Journal of Research in Science, Mathematics and Technology Education
https://jrsmte.com/

A Curriculum Evaluation of a Genetics Unit from a Science Identity Perspective

Sarah E. Fogelman, Maria A. Moreno Vera and Katherine L. McNeill
Boston College, USA

Abstract: Science identity refers to an individual's identification with the field of science and their sense of belonging, engagement, and affiliation with science-related activities, values, and communities. A lack of representation and opportunities to engage in science, however, may hinder students from developing a strong science identity, particularly those from marginalized populations. Research suggests that curriculum materials can have an impact on teacher and student learning, including attitudes and motivation towards science. Nonetheless, further investigation is needed to understand which specific aspects of curriculum play a role in students' science identity. Given the potential that curriculum materials have in promoting equitable science instruction, this study sets out to analyze, as a preliminary step, the extent in which the genetics unit of a reform-oriented storyline curriculum promotes positive student science identities with self-concept, perspective-taking, and community as evaluating criteria. Findings show that the curriculum addresses all three criteria but that there is room for expanding the depth in which science identity is fostered, particularly in the perspective-taking criteria. Further research, including research validation and classroom implementation, is needed to provide more comprehensive evidence of these effects.

Keywords: Science Identity; Science Education; Science Curriculum.
DOI: https://doi.org/10.31756/jrsmte.419SI

Introduction

Science identity, which is the way individuals perceive themselves and are recognized by others as science knowers, is a crucial factor in shaping students' engagement, persistence and success in science (Carlone & Johnson, 2007; Hazari et al., 2010). It influences how individuals perceive themselves in relation to scientific endeavors, affecting their participation, persistence, and sense of belonging within science-related communities (Brickhouse et. al., 2000; Calabrese Barton et. al., 2013). A robust science identity is crucial in fostering individuals to see themselves as capable of understanding and participating in addressing societal issues with scientific dimensions (Avraamidou & Schwartz, 2021). High-quality curriculum materials have the potential to support students' science identity development by broadening representations of science and scientists, and by making space for students' own lived experiences and ways of knowing to be leveraged in new ways that support sensemaking and participation (Bang et al., 2017). Yet little is known about how to integrate science identity into curricular design.

This paper addresses that gap by analyzing a middle school genetics unit from the OpenSciEd curriculum through a novel framework developed from the science identity literature. Our analysis focuses on three key dimensions: self-concept, perspective-taking, and community as means to examine the opportunities embedded in the unit materials to support the development of science identity. We ask the question: What opportunities that support students' science identity are embedded within the unit materials of a reform-oriented curriculum? By offering an explanation of our framework and evaluating a unit from an open-access, reform-oriented curriculum, we seek to illuminate the degree to which such materials consider and integrate elements crucial for fostering students' science identities.

Literature Review

This section will first explore sociocultural theories of learning, emphasizing the role of social interaction and context in shaping cognition and participation in disciplinary practices. Second, we define science identity and highlight its key components. Finally, we connect these theoretical frameworks by examining how sociocultural perspectives inform our understanding of science identity development, particularly for marginalized populations.

Sociocultural Theories of Learning

Sociocultural theories of learning emphasize the participation of learners within particular contexts as means to develop cognition and learning (Danish & Gresalfi, 2018). Central to this perspective, as articulated by Vygotsky (1978), is the understanding that higher order mental functions originate in social interactions and are then internalized by the individual.

Epistemologically, this stance holds that knowing and engaging with knowledge comes from the cultural and historical practices where an individual is part of— in other words, "how one comes to know something is inseparable from what one ultimately comes to know." (Danish & Gresalfi, 2018, p. 52-53). Moreover, onto-epistemic heterogeneity builds on this construct by highlighting "that knowing and being are inextricably tied" and proposes a liberatory education that "sustain[s] and imagine[s] multiple values, purposes, and arcs of human learning" (Warren et. al, 2020, p. 278). This viewpoint opposes the idea that disciplinary knowledge and practices are settled, and that learning simply occurs by gaining access to said dogma (Warren et. al, 2020). Furthermore, it highlights the importance of communities of practice with shared norms and values (Wenger, 1998; Stroupe, 2014).

Consequently, sociocultural theories of learning are essential for understanding identity development, as they recognize the shaping influence of environmental interactions across individual, institutional, societal, and political levels (Avraamidou & Schwartz, 2021). For the past several decades research in science education has found it crucial to specifically examine the alignment between students' broader identities and their science identity (Brickhouse et. al., 2000; Carlone & Johnson, 2007; Kim et al, 2018; Calabrese Barton et. al., 2013). Specifically, the focus has been directed towards studying the experiences of traditionally marginalized populations (e.g. gender, race) to understand how students "view themselves and whether or not they are the kind of person who engages in science" (Brickhouse et. al., 2000 p. 441). This perspective informs the development of more equitable science learning environments.

Science Identity

Identity refers to an individual's perception and understanding of themselves, encompassing various intersecting dimensions such as personal, social, cultural, and contextual (Kim, et al., 2018; Carlone & Johnson, 2007; Carlone, 2022). It is shaped through complex interactions between one's self-concept, experiences, and community environments, and can influence how individuals perceive and interpret the world around them (Kim et al., 2018; Avraamidou & Schwartz, 2021). While related, science identity specifically refers to an individual's identification with the field of science and their sense of belonging, engagement, and affiliation with science-related activities, values, and communities (Kim et al., 2018; Carlone, 2022). It is the extent to which a person sees themselves in relation to science spaces, and the cultural norms present in these environments (Kim et al., 2018; Carlone, 2022).

This self-concept within science spaces can be understood by examining students' competence, performance, and recognition of self within this context (Carlone & Johnson, 2007). Competence refers to students' belief in their ability to understand and do science beyond learning facts. Performance refers to the different ways in which individuals do science by participating in science-related practices, such as asking questions, designing experiments, analyzing data, and communicating scientific ideas. Finally, recognition refers to an individual's self perception of whether or not they are a science person. This self-recognition is concurrently informed by external validation where an individual's feelings of belonging is greatly influenced by the degree of being seen and acknowledged by others (Carlone & Johnson, 2007).

Having positive perceptions across competence, performance, and recognition influence the development and maintaining of strong science identities. Science identity can shape individuals' attitudes towards science, and can impact their participation, persistence, and success in science-related endeavors (Kim et al., 2018; Carlone, 2022). For this reason, delving into this construct is particularly important for cultures that have been traditionally excluded within science spaces. We therefore position the exploration of science identity as a stance to promote equitable learning in the science classrooms.

Science Identity as a Lens for Social Justice

Identity, as a multidimensional construct, plays a crucial role in shaping an individual's thoughts, emotions, behaviors, and actions (Kim et al., 2018; Nasir et al., 2014). Understanding how identity is formed, developed, and enacted can provide valuable insights into individuals' learning, motivation, and engagement in various contexts, including educational settings (Nasir et al., 2014; Wenger, 1998). Specifically, understanding the interplay between aspects of identity and how they intersect with experiences in science learning environments is crucial for addressing issues of equity and justice.

