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Bridging Culture and Science Education: Implications for Research and Practice

Izzah Mardhiya Mohammad Isa
School of Education, Universiti Teknologi Malaysia

Muhammad Abd Hadi Bunyamin*
School of Education, Universiti Teknologi Malaysia

Fatin Aliah Phang
Centre for Engineering Education, Universiti Teknologi Malaysia

Abstract. Since the 19th century, many studies have claimed the importance of integrating culture in science education, grasping everyone's experience and background. However, from 2012 to 2015, many recent works within these years describe how standardized curricula have marginalized cultural-based education. Scholars then re-emphasized the role of bridging funds of knowledge (FOK) as a conceptual framework to counter the deficit of marginalized groups and advance social justice in science education. However, up to this point, the extent and pattern of the growing body of literature on cultural-science integration is still less explored. Hence, in this review, we sought new and current inquiries that connect FOK or cultures with science education reform discourse to identify and understand the current trends of the integration phenomena by doing a systematic literature review. After constantly comparing the articles, we found three trends of the integration, which are (1) cultural-based lesson plan for equity in science educational opportunities, (2) effectiveness of integrating culture in science education, and (3) cultural-based science education as a voice of multidimensional perspectives. We hope that this review of research could reshape the future direction of research on equity and social justice issues in education and reshape the practice of education, particularly science education.

Keywords: funds of knowledge; marginalized groups; culturally relevant pedagogy; culturally responsive teaching; social justice

1. Introduction

The paradigm of discontinuity between science and real-life experience among learners is still happening for decades due to its abstract notion, which seems

* Corresponding author: *Muhammad Abd Hadi Bunyamin, mabhadi@utm.my*

empirical, analytical, and positivistic (Lee et al., 2020). Moreover, Pejaner and Mistades (2020) believe the science decontextualizing issue happened due to the westernization of the science content. This is because the curriculum was first introduced in many school education systems globally and historically, thus impacting the non-western learners' achievement and epistemological beliefs (Aikenhead, 1996). Scholars have suggested that this issue has disadvantaged marginalized students in many countries and contributed to achievement gap phenomena, dragging the equity and social justice issue in education (Johnson & Newcomer, 2020; Suárez, 2019). A decade ago, Hursh (2007) argued about neoliberal ideology in the United States education system, which was reflected in the policy of No Child Left Behind (NCLB). Neoliberal policies, reflected in NCLB, aimed to increase students' achievement and close the achievement gap. However, Hursh (2007) found that NCLB did not attain its goals. In fact, neoliberal policies undermined equity and diversity in education with regard to diverse ethnics, cultures, and belief systems (Fortney et al., 2019) because of the notion of "individual responsibility" that is not realistic in a society that is unjust in terms of wealth distribution and equitable access. To this extent, equity and social justice issues are still growing-current topics in science education research and practices, which need global attention to project a better solution ahead.

Historically, many studies have introduced sociocultural integration into science, namely funds of knowledge -hereafter referred to as funds of knowledge (FOK) (FOK)- as a conceptual framework to encounter injustice in education. This is where stakeholders should emphasize the sociocultural theoretical elements (Vygotsky, 1978) in the classroom through culturally relevant education (CRE) (Ladson-Billings, 2006; Llopart & Esteban-Guitart, 2018) and culturally responsive teaching (CRT) (Gay, 2010, 2015; O'Leary et al., 2020). Other than that, Aronson and Laughter (2016) argued that CRE and CRT could be used to reframe public debates in education so that education would not be excessively interpreted from the perspective of neoliberalism but from the cultural lens comprehensively.

Nevertheless, the growing body of literature in cultural science studies always discusses the opportunity and achievement gap between dominant and minority students. It also puts equity as the main focus for the research problems to make science relevant, improve disadvantaged students' performance, and advance social justice (Volman & 't Gilde, 2021). Hence, many studies come with solutions, enhancement, and advancement by years, and finally believe that integrating culture is the best (Aikenhead & Jegede, 1999; Avery, 2013; Fortney et al., 2019; Hogg, 2016; Hutchison et al., 2020; Ladson-Billings, 2014; Milner IV, 2013; Upadhyay, 2009). This is because culture is not a possession but a means of running lives (Cole, 1996). Meanwhile, science is a discipline of knowledge that discusses real lives phenomena. Hence, bridging sociocultural and real-life experience (FOK) with science in prior studies seems to have promising positive outcomes among learners. In fact, Aikenhead and Jegede (1999) even conceptualized the transition between a student's lifeworld and school science as a cultural border crossing.

Scholars also argue that linking students' background or FOK with science is essential by reinforcing the connections between culture and science content. This is because bridging home and school through science education increases the authenticity of science learning. Hence, home and school will not be isolated and not become homogenous in students' minds and lives. Nevertheless, the pattern of how culture is integrated into science education for studies up to 2015 is still less explored in scientific discourses. It is important to study the pattern and implication as a guideline for future educational policies to advance social justice and equity based on the current trends. Therefore, to address this gap, authors synthesize the recent studies based on these inquiries:

(i) How culture and social context are cultured in current science education?
(ii) To what extent cultural studies in science education has promised positive outcomes?

