issues important to the classroom, school, and community.	CRIOP Indicator: The curriculum and planned learning experiences incorporate opportunities to confront negative stereotypes and biases.
	Climate Change Student Packet (Document)	Climate change case scenarios from all over the world for global citizens. (Observation)	"You have to let go of like a lot of your biases. You have preconceived notions about certain groups, ethnicities, nationalities, and cultures, and you just have to let go of those because, you know, it's a stereotype. And I think doing that helps out a lot." (Final Interview)

Cross Case Analysis

Each case study was examined using the CRIOP as an analytical framework to identify culturally responsive teaching attributes. While each participant is different and unique, there were some commonalities that existed among their teaching practices and attitudes toward culturally responsive teaching in science. Comparisons of each of the CRIOP categories are divided into sections below. Each category section has CRIOP indicators *italicized* to thoroughly compare and contrast the participants in relation to that CRIOP category or pillar. Furthermore, there is a table at the end of each section that compares the indicators and gives evidence of

which research question (plan, teach, or reflect) it addressed. If a specific CRIOP indicator is not mentioned or represented in the table for a participant, that does not mean that indicator is not present for that teacher but it was simply not accounted for during this study.

Category 1: Classroom Relationships

One of the culturally responsive indicators for classroom relationships is the *teacher demonstrating an ethic of care for their students*. As can be seen in Table 9, all three participants demonstrated this in the planning and teaching aspects of culturally responsive teaching. Whether it was Helen relating her **relationship building** with students through discussions in the hallway or Isabella acknowledging that each student has something "to bring to the table" (Initial Interview), all three participants clearly value students and the relationships that they establish with them. Irene was especially competent at differentiating her interactions with **linguistically diverse** students. She knew all the students' names and, depending on their home language, was able to communicate with them effectively in French or English. Isabella clearly had strong relationships with her students based on her willingness to share her personal experiences. By sharing her background of growing up in Hawai'i and her travels as an elite international athlete, Isabella is able to **bond** with her students.

The *teacher setting high expectations for all students* is also a CRIOP indicator of classroom relationships that was expressed by all three participants. Irene and Helen, who both teach at the high school level, were more explicit about the high expectations for students. Irene communicated high expectations for her students and wanted to provide academic excellence in an international environment. Helen's expectations stemmed from her adherence to the MYP curriculums. She believed that communicating these high expectations to her students helps them to be successful in the challenging curriculum. While Isabella has no less expectations of her

middle school students, she relayed those expectations in a grade-appropriate manner through her classroom expectations and the goals she has for students.

Isabella and Helen had indicators for *a classroom environment that engendered respect for one another and toward diverse populations*. It was especially evident during Isabella's lesson on climate change that there was respect and appreciation for different cultures from the case scenarios that were read aloud. Additionally, Isabella encouraged students to share their stories about **cultural identity** and different places they had lived throughout the world. Meanwhile, Helen's "hands from around the world" throughout her classroom celebrated each student's cultural identity.

The final indicator for the classroom relationships pillar is that *students work together productively*. This was evident in all three participants' observations, and Irene referred to students working together during her interview. Additionally, students were encouraged to view each other as **resources** and to have engaging **conversations** related to the lab or activity in class.

Table 9 shows that Helen and Isabella had classroom relationship indicators throughout all components in the cycle of instruction (i.e., plan, teach, reflect), whereas Irene had these indicators in the planning and teaching portion but not in the reflection portion.

Table 9

Comparison of Classroom Relationship Indicators

Participant	Classroom Relationship Indicators	Plan (P) Teach(T) Reflect (R)
Helen	● Informal relationship building	P-T-R
	● Respect for diverse populations	T-R
	● Students work together	T
Irene	● Language/Linguistic diversity	T
	● Students work together	P-T
Isabella	● Sharing personal experiences/background	P-R
	● Knowing names and personal history.	P-T-R
	● Respect for diverse populations	P-T-R
	● Students work together	T

Category 2: Family Collaboration

In regards to the CRIOP indicator of *teachers establishing genuine partnerships with parents,* all three participants had evidence of this in their interviews. Irene used school events to establish partnerships with parents and families. She relayed the story of a parent night where she was talking with the parents about her Biotechnology class, and they all figured out that only one of them was from the United States (Initial Interview). She said this bonded them together and let her know that most of her students were from other parts of the world, like herself. As can be seen in Table 10, Helen utilizes her role as a fellow parent to **understand families** in nontraditional settings but is also cognizant of maintaining professional boundaries. Before and during parent-teacher conferences, Isabella takes the time to get to know her students and their families. She is especially aware of what the parents at her school do for careers, as many of them are in high-level government, academic, or business positions. In turn, Isabella *encourages parent involvement,* especially when it relates to science.

Table 10

Comparison of Family Collaboration Indicators

Participant	Family Collaboration Indicators	Plan (P) Teach(T) Reflect (R)
Helen	● Non-traditional settings (e.g., swim meets)	P-R
	● Values differences in culture	P-T-R
	● Utilizing her role as a parent	P-R
Irene	● Traditional settings (e.g., parent-teacher conferences)	P
	● Linguistic expertise	P
Isabella	• Knowledge of families (e.g., parent careers, countries lived in)	P-T-R
	• Encourages family involvement (e.g., climate scientist parent speaker)	P-R
	• Established relationships within the school community	P-R

Category 3: Assessment Practices

With respect to assessment, both Helen and Isabella used a great deal of *formative assessments* in their science classes. Consistent use of formative assessments, along with other indicators for assessment practices, can be seen in Table 11. Helen felt that the MYP program gave her structure for that formative work and for students to be able to identify what they need to work on. Isabella's use of formative assessments could be seen throughout the materials and documents she used in her course (e.g., syllabus, worksheets)

To some degree, all three educators were found to give students the *opportunity for self-assessment*, wherein students were able to evaluate their work based on a determined set of criteria. These criteria were usually found in the form of a **rubric** that included preestablished expectations for the students. Since Irene's class was skills-based, the predominant percentage of a student's grade came from a skills rubric that she used throughout the course. The class activities were designed to help the students achieve the various skills found on the rubric and were published in both French and English. The rubrics represent a **task-embedded assessment**

that Irene used frequently in her class. Helen's assessments were based on rubrics, and she communicated to the students that the standards in the rubric were what they were consistently working towards. Isabella and Helen also utilized the rubrics for peer assessment as well as *self-assessment*. An example of this was when Isabella used reflection activities and thinking routines to look back at projects and assignments. In Helen's case, with older students, she could use rubrics for self-assessment in labs where students had to reflect and troubleshoot on their own. This use of rubrics is an indicator that *authentic assessments are used to determine students' competence*.

Isabella also drew a parallel between student choice on assessments and diversity when she said that student choice on assessments helped with meeting the diversity emphasis that her school focused on. All three participants clearly utilized authentic assessments that are culturally responsive in nature but do so with different emphases that are age-appropriate and course-specific.

Table 11

Comparison of Assessment Practices Indicators

Participant	Assessment Practices Indicators	Plan (P) Teach(T) Reflect (R)
Helen	● Making test language accessible	P-T-R
	● Giving students a choice in the final product	P-R
	● Consistent formative assessment practices	P-T-R
	● Use of rubrics	P-T-R
Irene	● Authentic assessments	P
	● Task-Embedded Assessments	P-T
	● Opportunities for students to self-assess	R
Isabella	● Giving students choice in final product	P-T-R
	● Uses multiple assessment methods	P-R
	● Consistent formative assessment practices	P-T-R
	● Use of student goals for learning	P-T-R

Category 4: Instructional Practices

There are five indicators in the CRIOP for the instructional practices pillar. As can be seen in Table 12, all three participants showed three of the five indicators in this study. The first indicator that all three met was that *students engage in active, hands-on, meaningful learning tasks, including inquiry-based learning*. An example of this was when Irene stated the importance of hands-on activities in her biotechnology course. Another example of meeting this indicator was the ruler drop lab observed in Helen's 10th-grade classroom. While Isabella mentioned several lab-type activities, there was also the upcoming field trip where students were going to be doing water testing nearby. These types of activities qualify as not only **hands-on** but also inquiry-based and connect students to the **local community** and environment.

The second indicator that all participants met was the *teacher uses instructional techniques that scaffold student learning*. Isabella showed this technique in multiple ways during her observation when she used visual aids, reviewed vocabulary, and chunked or grouped the material together in the read-and-discuss portion of the class. Both Irene and Helen used modeling to scaffold learning in their lab settings to explain and demonstrate the necessary skills and procedures. Helen modeled several methods for conducting the ruler drop lab in her class. During Irene's lesson on plant cell cultures, she modeled the skills of preparing plant cultures and sterile techniques.