Science identity is particularly relevant in the context of promoting science engagement, diversity, and equity (Kim et al., 2018; Pinkard et al., 2017). Understanding how individuals develop and maintain a positive science identity can inform efforts to increase science participation and representation among underrepresented groups, such as women and minoritized groups, who have traditionally been marginalized in science fields (Kim et al., 2018; Pinkard et al., 2017; Warren et al., 2020). This marginalization has led to significant disparities in STEM fields (NSF, 2023). Addressing these disparities requires a deep understanding of how science identity is shaped by social and cultural contexts. Researchers can investigate how factors such as educational interventions, like curriculum, can influence individuals' science identity development (Kim et al., 2018; Pinkard et al., 2017; Warren et al., 2020). These concepts provide a theoretical lens to understand how individuals perceive themselves, engage with their environments, and participate in science-related activities, and offer insights into how to promote equitable and inclusive educational practices and policies (Kim et al., 2018; Nasir et al., 2014; Pinkard et al., 2017; Warren et al., 2020; Wenger, 1998). By focusing on science identity, we can better understand the barriers that prevent students from fully engaging in science and identify pathways to foster their participation and success, ultimately contributing to social justice in STEM.

For example, research by Carlone et al. (2014) indicates that students with a strong science identity view themselves as “science people” – not only proficient in understanding scientific concepts and procedures but also as individuals who can contribute meaningfully to the scientific community through their own unique perspectives and approaches to problem-solving. This includes seeing themselves as capable of asking critical questions, designing investigations, and interpreting data, aligning with the core science practices. In contrast, students who do not identify as science people often perceive science as an external and fixed body of knowledge that is irrelevant to their personal lives and struggle to see themselves as active participants or contributors to scientific understanding. Similarly, Calabrese Barton et al. (2013) found that girls with a robust science identity perceive science as personally engaging and relevant, which fuels their motivation to pursue science-related careers. This sense of relevance and connection to their lives is a key aspect of their science identity. Conversely, those with a weaker science identity view science as disconnected from their lives. These examples highlight how the development of a positive science identity can serve as a pathway to greater inclusion and equity in science.

Curriculum and Unit Overview

In this section we provide an overview of OpenSciEd’s approach to science instruction and the structure of its curriculum. We then focus on the eighth-grade genetics unit, detailing its anchoring phenomenon, learning goals, and instructional design. We move on to presenting the rationale for choosing this unit, emphasizing concerns about genetic determinism, race, and science identity. Finally, we state our positionalities in relation to this work.

OpenSciEd Curriculum

OpenSciEd is a nonprofit organization that provides high-quality, freely available, and research-based science instructional materials aligned to the Next Generation Science Standards (NGSS). The NGSS is not a set of daily standards, but a set of expectations for what students should be able to do by the end of instruction (years or grade-bands), and while performance expectations (PEs) set learning goals for students, they do not describe how students get there (NGSS, 2013). The overarching goal of OpenSciEd is to provide high-quality, research-based science instructional materials that help teachers engage students in the practices of science and develop a deep understanding of key scientific concepts. OpenSciEd offers a comprehensive middle school science curriculum for 6th through 8th grades, consisting of 18 units with six units per grade level. The curriculum is freely available on their website and includes not only the instructional units but also professional development materials for teachers (OpenSciEd, 2021).

Each unit in Open SciEd opens with the anchoring phenomenon routine. This routine is a pedagogical strategy employed at the outset of a unit of instruction to stimulate student interest and sustain their engagement throughout the course of the unit. It does so by introducing a puzzling or compelling phenomenon that students cannot yet fully explain, prompting them to generate questions and make initial connections to their prior knowledge. Through class discussions and the development of an initial model, students collectively identify areas they need to investigate further, creating a shared sense of purpose and intellectual curiosity that drives their inquiry throughout the unit (Edelson et al., 2021). The objective of the anchoring phenomenon routine is to create a collective purpose for the learning community, motivating students to engage in the exploration of phenomena or design challenges (OpenSciEd, 2021).

Genetics Unit Overview

The genetics unit is taught in eighth grade within the scope and sequence–it is the fifth unit in the year. Six PEs are covered within this unit. These include: how environmental and genetic factors influence growth; develop and use models to explain genetic mutations in terms of function of an organism; models of asexual vs sexual reproduction and the resulting genetic identicality or variation; human influence of desired traits in organisms. While this unit contains 17 lessons (OpenSciEd, 2021) our analysis hones in on the first three lessons, as summarized in Table 1.

The anchoring phenomenon for genetics is based on the question: how do organisms get their differences? This first lesson involves observing photos of two bulls, one with typical musculature and the other with extra-big muscles and recording observations and questions in a science notebook. Students then view other examples of animals with significant differences in musculature and develop individual models to explain how one of these animals might have gotten its extra-big muscles. They compare and contrast their initial models with partners and co-construct an initial model as a whole class, finding points of agreement and disagreement. Students also examine collections of photos of cattle and tulips to notice variations in traits and list examples of variations among otherwise-similar organisms. Throughout this process, they generate and refine questions, which are recorded on a driving question board (DQB)—a visible, evolving record that organizes their inquiries and helps guide future investigations by connecting their questions to upcoming lessons and activities. The lesson ends with generating initial questions and creating a DQB to guide the work of the class going forward (OpenSciEd, 2021).

Genetics Unit Rationale

The genetics unit was chosen for this assignment because historically there have been concerns about the representation of genetics in terms of race and ethnicity. Historical teachings may have perpetuated harmful and inaccurate ideas about genetic determinism and racial superiority. Genetic determinism is the belief that an individual's genetic makeup is the primary factor in determining their traits and characteristics, including physical, behavioral, and intellectual traits. This view suggests that genes alone dictate an individual’s abilities, predispositions, and limitations, regardless of environmental or social factors. Genetic determinism has been criticized as an oversimplified view of human biology that ignores the complexity of gene-environment interactions and the role of non-genetic factors in shaping human development and behavior (Donovan, 2017).

Table 1

Summary of Lessons used in Analysis

Lesson#/days	Lesson Question	Key Activities	What Students Figure Out
Lesson 1 (3 days)	How do organisms get their differences?	-Observe photos of animals with varying musculature -Develop and compare initial models -Identify trait variations in other organisms -Create a Driving Question Board	-Some animals have unusual muscle sizes -Traits vary within species -Students generate questions and ideas for investigation
Lesson 2 (1 day)	How do extra-big muscles compare to typical ones up close?	-Watch animations and read about muscle structure -Compare photos and data of muscle cells -Conduct gallery walk -Update models	-Muscles are made of cells and proteins (actin & myosin) -Extra-big muscles have more/larger cells and more mass
Lesson 3 (1 day)	How do diet and exercise affect muscle size?	-Analyze texts, graphs, and charts -Learn how microtears from exercise lead to muscle growth -Examine the role of protein in repair	-Exercise causes muscle fiber microtears that lead to growth -Protein is essential for muscle repair and development -Exercise has more impact than diet on muscle size

Donovan (2014) discusses the impact of reinforcing genetic essentialist views of race and gender in school where race is taught to be a biological category determined by genetics. Genetic essentialism, as the idea that individuals can be classified into discrete and unchangeable biological categories based on genetic differences, reinforces conceptions of race and gender that are innate, which can lead to stereotypes and discrimination. Instead, it is imperative to teach genetics in a way that emphasizes the complexity and variability of genetic traits and how they are influenced by both genetics and environment (Donovan, 2014; Donovan et al., 2019).