The authors want to define key terms used in this paper so that readers become clear with the meaning of those terms. First, funds of knowledge (FOK). Initially, FOK emerged as "bodies of knowledge of strategic importance to households" (Vélez-Ibáñez & Greenberg, 1992). Subsequently, it was termed "funds of knowledge" (FOK) by Moll et al. (1992). They later defined FOK as the term that refers to these historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being. Recently, Albrecht and Upadhyay (2018) defined FOK as all knowledge and skills learned at home from one's cultural, social, historical, linguistic, and political acts that establish a foundation for further learning and support in students' engagement during science learning in schools. Note that FOK is an empowering tool for students from immigrants and underrepresented groups as they have delineated how science is experienced at home and how it could build their classroom learning.

Second, culturally relevant pedagogy (CRP) and culturally responsive teaching (CRT). In social justice educational studies, most research used CRP and CRT as their frameworks with positive outcomes. For example, Ladson-Billings (1994) defines CRP as one that empowers students intellectually and, in all aspects, including social, economic, and politics, using culture as the main tool to teach knowledge, skills, and attitude. Meanwhile, Gay (2010) defines CRT as using the cultural knowledge, prior experiences, frame of reference, and performance style of multiethnic students to make learning more significant to them. These theories were often used when researchers were studying integrating science contents with social context, cultures, funds of knowledge, experience, participants' background, families, and socio-politics.

Third, marginalized groups. The people who come from indigenous groups, females, African Americans, Asian Americans, Hispanics, immigrants, people with disabilities, poor people, and people who come from the global south are deemed marginalized groups (Upadhyay et al., 2020). Many equity and social justice educational studies have been conducted on these people.

2. Method

We describe our search process, inclusion criteria, and how the articles we reviewed were chosen. First, it is important to mention that our multistep review was informed by systematic and narrative approaches to answer our research questions. We utilized electronic searches using two engine databases: Scopus and Web of Science (WoS), since they are the most recommended database for educational research while consisting of quality articles (Gusenbauer & Haddaway, 2019). In addition, these two-engine databases are available at our university subscription, and its index is believed as one of the best databases in our country, Malaysia. We did not arbitrarily pick articles that had shown up in the results, but we had limited and selected them based on our search criteria, which are depicted in Figure 1 and will be detailed further below.

