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Becoming an inventor: a young Latina's narrative

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Latinas, along with many other minoritized groups, are underrepresented as inventors in the United States. Despite accounting for over 9% of the population, <1% of U.S. patent holders are Latina. In an effort to increase diversity among inventors and patent holders, a number of K-12 programs have been created to provide opportunities for students to participate in the iterative and recursive processes of inventing. One example is the emerging field of invention education. Invention education is an educational approach which teaches students how to identify and solve problems within their communities. Little is known about the experiences of Latina students who have participated in invention education and have begun developing identities as inventors. Through narrative methodology, we analyzed how the life experiences of one Latina student contributed to her identity development as an inventor. Four themes were developed through the analysis of the Latina student's narrative. The first was the early and consistent support of her family members. The second theme was the student's understanding of the importance of Latinx representation in STEM. The student's participation in extracurricular STEM activities was the third theme that contributed to the development of her identity as an inventor. The final theme was her continued involvement in engineering at the university level. While early, consistent, and continued identity work in extracurricular invention and STEM activities contributed to the development of an inventor's identity, literature has shown that opportunities such as these are not available to all students, especially those who have been historically underrepresented as inventors. We argue for making access to invention education more equitable by embedding it within the school day.

KEYWORDS

Latinx, Latina, identity, inventor, invention, identity work, narrative

1 Introduction

Less than 2% of United States patent holders are Latina (Nager et al., 2017). According to a widely cited study by Bell et al. (2019), nearly 90% of all patent holders in the U.S. are white or Asian males with advanced STEM degrees while Latinas are one of the many demographic groups underrepresented as patent holders. In this study, we focus on Latinas because Latinx is the fastest growing minority group in the U.S. Currently 25% of students in U.S. K-12 schools are Latinx, and by 2050, it is anticipated that one out of every three Americans will identify as Latinx (Excelencia in Education, 2019). While the Latinx population has shown tremendous growth in the number of students enrolling and graduating from higher education institutions, Latinas continue to be overlooked within the invention ecosystem.

Seeking to increase diversity among potential inventors, in recent years an increasing number of organizations have provided opportunities for students to participate in invention education and learn the invention process (Invention Education Research Community (IvERC), 2019). Invention education is an educational approach that engages students in identifying problems within their communities and then developing novel solutions to those problems, with feedback from the beneficiaries and stakeholders (Invention Education Research Community (IvERC), 2019). One of the longest sustaining invention education programs has been the Lemelson-MIT InvenTeams™ grants initiative at the Massachusetts Institute of Technology.

Multiple studies have been published on the LMIT Program's InvenTeams™ work (Couch et al., 2018, 2019a,b, 2020), but so far none have focused directly on the experiences of high school aged Latina inventors who have participated in invention education in the United States. Learning about the life experiences of young inventors from marginalized groups, such as Latinas, can provide insight into the contextual elements of their lives (Saenz and Skukauskaite, 2022) and can highlight distinctive perspectives diverse students bring to the growing field of invention education. Gaining a deeper understanding of the contextual elements of their lives, researchers have an opportunity to examine how underrepresented students develop identities as inventors. Examining the narratives of young inventors also provides an opportunity to illuminate how identities are developed and constructed over time through identity work. The research question guiding this study was *What are the life experiences which contribute to the development of an inventor's identity of a young Latina inventor?*

Identities are not static (Carlone et al., 2014); they are constructed over multiple time scales and certain aspects of identities become more stabilized or grow thicker over time (Calabrese-Barton et al., 2013). Scholars who conceptualize identity in this way have used the term "identity work" (Calabrese-Barton et al., 2013; Kelly, 2017). Identity work is the theoretical framework for this study and is defined as the actions individuals take in addition to the relationships they form (Calabrese-Barton et al., 2013) "in a given moment, with the available resources, constrained by the sociohistorical norms, rules, and expectations" (p. 38). Researchers who adopt identity work as a theoretical framework seek to understand how the resources an individual cultivates in one setting can be drawn on to support developing identities in engineering and invention settings (Calabrese-Barton et al., 2013; Couch et al., 2019b). From this perspective, identities are plural and ever-changing and identity work is an inductive, ongoing process.