Genetics is deeply connected to questions of both general identity and science identity. For middle school students, learning about genetics provides a powerful opportunity to explore who they are, where they come from, and how science can help explain patterns of inheritance and variation. This connection between genetics and identity can be particularly meaningful for students from historically marginalized backgrounds, as it opens space for discussions about the social and ethical dimensions of genetic science, including ancestry, race, and health disparities. By incorporating science identity into the curriculum, students not only engage with scientific concepts but also see themselves as capable participants in scientific inquiry. This approach reinforces science identity, helping students recognize that their lived experiences and questions about the world are valid and valuable in the scientific process.

Author Positionalities

We offer the following positionality statement to contextualize our perspectives in relation to the developed rubric and its application to the OpenSciEd genetics units. As authors, our backgrounds and experiences shape our analytical lens and inform our interpretations. This project was initially undertaken as part of a doctoral course on designing learning environments providing a foundation for our collaborative analysis.

The first author is a doctoral candidate who taught secondary science for fifteen years in urban settings, both public and private, within the northeastern United States. This extensive classroom experience has provided her with a deep understanding of the challenges and opportunities in fostering science identity within diverse learner populations. Her practical knowledge of curriculum implementation, student learning trajectories, and the nuances of classroom dynamics directly informs the development and application of the rubric, ensuring its grounding in real-world educational contexts.

The second author, a doctoral student from Mexico, is a former teacher who taught middle school and high school science for 13 years before becoming an educational researcher. Her experiences with teaching in multicultural environments across the world, informs her views on student perceptions around science. Furthermore, her understanding of curriculum design for both formal and informal settings informs the development of the rubric for this study.

The third author is a professor and a former middle school science teacher. For the past eight years she has been designing and leading professional learning to support middle and elementary teachers, particularly in urban settings, in customizing and enacting the OpenSciEd curriculum materials. These experiences inform her evaluation and recommendations for the curriculum materials as she recognizes that although they have strengths, teachers need to be responsive to their students in their use of the materials to support more equitable classrooms.

Furthermore, all authors have experiences with the OpenSciEd curriculum, which have provided familiarity with the pedagogical approaches. However, none of the authors were curriculum designers for the OpenSciEd units, including the specific genetics unit under evaluation. This perspective on the unit content allows for an evaluation based on the principles articulated within the rubric.

Methods

This section outlines the methodological approach used to evaluate the curriculum through the lens of science identity. It begins by introducing the criteria for evaluation—self-concept, perspective-taking, and community—grounded in research on identity development. Each criterion is then discussed in detail, highlighting its significance in fostering student science identity and the ways in which curricular materials can support or hinder this process. Finally, the section presents a rubric designed to assess the curriculum, providing a structured framework for analysis.

Criteria for Evaluation

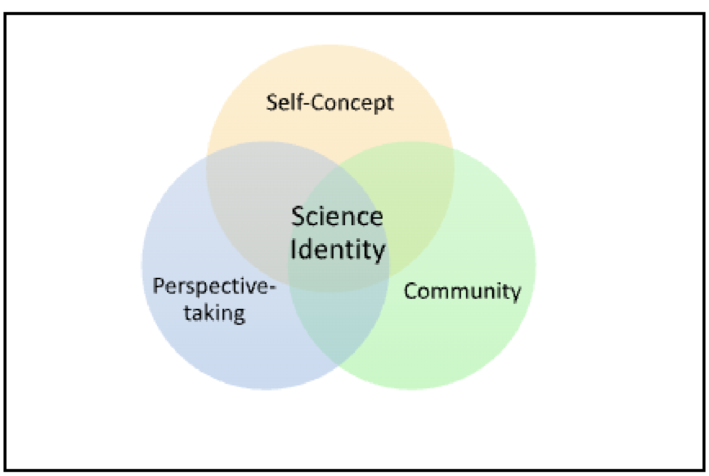
Identity is a construct that goes beyond the self (Carlone, 2022). It is not static, but rather, identity is continuously being shaped by the multitudinal contexts where individuals interact (Johansson & Larsson, 2023). As such, an individual's science identity is not a personal characteristic, but rather, a view of the self informed by the complex interactions that occur with others and the community. In this sense, science identity involves a constant negotiation of an individuals' admittance to the field defined by organizational, institutional, societal, and historical systems (Carlone, 2022). Given the complex interactions between the self and the micro-, meso-, and macro-systems in which individuals interact (Carlone, 2022), this framework identifies self-concept, perspective-taking, and community as key dimensions for fostering positive student science identities. For this study, a rubric was developed to assess the curriculum being used. Figure 1 shows the three criteria for science identity that will be used for evaluation: self-concept, perspective-taking and community.

Science Identity Criterion: Self-Concept

Self-concept plays a crucial role in science identity development, as it shapes how students perceive themselves in relation to science and their potential to participate in scientific inquiry. It encompasses students' beliefs about their abilities, motivations, and agency in learning, all of which influence their engagement with science (Lee, 2017). Because self-concept is not formed in isolation but is shaped by cultural backgrounds, family experiences, and learning environments, science curricula must intentionally provide opportunities for students to connect their personal and cultural identities to scientific concepts (Williams et al., 2018; Warren et al., 2020).

Figure 1

Science Identity Criteria for Evaluation



A key consideration in evaluating curriculum materials is the extent to which they allow students to reflect on their own interests, values, and lived experiences in relation to science. Effective curricula leverage students' backgrounds by incorporating culturally relevant contexts, enabling them to see science as personally meaningful. This approach fosters a sense of agency, positioning students as active participants in constructing scientific knowledge rather than passive recipients of information. When students are encouraged to draw on their own experiences, they develop confidence in their ability to contribute to scientific discussions and problem-solving, strengthening their science self-efficacy—the belief in their capacity to engage in scientific practices.

Traditional narratives about who belongs in science often privilege individuals who excel in technical precision, maintain an emotionless objectivity, and conform to a narrow image of a "science person" (Carlone, 2022). These exclusionary norms can alienate students who do not fit these expectations, leading them to question their place in science. To counter this, curricula should be evaluated based on their ability to create learning environments where students feel a sense of belonging and see themselves as capable science learners. This includes designing classroom spaces that encourage student agency, foster creativity, and normalize failure as part of the learning process. By positioning students as knowledge producers and valuing diverse ways of knowing, curriculum materials can play a vital role in reinforcing students' self-concept and strengthening their science identity (Nasir et al., 2014; Carlone, 2022).

