Concept Paper

STEAM Education for Transformative Mathematics Learning

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Abstract

In this paper, I have tried to explore hegemonic western cultural worldview which heavily influences the traditional disciplinary egocentric curriculum practices. Western hegemonic culture's overriding inspirations in mathematics education have established western modern worldviews, culture, and traditions as universal standards. Through the so-called standard norms and values, the powerful countries (mainly western and European countries) have seized others' cultures, values, and perspectives and thus developed the culture of silence. Conventional disciplinary egocentrism indoctrinates hegemonic culture that makes the learners unaware of their ways of being, knowing, and doing. It severely affects less powerful (politically, economically and technologically) countries' education systems by pervading instrumental, decontextualized and bureaucratic thought and beliefs. It engulfs humanitarian, biocultural, political, and spiritual perspectives of mathematics education. It signifies that we urgently need to revitalize mathematics education by incorporating newly emerging perspectives; one such perspective might be STEAM education. I would like to discuss the different perspectives of STEAM education and explore how STEAM education contributes to creating new synergetic learning spaces in mathematics education by enhancing transformative learning practices. The primary concern of STEAM education is to acknowledge local and contextual ways of beings, knowing, and doing. The recognition of the local cosmological knowledge, perspectives, and values support authenticate the learning process. The learning authentication widens the possibilities of active engagement of learners in the learning and decision-making process by deploying creative, critical, and imaginative thinking and skills. A deep engagement in a multi/inter/transdisciplinary learning process embraces the learners into bio-cultural differences; the lifelines of the human being support developing awareness,

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self-consciousness, and spiritual sensibility. STEAM perspectives always focus on enriching transformative agendas to create more authentic, inclusive, and empowering educational practices. It also empowers the learners to act as change agents for enhancing socially, ecologically, and bio-culturally just society that underpins to transform mathematics education

Keywords: *Disciplinary egocentrism, STEAM education, self-consciousness, biocultural differences, transformative pedagogy, sustainable development*

Entry and Insight

Western modern scientific thought has guided a conventional curriculum practice pervasive in mathematics education. It regards curriculum as a dark tunnel route in which most activities have been already channelled. Other factors that might have been encountered in a route are merely regarded as an obstacle to reaching the intended destination within the stipulated time (Yu, 2009). Students and teachers are not allowed to enjoy the scenery during the journey of teaching-learning activities. Most of the time, they are urged to allot to get mastery of contents, which the experts determine as worthy of learning. The curriculum becomes isolated from the practitioners and remains somewhere in the realm of the experts. It separates the knowers from the known (Dewey, 2001). In my opinion, such isolated curriculum practices in education in general and mathematics education, in particular, create havoc in educational institutions and practitioners. There is no space for teachers and students to engage in teaching-learning activities with their styles by bringing contextual contents, cultural artefacts, and adapting socially relevant pedagogy because the curriculum is regarded as a complete package prescribed by external authorities and experts.

The nature of the prescriptive curriculum is highly centralized and guided by bureaucratic thinking in which every action governed by the curriculum is inevitable. Its major intentions are to transfer the universal mathematical facts and knowledge without considering learners' voices and sociocultural, historical, and lingual backgrounds. It explicitly enforces the learners to become passive receivers of knowledge and restricts the role of teachers as the disseminators of pre-packaged knowledge. They simply perform robotically within the framework of the already installed program. Such disempowering and decontextualized curriculum has incarcerated mathematics within the four walls of the classroom.

The prolonged practices of decontextualized mathematics curriculum in school and university support fostering the views of mathematics education as apolitical, acultural, and ahistorical. It appeals to practitioners to remain aside from

these perspectives. It indicates that mathematics becomes ultra-rational subjects uncontaminated from the general people experiences and remains in the realm of elite class and nations. In the name of providing scientific modern mathematics education, those nations and people in power legitimize their perspectives, values, and norms as standards. The impact is that learners become the unconscious consumer of knowledge. In this context, I realize that the central motto of the western modern curriculum practices intends to overlook the present crises of the world.