Writing about identity work, Kelly (2017) argues that engineering identity work occurs on two different levels, the epistemological and the ontological. As students study engineering, they become familiar with the disciplinary knowledge of engineering which contributes to an epistemological identity. Kelly explains that to become a member of the engineering community, understanding and knowing engineering is not enough. One must also self-identify as an engineer, or inventor, which occurs on the ontological level. Ontological identities, as Kelly explains, develop over time through discourse, interaction, and disciplinary practice within epistemological communities. Taking part in the practices of engineers, and, by extension, the practices of inventors, identity work provides opportunities for students to engage in engineering while also seeing themselves as engineers and inventors, and also as co-collaborators in the learning process. By providing underrepresented students with the opportunities to engage in identity work on both the epistemological and ontological levels, educators and institutions actively recognize the importance of developing strong identities as engineers (Calabrese-Barton et al., 2013; Kelly, 2017) and inventors (Couch et al., 2019b).

In developing arguments about the ways inventor identities develop over time, we draw on studies which focus on Latina identity development in engineering, as these studies most closely parallel our focus on Latina inventor identity work. The purpose is not to compare or contrast inventor identities with engineering identities, but rather to describe how the experiences of Latinas in invention and engineering inform their identity work. Though not specifically about identity work, these studies provide a robust description of the varied influences and experiences that impact how Latinas in engineering develop their identities. How students engage in identity work in engineering and invention is influenced by students' perceptions of self and whether they see themselves as a person who participates in engineering (Carlone and Johnson, 2007; Kelly, 2017) or invention (Couch et al., 2020). Understanding the multiple intersecting identities of race, ethnicity, gender, and socioeconomic status is critical in understanding how Latina students engage in identity work and develop their identities as engineers and inventors.

Latina students may experience tensions between their engineering identities and other identities (Rodriguez et al., 2019b; Banda, 2020). For example, Rodriguez et al. (2021) found that while families may offer critical support for the identity development of Latinas in engineering, Latina students may also experience conflict between expectations associated with stereotypical gender roles within their home and their engineering identities. Authors describe the experiences of Latinas in engineering as one "on the borderlands" (Camacho and Lord, 2013). Latinas who participate in engineering are not the norm in engineering settings, just as Latina engineers are not the norm within their own communities.

Authors who study Latinas in engineering have found that developing a strong engineering identity contributes to persistence and resilience in the field. Persisting in engineering for Latinas also requires that they see themselves as the type of people who can do engineering, while simultaneously feeling they can succeed in engineering (Rodriguez et al., 2019a,c; Verdin, 2021). Building on the work of Carlone and Johnson (2007), Rodriguez et al. (2019a,c) emphasize the role of both inside and outside recognition in the development of engineering identities for Latina students as contributing factors to their persistence. Rodriguez and Blaney (2021) explain that while Latina students report feeling marginalized in engineering and STEM settings, they resist and persist by describing themselves as "trailblazers" and by joining STEM identity-based organizations on campus. Additional research in the field has also demonstrated the role of student support groups and campus organizations (Banda, 2020).

Having supportive faculty and role models, specifically Latinas who have been successful in engineering, provides an opportunity for Latina students to claim intersecting identities simultaneously (Verdin and Godwin, 2018). Family support has also been identified as a contributing factor to the development of an engineering identity for Latinas in engineering (Rodriguez et al., 2019b). Scholars suggest that with supportive mentors and family, along with access to engineering organizations, students' engineering identities have opportunities to

develop and thicken. Understanding these complex factors that influence inventor identity development over time calls for research approaches that engage participants in reflecting on their lives, perspectives, and actions in context. Narrative inquiry, with its focus on the stories participants share and co-construct in dialogue with the researchers, offers a theoretically grounded approach to inquiry that is consistent with the theories of identity development over time.

