International Journal of the Whole Child
2022, VOL. 7, NO. 1

STEAM
Holistic Identity Development in STEAM

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Abstract

Holistic STEAM programs can benefit children by allowing them to develop an intersecting identity in STEAM disciplines, explore real-world issues more broadly, think critically and innovatively, solve problems using integrated approaches, and have confidence across multiple fields of study. Much of the current research situates identity development in single subjects such as science, math, or engineering. However, a broader conceptualization of identity in STEAM can influence the creation or progression of STEAM curriculum, environments, and programs to support the unique, organic construction of a child's identity development across multiple disciplines. Suggestions for creating optimal conditions for holistic STEAM identity development include using an interactionist approach, developing meaningfully integrated and

relevant real-world explorations, utilizing inquiry, interest, and play, and using a flexible curriculum that allows for divergence and creativity.

Keywords: STEAM, STEM, Play, Inquiry

Introduction

Identity studies are increasing in STEM research. Students' construction of scientific identity is well documented, as is identity development in mathematics. Young scientists and mathematicians view themselves as such through their own interests, passions, sense of belonging, and natural proclivities and talents (Kim & Sinatra, 2018; Peart, 2018). Likewise, research in engineering and technology have explored identity development, and the benefits are clear. When students establish an identity in their field of interest (e.g., a child who self-identifies as an engineer), they develop confidence, competence, and persistence (Choe & Borrego, 2019). They also tend to operate within or develop a growth mindset, which allows them to persevere through the difficulties or challenges of their discipline (Peart, 2018). Despite the substantial literature on identity in each of the individual STEM fields, very few scholarly works examine identity in STEM as a whole and fewer still investigate the phenomenon within the STEAM framework.

Drawing on constructivist theory and aspects of the whole child, the author of this work examines the literature and theoretical undergirding for identity development in STEAM. Furthermore, the author of this paper presents the case for a holistic connectivism in STEAM identity development that involves an interactionist approach, meaningful integration and relevant contextual explorations, inquiry and interest-based learning, play-based environments, and a flexible curriculum that allows for creativity and divergence. It is well documented that children can develop an identity in an individual STEAM field, but a broader, more holistic approach can provide children with the opportunities and meaningful contexts to expand that identity to include multiple, interconnected disciplines and sub-disciplines within STEAM as a whole.

Relevant Background and Literature

In 2001, administrators at the National Science Foundation (NSF) reorganized the acronym, SMET (Science, Mathematics, Engineering, and Technology) to form the now-widely recognized acronym, STEM. Following critical reports, such as the *Rising Above the Gathering Storm* (2005), which was published out of the National Academies of Science, Engineering, and Medicine, the academic proficiency and post-education productivity of U.S. students in STEM fields was critically analyzed. It was determined that despite the vast and growing evidence that STEM proficiency had both measurable and immeasurable societal benefits, U.S. students were lacking in STEM achievement as compared to other countries (Hallinen, 2021).

STEM education efforts aimed to help students develop STEM literacy, or the ability to apply content knowledge from multiple disciplines to solve problems that could not be solved through the lens of a single discipline (Perales & Arostegui, 2021). Furthermore, STEM education was meant to "improve critical thinking skills, and be creative, logical, innovative, and productive" in

real-world contexts (Widya & Rahmi, 2019, abstract). STEM leaders also sought to build up traditionally disadvantaged groups including students of color and students from low SES backgrounds to participate and prosper in STEM fields (Xie et al., 2015). Beyond the benefits to the individual, STEM education also provided a mode for the U.S. to preserve and grow its economic and societal prosperity, address problems through innovation, and prepare a globally oriented workforce with the knowledge and skills necessary to fill rapidly expanding/evolving STEM careers (Hallinen, 2021).

