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Sociocultural and Sociopolitical Challenges for STEM Education in the Current Era

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Abstract: To ensure learner engagement, the importance of integrating learners' culture or, at the very least, being cognizant about it while carrying out formal/informal STEM activities has been well recognized in the STEM literature. However, the importance of considering learners' political identity while designing such activities has not been well-addressed. The lack of scientific literacy coupled with the distrust that a wide range of people has with scientific efforts of any kind that go against their worldviews, values, and beliefs can potentially have a significant impact on STEM educational activities' effectiveness. This research is grounded in the idea that both sociocultural and sociopolitical realities of learners' lives and the interplay between those realities need to be exhaustively investigated to better communicate science via STEM activities. STEM activities should be designed that should guide people to discern among evidence, opinion, misinformation, and disinformation regardless of their cultural and political identities and develop STEM identities that can coexist with them. To this end, this paper specifically will address the following research questions: *(1) what approaches STEM researchers and practitioners have traditionally adopted to include culture and politics into the learning process?, (2) what challenges have they experienced in advancing or promoting science with cultural and political resistance?, and (3) what new mechanisms can be adopted or existing mechanisms can be modified to address evolving challenges in the sociocultural and sociopolitical landscape?*. With increasingly sophisticated tools and techniques available for conducting research syntheses, it is now possible to look at different research domains and find answers regarding the complex interplay of sociocultural and sociopolitical factors in STEM education. Multiple bodies of peer and field-reviewed literature will be consulted in this research. *First*, the research team will review formal and informal STEM-based peer-reviewed articles and white papers to understand how STEM practitioners addressed different sociocultural and sociopolitical challenges. *Second*, the research team will review different mechanisms available in the existing literature to debias people and how they can be adopted by STEM practitioners. Essentially, the findings presented in this paper will provide the foundation to better understand the relationship between culture, politics, identity, and STEM. The direct beneficiary of this research endeavor will be professional audiences who are (1) individuals or organizations working in designing and implementing formal/informal STEM activities, and (2) students, faculty, and researchers interested in formal/informal STEM outreach and citizen science focus. The broader impact of this research is that it can potentially provide a better understanding to the STEM community about why marginalized populations such as the rural population or communities of color have historically demonstrated unique social, cultural, and political traits that are typically averse to science learning and acceptance and what needs to be done to alleviate such a pressing issue in the current era.

Introduction

The importance of integrating learners' cultural aspects (i.e., sociocultural) or, at the very least, being cognizant about it while carrying out STEM activities has begun to be recognized in the STEM literature (both formal and informal). In existing STEM literature, culture has been considered to be a multi-layered concept that includes factors such as race, social class, ethnicity,

religion, and gender. When cultural influences are not adequately integrated into a learning activity, students/learners will likely experience a level of disconnect that hinders interactions between students and teachers [1–3]. Integrating culture can reduce the dominance of particular societal groups and the respective culture of science in STEM learning settings [4]. STEM researchers have begun to investigate how such factors affect the effectiveness of different STEM learning efforts/strategies and how to better design them accordingly. Compared to sociocultural aspects, the importance of considering learners' political identity while designing STEM learning activities has not been well-investigated. One can be a STEM educator, scientist, or engineer and at the same time be a community activist advocating for legislative reforms. He/she may use their technical knowledge and understanding to imagine and design new technologies that resist oppression and empower marginalized groups in society. Many researchers have recently argued that regardless of whether or not political issues are explicitly engaged, learners have already developed political identities, values, and beliefs about the role of science in society [5–7]. Only a few studies are available that explicitly investigated the roles of STEM institutions in providing information, activating, and brokering discussions, and decisions around scientific issues while being cognizant of political influences [8].

This research will contribute to STEM scholarship by exploring the impact of learners' cultural and political identities on STEM education effectiveness and how to develop more effective STEM education activities accordingly. This will be achieved through a review of national and international scholarly research and field practices. *This paper will specifically present the preliminary findings of the review that will highlight the approaches STEM researchers and practitioners have traditionally adopted to include culture and politics into the learning process, the challenges they have experienced in advancing or promoting science with cultural and political resistance, and the new mechanisms that can be adopted to address evolving challenges in the sociocultural and sociopolitical landscape*. Upon further analysis based on the findings in this paper, a novel integrated framework linking culture, politics, identity, and STEM will be developed and subsequently validated. The ultimate goal is to provide STEM practitioners with a blueprint on how to better integrate cultural and political factors into the STEM education design and implementation process.

Research Steps

The literature review search was primarily conducted using *Google, Google Scholar, and informalscience.org*. The steps taken during the search are illustrated in Figure 1. First, using a set of keywords, abstracts of relevant studies were identified. Second, the focus of these abstracts was identified via a manual abstract scan. For example, some studies focused on formal STEM education and investigated how to better incorporate learners' race into the design process. On the other hand, some studies focused on informal STEM but also investigated the effects of race in the design and implementation process. Third, duplicate studies were removed from the database. As using keywords may generate duplicates due to searching in multiple databases, they were removed from the analysis. Fourth, a relevance check was conducted via reading the entire article to determine if they could contribute to answering the required research questions. In this step,

literature was again removed from consideration if they were of poor quality and failed to provide key insights into the research questions.