The present crises of terrorism, global warming, unjust social practices, and loss of biocultural diversity, to name a few, are seen to be the footprint of the more than 200 years of the modern educational system (Taylor & Taylor, 2019). The globalized western Eurocentric modern mathematics and science education focuses on developing technical and mechanical skills guided by economic imperative. The only economic imperative of the developed countries, thereby ignoring the voices, values, and perspectives of culturally different others (Luitel & Taylor, 2019), essentially foster social Darwinism views (Stetsenko, 2017).

Social Darwinism helps practitioners become blind supporters of social exclusion, unjust practices, and exploitation as the natural process and have not connected with mathematics and science education. Practitioners cannot relate the economic, ecological, environmental, and social disequilibrium. They become more fatalistic help maintain the status quo in the classroom, society, and nation. In this connection, Slattery (2006) argued that western-centric educational practices could not call into the questions of poverty, gender and ethnic diversities, exploitation of natural resources and workers, cooperate scandal, social and political violence, and ecological devastation for the betterment of the society, nation and the world. Such a disempowering notion of education emerges through the western-centric mathematics and science curriculum, which exclusively focuses on improving the test scores without considering the aforementioned attributes of education and schooling. It reveals that conventional western modern curriculum practices could/should not address the present crisis of the world.

To address the world's current crisis, the United Nations (UN) has developed the agenda for sustainable development by 2030. One of the most significant agendas is quality education (Goal 4), which suggests that constituent countries should improve access to education for their people through the principle of equity and inclusiveness (UN, 2015). However, the condition has not seemed to be satisfactory. The International Commission on Financing Global Education Opportunity (2016)

projects that the children of school age in 2030, approximately 69%, 21 %, and 8 % from the low, middle, and high-income countries, respectively, will not learn the basic primary skills. What does it indicate? Is the conventional teaching-learning activity resembling to meet the sustainable development goal?

Similarly, we have observed the massive disparity of distribution of wealth and income within the world regions. In 2016, the top 10 % of earners accounted for approximately 50 % of national income, and the top 1 % captured 26% of total growth, but the bottom 50% captured only 15% of total growth (World Inequality Lab, 2018). Moreover, the report also revealed an increasing trend of large transfers of public property to private property during the last 40 years, which has also yielded the rising wealth inequality among individuals. The report also warns that if the economic disparities have not been addressed properly, it will bring unimagined socio-political, economic, and environmental catastrophes (World Inequality Lab, 2018). It indicates the conventional education system would not support meeting the sustainable development goals and almost seems to fail to resolve the present crisis of the 21st-century complex world.

In this connection, my argument is that it is hardly possible to reshuffle the existing curriculum practices of mathematics and science education. It does not connect mathematics with the life-world of the learners so that they can understand and explore natural phenomena and act accordingly for the betterment of all human beings and the rest of the world. We need to have inter/multi/transdisciplinary knowledge and problem-solving skills in doing so. It will be hardly possible unless we can develop alternative visions of curriculum that acknowledge learners as holistic beings and support for creating a transformative learning environment for a sustainable future; one such perspective might be STEAM (Science, Technology, Engineering, Art, and Mathematics) education (Taylor & Taylor, 2019; Weidong, Wei, & Mimi, 2019; Radziwill, Benton, & Moellers, 2015). In this context, I would like to discuss the different perspectives of STEAM education and explore how STEAM education contributes to creating new synergetic learning spaces in mathematics education by enhancing transformative learning practices in the following sub-sections.

Perspectives of STEAM Education

STEAM is not another curriculum fad to be included in a mathematics education program. It is one of the perspectives in education which brings together the significant attributes of Science, Technology, Engineering, Art, and Mathematics for developing

interdisciplinary and/or transdisciplinary thinking skills to solve real-world problems. It breaks the egocentric disciplinary approach of conventional curriculum practices that have prevented the students from engaging in multidisciplinary education for exploring the interconnectedness among and within the fields by acknowledging the multiple perspectives and possibilities (Connor, Karmokar, & Whittington, 2015). The ability to connect the different concepts within and among the disciplines supports developing the conceptual and relational understanding of the subject matters that inhibit evolving the negative perception and feelings towards mathematics, which is necessary for conceptual understating and engagement in mathematical activities. Similarly, incorporating new perspectives, ideas, and values leads learners to engage in creative, imaginative, and critical inquiry.