By 2006, Yakman (2019) created the first STEAM framework, not to arbitrarily add another subject, but to provide a meaningful, real-world context (situated in the liberal arts) for which the other subjects could be explored. This framework has led to highly creative and innovative approaches in the Arts and STEM fields, and has led to meaningful, contextualized interdisciplinary and transdisciplinary links in STEAM education programs (Mejias et al., 2021). STEAM education efforts sought to incorporate the humanities, as STEM fields are still a human endeavor, and to blur the lines between academically separated disciplines through a more integrated approach. As Perales and Arostegui (2021) put it, "STEAM education could be defined as one that proposes an integrated teaching of scientific-technological, artistic, and, in general, humanistic competencies, with integration understood in a progressive sense that goes from interdisciplinarity to transdisciplinarity" (para. 8). STEAM was also meant to utilize the arts to leverage methodologies and strategies like problem-based learning and inquiry-based learning to boost critical thinking, creativity, and the interconnectedness of concepts (Flocchini, 2017).

In recent years, STEM and STEAM education efforts have seen a significant boost in funding and overall support with the U.S. Department of Education's STEM Education Strategic Plan, *Charting a Course for Success: America's Strategy for STEM Education*, which was released in 2018. As a part of this framework, three priorities have arisen, including building STEM literacy, increasing DEI (Diversity, Equity, and Inclusion) in STEM fields, and developing the STEM workforce for an ever-changing future (Committee on STEM Education, 2018). However, the federal framework lacks a substantial emphasis on helping students build identity in any of the STEM or STEAM fields, let alone an intersecting identity across multiple fields.

Identity in STEAM Fields

The development of identity in individual STEAM fields has been well researched, but there are some inconsistencies regarding how identity is developed. It could be built upon interest in the subject, through successful experiences within the subject, like a student getting good grades in science, for example, or it could also be an entirely independent construct that is unique to the individual (Vincent-Ruz & Schunn, 2018). Factors that are critical in identity development are interest, intrinsic motivation, positive experiences, relevant (real-world)/practical experiences, and representation (i.e., students see people in those fields who look like them) (Eren, 2021; Vincent-Ruz & Schunn, 2018). The benefits of identity development include a robust sense of belonging, increased performance and success and perseverance through challenges (Chen et al., 2020; Hernandez et al., 2017).

A Conceptual Framework for Promoting STEAM Identity Development

To provide meaningful opportunities for children to build intersecting identities across STEAM fields, it is necessary to understand the nature of STEAM, which encourages transdisciplinary learning. The world is complex and evolving with new challenges that arise every day. New and old problems alike cross boundaries and require people to have a varied toolkit for solving those multi-disciplinary problems. As such, the "transdisciplinary integration of STEM teaching and learning across STEM fields and with other fields such as the humanities and the arts enriches all fields and draws learners to authentic challenges from local to global in scale" (Committee on STEM Education, 2018, p. 20).

If students are exposed to problems that foster the development of critical thinking and analysis, problem-solving, and creativity, they will be better equipped to identify and actively engage with future problems (Committee on STEM Education, 2018). Therefore, it is not just a novel or trending educational recommendation, but a necessity that students build these types of skills through relevant, active experience. However, to be well equipped does not guarantee the necessary drive or motivation to enter STEAM fields or careers. An identity, built through years of sustained, relevant, educational practice, meaningful experiences, and at least some modicum of academic success can foster that intrinsically motivated drive. In other words, it can give children a purpose or mission to explore those fields throughout their careers.

Identity in one STEAM field is healthy with many benefits, as noted in the literature review, but it is limited in its capacity to engage across multiple disciplines. In other words, students may stick with what is safe and familiar, rather than take the risk of venturing too far outside their field of interest/expertise. If children are well versed in the content, strategies, and culture of multiple STEAM disciplines, they can cross boundaries more easily. When children are comfortable and confident in more than one subject, they can engage in the practice of code-switching. This means they use the language, tools, and methods of inquiry for multiple disciplines, which allows them to explore more robust, complex, and interconnected real-world problems. Identity in multiple areas is not necessarily the same as expertise, but it does afford the individual the confidence, competence, and persistence to engage more broadly, which has considerable value.

Theoretical Scaffolds and Conditions for STEAM Identity Development

Children cannot be told to develop an identity. It cannot be transferred through social transmission. Identity development is complex with multiple educational, social, emotional, and cognitive contexts and experiences that factor into an individual's construction of self. However, the educational environment can provide optimal conditions for children to build their identities with an intersection in the STEAM domains.