2 Methods

Scholars posit identities are constructed through storytelling, and identities are the stories individuals tell themselves and others about themselves (Riessman, 2008; Kim, 2019). Given the connection between the construction of identity and life stories, we utilized narrative methodology to examine the identity development of one young Latina inventor. Taking a narrative approach enabled us to examine how a young Latina student described her life experiences and in what ways she connected particular experiences to her identity as an inventor.

Riessman (2008) describes narrative inquiry as a collaborative process between participant and researcher that takes place over time. Together with the researcher, participants (re)construct their lived experiences through stories. These stories are the foundation of narrative inquiry. As a methodology, narrative inquiry is most frequently used within the social sciences, but is also gaining popularity in other fields, such as business and law (Kim, 2019). Narrative inquiry challenges dominant knowledge paradigms with the goal of reshaping views through an understanding of people's lived experiences (Clandinin and Connelly, 2000; Kim, 2011). In narrative inquiry, researchers seek to illuminate the unique and contextual elements of the participants' lives, as it is within the contextual elements of the participants' lives that their narratives are embedded (Clandinin, 2013).

Narrative inquiry provides an opportunity for participants to make meaning of their past experiences while providing the researcher and readers with the opportunity to create their own meaning of the stories the participants have shared. The goal of sharing temporal, particular, and local stories is to invite the readers to vicariously experience the events described by the participants by engaging in their own meaning-making of the experiences (Kim, 2011).

We chose narrative as the methodology because the goal of narrative is to gain a deeper understanding of the life experiences of human beings through their stories (Riessman, 2008). Narrative researchers contend an individual's story is powerful because individual stories are inherently social (Chase, 2003). Therefore, the unique story of one individual has the ability to reflect larger social patterns (Kim, 2019). Kim (2011) explains that an individual story can serve as a metaphor to connect to others with similar experiences whose stories have not yet been heard.

In this paper, we draw on Saenz (2022) dissertation to highlight the identity development of one of the Latina inventors Saenz interviewed. The larger study included analysis of three Latina's narratives and connected the narratives to theoretical arguments about the importance of asset-based educational perspectives. By focusing on the life story of one young Latina, for this paper, we analyze the selected life story in detail and identify the key contextual elements contributing to the chosen person's development as an inventor.

The participant whose narrative we analyze in this paper was one of eleven high school students and one of the five Latinas who participated on an LMIT InvenTeam™ during the 2018–2019 school year. She was a member of an Oregon high school InvenTeam™ whose members, including the teacher, technical mentors, and all 11 students, had signed assent and consent forms for participating in a larger study of networks supporting one team's invention processes and practices (Skukauskaite and Sullivan, 2023). Noting the diverse composition of the team and the active participation of Latina students on the InvenTeam™, Saenz extended the original study by developing a narrative dissertation study focused on three of the five Latinas on the team. The three were chosen to represent those with a range of participation in out-of-school invention education prior to the InvenTeam™ experience. Because one participant, Lesly, had begun participating in STEM in middle school, we selected her narrative for this paper because her story highlights in most detail the overtime nature of a person's identity development (Calabrese-Barton et al., 2013; Kelly, 2017).

To conduct a narrative study on young Latina inventor identity development, Saenz received approval from the Institutional Review Board (IRB) at the University of Central Florida, where Saenz was a doctoral candidate at the time. She then reached out by email to the potential participant Lesly to invite her to participate in the study. Saenz met with Lesly over Zoom to explain the goals of the study and answer any questions or concerns Lesly had about the study. During the first Zoom call, the researcher and potential participant reviewed the informed consent form, potential risks, and Saenz assured Lesly that she had the right to opt out of the study at any point. Once Lesly agreed to participate, Saenz also explained the option to use Lesly's real name or maintain confidentiality. Lesly expressed her desire to use her own name because, as she said, she was proud of her story and knew others would be reading her narrative. When Lesly mentioned her siblings during narrative interviews, Saenz asked her to check with her siblings to see if her siblings would like to use their names or pseudonyms. All siblings elected to use their own names as well, as they also wanted others to know their stories and to contribute to the larger conversations and changes in Latinx youth's engagement in invention education and engineering opportunities.