Contextualizing instruction in students' lives is the last indicator that was found in all three participants. This was highly evident during Helen's observation when she continuously prompted them to relate their study of the nervous system to their own experiences. Meanwhile, Irene referred to discussions about student use of antibiotics and the COVID-19 virus in her biotechnology class. Isabella was especially adept at contextualizing for students who had lived

abroad and experienced life in other countries. For instance, in the curling iron example during the discussion on electricity, she relayed the story of using different voltages in Europe during her travels. Isabella knew that most, if not all, of her students had traveled or lived abroad and could relate to the story.

One of the CRIOP indicators that two of the participants showed was about *the teacher developing students' academic language*. Helen had evidence of this in her classroom, where she utilized a word wall to reinforce science vocabulary and content. Meanwhile, Isabella addressed academic language in her climate change packet, where students were expected to investigate terms such as greenhouse gases.

The second indicator that was met by two of the three participants was *students having a choice in their learning based on their experiences, interests, and strengths*. This was evident when Isabella gave her students a choice on which part of the world they would like to focus on during their 7th-grade energy project. She further explained that this helped to develop the students into global citizens when they were able to focus on other parts of the world that interest them. Helen implemented this strategy by giving her students a choice in a major project and allowing them to select which variable to change in the ruler drop lab.

Table 12

Comparison of Instructional Practices Indicators

Participant	Instructional Practices Indicators	Plan (P) Teach(T) Reflect (R)
Helen	● Inquiry-based learning (e.g., labs)	P-T-R
	● Lessons are contextualized in students' lives	P-T-R
	● Develops academic language (e.g., Word Wall)	P-T
	● Student choice in lessons	P-T-R
Irene	● Hands-on learning (e.g., skill-based activities)	P-T
	● Used modeling to scaffold skills in labs	T
	● Content contextualized in student lives	T-R
Isabella	● Student choice in lessons	P-T-R
	● Used modeling during mind mapping activity	T-R
	● Lessons are contextualized in students' lives	P-T-R
	● Hands-on learning (e.g., field trips, labs)	P-T-R
	● Develops academic language (e.g., sentence starters, visible thinking routines)	P-T-R
	● Use of graphic organizers (e.g., mind map)	T

Category 5: Discourse

Most of the four CRIOP indicators for discourse were observed from all three participants in this study and evidence of this can be seen in Table 13. For the indicator of *the teacher promoting active student engagement through discourse practices,* students in Helen's class were encouraged to participate in the call and response at the beginning of class when Helen threw out a stuffed hedgehog to the students who had permission to talk. Irene encouraged students to participate in discussions during her science class when she modeled the use of multiple languages. The read-aloud and subsequent discussion in Isabella's class were examples of this indicator.

Multilingualism was encouraged in all of the classrooms, and this is an example of the *teacher promoting equitable and culturally sustaining discourse practices*. Equitable participation and wait time were evident in the observations of all three participants' classrooms.

As previously mentioned, Irene's classroom was a cacophony of bilingualism throughout the lesson. Students spoke in their home language when it was appropriate to do so.

During the mind map-building portion of Isabella's observation, she provided several prompts that elicited different viewpoints, which provided a structure that *promoted academic conversation*. Helen accomplished academic conversation through genuine discussions about the nervous system she used to start class. The structure of Helen's class allowed students to engage in extensive discussions and delve into the content they were studying.

Providing opportunities for students to develop linguistic competence is the final indicator in the discourse pillar. This was evident in all three participants to varying degrees. The use of formal academic language was evident in Helen's class as students discussed the validity of the trials being conducted in their lab (Observation). Students in Isabella's class were called upon to use proper use academic language in their summary of their climate change scenarios. In Helen's class, students were given opportunities to use language about the lab in meaningful, authentic ways.

Table 13

Comparison of Discourse Indicators

Participant	Discourse Indicators	Plan (P) Teach(T) Reflect (R)
Helen	● Student engagement through discourse	P-T-R
	● Academic conversation (e.g., nervous system)	P-T-R
	● Equitable and culturally sustaining discourse (e.g., home language, Latin-based words)	P-T-R
	● Wait time and all students having opportunity to speak	P-T-R
Irene	● Bilingualism was encouraged	P-T-R
	● Codeswitching	T-R
	● Small group conversations encouraged	P-T-R
Isabella	● Student engagement through discourse	P-T-R
	● Equitable and culturally sustaining discourse	P-T-R
	● Academic conversation with different viewpoints	
	● Academic language in meaningful context	P-T-R
		P-T-R

Category 6: Critical Consciousness

The first indicator of the critical consciousness pillar is that *the curriculum and planned learning experiences provide opportunities for the inclusion of issues important to the school and community*. As seen in Table 14, all three teachers displayed this criteria and relayed that the very nature of these international schools is inclusive and by their very nature promotes a closely bonded community driven towards educating the global citizens of tomorrow. As previously quoted, Irene referred to the philosophy of the school as being important for the inclusion and tolerance of students from all backgrounds. In the case of Isabella, her students take part in learning experiences through field trips to local areas to investigate real-world issues such as the effects of pollution and climate change on waterways. The MYP drives the curriculum experiences that allow Helen's students to explore contemporary issues at an international level.

For the second indicator focusing on *learning experiences that incorporate the opportunities to confront negative stereotypes and biases*, two of the three teachers displayed these indicators. Helen discussed addressing biases in science in reference to women. She also mentioned that when talking about groups that are underrepresented, she was able to address stereotypes and preconceived notions. Both teachers take time in their own way to confront stereotypes and biases in their classes.

The final indicator, again met by two teachers, in the critical consciousness category is the *curriculum and planned learning experiences integrate and provide opportunities for the expression of diverse perspectives.* It is clear that Isabella encourages her students to express and even embrace their diverse perspectives. During her climate change lesson, students were encouraged to explore alternative viewpoints from various parts of the world. Isabella relayed that her school emphasizes the expression of diverse perspectives and even has a place for teachers to document when they take into account other perspectives. Besides encouraging students to challenge the ideas that they are studying in class, Helen also uses examples to add diversity and a global perspective. Helen also referred to the responsibility of talking about sex and gender determination in her biology classes. She said that the school promotes the use of "he, she, and they pronouns" but that she has to be careful around the conversation about sex determination in biology class because of how certain parents might perceive it.

Table 14

Comparison of Critical Consciousness Indicators

Participant	Critical Consciousness Indicators	Plan (P) Teach(T) Reflect (R)
Helen	● Curricular experiences important to school and global community	P-T-R
	● Confrontation of negative biases	T-R
	● Diverse perspectives encouraged	P-T-R
Irene	● Curricular experiences important to school and global community	P
Isabella	● Diverse perspectives encouraged	P-T-R
	● Curricular experiences important to school and global community	P-T-R
	● Confrontation of negative biases	P-T-R

CHAPTER V

DISCUSSION

This dissertation explored the practices and reflections of international school science teachers in relation to planning, teaching, and reflecting on culturally responsive science instruction within diverse classrooms. Additionally, the study examined the potential use of the CRIOP as an analytical framework for culturally responsive teaching practices. The study found that while international educators may consider their practices to be culturally responsive, how they manifested these practices in their teachings varied substantially and was impacted by other practical forces such as curriculum. The findings illuminate several insights into how these educators approach the complex task of addressing cultural diversity in their science teaching.

This study adds to the existing literature on culturally responsive science teaching practices and answers the call for additional research on culturally responsive teaching knowledge, behaviors, and dispositions (Atwater et al., 2010; Hernandez et al., 2013). This research is contributing to the field of science education through its approach and sample of teachers. Working with a small niche of teachers in United States-based international schools allowed for the research to focus on culturally responsive teaching with diverse student bodies.

Discussion of the Findings

In this research, the researcher endeavored to deepen the understanding of how science teachers at three United States-based international schools used culturally responsive teaching practices to meet the needs of their highly diverse student populations. Interviews and observations were conducted to examine how international school science teachers planned, taught, and reflected upon their experiences in the classroom. The findings from Chapter 4 are

further expounded upon here in reference to each research question, followed by limitations of research, implications for practice, future research, and a conclusion.

Research Question #1

Research Question #1 is: How do international school science teachers (ISSTs) deliberate and plan for teaching culturally diverse student populations?

The international school science teachers in this study demonstrated a nuanced approach to planning for culturally diverse classrooms through a variety of strategies that reflected an awareness of their students' diverse backgrounds and needs while balancing this with the school curriculum demands. Effective planning included the consideration of cultural contexts and school climate through a global perspective in making the science curriculum accessible and engaging for all students.