Creating opportunities for identity development requires a holistic, constructivist approach, situated in child-centered and whole-child philosophies. This means that direct instruction, or a specific STEAM identity curriculum focused on building these personalized traits can only accomplish the socially transmitted aspects of identity construction. For example, a teacher may use an identity curriculum that emphasizes representation and diversity in STEAM fields. This is

important and necessary for children of all types to see themselves represented in those who have gone before them in science, technology, engineering, mathematics, and the humanities. However, simply showing children that others like them have succeeded in STEAM fields does not create the sustained, relevant, meaningful experiences one needs to build their own identity. Furthermore, identity development, though influenced by many social factors, is a deeply personal, and uniquely constructed experience.

To take a holistic, connectivistic approach means that multiple, interrelated factors must be considered. Connectivist theory suggests that children should combine thoughts, theories, and information in usable ways, while also considering different viewpoints, and using technology as a central hub for informational learning through such strategies as simulations, gamification, and even social media (Western Governors University, 2021). Constructivism also fits within this paradigm as children must construct their knowledge and their identity through their own unique experiences and understandings. All STEAM classroom experiences must involve meaningful, relevant, active explorations that put the learner in the driver's seat for investigations and experiments. Furthermore, this conceptual work draws from child-centered practices as children's needs, interests, development, and individual continuums of learning must be considered in the classroom. Finally, this work draws from whole-child philosophy in that the development of any identity is a multi-domain endeavor that involves cognitive, social, emotional, physical, and cultural elements.

Practical Suggestions

The first suggestion for creating optimal conditions for STEAM identity development is for teachers to use an Interactionist Approach. Kim and Sinatra (2018) suggest that the onus for developing an identity in these fields should not rest solely with the individual child to develop the "knowledge, skills, interests, and abilities required to be successful" (para. 1), but that the educational context and environment where students experience these subjects is critically important. The STEAM environment must be welcoming with a rich, immersive culture and context for explorations. There must also be a balance between students' creativity and independence and their abilities/capacities to successfully complete realistic projects (Kim & Sinatra, 2018; Vongkulluksn et al., 2018). Interactionist theory in STEAM would suggest that all individuals can develop an identity in multiple fields, that the development of that identity takes time, and that the educational environment is a critically important influence in identity development (Kim & Sinatra, 2018). Practically, this means that teachers need to construct (or even co-construct with their students) an exploratory, investigative, and integrative STEAM environment that offers children immersive opportunities to interact with various STEAM problems or concepts. The teacher can guide this process and develop the environment to match the students' interests, abilities, and authentic inquiries so that they can find success while also exercising their choices to control the process and the direction of the explorations.

STEAM environments and curricula need to be highly integrative, thus allowing students to see the nature of more complex problems that require a transition away from separate subject explorations to multidisciplinarity, interdisciplinarity and transdisciplinarity. Choi and Pak (2006) define interdisciplinarity as anything that "analyzes, synthesizes and harmonizes links between disciplines into a coordinated and coherent whole" (p. 351). Transdisciplinarity, on the

other hand, “integrates the natural, social, and health sciences in a humanities context, and transcends their traditional boundaries” (Choi & Pak, 2006, p. 351).

Multidisciplinary approaches tend to organize content around a theme, but they also tend to keep disciplinary knowledge and boundaries intact (Drake & Burns, 2004). The level of content integration can vary in a multidisciplinary approach. This approach would foster code-switching as children jump from one disciplinary idea to another as they relate to a main theme. For example, children exploring a theme of space could use math skills to explore distance, time, size/shape, weight, and mass by using the tools and terms of math inquiry. Then, as they switch to science, they could explore the differences between terrestrial planets and gas giants by using scientific inquiry and related terms. A multidisciplinary approach offers children the opportunity to operate within multiple content domains, but also maintain the structure of subject boundaries.

An Interdisciplinary approach shifts the emphasis away from separate disciplines, and instead offers children the opportunities to use common skills and concepts from multiple disciplines (Drake & Burns, 2004). There may still be a theme, like space, but instead of having children do separate activities within separate content domains as they relate to the theme, the children will use concepts and skills that transcend a certain topic. Perhaps they decide to develop a rocket, but as they do so, they use language skills, critical thinking, research, and problem-solving skills that can transfer to any problem or discipline. In this approach, children can construct an identity that is broader in scope (across multiple disciplines) by using relevant skills and concepts that may apply to many different content explorations.