The study of Lesly's story included three narrative interviews conducted over 3 months. Interview length ranged between 29 and 75 min and averaged 56 min. The first two interviews were longer than the third interview, which served mainly as a member-checking opportunity. All interviews took place via Zoom.

Narrative interviews consisted of open-ended questions and follow-up probing questions which built on what Lesly shared in her initial responses. The first interview started with the general question, "Tell me about yourself," which allowed Lesly to choose what she wanted to share with Saenz and in what ways. Throughout the interviews, the narrative researcher and the participant were actively co-constructing the interview process (Riessman, 2008). Although the researcher initiated key questions, the participant was the trail guide throughout the interview process. She chose what to share, in what ways, and how much detail to provide. The researcher followed Lesly's story and asked probing and clarification questions, inviting Lesly to add contextual details, to remember, and to connect the different experiences.

The goal of the first interview was to develop rapport and trust (Kim, 2019) and build on the introduction and relationship established through their first Zoom meeting. During the initial interview, Saenz and Lesly talked about Lesly's InvenTeam™ experience, her roles, and

what brought Lesly to the InvenTeam™. The second interview, focused more on Lesly's family background. Lesly had brought up her family in the first interview, and the second interview gave her an opportunity to talk more about the ways her family shaped her developing inventor identity. The final interview followed up on major themes generated through the first two interviews. The third interview also served as the first member checking opportunity about initial findings. Final member checking was done at the end of the study, when Saenz shared her full analysis and Lesly expressed that she was happy with how her story was represented.

In addition to the three narrative interviews, Saenz also exchanged text messages with Lesly throughout the process. Text messages included exchanges for scheduling interviews, member checks on particular details, and to clarify questions arising throughout the analysis process. By email, Lesly received two drafts of the analysis; one was sent before the final interview and one after the analysis was completed. Lesly used text messaging to correct certain typos or small mistakes she noticed in the drafts; there were no substantial corrections to the main analysis topics.

Data analysis included transcribing interviews into sequence and information units (Skukauskaite, 2014), and then engaging in a three-step analysis process shown in Table 1.

We followed the inductive process of narrative inquiry to explore how the participant connected different aspects of her life into a narrative of inventor identity work. The first step of the analysis process was to create a general chronological timeline to gain an understanding of the events in the participant's life. This was done by listing the major events in an Excel spreadsheet then member checking with Lesly to confirm if the events and dates were accurate. After developing a general timeline of Lesly's life, the second step was analyzing for specific experiences Lesly identified as contributing to her development of an inventor's identity. The final step of the analysis process was examining each of the key events identified in step two to understand the contexts and processes shaping Lesly's engagement in activities impacting her development as an inventor. Based on the stories Lesly shared around the key events, we then developed broader themes connecting Lesly's varied experiences into key influences for her development of an inventor's identity.

3 Results

In this section, we present a thematic analysis of Lesly's narrative to answer the research question, *What are the life experiences which contribute to the development of an inventor's identity of a young Latina inventor?* We began by organizing Lesly's life events chronologically to gain a general understanding of her life story. We then identified which of her life experiences connected to the development of her identity as an inventor. Through inductive analysis, we developed themes based on the life experiences Lesly shared throughout the interview process. We identified four unique themes which contributed to Lesly's identity work as an inventor.

TABLE 1 Data analysis process.