Findings from this study indicated that teachers view planning for culturally responsive teaching to be unintentional and organic in nature. In other words, CRST is not something that the participants deliberately set out to do or specifically identified in their planning. Finding out about students and their culture was viewed as a natural part of their teaching. The organic, nuanced approach that teachers took to culturally responsive science teaching is indicative of teachers approaching culturally responsive teaching as a perspective or stance toward teaching, not a focus for specific parts of the year or unit of study (Ebersole et al., 2016).

Previous studies on culturally responsive science teaching have had an intervention of some sort (Johnson, 2011; Laughter & Adams, 2012) or been based on professional development (J. C. Brown & Crippen, 2016). However, this study was a snapshot of practicing teachers who had not had any formal or informal training on culturally responsive teaching. Besides hearing a researcher-generated definition of culturally responsive teaching at the onset of the initial

interviews (i.e., Culturally Responsive Teaching: a pedagogy that uses students' customs, characteristics, experiences, and perspectives as tools for classroom instruction.), these teachers were left to formulate their own opinions and deliberations about CRST.

Context of International Schools on Planning

While the teachers were presented with the researcher-defined concept of culturally responsive teaching, they had their own interpretations based on the context of working in international schools. There were indicators that the way some of these teachers view CRST does not match that of the literature (Gay, 2010; Rodriguez, 2015). For instance, one of the participants indicated that she was a culturally responsive educator because she worked at an international school, as if the circumstances and environment dictated that she be culturally responsive. While the intention of being a culturally responsive teacher is there, it may do more harm than good if teachers do not critically examine their approach to teaching students from different cultures (Evans et al., 2020). Another participant indicated that how she approached culturally responsive teaching would change depending on whether she was teaching in her home country or not. This begs the question of how teachers may or may not assume a degree of cultural understanding based on their teaching location and how familiar they are with that community. Furthermore, this raises the important issue of how teachers' assumptions about cultural understanding are influenced by their location and by the environment of international schools in which they work.

A large portion of teachers' planning for culturally responsive teaching is considered the type of school in which they are employed, that is, the international school. The context or ecological perspective (Priestley et al., 2015) in which teachers work is important when it comes to being a culturally responsive educator (Min et al., 2022). The school environment and ethos at

these international schools are focused on valuing and incorporating a global perspective. Whether the school mission targets "global citizenship," or the teacher incorporates global perspectives in a climate change project, they are all culturally responsive components that extend the learning beyond the school community. This emphasis on global perspectives provides opportunities for diverse perspectives and the feeling of belonging to the world at large. Research indicates that a diverse student body is essential for fostering international mindedness (Belal, 2017), and this principle may also apply to international science teachers who seek to implement culturally responsive teaching to address the needs of their varied students. This study contributes to the knowledge base on how teaching through a global lens can be used as an asset to foster culturally responsive teaching and enhance teaching for diversity (Hattam, 2018; Tichnor-Wagner et al., 2017). The school's mission and ethos were mentioned on several occasions as impacting the teachers' planning choices. Additionally, these schools are expected to function at a high academic standard, and therefore, teachers automatically communicate this expectation to all their students. Challenging work is the norm, and teachers have high expectations for student learning.

Factors Impacting Planning Agency

Several factors impact teachers' agency toward planning culturally responsive instruction. One factor that aligns with previous research is support from administration (Min et al., 2022; Minkos et al., 2017). In this study, support from the administration took different forms, such as encouraging teachers to scrutinize how the curriculum involved different perspectives, forming affinity groups for teachers of color, and creating opportunities for place-based learning. Furthermore, culturally responsive teaching was possible within these schools because of a school-wide narrative of appreciation for diversity (Hattam, 2018).

Another factor that leads to teachers being able to plan culturally responsive instruction is the autonomy that teachers are given to plan their lessons. From Irene creating her own course to Isabella being able to plan and conduct field trips and experiences that enhance the science lessons, the degree of teacher autonomy allowed them to incorporate culturally responsive practices and strategies (Barron et al., 2021; Min et al., 2022; Pantić, 2015). The findings from this study support the literature that espouses teacher autonomy as a factor that promotes culturally responsive teaching (Min et al., 2022).

Connections to People While Planning

When discussing how they plan for CRST, participants cited connections to people through their knowledge of demographic details (i.e., nationalities, socio-economic status) about students and their families as well as background experiences (i.e., travel, other schools) that students bring to the classroom. Each participant gathered information on their students in different ways, both formal (i.e., forms, information cards) and informal (i.e., discussions, parents, events). For teachers to address the learning of students in a culturally diverse classroom, they must learn about the different aspects of their students in order to teach in a culturally responsive manner (Kozleski, 2010; Mensah, 2011; Powell et al., 2016). However, all of the participants felt that their approach to gathering information about students was casual and a natural part of teaching. The teachers in this study were not deterred by the high level of diversity and seemed to embrace it. This adds to the literature by recognizing that teachers must go beyond merely developing an appreciation of diversity to genuinely embracing it. Teachers were cognizant that part of establishing relationships is getting to know their students, but they were also aware that they were not being too intrusive.

In addition to establishing positive relationships with students, it was evident that participants valued relationships with students' parents and families. These connections with students and parents play a crucial role in forming and enhancing their planning for instruction. For the most part, international schools are close-knit communities (Michetti et al., 2015), which may in turn make the process of connecting with families easier. In addition, the teachers in this study also valued the linguistic and cultural diversity of parents and how the parents might contribute to the classroom environment through their own expertise as scientists or professionals. Viewing parents and families as assets to science learning helps to build strong, culturally responsive partnerships (Amatea, 2013; Bottoms et al., 2017). In this study, Isabella regarded parents as valuable assets to the learning process and leveraged their expertise by inviting those with science-related professions to serve as guest speakers. This study adds to the literature on establishing positive relationships with families and leveraging parent expertise in culturally responsive science teaching. While parent involvement in school may change as students get older, it was evident that the secondary teachers in this study viewed families as assets and valued positive relationships.

Planning for Assessment

When planning for assessment and instruction, the teachers in this study were open to various methods of how students could display their learning or mastery of the content. Some of the culturally responsive methods employed included but were not limited to student choice in their end product, consistent use of rubrics, self-assessment, and informational formative assessments. Giving students choices throughout the learning process and in the final demonstration of their learning empowers them to not only take responsibility for their learning but also to use their strengths of expression (J. C. Brown, 2017; Rodriguez, 2015). For example,

Helen allowed students to do a visual representation during an oral assessment. The consistent use of rubrics ensures that the evaluation of work is consistent and task-embedded (Montenegro & Jankowski, 2017; Powell & Cantrell, 2021). The use of rubrics is a culturally responsive form of assessment when they are utilized consistently and allow all students to demonstrate their learning in a variety of ways that are best suited to their needs and strengths (Montenegro & Jankowski, 2017). Giving students the opportunity to self-assess contextualizes the knowledge and encourages them to be metacognitive about their learning (Conley, 2014).

A final area that was identified as impacting culturally responsive teacher planning was how aware these teachers were of their own cultural identity. Hammond (2014) argued that self-awareness is essential in order to be a culturally responsive teacher. Helen brought her experiences of teaching in other countries to help her plan for a culturally responsive approach to science education. Irene, on the other hand, used her linguistic background to plan how she would conduct her science course. Isabella displayed a strong sense of cultural identity and consistently referred to how she utilized this in her teaching. The various cases in this study show the variation and potential strategies for the development of globally competent teachers, which is needed in teacher training (Kopish, 2017; McGaha & Linder, 2014; Walters et al., 2009). As previously stated, all of these teachers identified as culturally responsive educators, but they also identified as international educators. Throughout this study, and especially in the planning and deliberating portion of the research, the teachers brought their international perspectives and global mindedness to the forefront when planning to teach their students.

Research Question 1 Summary

The international schoolteachers in this study deliberated and planned for culturally responsive science teaching in an organic manner that arose from the unique context of working

in international schools. The context of teaching in an international school fostered the teachers' abilities to approach their diverse student populations through a global lens with culturally responsive strategies. Teacher autonomy and support from the administration were factors that impacted teachers planning and deliberation around culturally responsive teaching. Student diversity did not deter these teachers from knowing their students and making family connections that furthered their culturally responsive science teaching. Like many effective teachers, the educators in this study planned for culturally responsive teaching when designing their assessments. Finally, the teachers' own cultural identities as science teachers and international educators impacted how they planned for culturally responsive teaching.