In the inquiry process, these seemingly different disciplines collaboratively play a significant role. Science plays a role in exploring standard rules and laws that describe the world. Technology develops and provides the necessary tools and techniques that scaffold scientific inventions. Engineering enriches the designing and modelling process that helps represent the world more precisely. The most crucial constituent factor is art, largely missing in conventional STEM education. It supports the learners in engaging in creative and critical thinking before and after the invention. It opens a new path to envisage alternative views for the world's goodness. It also provides the best communication and sharing to the wider practitioner community.

Last but not least, mathematics helps learners analyze and interpret the results by connecting, differentiating, and integrating different constituent factors for generalizing the new knowledge and concepts for broader application of the finding/model to re/solve real-world problems. It signifies that STEAM perspectives do not restrict the learner within the narrow lock step approach of solving routine problems. It widens the learner's thinking and acting by providing multi-perspectival views of learning and solving real-world problems. Similarly, STEAM perspectives do not necessarily believe in having all of these skills and concepts as an individual, so it appeals to collaborative and cooperative teamwork to solve the problems. The collaborative working culture helps develop communication and social skills and enriches the culture of respect within and outside the school premises, fostering social harmony.

Creating and enriching social harmony is one of the most attributable aspects of STEAM education, which is being practised through the calls of an empathetic learning environment in a mathematics classroom. An empathetic learning environment offers learners to express the true essence of meaningful learning experiences that contribute

to the inquiry process. At the same time, they have a passion for listening and are willing to incorporate others' perspectives, experiences, and thoughts that heighten the learners' motivation, willingness, and desires to engage in the learning process (Culén, & Gasparini, 2019; & Interaction-Design. org, n.d). It is primarily a human-centric perspective in education. It does not treat human beings as simply cognitive; instead, it views them as holistic beings with cognitive, affective, spiritual, social, cultural, and contingent sensibility. It blends head, heart, and hand to foster the eagle eyes' views to actualize the interdependency of the human being with the rest of the world (Luitel & Taylor, 2019).

In my opinion, unconscious human activities, the unhealthy competition of big corporate houses, the only economic imperative of capitalism, extreme patriotism, denunciation of cultural, social, and historical values of disenfranchised groups and nations through the endorsement of so-called modern education seem to be more responsible for the most of the present crisis of the world (Slattery, 2006). The STEAM education practices also call into attention through the lens of critical inquiry and help to explore the causative forces behind the existence of such inhuman and disempowering practices pervasive in our society, nation, and the world. In this context, the conventional disciplinary egocentric practices of mathematics and science could/ should not resolve these complex problems because of their unidimensional modes of analyzing, representing, and presenting the phenomena. To address these problems in the long run, we need a holistic educational program that might provide the grounds for learners in which they will have been taught to explore the social, biological, lingual, economic, environmental, and ecological connectedness.

For the holistic development of the learners, it is not sufficient to focus on the cognitive aspects of the students. We need to pay attention to enriching the affective, spiritual, social, and cultural dimensions so that students become change agents (Luitel & Taylor, 2019) rather than simply spectators and describers of the social reality. When the learners start to solve real-world problems, they will gradually begin to understand the interconnectedness and interdependency of a human being with the rest of the world.

The principal argument of STEAM education is that our world is not linear; it is more complex and multidimensional. To resolve and make a wise decision in the present complex and bourgeoning world, learners need multidisciplinary and/or transdisciplinary knowledge and skills. These are some of the reasons behind spreading the STEAM education perspective throughout the world, not only within the boundary

of science, technology, engineering, and mathematics but in geography (Weidong, Wei, & Mimi, 2019), social science and liberal education (Gogus, 2015) and many more. It signifies that STEAM education is not a subject to be mastered in a pre-assigned period. It is a new perspective of engaging in critical, creative, and imaginative activities to explore new knowledge that helps solve a real-world problem. It allows learners to take ownership of their understanding and learning (Hawkins & Pea 1987, as cited in Stroud & Baines, 2019). From this discourse, I realize that STEAM education considers social, political, cultural, economic, environmental, ecological, linguistic, etc., as potential constituent dimensions of mathematics education that support to attainment of sustainable development goals.