	Steps in the data analysis process
1.	Created a chronological timeline of major events
2.	Determined which events contributed to the development of inventor's identity
3.	Inductively developed themes based on individual life stories

3.1 Lesly's story

At the time of the study, Lesly was 19 years old and a first-year student at Oregon State University majoring in electrical and computer engineering. She was soft-spoken and humble, yet confident. Lesly was born in Salem, Oregon, to parents who immigrated from Mexico. She was the oldest of three children, with two younger brothers who were 15 and eight at the time of the study. She described herself as a first-generation student and first-generation Mexican American. Lesly explained that although her parents did not have the luxury of continuing with their education beyond high school, they consistently emphasized education was a privilege. Lesly always wanted to make her parents proud, and she described a happy childhood with supportive parents. She spoke of her early years fondly and held back tears as she described what it was like growing up in her family. Her mother was a stay-at-home mom for the majority of her childhood, occasionally working seasonal jobs at a local blueberry cannery. Her father worked at a grass farm where he operated heavy machinery.

From a young age, Lesly knew she was going to go to college. Lesly had a third grade teacher who frequently spoke to the students about her experience in college. Lesly explained hearing about college at a young age helped make it seem like a realistic possibility for her.

> My third grade teacher talked so much about her college experience. Even though I already knew I was going to go, I feel like her talking so much about her college experience in elementary school made a really big impact.

Lesly took advantage of the opportunities she was presented throughout her educational journey, both in the classroom and out. She attributed her competitive streak to her participation in orchestra growing up.

In analyzing the different life experiences Lesly described, we identified four themes which contributed to her development of an inventor's identity. For Lesly, the support of her family was a major theme. Her participation in extracurricular STEM activities also played a significant role in the development of an inventor's identity. Additionally, her acute awareness of the importance of representation of Latinas in STEM and her continued exposure to engineering at college were also themes identified through inductive analysis of Lesly's narrative. Figure 1 provides a visual which captures the four themes developed through inductive analysis of Lesly's narrative.

3.2 Early and consistent family support contributing to Lesly's identity as an inventor

The support of Lesly's family throughout her educational journey contributed to her development of an inventor's identity starting at a young age. Lesly explained, "Yeah, my mom and dad, they are my number one supporters. Again, they are very education driven, even though they did not have that opportunity." Lesly positioned her

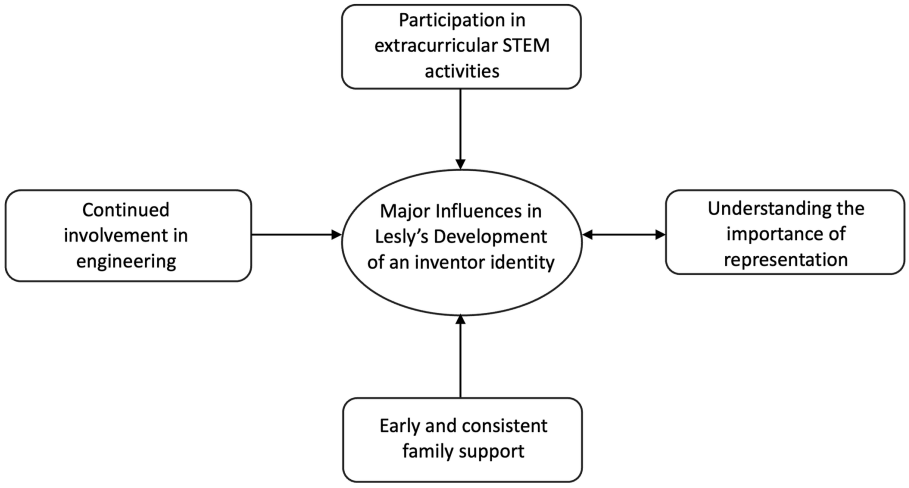

FIGURE 1
Concept map of themes developed from Lesly's narrative.

parents as her "number one supporters" and explained that although her parents did not have the opportunity to continue with their own formal education, "they are very education driven." Lesly remembered as early as first and second grade, her father would come home from work and help her with her homework and assist her in making corrections if needed. She explained:

> So that was my childhood, it was just school and learning. I always knew it was a privilege because they always told me about it. So yeah, by first or second grade, I knew I was going to go to college. At some point we talked about it, like, do you want to go to college, Mija? Some parents ask their kids, I would say yes.