This rubric criterion assesses whether curricular materials promote student agency by allowing for self-exploration, personal connections to science, and opportunities for students to see themselves as competent and valued members of the scientific community.

Science Identity Criterion: Perspective-Taking

Perspective-taking is a vital aspect of science identity development, as it shapes how students understand and appreciate the diverse viewpoints within the scientific community and beyond. It involves recognizing and considering the cognitive and emotional perspectives of others, which enables students to navigate and contribute meaningfully to the broader scientific discourse. By engaging in perspective-taking, students can better understand how various individuals, communities, and cultures contribute to and shape scientific knowledge (Berkowitz, 1997; Kahn & Zeidler, 2016). This process is integral to forming a science identity, as it allows students to see themselves as part of a collective effort, rather than isolated in their individual understanding of science.

When evaluating curriculum materials, a key consideration is the extent to which they provide opportunities for students to explore and appreciate diverse perspectives, including those of their peers, communities, and the broader world. Effective curricula encourage students to see connections between science and their personal lives, local communities, and global issues. These curricula engage students by fostering empathy, encouraging moral reflection, and challenging them to consider the social and ethical dimensions of scientific inquiry (Kahn & Zeidler, 2016). By positioning science as a tool for social justice and societal betterment, these curricula invite students to see science not only as a technical endeavor but as a human-centered, collaborative practice.

Curricula that promote perspective-taking create a classroom environment where students are encouraged to engage with, rather than simply recognize, diverse viewpoints. This approach helps students appreciate the different ways in which individuals and communities contribute to scientific knowledge. For example, lessons may include case studies that explore local or global phenomena, encourage students to interact with scientists from diverse backgrounds, or address the ways in which science intersects with social issues. These opportunities allow students to see science as a multifaceted discipline shaped by a variety of voices and experiences.

In this context, perspective-taking supports the development of science identity by validating students as legitimate participants in the scientific community. When students are encouraged to consider the perspectives of others and recognize their own role in shaping scientific knowledge, they are more likely to view themselves as capable and valued contributors. This process not only strengthens their science identity but also fosters an inclusive environment where students from diverse backgrounds feel empowered to engage in scientific practices and co-construct knowledge. Furthermore, by valuing diverse perspectives, we can move towards a more expansive understanding of science that acknowledges multiple ways of knowing and being, potentially broadening who sees themselves within science (Bang et al., 2017).

This rubric criterion assesses whether curricular materials provide opportunities for students to engage in perspective-taking, encouraging them to understand and appreciate diverse viewpoints and positioning them as active, legitimate participants in the scientific community.

Science Identity Criterion: Community

The community dimension of science identity emphasizes the social aspects of learning, including the interactions students have with peers, teachers, and the broader scientific community. It involves positioning students as competent knowers and contributors to scientific knowledge through collaborative engagement, fostering a sense of belonging and ownership within the science classroom. This dimension considers how students negotiate their acceptance within the science community, how they are viewed socially by their peers, and how the curriculum structures these interactions to support or hinder their science identity development (Pinkard et al., 2017; Warren et al., 2020).

When evaluating curriculum materials, a key consideration is the extent to which they provide opportunities for students to engage collaboratively, both with their peers and with the wider community. Effective curricula encourage students to work together on scientific investigations, share ideas, solve problems collectively, and engage in discussions that promote knowledge exchange. These activities should allow students to take on roles as both learners and contributors, recognizing their expertise and valuing their unique perspectives. Moreover, the curriculum should foster an inclusive classroom environment where all students feel respected and empowered to participate, promoting equitable opportunities for all to contribute to the learning process. This emphasis on collaborative learning helps students develop key social skills, such as teamwork, communication, and problem-solving, which are essential for their science identity formation.

In addition to fostering peer collaboration, the community dimension of science identity focuses on how students perceive and engage with the social structures of the classroom, including power dynamics and norms. It asks how the classroom environment influences who is recognized as a "science person" and who has the authority to define what counts as science (Carlone, 2022). Curricular materials that promote a community-based science identity encourage students to view science not as an isolated, individual pursuit, but as a collaborative and collective endeavor. This requires a careful examination of the classroom's power structures, including the teacher's role in positioning students as competent knowers and doers of science. Effective curricula avoid promoting individualistic or competitive classroom environments and instead foster supportive and collaborative spaces where students can take risks, make mistakes, and view failure as a learning opportunity rather than a threat to their science identity.

Furthermore, the community dimension extends beyond the immediate classroom setting to include the broader local and global communities. The curriculum should provide students with opportunities to connect their scientific learning to real-world contexts, reinforcing the relevance and application of science in their lives and in society. This transfer of knowledge allows students to see themselves as part of a larger scientific community, extending their sense of belonging to global contexts where science is used to address complex, societal challenges. This global perspective helps students understand the interconnectedness of science, community, and society, strengthening their science identity as they recognize their potential to contribute to scientific discussions and practices on a larger scale.

This rubric criterion assesses whether curricular materials provide opportunities for students to engage in collaborative, community-based learning experiences and whether these materials create a classroom environment that values each student's contributions and fosters a sense of belonging within the scientific community. Table 2 shows the scoring rubric that was developed for use in the curriculum evaluation. Each lesson was rated on a scale where the science identity criteria ranged from one point (not evident) to three points (highly evident).

Data Analysis

To assess the degree to which key instructional elements, conducive to fostering science identity, were present in the focal lessons, we developed a novel rubric (Table 2). This decision was made after considering existing instruments designed to measure students' science identity (e.g., Hazari et al., 2010) and determining that their direct application to evaluating the potential of curriculum materials presented significant limitations. Student-centered instruments often capture individual perceptions influenced by a multitude of classroom and personal factors (Carlone & Johnson, 2007). Our rubric, in contrast, was specifically designed to evaluate the presence and prominence of key instructional elements within the curriculum that research suggests are critical for science identity development, such as opportunities for self-reflection, perspective-taking, and building a sense of science community (Brickhouse et al., 2000; Carlone & Johnson, 2007). This targeted approach allowed us to analyze the curriculum's design features in relation to these specific constructs.

Table 2

Rubric for Curriculum Evaluation from a Science Identity Perspective

Science Identity Criteria	1=Not Evident	2=Partially Evident	3=Highly Evident
Self-concept: *Does the curriculum provide opportunities for students to reflect on their own interests, values, and beliefs, and how these relate to science concepts?*	The curriculum does not provide opportunities for students to engage with their personal/cultural identity.	The curriculum provides basic opportunities for students to engage with their personal/cultural identity, such as reflecting on their strengths and interests.	The curriculum provides multiple opportunities for students to engage with and reflect on their personal/cultural identity, including exploring their values and beliefs. The curriculum provides questions that encourage students to think about their prior experiences and knowledge related to the topic.
Perspective-taking: *Does the curriculum provide opportunities for students to explore and appreciate the perspectives of others in the context of science?*	The curriculum does not provide opportunities for students to explore and appreciate the perspectives of others.	The curriculum provides some, but not enough opportunities for students to explore and appreciate the perspectives of others.	The curriculum has built in places for students to engage with each other, including learning about the perspectives of others related to the science topic within the unit. There are additional opportunities to engage with other students from different backgrounds.
Social: *Does the curriculum provide opportunities for students to explore, learn and answer questions together as they shape their science community?*	The curriculum does not provide any opportunity for interactions with others.	The curriculum provides some opportunities for students to collaborate with peers in the school setting, such as through group discussions or small-scale cooperative activities. Students may work together on specific tasks or share their findings with their classmates. However, these collaborative opportunities may be limited in scope or frequency.	There are a multitude of opportunities for students to collaborate with peers in the school setting. The curriculum fosters a supportive and inclusive classroom environment that values teamwork, respectful communication, and equitable participation. Students are positioned as active knowers and experts, where their contributions are acknowledged and respected by their peers and teachers.