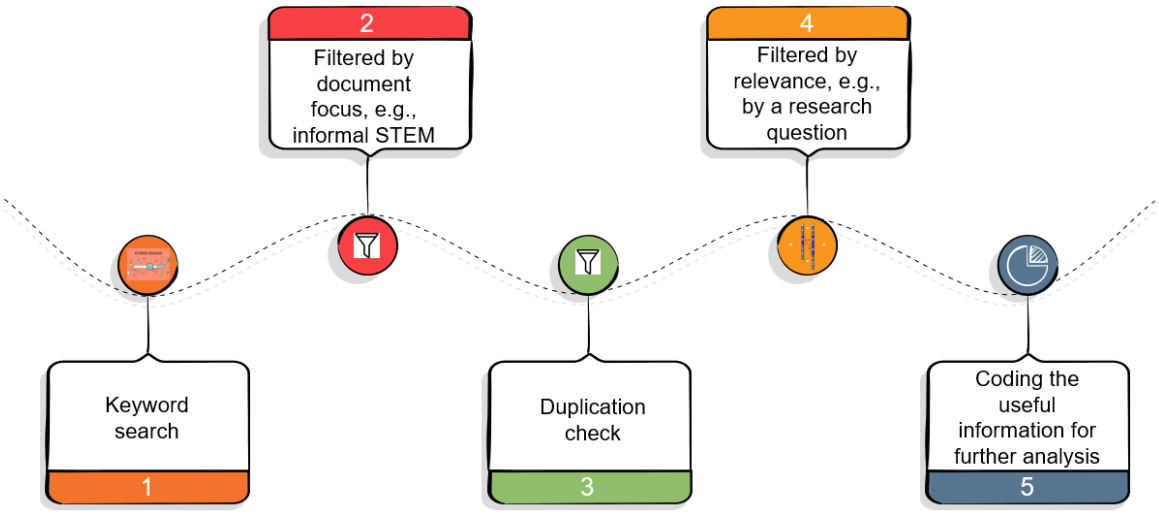

Figure 1. Research Steps taken in this study

Table 1. Identified studies via preliminary literature review

Literature review goal	Sample keywords	Unique studies identified
Identify the *approaches adopted* by STEM researchers and practitioners to integrate culture and politics into STEM	"STEM learning", "informal STEM", "informal STEAM", "race/gender/class/culture/politics and STEM/School/Universities/Curriculum/ informal STEM/STEAM/learning/ non-formal learning/museum/early childhood education/after-school/maker education"	25
Identify the *challenges experienced* by STEM researchers and practitioners to integrate culture and politics into STEM	"STEM learning", "informal STEM", "informal STEAM", "race/gender/class/culture/politics and STEM/School/Universities/Curriculum/ informal STEM/STEAM/learning/ non-formal learning/museum/early childhood education/after-school/maker education"	25
Identify *new mechanisms* that can be adopted to address evolving challenges in the sociocultural and sociopolitical landscape	"Cognitive debiasing", "debiasing in decision-making", "debiasing mechanisms"	17

Finally, a detailed coding sheet in Excel was developed after finalizing the literature that included categories such as author, title, type (qualitative vs quantitative), year of publication, keywords, cultural indicators, political indicators, focus group, sample size, analysis criteria, main findings, implications, and limitations. A final check was conducted to ensure that enough

information was available in the excel sheet for further analysis and that the contents matched the requirements for addressing the research questions. Table 1 lists the sample keywords used in the literature review with respect to each of the research questions and the unique studies that were identified. Note that the reference section does not include all the articles (67) reviewed during the course of this study. For brevity, only a subset of the studies needed to highlight the findings was included in the reference.

Findings

Three sets of findings are presented briefly in this section. Each set of findings corresponds to the three research questions posed before.

Research Question 1. What approaches have STEM researchers and practitioners traditionally adopted to include culture and politics into the learning process?,

To address the first research question, 25 studies were identified that in general considered many aspects of sociocultural and sociopolitical factors during STEM activity design and implementation. The preliminary literature review identified a wide array of such factors that included *gender, race, class, ethnicity, party affiliation, religion, and geographic location* [9–16]. Studies that identified sociopolitical factors to be crucial in STEM learning often considered it as part of the sociocultural phenomenon. Currently, much of the literature groups them interchangeably which may not be accurate. Political identity highlights the subjective values and intentions chosen rather than cultural identity which lays particular stress on the group destiny of a people or ethnic group from which its members cannot withdraw [17].

Preliminary findings also suggest that researchers and practitioners adopted approaches such as *identifying role models in the respective STEM field, agential realism, customizing STEM experience through citizen science, providing a continuous communication channel, creating a space of affirmation and care, curricular integration programs, connecting the learner's salient identities and their understood meanings with the theoretical frames supporting relevant scholarship by experts with similar cultural and political experience, and in general developing culturally and politically relevant pedagogy practices during the STEM educational activity design and implementation process* [7,13,18–20] . In practice, these approaches encourage educators to analyze the program's cultural and political context, develop evaluation questions with the active inclusion of multiple stakeholders, use participatory and collaborative approaches, utilize culturally commensurate data collection and analyses methods, and share findings with a variety of audiences[2].