Lesly recalled the focus of her childhood being "school and learning." In the second sentence of the above quote, Lesly identified herself as a person who was aware of the "privilege" of education because her parents reinforced the idea. As early as first grade, Lesly already saw herself as a person who would be going to college. Lesly stated "some parents" ask their kids about their intentions to attend college, positioning her parents in the larger group of parents who support their children's choices for college. Lesly described how their discussions about college with Lesly as a young child had an impact on her educational trajectory. Lesly recalled a conversation with her parents in which they asked her, "do you want to go to college, Mija?" As a child, Lesly told her parents "Yes," and maintained that intention throughout her K-12 experience. She was the first person in her immediate family to attend college.

Throughout the interviews, Lesly shared how her mother and father were both deeply invested in her education. She explained her father's support as she progressed through school:

> There were times, as I got into middle school and high school math, you know, my dad wasn't able to help me in any way, but he had already provided that path of asking questions and asking how we will get to the right answer and that kind of thing. I had learned that in this household, we get good grades, and we try our best, and we do the best that you can.

Lesly explained there were times her dad was not able to help her as she progressed into higher level math; however, he had already "provided the path of asking questions" and asking how "*we* will get the right answer." Her use of the word "we" signaled recognition of her father's support and the collective family interest in her success in school. She continued to use the word "we" as she explained "I learned that in this household *we* get good grades, and *we* try our best and *we* do the best that you can." Lesly positioned herself as part of a family who do their best and get good grades. The support of Lesly's parents contributed to her identity as a person who works hard in school and cares about academics. This continued as Lesly progressed into high school and on to college.

As Lesly made decisions regarding which high school and college to attend, her parents were deeply invested in the decision-making process. Lesly remembered when it was time to select a high school, it was a decision her family made together. She explained:

> My family has been very, my dad, specifically, but my mom as well have been like, we have to choose the right direction for your education path. I had three options of where I could potentially be going, so it was Early College High School, which would allow me to complete my high school in 2 years and go on straight to college, which we were really considering. Then we were considering South Salem High School which is a little bit more rigorous. It's an IB program rather than AP. And then there was McKay High School, the one that was near my zip code, but they had MESA and I had seen the Recycl3D team.

Lesly also recalled her parents' recognition of the importance of "choosing the right direction" for her "educational path." She described the three options and included reasons the family "considered" these schools for Lesly. Lesly's repeated use of "we" in the above quotes signaled the support of her parents and their involvement in her academic endeavors.

In the end, she decided on McKay because there was already a Mathematics, Engineering, Science, and Achievement (MESA) chapter at the school, run by Katrina Hull who would later become Lesly's InvenTeam™ teacher, and because of her exposure to the

Recycl3D team. The Recycl3D team was an engineering team of all Latinx students from McKay High School the team had competed against college teams and earned thousands of dollars for the new engineering program at McKay. We expand on MESA and the impact of the Recycl3D team on Lesly's development of an inventor's identity in the Lesly's Understanding the importance of representation in STEM and its contribution to her identity as an inventor. In the next section, we describe how participating in extracurricular STEM activities was important identity work for Lesly which contributed to the development of an inventor's identity.

3.3 Participating in extracurricular STEM activities and their contribution to an inventor's identity

Lesly's first exposure to extracurricular STEM activities began in 7th grade with her participation in MESA (Mathematics, Engineering, Science, Achievement), a club at her middle school which met weekly on Thursday afternoons. MESA is a nationally recognized organization committed to engaging underrepresented students in STEM and improving academic outcomes for participating students (MESA USA, 2023). MESA programs currently run in 10 states, including Oregon. Lesly knew about the club because her friend was joining and initially, Lesly joined because she wanted to spend more time with her friend. Lesly explained she was hesitant to join because she wasn't sure what engineering was and she was already an active member of the school orchestra. She did take the risk, and the first MESA challenge in which she participated in was her first exposure to invention education. Lesly explained how this experience "hooked" her into engineering. In the quote below, she described this first design challenge, which focused on creating a wallet.