The development of our rubric was informed by established principles of rubric design and best practices in educational evaluation (Luft, 1999). We identified key theoretical constructs (related to science identity) and translated these into observable criteria and indicators. Recommendations for developing reliable and valid rubrics, including clear definitions of criteria and consistent scoring scales, were also considered (Dickinson & Adams, 2017). To assess the degree to which key instructional elements were present in the focal lessons, a three-point rating scale was used: 1 (not evident), 2 (partially evident), and 3 (highly evident).

To ensure the reliability of our data analysis, the first and second authors independently rated each of the three focal lessons from the OpenSciEd genetics unit ("Why are living things different from one another?") based on the developed rubric.After the initial ratings, the authors convened to review their scores, discussing any discrepancies and reaching a consensus on the final ratings. This collaborative process ensured the reliability of the scores and allowed for refinement of any judgments. The use of independent ratings followed by adjudication aimed to increase the accuracy and consistency of the data analysis (Mang et al., 2023).

To illustrate the consensus-building process, consider the following example from our analysis of Lesson 1. During the independent rating of Lesson 1, a discrepancy arose regarding the “Self-concept” criterion. Author 1 initially scored it a 3, emphasizing the open-ended modeling activity and prompts that encouraged students to draw upon prior knowledge and explain their reasoning. Conversely, Author 2 scored it a 1, focusing on the lesson’s primary goal of eliciting initial scientific explanations rather than explicit personal reflection. Through discussion, the raters agreed that while the modeling offered a potential connection to student interests, it lacked explicit guidance for reflecting on personal values or beliefs directly related to the science concept of biological variation. Consequently, a consensus rating of 2 was reached, acknowledging a partial alignment with the “Self-concept” criterion by providing a basic opportunity for connection to prior knowledge without explicit prompts for deeper personal reflection.

Findings—Detailed Analysis of Focal Genetics Lessons

The analysis focuses on the initial lessons of the Genetics Unit, with an emphasis on evaluating science identity development across three criteria: self-concept, perspective-taking, and community. The first three lessons from the unit were chosen for evaluation as those initial lessons can set the stage for the rest of the unit. This section shows the ratings in Table 3. Due to space constraints, this section will describe one example from each of the criteria and offer recommendations for improvement.

Science Identity Criteria: Self-Concept

For the self-concept criteria, Lesson three received a rating of two based on the rubric. Sample lesson materials can be found in Figure 2 and Figure 3. In this lesson, a think-pair-share activity offers students an opportunity to explore aspects of their own identities. However, because the activity is confined to a five-minute duration, students have limited time to engage in deep reflective practice. Reflective activities require sufficient time for students to critically examine their interests, values, and beliefs. When such reflection is rushed, the process does not allow for a meaningful exploration of personal identity. Furthermore, although the activity includes prompts intended to connect with students’ lived experiences, these could be more explicitly aligned with personal beliefs and experiences related to exercise, nutrition, and fitness. Such alignment would enable a richer discussion that might eventually broaden into conversations about body image and self-perception.

Table 3

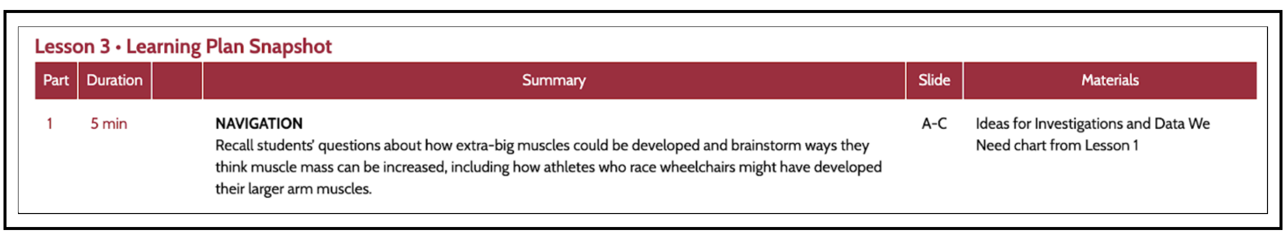
Ratings for Science Identity Criteria by Lesson

Lesson #	Self-concept	Perspective-taking	Community	Lesson Average
Lesson 1	2	1	3	2
Lesson 2	1	1	2	1.33
Lesson 3	2	1	2	1.67
Average	1.67	1	2.33	

To enhance the self-concept aspect of science identity in this unit, we recommend that students be provided with extended opportunities to explicitly share their personal experiences and ideas related to muscle growth, exercise, and overall fitness, thereby connecting these discussions to their own lives and interests. Allowing more time for reflective practice would enable students to critically evaluate their experiences and articulate how these relate to scientific concepts. In addition, incorporating discussions that explore various dimensions of physical development—including topics such as the impact of performance-enhancing substances and the adaptations of athletes with physical limitations—could further deepen their understanding. These expanded opportunities could potentially strengthen critical thinking and self-awareness but also empower students to see themselves as active, valued contributors to scientific inquiry, thereby reinforcing their self-concept in the realm of science.