Research Question 2. What challenges have they experienced in advancing or promoting science with cultural and political resistance?

The same sets of identified literature were used to identify the challenges, primarily experienced by STEM practitioners. Challenges in this context refer to the difficulties faced by researchers and practitioners during the STEM educational activity design and implementation process. These challenges may come from the participants, communities, families, and/or due to the need for more understanding by the researchers and practitioners about the underlying issues[21]. Different challenges, primarily associated with the perception of one's identity and position within

STEM were focused on factors such as *stereotypes and gender bias.* For example, due to stereotypes of what is possible by a particular group, many learners could dissociate themselves from the STEM learning process. Getting them motivated was a significant challenge experienced by the STEM practitioners. Parent/guardian values regarding the need for STEM learning were another factor that STEM practitioners have to contend with due to cultural and political values [22–24]. Community participation was identified as the major remedy to address many of these challenges. Debiasing was also identified as a potential tool to address the identity-based challenges experienced by STEM practitioners.

Other challenges that are not related to participants or educators but arise due to the surrounding environment within which educational activities are carried out have also been identified. For example, the increasing diversity of technologies and the complex problems posed by globalization, policies and procedures taking precedence over student learning and development, and funding were identified as the three major factors that affect the successful implementation of STEM educational activities [25,26]. Unlike the previous issues, solutions to the majority of these issues can be provided with careful strategic planning that can allocate sufficient monetary resources to ensure culture and politics-conscious educational activities can be carried out effectively.

Research Question 3. What new mechanisms can be adopted or existing mechanisms can be modified to address evolving challenges in the sociocultural and sociopolitical landscape?

This research question attempts to address the identity-based challenges experienced by STEM practitioners. A total of 17 studies were reviewed that particularly focused on mechanisms for debiasing people in general. The goal was to identify mechanisms/approaches that can be adopted by STEM educators to accommodate learners with various political and cultural beliefs and viewpoints. These studies ranged across various social science disciplines such as behavioral economics and political psychology.

Biases typically develop via metacognitive experiences or subjective experiences that accompany the thinking process of an individual. It was identified that debiasing requires long-term planning via different mechanisms that can enhance learners' scientific awareness, ability to detect bias, initiate strategies to accomplish change, and finally, maintain the change [27]. It was identified that debiasing can take effects in three manners, i.e., (*1) by simply being informed of a potential bias, (2) by contemplating past judgment that has raised the possibility one might be biased, and (3) by developing insight into the adverse consequences of bias* [28]. A number of different mechanisms were identified that can lead to debiasing such as encouraging perspective-taking, training in rules and representations, and considering the opposite/alternative during decision-making [29–31]. For example, perspective-taking refers to envisioning the world from another person's point of view. This can encourage learners to step outside their usual thought patterns and process scientific information differently than they may typically do [32]. These activities (i.e., perspective-taking, training in rules and representations, and considering the opposite/alternative during decision-making) may also be incorporated in conjunction with different computerized tools such as simulation training and cognitive tutoring systems [33,34].

Conclusions and Future Research Directions

Culture and politics are integral parts of learner engagement in STEM education. This study aimed to identify the current state-of-the-art research on this topic to understand how to

enhance educators' abilities in addressing this complex issue while teaching. Both formal and informal STEM education-based studies were reviewed to ensure that the research findings can be adopted by practitioners and researchers in both fields.

The contributions of this study are multifaceted. First, it illustrates the need to consider the sociocultural and sociopolitical factors during STEM design and implementation. Second, it provides a list of such factors based on the existing studies. Third, this study captures the experiences of STEM researchers and practitioners in capturing and analyzing these factors as well as implementing different pedagogical approaches based on that. Fourth, several debasing mechanisms are presented that can be adopted by STEM researchers and practitioners to enhance STEM education effectiveness and reach a broader set of audience.

There are several potential future research directions. First, distinctions need to be made between sociopolitical and sociocultural factors in STEM. Existing studies mostly do not differentiate among them which may not be accurate. Second, an extensive literature review is needed to identify the connections between culture and politics, their effects on learners' identity, and the relationship between learners' identity and STEM effectiveness. During the literature review, no study has been found that links these three key issues together. Without a more holistic understanding of how culture and politics affect learners' identity, effective STEM activity design and implementation may be suboptimal. Third, identifying the differences in relative effectiveness between different approaches (e.g., identifying role models vs. agential realism, etc.) under different circumstances can be beneficial to the practitioners. Such an empirically driven comparison has not been conducted yet. Fourth, a case study can be developed that addresses at least a subset of the findings of this study and determine whether being cognizant of cultural and political underpinnings is indeed beneficial and can enhance STEM effectiveness. The authors are currently working on addressing these questions. More literature is currently being reviewed from sources such as IEEE and ACM to develop a comprehensive integrated framework that links culture and politics with learners' identity and STEM effectiveness.

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