With the rapid development of modern sciences and technologies after the European industrial revolution, we have observed a paradigm shift in every sector of human beings. Due to the over-reliance on fossil fuels, unconscious and excessive use of natural resources through the power of modern sciences and technologies to generate immediate benefits have a significant detrimental effect on the planet's natural system. The environmental degradation, ecological unbalance, disappearance and melting glacier lakes, loss of habitats, global warming, loss of marine lives, etc., are examples of human victory and control over nature (Taylor & Taylor, 2019). The impacts of climate change, loss of habitats, and environmental degradations have drawn public attention. However, loss of sociocultural and lingual diversity have not been embedded in the public consciousness that together forms a loss of bio-cultural diversity (Taylor & Taylor, 2019), which threatens the lives of the earth, and inhibits the paths for achieving sustainable development goals.

Implementing western Eurocentric informed mathematics and science education in school and university, local and indigenous knowledge, languages, and rich sociocultural practices have not been recognized as being potential/worth to be included in a formal education program (Giroux, 2011). An externally imposed mathematics education disconnects learners' lived experiences with classroom mathematics practices. Mathematics education has been highly informed by technocratic rationality. Thus, it has become less about learning and more akin to vocational training to learn technical skills. It denies the role and importance of socio-historical consciousness that guides learners to become reluctant to prevent global crises. The conventional disciplinary egocentric approach of mathematics education focuses on technical rationality, which ignores mathematics education's political, social, and historical dimensions and indoctrinates immediate materialistic and economic benefits. It serves the interests of

big corporate houses that explicitly/implicitly enrich the economic disparities among individuals and nations, snub the issues of social justice that ultimately work as the hidden forces of terrorism, violence, and famine (Slattery, 2006). These are some challenges directly/indirectly related to the sustainable development appeal to socially and ecologically responsible education that would incorporate the issues mentioned earlier and the value of education. It further contributes to producing critical citizens to act as change agents.

Undoubtedly, disciplinary bounded knowledge and skills are insufficient to address complex real-world problems. In addition to developing students' multidisciplinary and transdisciplinary knowledge and skills, we need to adapt socially responsible STEM pedagogy to prepare the students to internalize their significant roles to address the issues (Mchombo, 2019). After integrating 'A' in STEM to form STEAM education, it provides enough space for both students and teachers to engage in creative, critical, and imaginative inquiry leading them to understand the roles of education to resolve the present crisis of the world by shifting the paradigm of mathematics education. The above discussion foregrounds that the STEAM approach brings a paradigm shift in mathematics education that helps break ahistorical, apolitical and acultural notions of mathematics. It supports pupils to understand social, biocultural, political, and historical sensibilities of mathematics education that opens a new avenue for the transformative learning process (Guyotte, Sochacka, Costantino, Kellam, Kellam, & Walther, 2015; Gogus, 2015; Marmon, 2015; Doniger, 2018; Taylor, & Taylor, 2019), which is one of the major intentions of the STEAM education.

Transformative Mathematics Learning

I have just discussed different perspectives of STEAM education that highlight its necessity in the context of the 21st century. It conveys those conventional pedagogical practices in school and university seem to be unable to produce a critical productive citizenry. Most of the curricular activities in our schools and universities have been suffered by the western Eurocentric ways of informing pedagogy that implicitly aim to prevent the creative, imaginative, critical, and messy process of learning (Culén, & Gasparini, 2019). Learning is regarded as accumulating vast amounts of information and highly technocratic skills appropriate to a particular field. The rapid development of science and technology is necessary for the faster economic growth of the nation, so why educational institutions might under pressure to produce technocratic human resources.

In my opinion, it is necessary to develop the technical knowledge and skills for accelerating the industrialization process. It seems to create an employment opportunity and support enhancing the economic aspect of the individual and the nation. However, it is not sufficient for transforming the world into better ones. It has been almost justified by more than 200 years of an industrialized era that our world and planet become gradually uneven for human beings and other creatures. In this context, I have some thrilling questions. Why do education systems fail to address global crises? Why are our curricula and pedagogical approaches not able to bring real-world problems in mathematics classrooms? Why do curriculum and pedagogical practices always focus on specific thumb rules as the standardized form of knowledge to be learned? The conventional disempowering notion of mathematics education seems to contribute to technological and industrial development; however, it has not considered the humanitarian, sociocultural, ecological, and political perspectives as significant constituent factors for the overall wellbeing of the practitioners and the earth. The most possibly negative impact of the only economic, technological, and industrial imperatives on educational policies and curriculum development is that it welcomes the logocentric thought in education.