> My crazy mind was like, Okay. We're going to put chargers in this, you are going to be able to charge your phone and three million pockets. You're going to be able to do this and this. I was so excited. I made a little cardboard prototype and that was my first insight into invention education and kind of using my mind to do these crazy things and to think of these crazy ideas that nobody else thinks about. So, I was obviously the only one in the class that actually took it, not seriously, but more to the next level. I remember it so clearly and that's kind of how they hooked me in.

Lesly recalled "being so excited" about her first design challenge and described her "crazy mind" considering all the different features the wallet would have. Designing the wallet in MESA was her "first insight into invention education" which allowed her to develop her own unique perspective on creating new things. While her fellow MESA classmates also designed wallets, Lesly stated that she was "obviously" the only one in the class who "took it to the next level," signaling her desire and willingness to learn beyond what was assigned. Lesly designed the wallet so that it would be able to charge a cell phone and also added multiple pockets. She also considered the bulk of the wallet knowing that the user would most likely have to sit on the wallet. Lesly said the experience of designing the wallet was how they "hooked" her into invention education.

By the spring of her eighth grade year, Lesly was building a prosthetic arm through her participation in MESA. As Lesly reflected on her experience with building the prosthetic arm, she recalled the exact moment in the eighth grade when she told herself, "Ok, this is what I am going to be doing for the rest of my life." Lesly's statement captures the effect of participating in engineering and design challenges on the development of an inventor's identity. Starting in the seventh grade, Lesly was provided with opportunities to engage in identity work (Kelly, 2017) which allowed her identity as a problem-solver and inventor to develop and thicken.

Towards the end of the first interview, Saenz asked Lesly if she considered herself an engineer, to which Lesly responded, "I identify myself as an inventor. I think I will consider myself an engineer once I graduate. That's how I've been thinking about it, but I definitely consider myself an aspiring engineer." Lesly identified herself as an inventor, but not yet an engineer. To Lesly, being an engineer was tied to a credential she will receive. When Lesly stated "that's how I've been thinking about it" she signaled this is not the first time she has thought about her identity as an inventor or engineer. She continued, "I definitely consider myself an aspiring engineer." When Saenz followed up by asking, "So what is an inventor, then?," Lesly responded:

> An inventor for me is somebody who either has identified a problem or has made something in order to better something else. In this case, for me, specifically, it has been building something that would help others. So, for example, the adaptive cup for me, that was a process where I identified the problem for somebody who actually needs it and I made that for them. So that's an inventor for me or somebody who can just make something. Now that I think about it, it's somebody who identifies problems, it's a problem solver. An inventor is a problem solver.

Lesly defined an inventor as "someone who has either identified a problem or has made something in order to better something else." She positioned herself as an inventor because she has built something to help others. Lesly provided the invention developed by her InvenTeam™ as justification for why she saw herself as an inventor. She "identified the problem for somebody who actually needs it" and was able to "make" the adaptive cup for them. For Lesly, an inventor is a "problem solver" and "someone who can make something."

Lesly expressed her self-identification as an inventor confidently. To support her position as an inventor, she provided evidence of the adaptive cup she created with her McKay High School InvenTeam™. She also connected problem solving and inventing in her definition of an inventor. In the following subsection, we show the importance of Lesly hearing the word "inventor" on the development of her identity.

3.3.1 Hearing the word "inventor" and how it contributed to Lesly's identity as an inventor

Lesly traced the development of her inventor's identity to her exposure to the word "inventor" throughout her participation in MESA.