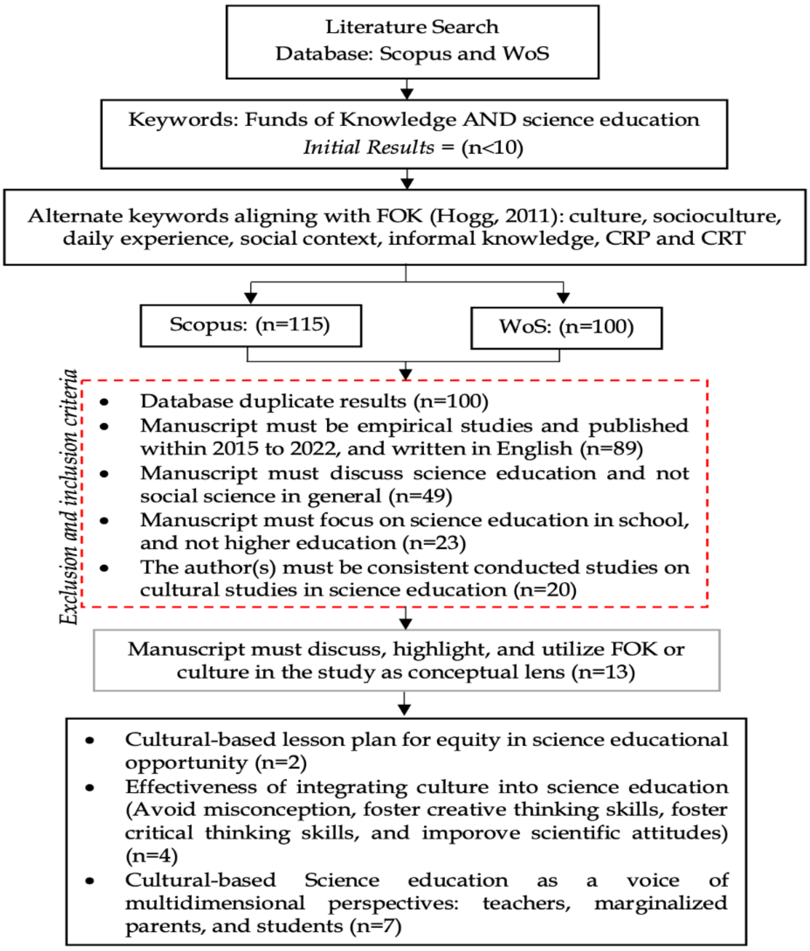

Figure 1: Method flow of systematic literature review

Originally, our searches started with our study keywords which are "funds of knowledge" AND "science education." As science is a root field for chemistry, biology, and physics, we then opened and included these three educational subjects in our searches. However, during the search process, the articles that explicitly mentioned "FOK" were limited in number, only less than ten. Hence, we used keywords synonyms with its terms, such as culture, sociocultural, daily experience, social context, informal knowledge, CRP, and CRT in science education, aligning with the meaning of FOK defined by Hogg (2011) in her review article. Next, we searched for combinations of these terms appearing in the titles, abstracts, and keywords of manuscripts on those databases. Without the restriction of our searches within that range of year and fields, it resulted in several manuscripts across the discipline. Consequently, we read the abstracts and used the following inclusion and exclusion criteria whether to keep the article for our review or exclude it.

First, we limited the search only to journal articles that appeared from 2015 to 2022. This was the crucial step to ensure the articles we got were recent to understand the current trend of integrating culture with science education. The articles, too, must be written in English. At this stage, we obtained 115 results in Scopus and 100 in WoS. However, all related articles in WoS are also encompassed in Scopus. Furthermore, some articles appeared not on science but social science in education. Hence, we need to be selective and focus during this process to choose only science education in school strictly, not higher education, due to time constraints.

Second, we checked the profile of the authors. We specified our search to pick scholars who have constantly conducted studies on culture in science education and/or have fought for equity and social justice in education. The reason was that scholars who keep doing research with a consistent paradigm and nature of the study conducting research would be experts in that particular area (Westerman, 1991). In addition, it will bring insights for the better understanding of the cultural integration pattern in science education.

Third, the next step was reading the abstracts to evaluate whether they met our criteria or not. A limitation arose from the exclusion of a bunch of articles that used "FOK," "culture," and "science education" as the keywords but did not match our needs after reading the abstracts, so those papers were eliminated. The mismatch occurred when those articles only mentioned culture or FOK but did not utilize it as its conceptual lens and the main scope of their study. Specifically, we only focus on reviewing the articles discussing FOK, culture, CRP, or CRT as the conceptual lens of a framework in science education to frame its implementation pattern for further guidelines in educational policies.

Fourth, we included articles that used any methodology, whether qualitative, quantitative, or mixed-method. We also did not specify our articles to any countries because we wanted to include all studies that would be able to provide insights into our specific area of research interests. We utilized the text's comparative analysis manually to extract, compare, and synthesize the pattern of the studies.

Finally, we included the articles that only reported their empirical data and not review articles. Initially, before these restrictions and limitations were set, the results appeared to be more than a hundred, then reduced to minimal results on both databases after several stages. However, after being restricted to the abovementioned criteria, we only found thirteen articles that met our search criteria: Albrecht and Upadhyay (2020), Albrecht and Upadhyay (2018), Brown and Crippen (2017), Esteban-Guitart et al. (2019), Kadmayana et al. (2021), Mohd Norawi et al. (2015), Mohd Norawi et al. (2017), Rahmawati et al. (2019), Soko et al. (2019), Stapleton and Reif (2022), Suastra (2017), and Upadhyay et al. (2017, 2020). The review presents the analysis of the literature and its description. Consequently, we critically analyze the articles using a constant comparative technique to provide and articulate a comprehensive understanding of how culture is nurtured in those studies with a positive outcome.

3. Findings

After analyzing thirteen articles connected to culture and science education, we summarize the findings and discuss them in the discussion part later. Finally, the results are categorized into three themes to determine the current trend of research and positive outcomes within these seven years.

3.1 Cultural-Based Lesson Plan for Equity in Science Educational Opportunity

Ali, Halim, and Osman (2015) and Ali, Halim, Osman, and Mohtar (2017) conducted studies in different years by integrating physics with funds of knowledge (FOK). Ali et al. (2015) discussed how vital FOK was integrated into a physics lesson. FOK possessed by the students was rich and diverse due to having mingled and participated actively in a multiethnic community. They designed a lesson plan on Archimedes' main topic with five phases of integration strategy: (1) teachers need to identify students' FOK, (2) matching physics content knowledge with FOK, (3) experience and language skills in science discourse were used, (4) creating hybrid space, and (5) using a constructivist approach. Other than that, they claimed that the integration would increase excellence in students' learning and equity of students in rural areas. This can be done by appreciating physics in their culture. Meanwhile, Ali and colleagues' studies (2015) were significant to science education in general and physics in particular due to the perception of physics as difficult to understand and irrelevant due to its abstract nature. Linking physics with FOK would be beneficial to students to make the subject comprehensible to students where they could realize that physics contextually happens in daily life. On the other hand, Ali et al. (2015) also strongly argue that nurturing culture in the lesson plan for implementation would provide equity for students as they learn what they are supposed to learn.