In a theory of deconstruction, Jacque Derrida criticizes logocentrism in which knowledge is centrally created and legitimized so that the function of a school is bound to delivering externally sanctioned knowledge to their pupils for preparing them as skill workers (as cited in Alam, 2013). The highly centralized and bureaucratic education system regarded learners as passive receivers of knowledge and teachers as the storehouse of knowledge. In this perspective, both teachers and students have not been recognized as cognizing, social and spiritual beings able to perform, manage, and control their learning. Similarly, Paulo Freire also strongly rejects the notion of a centralized form of the school system, termed a banking system.

The principal characteristic of the banking education system is to promote the one-size-fits-all approach of curriculum, pedagogy, and assessment. Schools are bounded within the narrow framework of transmitting purely objective knowledge to learners having grant purpose of preparing them for the tests that intend to measure the students' memorizing power rather than focusing on creative and innovative activities (Freire, 1993). This context explicitly/implicitly provides a space for social exclusion, ideological hegemony, economic disparities, etc., because developed countries and elite groups have hidden colonial interests (Silova, Rappleye, & Auld, 2020). They want to inculcate their perspectives and value as universal norms and ignore culturally,

economically, and socially different others by implementing the standardized form of education and evaluation system that, in the long run, inhibit individual and social transformation (Taylor & Taylor, 2019; Luitel & Taylor, 2019; Slattery, 2006; Giroux, 2011).

Transformative learning has not depended only on the notions of scientific, logical thinking in which hypothetic-deductive reasoning has a dominant role in mathematics teaching-learning activities (Luitel, 2013). Learning mathematics means knowing and accumulating the already given mathematical knowledge, skills, concepts and proved mathematical theorems based on an axiomatic approach. The axiomatic system in mathematics fundamentally adopts the lockstep procedures in which there are undefined terms, technological terminologies, definitions, propositions, and axioms/ postulates and based on these attributes, theorems are derived as a generalized rule of mathematics. A linear and conventional way of thinking and reasoning in mathematics leads the practitioners to form an absolutist view of mathematics, which appears as a transmissionist pedagogical approach that offers learners to adopt the lockstep algorithm to obtain a single solution of the bookish problems (Lamichhane, 2018). It does not provide autonomy for learners. Students, teachers, and other concerned authorities cannot take sole responsibility for teaching-learning activities. Learners feel lonely learning activities and teachers always exhibit sympathy for learners.

The sympathetic approach in teaching-learning activities in mathematics is more disempowering and regards students as incapable beings for learning. Teachers and authorities predominantly exhibit deficit attitudes towards students as dependent learners. The sympathetic pedagogical approach in mathematics classrooms implicitly appears in hegemonic practices in which learners are regarded as incapable beings and learning as the matters of the handout. It appeals to teachers and authorities to express affectionate and kindly behaviour towards learners. I think it is an improvised form of informing pedagogy that might bring minor changes in mathematics classrooms; however, it cannot address the present crisis of mathematics education and thus orients to preventing the transformative path of mathematics learning (Luitel, 2009).

The transformative learning process is not simply linear, predetermined, and lock steps one-size-fits-all approach that can easily navigate the learning process. It is a multi-pronged, multidimensional, and contextualized learning process. It offers the learners to engage in the learning process without constraints. Transformative learning theory describes learning as a fundamental shift in pre-existing frames of reference that begins with a disorienting dilemma and generally concludes with changed self-

concepts and world views by integrating new perspectives to arrive at a new meaning schema about the phenomena (Mezirow, 1978, 1990). It is not simply a deductive approach. It recognizes the multidimensional and contextual learning process in which learners' cognitive, convictional, and spiritual dimensions have equally been considered so that learners can/should create their learning spaces through critical self-reflective practices (Luitel & Taylor, 2019).

Critical self-reflective practices in mathematics teaching-learning activities begin when the learners question fundamental aspects of reality, knowledge, and values of mathematical concepts and adopt pedagogical practices. Learners always become skeptical about themselves, mathematical concepts, institutional settings, and the validity of taken-for-granted meaning perspectives (Liu, 2013). The critical self-reflective practitioners should have the habit of questioning minds that leads them to reflect, critique, and challenge their perspectives and orients to reconcile the old meaning perspectives with the new ones. Critical self-reflective practices also help the learners to tackle disoriented dilemmatic situations encountered in mathematics teaching-learning activities.