Figure 2

Sample Lesson Materials: Snippet of Teacher Lesson Plan from Lesson 3

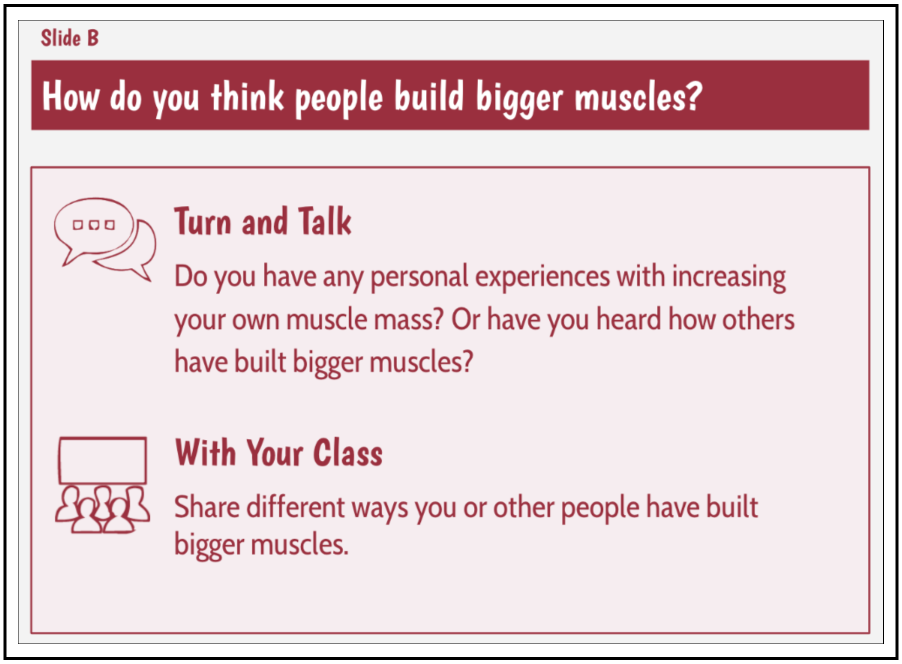


Lesson 3 • Learning Plan Snapshot

Part	Duration		Summary	Slide	Materials
1	5 min		**NAVIGATION** Recall students' questions about how extra-big muscles could be developed and brainstorm ways they think muscle mass can be increased, including how athletes who race wheelchairs might have developed their larger arm muscles.	A-C	Ideas for Investigations and Data We Need chart from Lesson 1

Figure 3

Sample Lesson Materials: Lesson 3 Student-Facing Slide



Science Identity Criteria: Perspective-Taking

For the perspective-taking criteria, lesson three was rated a one based on our rubric (see sample lesson materials in Figure 4 and Figure 5). Although the lesson includes activities in which students share their ideas, the structure does not provide sufficient support for them to engage with or adopt perspectives that differ from their own. The current design does not encourage students to critically consider or articulate alternative viewpoints from their peers or the broader community. This limitation restricts the depth of discussion and hinders the development of a more comprehensive understanding of diverse perspectives.

To address this, we suggest that future iterations of the lesson include structured exercises specifically designed to challenge students' initial viewpoints. For instance, rather than grouping students into static teams such as "Team Protein" or "Team Exercise," pairing students from different groups so that each student presents their partner's perspective could foster a deeper and more balanced discussion of the topic. Such modifications would not only encourage a richer exploration of differing viewpoints but also help students develop a more nuanced understanding of the scientific issues at hand.

Figure 4

Sample Lesson Materials: Lesson 3 Overview

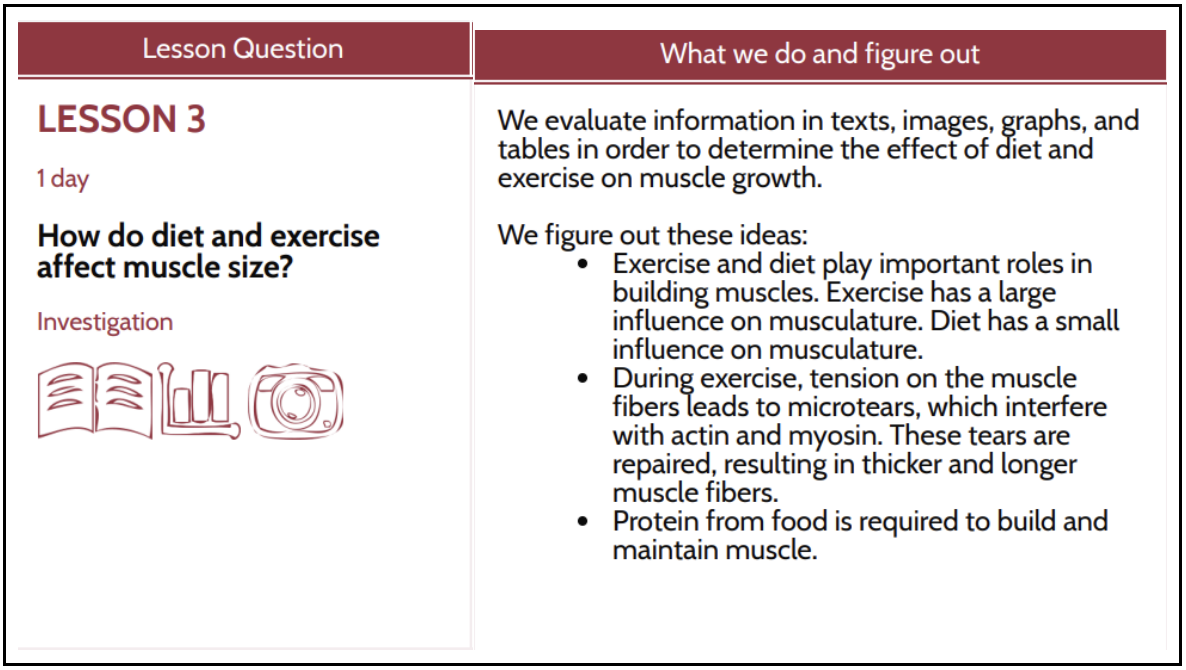
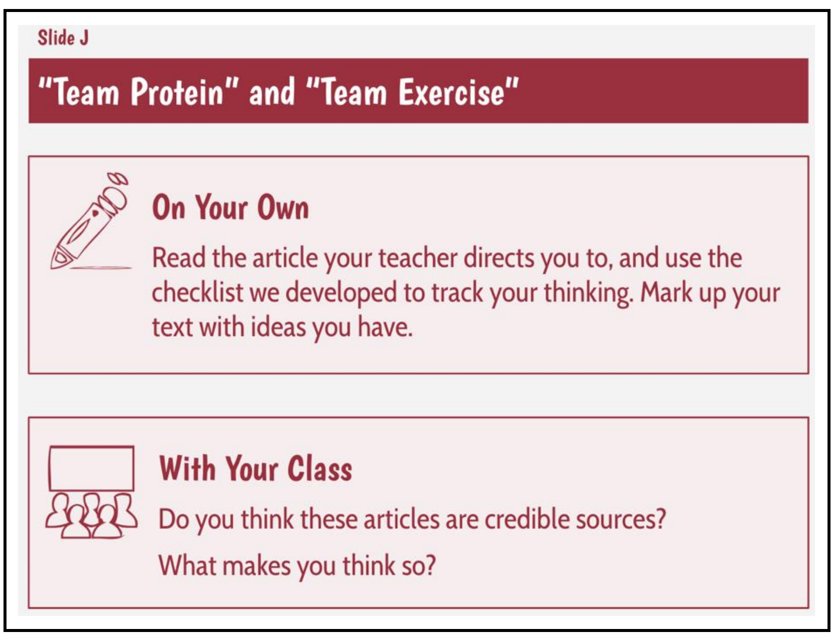