A transdisciplinary approach sees the curriculum organized around students’ interests and questions (Drake & Burns, 2004). Typically, these explorations are centered around project-based learning or problem-based learning in that students select relevant, real-world issues to explore. As they investigate, they use the terms, tools, skills, concepts, and methods of inquiry from multiple disciplines as they relate to a child’s topic of study. In terms of identity development, this could be considered a more applied approach, as the students themselves pick and choose what questions to explore, which skills to use, and the contexts behind their choices.

Ultimately, integration of content by using these different structures will allow students the opportunities to become intrinsically motivated, make powerful connections, explore open-ended questions, and apply their learning to new, unique, real-world problems (Curtis, 2002; Drake & Burns, 2004). These are the fertile contexts that will allow for healthy identity development in multiple areas.

When considering STEAM identity development, it is also necessary to consider the effects of inquiry and interest-based learning. Inquiry presents students with opportunities to authentically explore any of the STEAM domains and offers chances for students to gain proficiency with methods and procedures while also having choices in what/how they investigate (Sage 2YC, n.d.). Any chance that students have to engage in the work of real scientists, engineers, mathematicians, historians, and so on, is an opportunity to build the language, skills, and motivation to explore those subjects further. Interest is a necessary prerequisite, and inquiry is a driving process. Students must find value in the STEAM content, see how the content is relevant to their lives, and find a sustained interest in engaging in the content areas. This intrinsic value

includes task value (enjoyment of performing tasks within the content domain), attainment value (being successful), and utility value (relevance to the student's life and future pursuits) (Eccles et al., 1983; Harackiewicz et al., 2016). If students are intrinsically motivated, and can utilize authentic, student-directed inquiries that foster ownership of the questions, processes, and outcomes of any STEAM-related investigations, then they are more likely to develop an identity in those areas (Stone, 2020).

Play is also a mode for exploration, discovery, and inquiry. It is an enjoyable activity, but it also can lead to concept development and identity development (Stone, 2022; Stone, Lorentsen, & Schmidt, 2019). Esquivel et al. (2021) suggest that play cultivates identity, and that children develop in multiple realms through play and social interaction. Young children can use and develop the language, culture, and even concepts of a discipline or multiple disciplines through their play. Furthermore, play is "suited to developing not only science, technology, engineering, and mathematics skills but also inspiring children to tap into their artistic and creative abilities" (The Toy Association, n.d., p. 4). In other words, this process of identity development can start from an early age with play experiences in STEAM areas. Any STEAM educational setting should include multiple opportunities for children to play with concepts, ideas, and materials. Play can also lead to inquiry and foster science and engineering practices and processes.

Finally, to provide opportunities for children to build STEAM identities, any curriculum needs to be flexible rather than rigid. It should include representations of all types of people as scientists, engineers, mathematicians, artists, historians, and technologists. It should also expose children to the language, terms, concepts, tools, and culture of various disciplines, while situating explorations in real-world, integrated, immersive, and welcoming contexts. Furthermore, any curriculum needs to involve open-ended explorations that foster student-directed inquiry, build student interest and ownership, and allow for play.

STEAM Renaissance (Conclusions)

Leon Battista Alberti (1404-1472) once said, "A man can do all things if he will," which exemplified the Renaissance ideals that people were limitless in their capacities for development, and that all people should try to embrace all knowledge to develop themselves fully (Ray, n.d., para. 1). Much like the Renaissance ideal, the approach of STEM/STEAM education aims to help children solve problems that cannot be solved through the lens of one discipline. Furthermore, STEAM includes "conceptual, procedural, and attitudinal contents, so that if the mastery of each of them is necessary, so is the ability to recognize and appreciate the connections that exist between them" (Perales & Arostegui, 2021, para. 3). An identity that spans across and between multiple disciplines allows children to explore new possibilities, think divergently, and innovate. The child who explores science using the tools of the historian, or the artist who incorporates math into her work are just scratching the surface of what is possible. Holistic identity development in STEAM can provide the child with the traits necessary to expand their notion of self beyond a single discipline and to engage with broader issues throughout their education and career.

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