The ability to choose and select one of the equally undesirable meanings/ actions requires creative, innovative, and imaginative thinking and reasoning skills. The disciplinary egocentric curriculum practices cannot enhance these attributes in learners because of their narrow focus on imparting pure mathematical knowledge without linking with real-world problems. It "enables learners to create interdisciplinary STEAM curriculum spaces for designing transformative pedagogies that develop students' disciplinary knowledge and skills and awaken their creative self-consciousness elevate their moral/ethical and spiritual awareness" (Taylor & Taylor, 2019). Similarly, critical self-reflective activities help learners understand, realize, and appreciate the values of interdisciplinary knowledge for solving unconventional and real-world problems. Learners can create a self-learning space in mathematics that in turn help them become independent learners and critical citizens well. In my opinion, the central aim of transformative learning in mathematics is to prepare critically conscious citizens so that they would be able to explore the explicit/implicit forces that restrain the pedagogical practices of STEM education within the mesh of conventional informing and reforming frameworks.

To break the boundary of conventional informing and reforming pedagogical practices of STEM education and open a new avenue for transformative learning in mathematics, we need to incorporate arts in STEM to form the STEAM (Doniger,

2018). Integration of Art in STEM provides enough spaces for learners to bring spiritual, ecological, sociocultural, and humanitarian perspectives in STEM education. It further fosters the grounds for creative, critical, innovative, and imaginative thinking and reasoning skills enabling learners to act within the larger framework for enhancing the agendas for sustainable development (Taylor & Taylor, 2019). It unearths narrowly conceived disciplinary egocentric curriculum (Connor, Karmokar, & Whittington, 2015) and pedagogical logocentrism (as cited in Alam, 2013), which are too dull, too abstract, and too irrelevant from the perspectives of learners (Yakman & Lee, 2012). It inhibits not only transformative learning but also deterrent sustainable development.

For sustainable development, we need to foster multidisciplinary and transdisciplinary knowledge and skills among the learners by introducing an inclusive, authentic, and holistic curriculum in schools and universities to become independent learners and enable them to solve unconventional real-world problems. Without exploring the complex interwoven relationships embedded in sustainable development, we cannot imagine the socially and ecologically just society and nations. In this context, I realize an urgent need for a holistic understanding of the complex and changing phenomena to become a transformative learner and change agent. In doing so, we need to challenge the conventional curriculum practices that give birth to the images of the curriculum as discrete subject matters/contents, planned activities, and cultural reproduction (Schubert, 1986). These curricula already deskilled the teachers so that they could perform simply the file duties in which students become muted followers and uncritical consumers of knowledge (Grundy, 1987).

From the above discussion, I came to realize that the simple reformation of the mathematics education curriculum cannot resolve the present crisis brought by informing a pedagogical approach. In this context, we are ready to welcome the alternative perspectives that incorporate affective, sociocultural, political and spiritual dimensions of learning that acknowledge the learning as the process of becoming and thus open the path of transformative learning in tertiary education (Mezirow, 1991).

It conveys that transformative learning theory focuses not only on cognitive development but also on acknowledging physical, cognitive, spiritual, sociocultural, and affective aspects for the holistic development of the learners (Papastamatis & Panitside, 2014). In the 21st century complex and burgeon era, the conventional teaching-learning activities cannot address the present crises of the planet that predominantly appears as the result of more than 200 years of irresponsible modern industrial development eager to only economic and profitable imperatives (Taylor & Taylor, 2019). Describing the

different agencies and research groups finding regarding 21st-century skills, Jan, choo, Kang, and Liem (2017) highlight that innovative, creative, communicative, critical, collaborative, and problem-solving are some of the essential skills need to foster to tackle the challenges of the 21st-century complex society. To hone these higher-order thinking and reasoning skills, we need to create a transformative learning space that encourages learners to awaken their emotional, ethical, imaginative and spiritual motives. It leads to developing critical consciousness and spiritual wisdom that elevates the agentive aspects of the learners, encourages them to participate in creating a more inclusive and socially just society and provides fundamental bedrock for achieving sustainable development goals (Taylor, 2013). From the discourse, I realize that the STEAM perspective, transformative learning, and sustainable development are highly interdependent and infused to form a new synergetic learning space for the learner's holistic development.