Research Question #2

Research Question #2 is: How do ISSTs teach in culturally responsive ways?

During instruction, teachers employed a range of pedagogical techniques to foster an inclusive learning environment. These techniques include the use of inquiry-based science, building positive student relationships, encouraging students' cultural expressions within scientific discussions, and implementing interactive and collaborative learning strategies that are student-centered. By making science content relevant to students' cultural contexts, teachers facilitated deeper understanding and engagement, thus bridging the gap between students' prior knowledge and new scientific concepts. The level of facilitation varied among the three participants, with one teacher being strong with the linguistic side of being culturally responsive and the others excelling in several other areas such as discourse, physical space, and inquiry-based lessons.

Instructional Practices

Instructional practices are central to culturally responsive teaching and have a direct impact on how CRST is implemented in the classroom. There is a complementary relationship between inquiry-based science and culturally responsive science teaching that leads to equitable science learning (J. C. Brown, 2017). For the purposes of this investigation, inquiry-based science teaching was considered a component of culturally responsive science teaching (J. C. Brown & Crippen, 2017; Powell et al., 2016). Inquiry-based science learning looked very different in the three classrooms in this study. Helen's inquiry-based teaching also came in the form of a lab, where students investigated reflexes in the ruler drop lab by providing evidence and scientific explanations. In Isabella's classroom, students actively researched climate change impacts throughout the world and then communicated those connections to science on a mind map. During these inquiry-based moments, other components of culturally responsive teaching came about, such as student collaboration, student choice, and discourse.

Other instructional practices such as hands-on approaches and project-based learning can be attributed to culturally responsive teaching. For instance, Irene's Biotechnology class was all about hands-on skill development to answer scientifically oriented questions. Students in all of these scenarios took on the role of scientists and were empowered to investigate phenomena in a collaborative manner. This reinforces the idea that culturally responsive teaching does not happen as a result of methodological activities based on culturally responsive teaching but is more about the teacher's perspective and consistent decisions based on best practices and, more importantly, the diverse students in their classrooms (Ebersole et al., 2016).

Positive Student-Teacher Relationships

This study added to the literature about the importance of a positive student-teacher relationship in culturally responsive teaching. Student relationships are paramount as they form the foundation for a supportive and inclusive learning environment (Ebersole et al., 2016; Powell et al., 2016). Building strong connections with students allows educators to understand better their diverse backgrounds, experiences, and cultural contexts, which in turn informs more effective and personalized instruction (Ladson-Billings, 1995b). It was highly evident during the observation of teaching that these teachers all had positive relationships with their students.

When students feel valued and understood through more robust relationships, they are more likely to engage actively in their learning and contribute meaningfully to classroom discussions (Parsons & Taylor, 2011; Pianta et al., 2022). The class discussions that were observed had a variety of students choosing to contribute and participate in the class conversations. These teacher-student relationships also foster a sense of belonging and safety, which can significantly impact students' academic and social-emotional development (Schonert-Reichl, 2017). By prioritizing student relationships, the teachers created a classroom atmosphere where cultural diversity is celebrated, and all students are empowered to reach their full potential.

Discourse and Language During Instruction

Another aspect of empowering students that the ISSTs used in this study was the promotion of discourse and language within their classes. In his work with social linguistics, James Paul Gee (2014) introduced and developed the idea of small "d" discourse and big "D" discourse, wherein big D-Discourse refers to "the ways in which such socially-based group conventions allow people to enact specific identities and activities" (Gee, 2015, p. 2). Simply

put, he referred to Discourse as language within social and cultural contexts. Two of the teachers in this study (Isabella and Helen) promoted and facilitated discussion and both types of discourse within their classrooms. They are both knowledgeable and skilled at understanding how to create a learning environment that promotes Discourse and where students feel comfortable expressing their different social and cultural languages. By revealing both types of discourse (both big D and small d), this study begs the question of how different types of discourse are utilized in culturally responsive science teaching and builds upon prior research on Discourse in science education (Moje et al., 2001). Teachers also exhibited cultural competence while leading classroom discussions. One example of this is when Isabella cited cultural facts about countries in their climate change discussion.

Similar to promoting discussion as a culturally responsive strategy, the teacher focused on developing students' academic language in science. Developing academic language for all students in science is an integral part of culturally responsive teaching (J. C. Brown & Crippen, 2016; Laughter & Adams, 2012). Science vocabulary use was celebrated during Isabella's class observation. Helen promoted the development of student's science vocabulary through the use of a word wall. The development of students' science academic language is crucial for fostering a deep understanding of scientific concepts and enhancing their ability to communicate complex ideas effectively (McComas, 2013; Turiman et al., 2012). By creating opportunities for students to use scientific language in context and providing targeted feedback, these teachers were able to empower their students to navigate the complex world of science.

Irene displayed her ability to code-switch linguistically from one language to another, which supports linguistically diverse learners. This approach to scientific, academic language not only enriched students' understanding of concepts but also highlighted how teachers like Irene

can demonstrate exceptional linguistic flexibility. Multilingualism is the accepted norm in these international schools. As previously described, the schools offer several languages for study and, even in some instances, have language immersion as part of their program. In the confines of this study, it was evident that Irene organically used codeswitching throughout her observed lesson to assist students. Teacher codeswitching has been found to support students' understanding of subject matter, decrease student anxiety, and help teachers improve interpersonal relationships (Cahyani et al., 2018), which are all aspects of culturally responsive teaching. Irene was able to code-switch with French and English; however, students in that class spoke other languages. Even though it is beyond the purview of this study, this scenario begs the question of how those students who speak languages that are different from the teachers' languages are impacted. This study contributes to the field of science education by emphasizing the importance of codeswitching with culturally responsive science teaching to support linguistic diversity.

Discourse not only leads to communication between the teacher and students but also amongst students. Culturally responsive teaching centers on creating a student-centric learning environment that fosters high expectations and collaboration. In such a classroom, students are encouraged to work together, leveraging their diverse perspectives and experiences to enhance their collective learning (Tanase, 2020). All three of these classrooms exhibited an atmosphere of collaboration between students and between students and teachers. In addition to collaboration, another strategy that the teachers in this study used to put students at the center of the learning process was to make the content relevant to students' lives. The teachers did this by allowing students to engage with content in ways that resonated with their individual interests and backgrounds. Helen used examples of movies and music in her class, while Irene focused on relevant topics such as COVID-19. Isabella was able to take a global perspective through case

scenarios from around the world. Another strategy that teachers used in centering students was to provide students with choices in how lessons were carried out and how they would display their learning. Giving students choices helps them engage with content in ways that resonate with their interests and backgrounds and is considered culturally responsive (J. C. Brown & Crippen, 2017; Tanase, 2022).

Cultural Competence During Instruction

The final area that answered this research question and was unique to this study is how teachers used their cultural competence in teaching secondary science. In other words, these experienced international educators used what they learned about other cultures in their travels and life experiences and applied it to the classroom. The vast majority of studies that look at utilizing cultural competence in the science classroom are targeted toward tertiary institutions (Barnes & Brownell, 2017; Cross et al., 2020). However, this study brings to light the importance of cultural competence in dealing with diverse secondary science classrooms.

During the teaching portion of this research, the teachers all demonstrated cultural competence. Research indicates that cross-cultural experiences, such as traveling abroad and speaking a foreign language, are positively correlated with cultural competence (Lopes-Murphy & Murphy, 2016). All of the teachers in this study have traveled abroad and have spoken a foreign language. Isabella used her indigenous scientific knowledge to share science-relevant stories about Hawai'i and was able to discuss energy practices in Europe from her time living in London. Irene is French, lives in the United States, and co-exists between these two cultural worlds. Meanwhile, Helen brings her knowledge and experiences from being a global nomad and living in several countries into her classroom. The teachers are aware of how cultural factors can influence students' perspectives and understandings of scientific concepts. Ladson-Billings

(2006) remarked that "cultural competence refers to helping students to recognize and honor their own cultural beliefs and practices while acquiring access to the wider culture" (p. 40). The broader culture for these international school students is focused on them becoming world citizens, but first, they must have an educational experience with teachers that embrace and integrate their cultural identities.

Less Prevalent Components of CRST During Instruction

While the teachers' cultural competence may have been high, there were aspects of culturally responsive teaching that were less pronounced during instruction. Sociopolitical consciousness is one of Ladson-Billings' (1995a) three pillars of culturally relevant pedagogy, and Gay (2010) speaks to providing opportunities for students to think about inequities. Besides Isabella's comparison of climate change impacts across the world, there was little evidence of direct critical consciousness or social justice issues being explicitly addressed in these science classes. Helen's class had the curricular component that was mandated by the IB, but insofar as what happened directly in class regarding social justice, there was little to no evidence. Additionally, there was little mention of sociopolitical issues (e.g., racism, poverty, gender inequality) happening within their local communities and the United States.