Figure 5

Sample Lesson Materials: Lesson 3 Student-Facing Slide

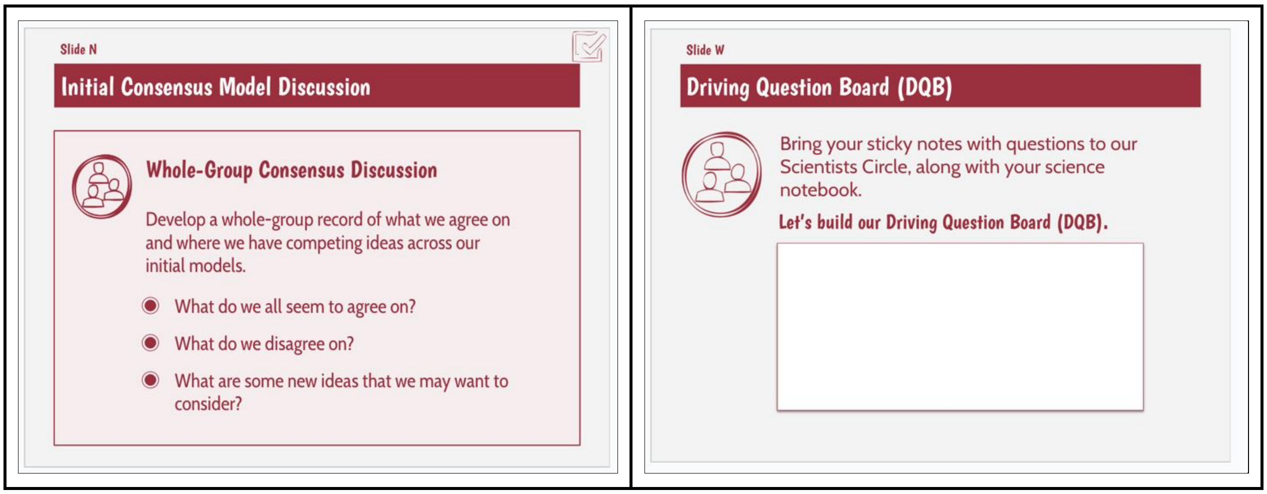


Science Identity Criteria: Community

Regarding the community criteria, Lesson one achieved a rating of three (see Figure 6). This lesson creates strong opportunities for students to engage in collaborative learning by exploring and deliberating on the potential causes of variations in organisms. The use of a consensus model discussion and the co-construction of a Driving Question Board (DQB) involve the entire class in shared decision-making, thereby reinforcing the principles of community learning. The DQB, in particular, stands as a robust example of how collaborative exploration and shared decision-making can foster a sense of belonging and collective ownership in science. The collaborative activities in this lesson illustrate how students develop their science identity through meaningful social interactions and communal learning experiences.

Figure 6

Sample Lesson Materials: Lesson 1 Student-Facing Slides



While the community criteria did receive the highest rating, it could be even further customized to bolster science identity. Inviting local experts—such as nutritionists, personal trainers, or even local farmers—to share their knowledge can enrich classroom discussions and provide students with firsthand insights into how science is applied in various real-world contexts. Moreover, designing group activities that involve evaluating diverse sources of information and discussing the criteria used for such evaluations can deepen students' understanding of how scientific knowledge is collaboratively constructed. Integrating discussions on societal impacts, ethical considerations, and the influence of media on topics like body image and athletic performance can also connect scientific inquiry to broader social issues, thereby reinforcing students' identities as active and informed participants in both their local and global scientific communities.

Overall, these findings underscore the importance of designing science learning experiences that allow for deeper reflection, structured perspective-taking, and collaborative knowledge-building. By refining the duration and structure of reflective activities, incorporating mechanisms for engaging with diverse viewpoints, and further enhancing opportunities for collaborative learning, the curriculum can more effectively support the development of students' self-concept, critical thinking, and overall science identity.

Discussion

This study evaluated a unit of the OpenSciEd curriculum through the lens of science identity, focusing specifically on the dimensions of self-concept, perspective-taking, and community. The findings revealed that while the unit possesses several strengths, there are clear areas for improvement, particularly in explicitly addressing the personal, communal, and social implications of science identity. One promising approach involves engaging students in reflective activities that help them recognize the role of science within their own communities. For example, students could be prompted to write about a community to which they belong and explore what defines that community, rather than simply describing it as a group of people (McNeill, 2023). This type of exercise not only highlights the connections between science and students' social identities but also demonstrates how scientific inquiry can impact and be integrated with their lived experiences.

Recommendations for future work include continued evaluation of individual lessons, training additional researchers to enhance interrater reliability, and adapting curricular materials to incorporate the insights generated by this study. Furthermore, the development of supplementary tools—such as dedicated sections in teacher handbooks that offer strategies and tips for addressing science identity—along with professional development opportunities, could further support educators in customizing instruction to foster robust science identities among students. This analysis of curriculum provides a foundational understanding of the embedded opportunities within the materials.

Looking ahead, there is a strong case for additional studies that focus on building student science identities through an in-depth examination of curricular materials. Future research should utilize dimensions such as self-concept, perspective-taking, and community to guide inquiry into how science identities are cultivated in classroom settings. Understanding these processes in greater detail will not only aid in the design of more effective educational materials but also empower teachers to create learning environments where students feel competent, agentic, and connected to science. This commentary expands our conceptualization of identity formation in the science classroom by emphasizing its multidimensionality. While the proposed framework may not capture every aspect of the ongoing work in identity formation, it offers a valuable starting point for operationalizing key dimensions in future studies, ultimately enhancing teacher instruction and supporting the development of students' science identities. However, one limitation of this curricular analysis is that we did not collect data from students or classroom enactment data such as students' science identity through surveys, classroom observations or student interviews. Future empirical research should study the enacted impact of such materials on students' science identity to better understand how and why the different criteria influence student identity development.

References

Avraamidou, L., & Schwartz, R. (2021). Who aspires to be a scientist/who is allowed in science? Science identity as a lens to exploring the political dimension of the nature of science. *Cultural Studies of Science Education, 16*(2), 337-344. http://dx.doi.org/10.1007/s11422-021-10059-3

Bang, M., Brown, B., Calabrese Barton, A., Rosebery, A & Warren, B. (2017). Toward more equitable learning in science: Expanding relationships among students, teachers and science practices. In Schwarz, C., Passmore, C., Reiser, B.J. (Eds.). *Helping students make sense of the world using next generation science and engineering practices* (pp. 205-228). National Science Teachers Association Press.

Berkowitz, M.W. (1997). The complete moral person: Anatomy and formation. In DuBois, J.M. (Ed.). *Moral issues in psychology: Personalist contributions to selected problems* (pp. 11-41). University Press of America, Inc.

Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What kind of a girl does science? The construction of school science identities. *Journal of Research in Science Teaching*, *37*(5), 441-458. http://dx.doi.org/10.1002/(SICI)1098-2736(200005)37:5%3C441::AID-TEA4%3E3.0.CO;2-3

Calabrese Barton, A., Kang, H., Tan, E., O'Neill, T. B., Bautista-Guerra, J., & Brecklin, C. (2013). Crafting a future in science: Tracing middle school girls' identity work over time and space. *American Educational Research Journal, 50*(1), 37-75. http://dx.doi.org/10.3102/0002831212458142

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching, 44*(8), 1187-1218. http://dx.doi.org/10.1002/tea.20237

Carlone, H.B. (2022). Understanding and Contextualizing the Field of Science Identity Research. In Holmegaard, H.T., Archer, L. (Eds.). *Science identities: Contributions from science education research* (Vol. 12, pp. 3-20). Springer, Cham.