Instead of generating a lesson plan as Ali et al. (2015) did, Soko, Setiawan, and Widodo (2019) identified the ability of Indonesian teachers to design a lesson plan utilizing culture-based physics learning activity. Moreover, Soko et al. (2019) tested the relationship between their ability to design a cultural-based lesson plan with the real implementation (teaching) in a physics classroom. They found that the majority (85%) of teachers in Nusa Southeast (*Nusa Tenggara Timur* (NTT)) could design a lesson plan for physics with culture-based activities even though they never designed a lesson plan that integrated students' culture. Note that this ability was assessed using a rubric comprising these criteria: selecting and organizing teaching material, learning models and methods, and selecting learning resources. The result indicates the teachers' maturity in decision-making is related to materials when choosing the essential content that would be taught in the classroom. Nevertheless, there was a junior physics teacher who was unable to adjust the material of cultural-based physics within the allocated time frame. This implied that lack of experience might have influenced the ability to organize teaching materials through the lens of culture. Apart from that, Soko et al. (2019) concluded that when physics teachers could design a culture-based lesson plan, they would be more prepared to identify the culture according to the physics content. In addition, experienced teachers, too, can design and implement their cultural-based lesson plans compared to junior teachers.

The growing body of literature on FOK and culture in science education has emphasized nurturing into the science lesson plans. By stressing the importance of FOK, teachers were given the trust and audacity to appreciate, dig and integrate students' life experiences in their lesson plans because teachers have the power to control their lessons in the classroom.

3.2 Effectiveness of integrating culture into science education

Avoid misconception. Ali et al. (2017) once again researched cultural-based science education. They performed a test on the effectiveness of FOK to fix the misconceptions that occurred among physics students in optics topics. They used pre- and post-tests on two groups (intervention and control groups) for comparison and validity of FOK effectiveness. In the pre- and post-tests, both groups were tested with the Physics Optics Conceptual Test (POCT) to identify students' misconceptions and conceptual understanding twice. From the quantitative findings, students in both groups had misconceptions in the pre-test but had significantly remediated in the post-test for the intervention group. This showed that integrating FOK in the hybridization strategy could enhance students' understanding of optics concepts and correct it successfully. Furthermore, even though physics equations need mathematics for calculation, this study had proven that integrating FOK could impact solving the mathematical equations in optics among students.

Foster creative thinking skills. Suastra (2017) conducted a study and found one model of innovative teaching that might challenge students: a local culture-based teaching model. The author used the model in the study to examine its effects on students' creative thinking skills and understanding level of the Nature of Science (NOS). Suastra proved that teaching linked to a culture, called the Local Culture-based Model of Teaching (LCBMT), was more effective than the Conventional Method of Teaching (CMT), with a significant difference in mean values. Other than that, students in the group that received LCBMT gained a better effect than CMT in terms of creative thinking and understanding towards NOS. In LCBMT, teachers initiated the lesson by identifying students' prior knowledge and beliefs concerning the material to be learned. Subsequently, inquiry-based learning (IBL) occurred using two perspectives. If the concepts were related to scientific concepts, then IBL took the form of a scientific inquiry. However, it could be investigated from the sociocultural perspective if it was related to sociocultural concepts. Hence, the flexibility of LCBMT eased students to make them think from both perspectives.

Foster critical thinking skills. Another study was identified among marginalized communities. To develop critical thinking among chemistry students who are Tegal ethnics, Rahmawati, Baeti, Ridwan, Suhartono, and Rafiuddin (2019) used culturally responsive teaching (CRT) to allow teachers to conduct meaningful activities. It was done by utilizing the students' contexts of daily experiences and culture with chemistry content. They designed a teaching model consisting of five phases: (1) self-identification, where students reflected their understanding of knowledge, (2) cultural understanding, where students needed to understand their culture to be integrated with ethnochemistry, (3) collaboration, where students worked together in a group discussing concepts and cultural perspectives, (4) critical reflective thinking, where students presented the results of the project to the class, and (5) the stage where students exchanged their values and understanding. The result found that students could develop, foster, and apply critical thinking skills at a moderate (satisfactory) level when teachers utilized CRT during the lesson. Students were also able to connect acid-base concepts in chemistry with agriculture with regard to the pH of soil that might be changing due to acid rain. Likewise, the research is able to prove that CRT in teaching made students more motivated to express their opinions actively in chemistry discussion through self-experience and culture as it aligns with their FOK. This helped students to understand the chemical concepts better, by relating it to their agricultural activities.

Improve scientific attitudes. On the other hand, Kadmayana et al. (2021) bridge culture by encouraging students to be culturally sensitive to the surrounding environment to make sense of the physics concepts that students have learned. They developed the contextual teaching and learning (CTL) model, which claimed to increase students' scientific attitudes and science process skills. In their quantitative study, Kadmayana et al. (2021) compared the pre-test and post-test to determine whether the CTL model they had developed reached their research objective or vice versa. As expected, they found that students were able to carry out the scientific investigation by themselves. They also improved their scientific skills in observation, classification, interpretation, prediction, communication, making hypotheses and questions, and conducting the experiment. Other than that, Kadmayana et al. (2021) argue that the CTL model improves students' scientific attitudes by behaving scientifically in seeking scientific knowledge. It shows that by making students culturally sensitive to their surroundings or FOK, they can develop scientific attitudes by appreciating the culture and their real-life experiences.