Culturally responsive science teaching can be instituted through social justice action and awareness of social justice issues (B. A. Brown et al., 2019; Hancock et al., 2017). The counter to this is that many international schools use a week of intercultural trips to highlight social justice issues. However, it is important to promote social justice issues throughout science curriculums in order to have more inclusive programs that recognize minoritized students and are relevant to today's problems (Calabrese Barton & Tan, 2020; Finkel, 2018). The concept of raising students' sociopolitical consciousness and looking critically at the world around them

was not evident outside of Isabella's climate change lessons in regards to answering the second research question of how these teachers teach in culturally responsive ways.

Research Question 2 Summary

In summary, research question two looked at the strategies and techniques that the participant teachers used to teach in culturally responsive ways. Pedagogical approaches included the use of inquiry-based science, hands-on activities, and project-based learning that was scaffolded to students' needs. The teachers centered on students and prioritized building positive relationships with their students. Different language and discourse methods that were embedded in culture could be found in all three science classrooms. The international educators in this study exhibited a great deal of cultural competence in dealing with a highly diverse student population. Regarding instruction, less prevalent components of CRST were critical consciousness and social justice.

Research Question #3

Research Question #3 is: How do ISSTs reflect on their culturally responsive teaching in science classrooms?

Reflection has been focused on as necessary practice in culturally relevant or responsive teaching (Civitillo et al., 2019; Howard, 2003; Rychly & Graves, 2012). Two of the three teachers in this study were found to reflect on their beliefs about people from other cultures and about their cultural frames of reference. For instance, Helen was reflective about resolving her own biases when she acknowledged having preconceived notions and letting them go. Isabella used very similar language to let go of biases and stereotypes about groups of people and how this helped in her teaching. This supports the research literature on culturally responsive teaching characteristics and the role of reflection (Rychly & Graves, 2012).

The international school science teachers in this study were confronted with many cultural differences from their own. The teachers did not view these differences as deficits but as the norm when working in a diverse classroom. Irene reflected on how she grew into a more compassionate educator when working in an international school. Helen utilized her knowledge of other cultures to incorporate them as teachable moments in her science classes. Isabella felt her diverse cultural background was an asset and readily shared her indigenous Hawaiian knowledge. She seized the opportunity to decentralize the dominant White narrative and give the perspective of her culture and background. This study extends prior research that raises concerns for pre-service teachers to understand their ethnicity and culture (Santoro, 2009). Additionally, it addresses the call for future studies to analyze the relationship between cultural knowledge and teacher self-efficacy or outcome beliefs regarding culturally responsive teaching (Siwatu, 2007). International schools have been studied as a gateway to intercultural development (Savva, 2013), and this study expands on that by showing how international schoolteachers can put this intercultural understanding into practice through culturally responsive teaching.

Reflection on the Science Curriculum

Science curriculums should help teachers connect to the multiple identities (e.g., race, gender, class) of their students (Mensah, 2021). When the teachers in this study reflected on their culturally responsive science teaching, all three mentioned the curriculum in some capacity. Irene noted that her course was self-designed, so she had the freedom to include what material she deemed fit. Isabella also mentioned freedom regarding curriculum and how she did not feel pressured to get through a certain amount of material in middle school science. She also noted that part of being a good teacher is being able to adapt the content and science curriculum to what is relevant to students (J. C. Brown & Crippen, 2016; Gay, 2010). She makes sure that she

is constantly “revisiting and revising” her curriculum and appreciates the autonomy she was given to do so. Helen had mixed feelings about her curriculum and how it enhanced or hindered her ability to teach in a culturally responsive manner. She was held to the MYP curriculum, and she felt specific components definitely encouraged and supported her students in addressing science issues on a global scale that fosters international mindedness (Stobie, 2005). However, she was also limited by the amount of content that she had to get through in a year.

There were limited signs of science curriculum materials specifically targeting culturally responsive science teaching. The curriculum is one of the most obvious ways to establish cultural responsiveness in teaching, and it ensures that students’ backgrounds are included (J. C. Brown & Crippen, 2016). However, culturally based science curriculum is a complex process (Bang & Medin, 2010). Although cultural responsiveness was not explicit in their curriculums, the experienced teachers in this study viewed culturally responsive science teaching as something that is born of good teaching. While the experienced teachers in this study recognized that cultural responsiveness was not explicitly addressed in their curriculums, they recognized that providing students with choices in their learning is essential to culturally responsive science teaching.

Reflections on Students in Culturally Responsive Teaching

The teachers in this study reflected upon how culturally responsive teaching impacted their students in a variety of ways. Students having choices in learning is a vital part of culturally responsive teaching (Gay, 2018). In order to make science teaching relevant to students, culturally responsive science teachers must give students choices and, subsequently, ownership of their learning. Teachers in this study reflected on giving students choices throughout the learning cycle. Student choice was given based on the type of variable students could manipulate

in an experiment or which group they would want to be in. Picking a country or area of interest to investigate for a project on energy was another example of student choice. Students were also given options to display their mastery of a subject in their final product. Giving students choices in their learning elucidates students' cultural values and background experiences. By empowering students to make choices in their learning, educators not only highlight their cultural values and background experiences but also lay the groundwork for culturally responsive teaching.

Culturally responsive teaching is a method that requires teachers to know their students' cultural identities and creates an environment where students are free to express their perspectives and use their background experiences. It stands to reason that the more students a teacher has in their class, the more cultural identities they have to know and master. Research shows that class size impacts student achievement (Ehrenberg et al., 2001; Shin & Chung, 2009). The teachers in this study all mentioned that they had ideal class sizes. None of the classes exceeded twenty students. In classrooms that are highly diverse culturally and linguistically, culturally responsive teaching can be quite challenging, and with more students, it makes it even more so.

Reflections on International Schools

On several occasions, some of the participants mentioned that the fact of teaching at an international school made them culturally responsive educators. However, to teach in a culturally responsive manner, teachers must go beyond mere recognition of differences. One teacher in the study cited International Day, which celebrates food and culture as an important part of being culturally responsive. However, in culturally responsive pedagogy, "the knowledge required is more sophisticated than differences in foods and holiday celebrations" (Rychly & Graves, 2012,

p. 46). While it is necessary for teachers to go beyond the surface in cultural understanding, especially when managing the diverse needs of students, being at an international school that embraces diversity helps to promote cultural acceptance and responsiveness. Working at an international school where all stakeholders (i.e., students, parents, teachers, and administrators) collaborate towards a shared mission of fostering global citizenship and international awareness offers unique benefits in creating a culturally rich learning environment.

Reflections on Culturally Responsive Teaching Directly

Another point is how teachers reflected on their culturally responsive teaching as something that they set out to do or, by nature of circumstance, have as part of their practice. Isabella stated, "I don't think it's intentional. Like, oh, let me throw some culturally responsive teaching in; I think it's just instinctual" (Final Interview). If, in fact, culturally responsive is "instinctual," then this could affect how we focus our efforts on teacher training for culturally responsive teaching. As with other research, there could also be a disconnect between their self-efficacy and their observed culturally responsive teaching practices (Stepp & Brown, 2021), meaning that what they believe about CRST and how they enact CRST are not connected.

Throughout this study, the teachers became more aware of culturally responsive teaching as it pertains to science classrooms. The act of participating in this study brought about questions and areas of interest for the participants and the researcher. They felt more cognizant of CRST, and two of the three expressed more interest in learning. The third teacher, Irene, who did not express any interest in learning more about CRST, was transitioning out of teaching science and the school setting. A reflective process supports a cycle of improvement and adaptation, leading to more effective and empathetic teaching practices in general (Çimer et al., 2013; Dewey, 1910, 2022).

Research Question 3 Summary

In addressing the third and final research question, teachers in this study reflected on their perceptions of culturally responsive science teaching. The participants engaged in reflection, which helped them recognize how cultural backgrounds and differences shape how students interact with and understand scientific concepts. All three teachers appreciated how small class sizes allowed for more personalized interactions with their students and enhanced culturally responsive teaching. Even though there were limited signs of explicit cultural responsiveness in the science curriculums, teachers still expressed an interconnection between the curriculum and their abilities to teach in a culturally responsive manner. Finally, the teachers in this study valued working at international schools and felt that culturally responsive teaching contributed to creating an educational experience that prepared students to thrive in an interconnected world.