For the holistic development of the learners, we need to consider the cognitive, affective, sociocultural, and spiritual dimensions of the learning. According to Taylor and Taylor (2019), transformative STEAM education orients to create the synergetic spaces for the holistic development of the learners by incorporating five ways of knowing: cultural-self knowing, relational knowing, critical knowing, visionary and ethical knowing, and knowing in action. In my opinion, cultural-self knowing supports learners in exploring how their shared values, beliefs, emotionality, and spirituality work as a dorsal spine to learn and make their different identities and worldviews. After that, learners begin to relate their values, norms, ways of being and knowing to the more significant perspectives of society, nation, and the world, which helps them understand the interdependency of human beings to the rest of the world. It elevates empathetic thinking supports enhancing inclusive visions that embrace the biocultural differences as driving forces of sustainable development. Likewise, understanding the relationships among the distinct forces within the sociocultural and institutional settings help the learners to internalize how political power has historically governed our social realities and knowledge production procedures. And why the people have been forced to acknowledge the gender, racial, ethnic, economic, etc., disparities as seemingly natural categories and structures necessary for social functionality. Likewise, critical engagement in learning gives to raise the questioning habits of the learners that further lead them to engage in creative, innovative, and imaginative works for the grand purpose of envisioning the better world and the planet by shifting the paradigms of beings, knowing and doing (Stetsenko, 2017).

It signifies that transformative learning in mathematics facilitated by STEAM perspectives always focuses on preparing the conscious citizenry who can envisage a better world and take actions accordingly rather than simply descriptors of the existing phenomena and the world. More precisely, transformative STEAM perspectives become tools for the holistic development of the learners. After participating in the learning process, they should become agentive actors and co-creators of society, culture, and history (Stetsenko, 2017). It indicates that the transformative STEAM approach brings inquiry, exploration, collaboration, empathy, creativity, and criticality into the forefront of the curriculum (Guyotte et al., 2015). It seems to be more volatile, uncertain, complex, and ambiguous because of having integrated interdisciplinary and transdisciplinary perspectives (Pennington, Simpson, McConnell, Fair, & Baker, 2013). It also provides enough spaces for learners to dance among these perspectives to create alternative visions of mathematics education, their lives, and the world. In this context, I came to understand that STEAM education certainly helps foster transformative learning by creating synergetic learning strategies that have wider implications in mathematics education.

Final Thoughts

A conventional mathematics education does not incorporate the culturally different perspectives as worthy of including formal mathematics programs and welcomes hegemonic narrowly conceived worldviews, which have supported incarcerating mathematics education within four walls of the classroom. It results in producing learners' negative images, attitudes, and beliefs towards mathematics that prevent learners' holistic development. Similarly, the notion of disciplinary egocentrism of conventional mathematics education ignores biocultural differences, socio-historical, and political aspects of the genesis of mathematical knowledge. It fails to address the present crisis of violence, famine, environmental degradation, and loss of inhabitants. It also elevates the fatalistic views that compel learners to accept catastrophic natural disasters, social inequality, and exclusions as a natural and normal process. It indicates the urgent need to revitalize mathematics education to break the narrowly conceived notion of mathematics, its pedagogy, and learning. In this context, STEAM education might be one of the alternative perspectives to bring the expected changes in mathematics education.

STEAM education is a broader perspective that helps to ignite alternative notions of mathematics education curriculum and its learning approach. It provides the

broader space and visions that emancipate mathematics education from the narrowly conceived apolitical, acultural, and ahistorical views. Because of its empathetic orientation, it focuses on enriching cognitive, affective, and spiritual dimensions by incorporating local and global knowledge perspectives for the holistic development of the learners. They can transform society, nation, and the world towards more inclusive, socially and ecologically just ones that provide a solid foundation for achieving sustainable development goals. Finally, I conclude that STEAM education fosters the grounds for transformative learning, reflecting on the holistic development of learners having the sensibility of bio-cultural differences that work as a healing agent for the better future of the planet.

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