To this extent, studies have shown that FOK and cultural studies in science education promise positive outcomes in avoiding misconceptions and fostering students' creativity, critical thinking skills, and scientific attitudes. In addition, it is suggested that the integration of culture helps students' cognitive ability and skills in science to be reinforced for better engagement and achievement.

3.3 Cultural-based Science Education as A Voice of Multidimensional Perspectives

3.3.1 Teachers' perspectives

Brown and Crippen (2017) argued in their research that science teachers struggled to enact culturally relevant pedagogy (CRP) during lessons. Other than that, Brown and Crippen characterized the knowledge and practices of culturally responsive science teaching and how they changed over time in a professional development program. They conducted classroom observations six times for each teacher and three semi-structured group interviews among teachers. This was done to examine teachers' beliefs and knowledge about CRP and their students, as well as the reflections on their teaching practices in a classroom that consisted of diverse students. Four findings in their research were: (1) teachers' view of students, (2) repositioning, (3) community building, and (4) utilizing a CRP toolbox. At the beginning of their research, they found that some teachers had implicit stereotypes and prejudices as the media had shaped them. Lastly, some teachers practiced positive words to students after getting involved in the Science Teachers Are Responsive to Students (STARTS) program. Teachers encouraged low self-esteem immigrant students to motivate themselves in learning science by utilizing their cultural background for canonical science learning. Apart from that, teachers realized that the micro-level knowledge (knowledge about students' experience, strengths, and needs) was what they should know and own. Thus, the interaction between students-students and student-teachers would be good in a multicultural classroom and further reposition them in their roles as learners.

Subsequently, Brown and Crippen (2017) found that repositioning would occur in the classroom as it was the site for social change. They argued that for repositioning to occur, the teachers must take the role of a facilitator and make the students an expert by "digging the knowledge out" of students (Ladson-Billings, 2014). Teachers must guide students to explain science specifically. It should result in students constructing, justifying, and evaluating the quality of their explanation. As a culturally responsive teacher that links social context and culture in science learning, they must encourage students to become a community that can solve scientific problems together rather than being an individualistic student and individual competitive achievement. On the other hand, the teachers also used the CRP toolbox, where they attempted to contextualize science instruction in students' life experiences and bridge home-school experiences. As teachers learned more about students' culture and home-based experiences, they noticed that strategies became tied to students' specific needs. Thus, students enjoyed the science learning.

Currently, Stapleton and Reif (2022) worked on the narrative reflection by bringing the emic perspectives of their co-author in their study, Kahlela Reif. Note that Reif is an elementary science teacher who shared her difficult transition from being a marginalized student who was learning science and lacked science experience until she successfully became a science teacher. This study framed her rich experience to reform ways of science teaching to the marginalized community. Using a third space theoretical lens, Stapleton and Reif advocate integrating FOK as the approach by implementing outdoor activities as outreach for students to empower science for their social justice and struggles.

3.3.2 Marginalized parents' perspectives

Albrecht and Upadhyay (2018) examined Somali mothers' perceptions of science, their challenges in dealing with science as well as their own social and cultural practices. Using CRP as their framework, they found that these three Somali mothers viewed science knowledge as most acceptable if and only if the topics were harmonious with their social, health, home experience, and cultural contexts. They agreed that their perceptions of science were shaped by what they learned at home from the adults. Additionally, they also admit that they knew the functions of each medicine, such as amoxicillin, and how dangerous it was when it was misused. Still, they did not know the scientific facts behind it.

The researchers also found that Somali mothers perceived science as an empowering tool for their feminine life, such as reproductive health issues, which was an unexpected response. They suggested that science learning should embrace and improve girls' and young women's safety issues. This is mainly due to the gender disparities where women held much less power in decision-making about everything, especially when bearing greater consequences of pregnancies and sexual violence towards girls. Other than that, they saw science as a platform to inform Somali students regarding this issue to be well-educated in reproductive health since this 'knowledge' is only passed down from the eldest to mother to daughter. In fact, it is crucial to understand the science beyond this health issue. Thus, to improve women's social status, those participants saw that science could empower girls. This is because taking a degree or profession in science seemed to empower Somali girls through better social status and provide them with the freedom to select their future educational and professional goals.

However, the heterogenous linguistics in the United States schools with science content is full of too many topics instead of being in-depth, creating a concern that the children might be moved to the next grade without a deep understanding of science content. Hence, Albrecht and Upadhyay (2018) put this research as a broader implication for urban science teachers to revise their curricular decision and teaching of science by connecting the Somali students' culture and empowering girls.