Additional Findings

In addition to the findings previously discussed, there were also findings concerning the importance of cultural competence and global connections in international school science teachers' culturally responsive teaching approaches. By incorporating these elements, international school science teachers were able to create a more inclusive and dynamic learning environment that prepares students to navigate an increasingly diverse and interconnected world.

Cultural Competence

Research has found that effective teachers have the capacity to adapt their instructional practices, change levels of learning support, and alter classroom management techniques (Collie & Martin, 2016; Kunter et al., 2013). In other words, teaching demands high cognitive flexibility in order to adapt to the teaching-related demands of the classroom while keeping up with the content delivery. The findings from this study suggest that culturally responsive teaching adds

another dimension to the teaching demands and requires a level of cultural competence to be able to integrate at the moment during a science lesson. These findings are similar to those in Thomas and Berry's (2019) study with mathematics educators.

Cultural competence is referred to as developing a cultural diversity knowledge base (Gay, 2002). Working at an international school can deepen intercultural understanding, but that does not necessarily translate into a teacher's professional practice (Savva, 2013). For the most part, the teachers in this study demonstrated cultural competence through creating inclusive educational environments and understanding the diverse cultural communities in which they worked. Additionally, these teachers were able to make in-the-moment decisions about cultural factors that may impact their students. For instance, Helen was able to curtail negative attention to a student wearing a mask, as this is a common practice in certain parts of Asia. Another example was Isabella being able to convey a cultural tradition about one of the countries her students were researching about climate change.

Teachers were also able to integrate aspects of their students' lives into their science lessons through class discussions. Additionally, Isabella was able to use her knowledge and cultural competence concerning her Hawaiian culture to convey another perspective of science outside of the traditional Western science model. Developing and integrating cultural competence into science teaching is quite challenging because science can be considered an inflexible discipline and has had a conventional Western approach (Cross et al., 2020; Cross et al., 2021). However, this study adds to the literature within the United States about teachers capitalizing on their cultural competence to teach diverse populations in culturally responsive ways.

Global Connections

The teachers in this study integrated diverse work and content through a global lens. The goals or missions of international schools are to produce globally minded citizens; therefore, it stands to reason that teachers emphasize a global perspective or at least one that is open to a variety of countries from around the world. However, it is crucial for international schools and teachers to reflect on their practice and mission as they are also subject to practices that are Eurocentric and propagate one perspective (Tanu, 2017).

The idea of critical consciousness goes beyond the local and national levels for many of the students who attend these schools and the teachers who teach them. Critical consciousness takes on a more global dimension for these teachers and how they address the curriculum and planned learning experiences through this global lens. This global perspective was seen in projects, assessments, and class activities that these teachers implemented. The interconnectedness to global events that many international teachers and international school students experience can be included in the concept of globalization, which has received much attention and critique for abuses, imbalances, and exploitations of culture. However, global citizenry within the realm of education can be fostered to advance social justice and sustainability (Torres & Bosio, 2020).

Limitations

As with any study, specific limitations exist within the confines of this research. First of all, qualitative research is dependent upon human interpretation from both the researcher and participants taking part in the study. The researchers are part of what they study and take on the roles of knowing and understanding at the same time (Hatch, 2002).

The potential for research bias is always present when data has to be interpreted through a qualitative lens. This is both a strength and a limitation of qualitative research methods. It must be stated that the researcher in this study has past experiences working within international schools and has brought their biases as educators and researchers to bear. However, consistent documentation and annotation of potential biases were acknowledged, and attempts were made to keep them in check. The data collection, observation, and analysis portions of this research were all done by one person. Additionally, the researcher was not fluent in French and, therefore, was limited in their understanding of the classes conducted in English and French. If there had been other perspectives, it could have improved reliability.

In order to ensure participants would be able to reveal the phenomena of the study, purposive sampling was used in this research (Creswell, 2014). The sampling of participants set certain limitations, and because this was an interpretive qualitative case study, the number of participants had to be kept small. The original line of inquiry was focused on international teachers who were teaching outside of the United States and could also speak to the perspective of living outside their native country. Once this line of inquiry was changed, the potential pool of participants would have to come from within the United States. The participants were only people who identified as female, and therefore, there was no male or nonbinary perspective. Only one person of color was able to be represented, with the other two identifying as White or Caucasian.

The findings of this study are specific to a particular subset of the educational landscape and may not be generalizable to the broader public education sphere. The sample's context and characteristics may differ significantly from those in other educational settings or systems. As such, the results should be interpreted with caution when considering their applicability to public

education more broadly, and future research is needed to validate the findings across different international school settings.

Implications

J. C. Brown (2017) stated that "Pre- and in-service teacher education programs must assist teachers in translating culturally responsive science from theory to reality" (p. 1167). This study contributes to that translation of culturally responsive science teaching and introduces implications for policy and practice among in-service and preservice teachers.

Practice

The implications of this study for teachers who face a highly diverse student population are multifold. One implication for practicing teachers is to have some degree of cultural competence in relation to their student population and the subject matter they are teaching. Ladson-Billings (2006) stated that cultural competence is the most challenging aspect of CRP to convey to teachers. The teachers in this study were aware of their students' backgrounds and cultural influences. Additionally, they had a degree of understanding of the school climate, how international schools operate, and the emphasis on global perspectives. Professional learning that targets culturally responsive science teaching should emphasize cultural knowledge and relationship-building with students. Teachers need to make sure they view their students as assets and know how to identify expressions of cultural identity that may manifest themselves in the classroom. School populations change, and teachers must be open to learning about students from different demographic areas.

Another important implication for practicing science teachers is the creation of a third space in science classrooms (Barton & Tan, 2009; Moje et al., 2001; Seiler, 2013) that builds a bridge for students to connect their learning to their personal lives. Teachers in this study did this

for students by relating science to the real world through a global lens, establishing positive classroom relationships, utilizing strategies that allowed students to capitalize on their linguistic strengths, and being flexible in how they had students demonstrate their learning. When teachers consciously or subconsciously choose to create a culturally responsive space where students are empowered to contribute their ideas, these third spaces come to fruition. Teachers must give up the traditional position of power in the classroom and make student-learning a shared responsibility.

Another implication that culturally responsive teachers could utilize in their classrooms is reflecting on other perspectives, as was done at Isabella's school. This allows teachers to constructively critique what perspective science is being taught from and whether other perspectives that are not the dominant narratives are considered. Examples of science education perspectives that need to be considered are traditional ecological knowledge (Kimmerer, 2002), Indigenous science (Snively & Corsiglia, 2001), and multicultural science education (Atwater, 1993). These perspectives and others must be considered if we are to disrupt the dominant discourse that has oppressed students for generations (Mclaughlin, 2014). By introducing other perspectives into the narrative of science, we make science learning more accessible and inclusive to all students.

For preservice teachers, it is crucial to focus on efficacy-building in relation to culturally responsive teaching (Siwatu, 2007). For this to happen, teachers must be cognizant of their cultural background and realize what identities they bring with them to the classroom. In their reflection guide on culturally responsive teaching, Muñiz (2020) listed reflecting on one's cultural lens as one of eight competencies for culturally responsive teaching. This is important for several reasons. It allows teachers to recognize what type of implicit biases they bring to the

classroom. One tool for addressing and bringing about awareness of implicit bias is the Implicit Association Test, which has been used in pre-service teacher programs (Batchelor et al., 2019; Denessen et al., 2022). Reflecting on one's cultural lens displays what cultural attributes teachers may be able to realize in their students and the families of those students.

Even the experienced teachers in this study questioned their capabilities concerning aspects of culturally responsive teaching. Preservice teachers must get the chance to learn about other cultures, and this can be done through exchange programs (Jaramillo Cherrez & Gleason, 2022) or international education abroad opportunities (Walters et al., 2009). As for inservice teachers, the focus should not be very different from that of preservice teachers as it would benefit everyone to continually reflect on their positionality in regards to bringing culture into the classroom. For inservice teachers, this may take the form of professional learning communities within the science education realm. While the National Science Teaching Association (NSTA) has several resources for culturally responsive teaching, giving in-service teachers a chance to share experiences surrounding culturally responsive science teaching would yield a plethora of strategies. Additionally, this type of professional learning community could bring awareness to the benefits of culturally responsive science teaching for diverse student populations.