Carlone, H. B., Scott, C. M., & Lowder, C. (2014). Becoming (less) scientific: A longitudinal study of students' identity work from elementary to middle school science. *Journal of Research in Science Teaching, 51*(7), 836-869. http://dx.doi.org/10.1002/tea.21150

Danish, J. A. & Gresalfi, M. (2018). Cognitive and sociocultural perspectives on learning: Tensions and synergy in the learning sciences. In F. Fischer, C.E. Hmelo-Silver, S.R. Goldman & P. Reimann (Eds.). *International handbook of the learning sciences* (pp. 51-59). Routledge.

Dickinson, P., & Adams, J. (2017). Values in evaluation–The use of rubrics. *Evaluation and program planning, 65*, 113-116.

Donovan, B. M. (2014). Playing with fire? The impact of the hidden curriculum in school genetics on essentialist conceptions of race. *Journal of Research in Science Teaching, 51*(4), 462–496. http://dx.doi.org/10.1002/tea.21138

Donovan, B. M. (2017). Learned inequality: Racial labels in the biology curriculum can affect the development of racial prejudice. *Journal of Research in Science Teaching, 54*(3), 379–411. http://dx.doi.org/10.1002/tea.21370

Donovan, B. M., Stuhlsatz, M., Edelson, D. C., & Buck Bracey, Z. (2019). Gendered genetics: How reading about the genetic basis of sex differences in biology textbooks could affect beliefs associated with science gender disparities. *Science Education, 103*(4), 719-749. http://dx.doi.org/10.1002/sce.21502

Edelson, D. C., Reiser, B. J., McNeill, K. L., Mohan, A., Novak, M., Mohan, L., ... & Suárez, E. (2021). Developing research-based instructional materials to support large-scale transformation of science teaching and learning: The approach of the OpenSciEd middle school program. *Journal of Science Teacher Education*, *32*(7), 780-804. http://dx.doi.org/10.1080/1046560X.2021.1877457

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M.-C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching, 47*(8), 978–1003. http://dx.doi.org/10.1002/tea.20363

Johansson, A., Larsson, J. (2023). Identity perspectives in research on university physics education: What is the problem represented to be?. In Holmegaard, H. T., Archer, L. (Eds). *Science Identities: Theory, method and research* (pp. 163-184). Cham: Springer International Publishing.

Kahn, S., & Zeidler, D. L. (2016). Using our heads and HARTSS*: Developing perspective-taking skills for socioscientific reasoning (*humanities, arts, and social sciences). *Journal of Science Teacher Education, 27*(3), 261–281. http://dx.doi.org/10.1007/s10972-016-9458-3

Kim, A. Y., Sinatra, G. M., & Seyranian, V. (2018). Developing a STEM identity among young women: A social identity perspective. *Review of Educational Research, 88*(4), 589-625. http://dx.doi.org/10.3102/0034654318779957

Lee, C. D., (2017). Expanding visions of how people learn: The centrality of identity repertoires. *Journal of the Learning Sciences*, *26*(33), 517-524. http://dx.doi.org/10.1080/10508406.2017.1336022

Luft, J. A. (1999). Rubrics: Design and use in science teacher education. *Journal of Science Teacher Education, 10*(2), 107-121. http://dx.doi.org/10.1023/A:1009471931127

Mang, H. M. A., Chu, H. E., Martin, S. N., & Kim, C. J. (2023). Developing an evaluation rubric for planning and assessing SSI-based STEAM programs in science classrooms. *Research in Science Education, 53*(6), 1119-1144. http://dx.doi.org/10.1007/s11165-023-10123-8

McNeill, K.L., "Class 12: Developing Community." Class lecture, EDUC 9301: Design of Learning Environments in the Learning Sciences, Boston College, Higgins Hall, April 12, 2023.

National Science Foundation (NSF), National Center for Science and Engineering Statistics (NCSES). (2023). Diversity and STEM: Women, minorities, and persons with disabilities 2023. Special Report NSF 23-315.

Nasir, N. S., Rosebery, A. S., Warren, B., & Lee, C. D. (2014). Learning as a cultural process. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (2nd ed., pp. 686–706). Cambridge University Press.

NGSS Lead States. (2013). Next Generation Science Standards: For States, By States. Washington DC: The National Academies Press.

OpenSciEd. (2021). OpenSciEd. https://www.openscied.org/about/

Pinkard, N., Erete, S., Martin, C. K. & McKinney de Royston, M. (2017). Digital youth divas: Exploring narrative-driven curriculum to spark middle school girls' interests in computational activities. *Journal of the Learning Sciences, 26*(3), 477-516. http://dx.doi.org/10.1080/10508406.2017.1307199

Stroupe, D. (2014). Examining classroom science practice communities: How teachers and students negotiate epistemic agency and learn science-as-practice. *Science Education, 98*(3), 487-516. http://dx.doi.org/10.1002/sce.21112

Vygotsky, L.S. (1978). Thought and language (A. Kozulin, Trans.). Cambridge: MIT Press.

Warren, B., Vossoughi, S., Rosebery, A., Bang, M & Taylor, E. (2020). Multiple ways of knowing: Re-imagining disciplinary learning. In N. S. Nasir, C. D. Lee, R. Pea, & M. McKinney de Royston (Eds.). *Handbook of the Cultural Foundations of Learning* (pp.277-293). Routledge.

Wenger, E. (1998). Communities of practice. Learning, meaning, and identity. Cambridge: Cambridge University Press.

Williams, D. R., Brule, H., Kelley, S. S., & Skinner, E. A. (2018). Science in the learning gardens (SciLG): A study of students' motivation, achievement, and science identity in low-income middle schools. *International journal of STEM education, 5*(1), 1-14. http://dx.doi.org/10.1186/s40594-018-0104-9

Corresponding Author Contact Information:

Author name: Sarah E. Fogelman

Department: Lynch School of Education

University, Country: Boston College, USA

Email: fogelmsa@bc.edu

Please Cite: Fogelman, S. E., Moreno Vera, M. A., McNeill, K. L. (2025). A Curriculum Evaluation of a Genetics Unit from a Science Identity Perspective. *Journal of Research in Science, Mathematics and Technology Education, 8*(SI), 219-240. DOI: https://doi.org/10.31756/jrsmte.419SI

Conflict of Interest: The authors have no conflicts of interest to declare.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Data Availability Statement: The data of this study is available upon request.

Ethics Statement: This research involved an analysis of publicly available curriculum documents and did not involve human subjects. As such, it was exempt from institutional review board (IRB) oversight.

Author Contributions: The author listed have made a substantial direct, and intellectual contribution to the work and approved it for publication.

Received: February 28, 2025 ▪ Accepted: May 27, 2025