After understanding the perspective of mothers on science, Albrecht and Upadhyay (2019) again conducted explanatory qualitative research by interviewing two Somali fathers to explore their perceptions of science and how to intersect science with their sociocultural practices so their children could learn science best. The study showed how bewildered the fathers were about the contradiction of human creation explanation in science with the Islamic paradigm that was not properly matched. Apart from that, Albrecht and Upadhyay (2019) found that 'jokes' or 'humor,' the oral tradition in Somali culture, was seen as the medium to break the tensions between learning human evolution either scientifically or Islamically. The Somali fathers encouraged Somali students to see the connections between the Islamic faith and science to dispel the myth that those two fields are incompatible. In addition, Somali fathers acknowledged that social and cultural experiences gained through the perpetuated parenting from their ancestors, parents, and themselves to the younger generation shaped how they and their children viewed science. It includes the effects of fasting on the human body during Ramadan, the effects of the environment in pastoral practices, climate change, dietary habits, and some health issues. Home experience with science content brought practical significance to Somali people.

3.3.3 Marginalized students' perspectives

Upadhyay et al. (2017) saw that many urban elementary students learned science topics decontextualized from their sociocultural and sociohistorical experiences, which made science learning less meaningful (Ladson-Billings, 2014). Using the sociocultural theory of learning (SCT) and CRP, Upadhyay et al. (2017) claimed that the sociocultural experiences among non-dominant students would enable them to gain a voice in influencing science content and practice. It would then lead them to get self-determining to recognize science was personally significant. Other than that, their varied sociocultural experiences, which came from diverse countries, made the classroom an ideal cultural space to infuse science activities. Thus, the researchers focused on the gardening activity. On the other side, the teacher, Ms. Hope, involved in the lesson, used culturally relevant science teaching, encouraging non-English speaking students to prioritize their home experience during the lesson and challenging students to doubt her ideas about science.

Finally, Upadhyay et al. (2017) discovered three findings in their research on how students leveraged their sociocultural experiences in science: (1) students gaining a voice in a science classroom, where they suggested to the teacher what activities they would like to do for tomorrow's lesson, (2) students acted upon their self-determination in science learning, such as bringing the agriculture issue then linking it with science content, and (3) making science learning as the sociopolitical awareness, where students saw the links between science learning with the larger communal and global issues. For example, Somali refugee camps in Kenya did not have the accessibility to water, but the city people got it. Note that these three findings were a success due to the outstanding teacher who knew ways to induce responses and make students leverage their home experience, FOK, and sociocultural content into science.

Alternatively, while other researchers used CRP and CRT as their theoretical framework, Esteban-Guitart et al. (2019) used the culturally sustaining pedagogy (CSP) as a theoretical stance proposed by Paris (2012). They conducted a study when a problem of a performance gap between migrant and immigrant students toward science was seen in the Program for International Students Assessment (PISA) 2015 report in Spain. Thus, they did an ethnographic visit and in-depth interview involving teachers, families, and students as the participants, but teachers were not there as experts but as learners.

Furthermore, Esteban-Guitart et al.'s (2019) study presented two empirical examples that were divided into context A (FOK intervention research) and context B (funds of identity (FOI) intervention research). The findings for Context A exposed a list of FOK that many shared similarities between hidden cultures and FOK. Note that they came from different families with different natures of traditional cultures, such as plurilingual competencies, gardening knowledge, practices, skills, and hobbies. The teacher was shocked when they found the similarities between those families and decided to embed them in the classroom to facilitate the science learning process.

In context B, a student developed a unique connection between the personal-family-school practice through the dialogue transitions, from resistance to bridging the school practice into their identity. Some students even said that somehow uncensored dialogue occurred on the notion of culture from one's experience of belonging. In fact, the subtle assimilation process happened in the classroom, but they resisted accepting it. These showed how inadequate essential approaches to the diverse culture in the education system were. Thus, Esteban-Guitart et al. (2019) concluded that teachers should not only recognize and highlight the importance of cultural diversity, but they have to sustain it. From both contexts, it could be inferred that inclusive educational practice should be brought into line with cultural sustainability pedagogies as well as connecting them to the curriculum objectives.

Lastly, the most recent research by Upadhyay et al. (2020), who conducted qualitative research on Tharu indigenous students identified as a marginalized group in Western Nepal, was presented. These indigenous communities are discriminated against and have to endure oppressive socioeconomic and political environments. Despite suffering in that situation, they have no choice but to continue to value and appreciate their culture and knowledge regarding the education system. Compared to boys, the girls have an outsized burden to secure their family needs as they are still expected to help mothers at home, fish at the nearest river, take care of their younger siblings, cook, and harvest. Moreover, most of the student's parents worked as bonded laborers, which kept them in poverty for over a century. Since the knowledge and skills are passed down orally and learned that survival skills a lot from one generation to another, students have varied experiences and indigenous knowledge about their geographic and economic activities. Hence, Upadhyay et al. (2020) conducted a study at a poor rural public school called Aasha using sociopolitical consciousness (SPC), CRP, and critical consciousness as their research framework. This was to explore how Tharu students utilized their science knowledge and skills to gain a voice to challenge and understand the socio-political issue and how they took action for social change and empowering the community for their social justice.