For all teachers, it is essential to stay curious in learning about students and be compassionate in the building of relationships with your students, so they have a sense that they are valued and want to engage in learning. Culturally responsive teaching does wonders for student-teacher relationships and encourages students to internalize their learning and become independent thinkers (Hammond, 2014). In addition, beginning teachers must be able to evaluate exemplars of culturally responsive teaching (J. C. Brown & Crippen, 2016). The three

participants in this study provided exemplars in different areas of culturally responsive teaching and could be used as examples in preservice or in-service teacher education. Irene displayed language practices that promoted a linguistically diverse classroom with students using multiple languages. Helen capitalized on her time as a global nomad to academically challenge her biology students in culturally responsive ways. Finally, Isabella drew on her own culture as well as her students' culture to deliver a globally focused curriculum.

Policy

Given the current political climate, it would be naive to recommend a policy encouraging all schools to mandate culturally responsive teaching. However, because culturally responsive teaching can strengthen student-teacher relationships, involve families in science learning, and connect learning to students' lives, it should be looked upon favorably. Schools should increase the focus on culturally responsive teaching. Promoting teacher cultural responsiveness has many benefits, such as a decrease in overall behavioral problems (Fallon et al., 2022). Culturally responsive professional development can be transformative (Bishop & Berryman, 2010; J. C. Brown & Crippen, 2016). Policies should be set forth that prioritize professional development for teachers to equip them with the knowledge and skills to implement culturally responsive teaching. School administrators who want to respond effectively to diverse student populations have to set a framework for professional development (Villegas & Lucas, 2002). Additionally, the time and opportunity should be set aside for the curriculum to be reviewed in order to ensure a wide range of perspectives and contributions from various cultures.

International Schools

International schools need to look at their policies toward culturally responsive teaching. Gay (2015) explicitly pointed out that international contexts are relevant for this form of

pedagogy. However, only one teacher's school in the study was found to take the approach of looking at curriculum and instruction from other perspectives.

Future Research

One line of potential research for the future would be to do a mixed methods study with quantitative measurements of teachers' self-efficacy, such as the Culturally Responsive Teaching Self-Efficacy or the Culturally Responsive Teaching Outcome Expectancy (Siwatu, 2007) and investigate how the different components of that survey match with the culturally responsive practices that are happening in their classrooms. In other words, it would measure the teacher's perceptions of their cultural responsiveness to the reality of what is happening in their practice.

Another area of research is to connect teachers in multiple international schools throughout the world in a professional learning capacity to see how they address their highly diverse classrooms with culturally responsive teaching. Many studies have been conducted on professional learning communities and culturally responsive teaching (J. C. Brown & Crippen, 2016; Comstock et al., 2023; C. W. Cooper et al., 2009; Wallace et al., 2022), but none in an international school context. To extend this even further, the teaching-learning community could be subject-specific (i.e., science, math), or it could be a cross-curricular project.

As previously described, the students who attend international schools are often considered a little different from their peers who attended school in their place of birth. International school students, or TCKs, have often had a mobile existence and spent their formative years in countries different from their birth or that of their parents. Research has been conducted on students' perspectives of culturally relevant teaching (Byrd, 2016) but not on the international school students' perspective. It would be interesting to research how TCKs view culturally responsive practices.

Recently, a number of studies have been done on culturally responsive teaching and early career teachers (O'Keeffe et al., 2019; Tangen et al., 2019; Wallace et al., 2022). However, I would like to specifically explore early-career science teachers in middle school and their culturally responsive teaching. Middle school is a critical time for students to stay engaged in science, and there is often little space left for leveraging students' interests and science identity, especially for girls from nondominant groups (Calabrese Barton et al., 2013; Carlone & Johnson, 2012). Therefore, it is critical that early career teachers interested in teaching middle school science utilize culturally responsive teaching to engage their students.

One area that was not abundantly observed in this study but is closely related to CRST is social justice. While the culturally responsive teaching seen in this study is worthwhile, teachers must go beyond advocating for equity and take a critical stance in order to disrupt the dominant narrative while giving students the tools to think critically (Calabrese Barton & Tan, 2020; Thompson et al., 2021). As previously mentioned in the literature review, one such program is *Ambitious Science Teaching* and the Critical and Cultural Approaches to Ambitious Science Teaching (C2AST) approaches that use social and restorative justice to challenge the culture of science and societal norms (Thompson et al., 2021; Windschitl et al., 2018). In the future, I recommend a program such as the C2AST be implemented within international schools to investigate how critical and cultural approaches work with highly diverse student populations.

A final area of potential research would be with teachers in different areas of science, such as Physics and Chemistry. Research has been done on these subjects separately (Barron et al., 2021; Jumarito & Nabua, 2021; Stewart, 2011), but there is no comparison to see how culturally responsive teaching is conducted in each specific science area. The teachers in this

study were primarily based in life sciences. The question of disciplinarity, particularly in the context of culturally responsive teaching, is indeed significant.

Conclusion

The stories of these three teachers have given us a small glimpse into some aspects of culturally responsive teaching in the international school science classroom. Through the telling of stories and others like them, we are able to explore the world of culturally responsive science teaching (Wallace et al., 2022). Additionally, by mere participation in this study, the participant teachers thought about and contemplated their practice in regards to being culturally responsive educators.

This study offers several significant contributions, primarily by utilizing a unique sample of international school science teachers. It introduced an innovative methodological approach by employing the CRIOP as a data analysis tool. Additionally, it provided valuable insights into teachers' perspectives on culturally responsive teaching when working with diverse students in science. Lastly, the study highlights the intersection of culture and science in third space classrooms.

In summary, the methods used by ISSTs for planning, executing, and reflecting on culturally responsive teaching are intricately linked, with one component supporting the others to establish a culturally responsive learning environment. Their approaches highlight the significance of culturally responsive pedagogy in science education by showing how important it is to address the needs of varied student populations with preparation, responsive instruction, and reflective practice. Each of the participants had strengths and weaknesses regarding certain aspects of culturally responsive teaching. For instance, Irene had strong evidence of the linguistic aspect of being culturally responsive, while Isabella used her unique cultural background as an

asset to contextualize learning through a global lens. The insights obtained from this research contribute to a greater knowledge of how to build equitable and inclusive scientific education experiences as educators continue to face and embrace the challenges of highly diverse classrooms.

APPENDIXES

APPENDIX A

DATA COLLECTION/ANALYSIS MATRIX

Appendix A

Data Collection/Analysis Matrix

Research Question	Data Sources	Data Analysis Approaches
1. How do international science teachers (ISTs) plan for culturally responsive teaching (CRT)?	•Initial Interview	•3-phase Interview Analysis (Framework, In vivo, Descriptive)
	•Documents/Artifacts	•Document Analysis (2 phase-Descriptive & Framework)
	•Post Observation Interviews	•3-phase Interview Analysis (Framework, In vivo, Descriptive)
2. How do ISTs teach in culturally responsive ways?	•Remote Observations	•Field Notes
	•Post Observation Interviews	•3-phase Interview Analysis (Framework, In vivo, Descriptive)
	•Documents/Artifacts	•Document Analysis (2 phase-Descriptive & Framework)
3. What do ISTs reflect about their culturally responsive teaching?	•Post Observation Interviews	•3-phase Interview Analysis (Framework, In vivo, Descriptive)
	•Documents/Artifacts	•Document Analysis (2 phase-Descriptive & Framework)
	•Final Interview	•3-phase Interview Analysis (Framework, In vivo, Descriptive)

APPENDIX B

INITIAL INTERVIEW QUESTIONS

Appendix B

Initial Interview Questions

Initial CRT Interview Questions

The following interview questions and subsequent study focus on ***culturally responsive teaching (CRT)***. In order to ensure transparency and understanding, the following definition of ***CRT*** is introduced.
Culturally Responsive Teaching: a pedagogy that uses students' customs, characteristics, experiences, and perspectives as tools for classroom instruction.

1. Can you tell me about your current teaching assignment? With follow-up questions about:
    a. School and country.
    b. Length of time in country.
    c. Experience with current grade level/subject matter?
2. Do you feel your culture/lived experiences have impacted your science teaching? If so, in what ways? Please describe or give an example.
3. How do you plan to work with students from diverse cultural backgrounds? Please describe or give an example.
4. Do you elicit or find out about students' culture or lived experiences? If so, in what ways? Please describe or give an example.
5. Do you incorporate students' experiences/culture into your science classroom? Please describe or give an example.
6. Do you connect science content to your students' lives? If so, in what ways? Please describe or give an example.
7. Do you assess learning in a culturally responsive way? If so, in what ways? Please describe or give an example.
8. Do you create a classroom environment where students respect and appreciate their own culture as well as other cultures? If so, in what ways? Please describe or give an example.
9. Do you address linguistic diversity in your classroom? If so, in what ways? Please describe or give an example.
10. Do you address the specific needs of English language learners in your classroom? If so, in what ways? Please describe or give an example.
11. Do you connect science to the local community? If so, in what ways? Please describe or give an example.
12. Do you integrate any host country/local culture into your lessons? Please describe or give an example.
13. What role do you think social justice (e.g. civil rights, social inequities, environmental justice) plays in the science classroom?
    a. How do you support developing students' critical consciousness? Please describe or give an example.
14. Do you incorporate indigenous science knowledge into your curriculum? Please describe or give an example.
15. Do you reconcile Western science perspectives versus those of indigenous science

knowledge? If so, in what ways? Please describe or give an example.