Throughout their study, Upadhyay et al. (2020) explored and understood students' SPC actions by profoundly focusing on their critical thinking and reflection during science class. Fostering social justice awareness in science class, where students have an aphorism that science could help them improve their skills to gain a voice for their social and cultural justice. For example, during science class, when the teacher talked about the water system (science content), girls who were fed up with being discriminated against kept asking why they always got impure water from the school and government. The discussion affected girls in the school and women in the community. They viewed that the issue could be solved by taking political action.

Since Tharu is one of the areas in Nepal famous for sickle cell disease, either the person is a carrier or affected patient, students sighed that the science curriculum has nothing about mosquitoes and ways to prevent it. Consequently, they complained about the textbook authors, who were all non-Tharus. They felt discriminated against, especially when that disease was stigmatized as 'Tharus disease.' Hence, students did the discussion and connected the diseases with their experiences in life though it was not in the government-prescribed science textbook. They took action by making a pamphlet and letter to the principal and the village council to tell their society the science behind the disease and its myths. The teacher named Mr. Binod, who practiced an activist pedagogy for SPC science learning, had connected the science contents with Tharu's culture. His action became a success when students responded positively. Other than that, he constantly coaxed students to leverage their experiences to link them with sociopolitical issues.

The study by Upadhyay et al. (2020) revealed how students made connections between science content with their culture, experience, and socio-politics. It also describes how they could take action as students who viewed social, political, and curricular structural forces have marginalized and discriminated against in their communal life. Note that marginalized indigenous students were able to engage their critical thinking, critical reflection, and taking action for their social change by connecting science with their social culture.

4. Discussion and Implication

The trend of current cultural-based science education within these seven years divided into three patterns of research: (1) cultural-based lesson plan for equity in physics educational opportunities, (2) effectiveness of integrating culture in science education, and (3) cultural-based science education as a voice of multidimensional perspectives.

For the first trend of integrating students' cultural values in science lesson plans by Ali et al. (2015), it was good to blend students' funds of knowledge (FOK) by considering their daily experiences or common things in activities. However, the researchers did not deeply explain the relation of the material density formula and ways to get the buoyancy force with FOK. The physics concept of buoyancy is explained in Archimedes' principle. Nevertheless, buoyancy is one concept that is difficult to understand. Therefore, it is important to connect the physics formula with students' social contexts or FOK, such as their daily experiences and culture (Rohandi, 2014). When describing the connection in-depth, for research purposes, it is necessary to reveal hidden stories of students' real lives regarding physics. Meanwhile, in a study by Soko et al. (2019), though physics teachers proved they managed to design a cultural-based lesson plan for the first time, teachers only did the relation of physics with culture through the experiment that had been suggested in the Scheme of Work (SOW) template. Science is beyond what has been written in a textbook (Upadhyay et al., 2020). From our perspectives, it is important for teachers to understand the nature, daily life experience and sociocultural elements of their students before design the lesson plans. Soko et. al (2019) have argued, too, that teachers who lacked experience in teaching were unable to design lesson plans that integrating students' FOK. We argue that pre-service teachers and new teachers should be given exposures in culturally responsive teaching (CRT) and culturally relevant pedagogy (CRP) practices (Nasri et al., 2021) especially in developing countries to extent the social justice and equity (Aikenhead & Jegede, 1999).

For the second trend, studies of the effectiveness of integrating culture in science education have been done by Ali et al. (2017), Suastra (2017), Rahmawati et al. (2019), and Kadmayana et al. (2021). Different from Ali et al. (2015), Ali et al. (2017) showed that integrating culture into physics concepts could tackle the misconception problems and immediately refine them. They showed an excellent example of a refractive index formula and connected it with students' FOK. However, they put a limitation only on the optics chapter. On the other hand, Suastra (2017) has shown the effectiveness of the Local Culture-based Model of Teaching (LCBMT) in physics learning by embedding culture into it. Nonetheless, the way they measured the understanding level was poorly explained and ambiguous. We have doubts about identifying students' understanding level toward the Nature of Science (NOS) with students' sociocultural perspective by only using questionnaires. Apart from that, we argue that students' understanding level could be better measured using subjective questions so that they can reveal the in-depth thinking of students. The connection of culturally responsive teaching with students' creativity in Rahmawati et al. (2019) deserves particular attention. This research claimed to develop students' critical thinking skills through culturally responsive teaching (CRT), which was implemented in a five-phase teaching model. However, they did not explain clearly how effective the CRT approach was in developing students' critical thinking skills. Thus, their research remained questionable.

For the third trend, research by Brown and Crippen (2017) is one that we found examining teachers' perspectives toward integrating culture with science education. This research impacted how discrimination in multicultural education was eliminated gradually after teachers were involved in the Science Teachers Are Responsive to Students (STARTS) program. The biases and bad assumptions among teachers toward their minority students become their regrets after realizing that students' culture is the main key to being linked in the science classroom to reach equity. Note that this research focused on teachers' perspectives, but the way students responded and how their academic performance would change were things that they did not mention. As the main center of education is students (Upadhyay et al., 2017), then it is important to indicate the successfulness of teachers' practices by looking into students' perspective of their teachers, as well as their performance.

The studies on marginalized parents' perspectives towards science education integrated with culture are reflected in Albrecht and Upadhyay's (2018) research. They conducted a study to get three Somali mothers' perspectives on science. Though this research collected the perspective of only three refugee women, the researchers wished science educators to adjust their science instruction so that Somali students could connect their culture, home experience, and science content. However, the findings were collected from Somali adults, not students or teachers. Thus, this research cannot be generalized to all Somali communities. Meanwhile, Albrecht and Upadhyay (2019) did qualitative research on Somali fathers. By gaining the perspective of cultural-based science learning on immigrant parents, teachers should be more inclusive of sociocultural experiences among students. This is vital to make science learning and pedagogy more meaningful and not isolated to students from underrepresented groups.

Lastly, the research trend of cultural-based science for marginalized students' perspectives can be seen in Upadhyay et al. (2020) and Upadhyay et al. (2017). Since students come from multiple locations, they have diverse cultures and home experiences. Therefore, when linked with science content, they could influence their teachers' teaching decisions for academic success and build a sociopolitical awareness. Other than that, this research indicates that science educators need to perceive the value of culturally responsive instruction and the sociocultural idea of learning, which support pluralistic and democratic practices. Hence, how many teachers have a right concern to support and embrace democratic practices needs further research because teachers are the central agents who connect culture and science when teaching. Teachers, indeed, need teaching practices of CRT and CRP to have the sense of urgency to become the agency of equity and social justice. This is because we believe that teachers are educators, facilitators, and their roles are more than just teaching.

In relation to Upadhyay et al. (2017, 2020) studies, critical consciousness is still limited in number in science education research, in which Brown and Crippen (2017) have mentioned their concern. Having critical consciousness does not mean we supposedly foster students to criticize the government, but it is about gaining a voice and taking action for social justice. In the study by Esteban-Guitart et al. (2019), FOK might seem easy but not be so practical due to the study's limitations. However, FOK would have a big impact on students with diverse cultures, migrant-immigrant students, dominant and non-dominant students, and marginalized students, as how Upadhyay (2006, 2009) did. Alternatively, Esteban-Guitart et al. believed that cultural pedagogy and sustainability identity should normalize diversity, including language, history, and students' FOK. Nevertheless, the researchers did not analyze the impact of FOK and Funds of Identity (FOI) on science learning as they put them as their limitations. Nonetheless, they proposed two concepts that could help teachers in that area, leveraging cultures into the curriculum and pedagogy toward multicultural education: FOK and FOI.

On the other hand, Stapleton and Reif (2022) brought a fresh and new insight into cultural bridging in science education when emic perspectives were tapped as FOK to become a guideline for outdoor teaching using a third space theoretical lens. Their study channel the voice of the science teacher who was once a marginalized student. Although "one size does not fit all" denies one solution that could solve science education problems in equity and social justice, FOK and third space were advocated as socially, contextually, and situated-based to improve marginalized students' engagement and performance by giving equal opportunity to learn. Other than that, upholding marginalized students' voices to reframe equity in science education is one of the efforts to channel the audacity of how they want to be taught. This, too, aligns with Upadhyay et al. (2017), where students bring their voices to the science classroom when the teacher leverages FOK during the lesson. Giving a spotlight to these disadvantaged students indeed promises many positive outcomes. Hence, it is time to reshape the science curriculum policy from the marginalized community's perspectives to advance social justice and bring equity to the disadvantaged.

5. Conclusion

To conclude, when it comes to social justice, we are on the right track when fighting for minority or immigrant people's achievement in science and equity in educational practices. However, fixing only the achievement gap is cliché because many scholars have put much effort into doing multiple studies to close the gap since the 19th century. Indeed, we are now in the modern era with uncountable technologies, yet we are still fixing the achievement gap among students. To fight for equity, solving the achievement gap is a must. Still, from the thirteen articles we have synthesized, the crucial thing that needs attention is fixing equity and social justice among disadvantaged students. It needs a strong commitment from students, teachers, parents, families, and the whole community to reshape society's education to ensure equity and social justice. However, from the current pattern of integrating culture in science education, there is a sense of urgency in developing model that emphasize the teaching practice for CRT and CRP to bridge FOK and science since teachers are the hopes for marginalized students and communities, especially in developing countries. We hope that from this review of research, we could reshape the future direction of research on equity and social justice in education and reshape the practice of education, particularly science education by looking into the mirror, not outside of the window.

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