16. Is there anything else you would like to add or would like for me to know about your perspectives on culture in the science classroom?

APPENDIX C

TEACHER DEMOGRAPHIC INFORMATION

Appendix C

Teacher Demographic Information

Demographic Information
(*Prefer not to say* is an option for all categories)

First and Last Name	
Gender	
Ethnicity	
Education/Degree(s)	
Country of Residence	
Country of Citizenship	
Years of Teaching Experience	
Current School	
Current Teaching Assignment (i.e., subject, grade level)	
Other information you want me to know about professional life.	

APPENDIX D

MAPPING OF INITIAL INTERVIEW

Appendix D

Mapping of Initial Interview

Interview Questions	Research Questions 1. How do ISTs **plan** for culturally responsive teaching? 2. How do ISTs **teach** in culturally responsive ways? 3. How do ISTs **reflect** on their culturally responsive teaching?
1) Generic Get to know	n/a
2) Do you feel your culture/lived experiences have impacted your science teaching? If so, in what ways?	#2- Teaching #3- Reflecting
3) How do you plan to work with students from diverse cultural backgrounds?	#1- Planning
4) Do you elicit or find out about students' culture or lived experiences? If so, in what ways?	#1- Planning #2- Teaching
5) Do you incorporate students' experiences/culture into your science classroom? If so, in what ways?	#1- Planning #2- Teaching
6) Do you connect science content to your students' lives? If so, in what ways?	#1- Planning #2- Teaching
7) Do you assess learning in a culturally responsive way? If so, in what ways?	#1- Planning #2- Teaching
8) Do you create a classroom environment where students respect and appreciate their own culture as well as other cultures? If so, in what ways?	#1- Planning #2- Teaching
9) Do you address linguistic diversity in your classroom? If so, in what ways?	#1- Planning #2- Teaching
10) Do you address the specific needs of English language learners in your classroom? If so, in what ways?	#1- Planning #2- Teaching
11) Do you connect science to the local community? If so, in what ways?	#1- Planning #2- Teaching

12) Do you integrate any host country/local culture into your lessons? Explain.	#1- Planning #2- Teaching
13) What role do you think social justice (e.g. civil rights, social inequities, environmental justice) plays in the science classroom? a. How do you support developing students' critical consciousness?	#1- Planning #2- Teaching
14) Do you incorporate indigenous science knowledge into your curriculum? How so?	#1- Planning #2- Teaching
15) Do you reconcile Western science perspectives versus those of indigenous science knowledge? If so, in what ways?	#1- Planning #2- Teaching

APPENDIX E

FINAL INTERVIEW QUESTIONS

Appendix E

Final Interview Questions

The following questions are meant to be answered based on the time of participation in this study or the current semester.

1. What do you feel are some of your strengths and weaknesses in working with students from diverse cultural backgrounds over the past semester?
2. How did the culturally responsive teaching and learning you planned for this semester play out?
3. Upon reflection, would you change or adapt any of your culturally responsive practices?
4. Member-checking question on researcher-developed emerging assertions. (e.g., Throughout the semester I have observed you using a variety of instructional methods/activities (i.e., Science in my Neighborhood) that were connected to students' lives outside of school and this leads me to believe that you believe that science learning is enhanced by using students' life experiences. Is that correct? What are our thoughts on this point, and do you agree or have anything to add?)

Element/Pillar	**Areas for Specific Follow-Up**
Classroom Relationships	
Family Collaboration	
Assessment Practices	
Instructional Practices/Student-Centered Strategies	
Discourse/Affirmation of Cultural and Linguistic Identities	
Critical Consciousness/Social and Restorative Justice	
Science Culture	

APPENDIX F

ARTIFACT AND DOCUMENT SHARING FORM

Appendix F

Artifact and Document Sharing Form

Artifact & Document Sharing

Instructions: Please share any documents or artifacts that you consider to have relevance to culturally responsive teaching and learning in your classroom. Pictures of objects or copies of documents are acceptable. Any student work should be de-identified in the interest of anonymity.

Artifact Name	**Artifact Description** (e.g. Worksheet- physics lab with culture integration, Student background form, Science night with community connection flyer, Flag from home country, Gift from student, Lesson plans, etc.)	**Intended Audience** (e.g. students, parents, administrators, myself, fellow teacher)	**Sharing Method** (i.e. Email Attachment, Google Docs, Dropbox, etc.)

APPENDIX G

REMOTE OBSERVATION SCHEDULE FORM

Appendix G

Remote Observation Schedule Form

Researcher/Teacher fills out the remote observation schedule (below) for each remote observation. Ideally, these observations will be scheduled after the first interview.

Description of Observations for teachers:
Observations (1 or 2) are opportunities for me to witness your science class and become familiar with the environment. Please do not feel obligated to do anything outside of what you would ordinarily do in class. These observations are meant to be organic and simply provide me with some frame of reference for your classroom. First and foremost, select lessons that you are comfortable with me observing, and secondly, select lessons that may present opportunities to identify culturally responsive practices. Besides the time for the remote observation, we will also take a few minutes (10-15) to debrief and talk about the lesson as soon after as possible (that afternoon or the next day). In so far as your students are concerned, you can make them aware that I will be watching and recording that day's lesson but that they are not the subject of the study. Please abide by any video recording protocols (e.g., permission slips, opting out, etc.) that your school has established.

Remote Observation Schedule

Proposed Date(s) (Mon., August 15)	**Proposed Time** (11:30-12:15 EST)	**Observation Platform** (Zoom, Google Meets, Skype, etc.)
Grade Level/Subject (e.g. 9th Grade-Biology)	**Class Description** (e.g.	

*Follow-up emails sent to the teacher one week before the observation.

APPENDIX H

POST OBSERVATION INTERVIEW QUESTIONS

Appendix H

Post Observation Interview Questions

PRIMARY – The first three questions will be asked to solicit teachers' experiences of the lesson. After question three the interviewer will ask 3-4 questions that are based on observed occurrences during the lesson that can further delve into culturally responsive moments.

1. How do you think the lesson went overall? What went well? What could have been better?
2. What obstacles/successes did you encounter in engaging students in a culturally responsive way?
3. Were there aspects of the lesson that you would consider culturally responsive? If so, please explain.
4. Question related to observed incidences.

SECONDARY – Pool of questions to be asked in the event that primary questions were answered and if key moments related to CRIOP categories need to be clarified.
(primarily based on Fourth Revised Edition shared by CRIOP authors)

Question	Category
How did you promote student participation in the science of culture during this lesson?	Science
How would you describe the classroom environment and learning atmosphere during this lesson?	Classroom Relationships
How were high expectations for all students (including emerging bilinguals) communicated during this lesson?	Classroom Relationships
Was there an opportunity to connect families' linguistic/cultural knowledge within this lesson? Explain.	Family Collaboration
Did you use assessment data to adjust instruction during this lesson? Please explain.	Assessment
How were students able to voice their learning throughout this lesson?	Assessment, Discourse
How did you assess students' competence in language and science content during this lesson?	Assessment
How was instruction contextualized in students' lives, experiences, and individual abilities?	Instructional Practices

Can you explain how students engaged in active, inquiry-based meaningful learning tasks during this lesson?	Instructional Practices
Did you focus on developing students' academic language? Explain.	Discourse, Instructional Practices
Were there any instructional techniques (e.g., graphic organizers, reducing linguistic density, demonstrations, etc.) that you used to scaffold student learning?	Instructional Practices
How did you promote equitable discourse and academic conversation during this lesson?	Discourse
Did this lesson provide opportunities to address social justice issues important to the classroom, school and community? Explain.	Critical Consciousness
Did this lesson provide opportunities to confront negative stereotypes and biases? Please explain.	Critical Consciousness
Did this lesson give opportunities to express diverse perspectives or empower students to challenge traditional and dominant ways of knowing (e.g., European science, Western science)? Please explain.	Critical Consciousness

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