> In MESA, the word inventor was used a lot, along with engineering and things like that. Oftentimes when you think of an inventor, you think of some of the biggest names out there, right? People do not usually think of themselves as inventors. I think what contributed to me considering myself an inventor, and in a way knowing that I am one, is being surrounded by that community of

> people who understand that inventors are people who are problem solvers and who like to solve problems and who like to build things.

Lesly recalled her first exposure to an inventor's identity related to the discourse used in MESA. She explained "the word inventor was used a lot, along with engineering and things like that." In the second and third sentence of the above quote, Lesly acknowledged the ambiguity and uncertainty around the word inventor. She stated, "people do not usually think of themselves as inventors" because they conceptualize inventors as "some of the biggest names out there." She explained she *knows* she is an inventor because she was surrounded by a "community of people" who understood "inventors are problem solvers who like to solve problems and who like to build things." Lesly's experiences in MESA and on the InvenTeam™ contributed to her development of an inventor's identity by allowing her to take part in the practices of inventors. In her extracurricular STEM activities, she was surrounded by the word "inventor" and by a community who defined inventors as problem solvers, which also contributed to her self-identification as an inventor.

Lesly's participation in MESA and on the InvenTeam™ contributed significantly to the development of her identity as an inventor. Of all the participants in the larger study, Lesly spoke the most confidently about her identity as an inventor. Lesly *knew* she was an inventor, because she was exposed to a community which used the word and defined inventors as problem solvers. Taking part in extracurricular activities such as MESA and the InvenTeam™ also allowed Lesly to engage in the iterative and recursive process of inventing. Next, we discuss how Lesly's understanding of the importance of representation in STEM contributed to the development of her identity as an inventor.

3.4 Lesly's understanding the importance of representation in STEM and its contribution to her identity as an inventor

3.4.1 The impact of Lesly's exposure to the Recycl3D team

Lesly was first exposed to the Recycl3D team, an engineering team from McKay High School composed of all Latino students, when she was in middle school. She saw them for the first time at MESA Day, an engineering challenge for teams from different high schools, and continued to follow their progress throughout her final year of middle school into high school. Lesly attended middle school at the local public school for which she was districted, and which was a feeder school for McKay. As mentioned above, Lesly described the impact of the Recycl3D team on her decision to attend McKay High and continue her involvement in engineering. Lesly's second time seeing the Recycl3D team compete was during her first year in high school when the MESA club at McKay took Lesly and fellow MESA participants on a field trip to an engineering challenge at a local university where the Recycl3D team were competing against college students. Lesly described her second encounter with the team below:

> They [Recycl3D team] ended up winning first place at the semi-finals and then second place at the finals, winning over $30,000.00 for our engineering program. So, I get to see them present, just people who actually look like me start winning these competitions. I really hoped that I could do that 1 day, but I had not seen it happen, and so when I saw that happen, I was like, I'm ready for what's next for me. I'm ready to take this to the next level. I want to do what they did.

In the above quote, Lesly described the importance of seeing Latinx students win engineering competitions. For Lesly, "seeing people who actually look like me start winning these competitions" made her "ready for what's next." When she stated, "I really hoped I could do that, but I had not seen it happen," she signaled that prior to seeing the Recycl3D team compete, she aspired to become an engineer, while also positioning herself as someone who had never seen Latinx individuals succeed in engineering competitions. When she "saw" the Recycl3D team's success firsthand, she wanted "to do what they did." Although Lesly was already passionate about engineering, the Recycl3D team provided her with an example of how to "take it to the next level." The above quote underscores the importance of students having direct, firsthand exposure to individuals to whom they feel connected through shared identity.

Seeing people who looked like her succeed in STEM inspired Lesly to continue her journey as an aspiring engineer. The exposure to the Recycl3D team also affected her decision on where she would attend high school, which had a lasting impact on her educational trajectory. Going to McKay High School and joining the InvenTeam™ reinforced for Lesly the importance of representation in STEM and inspired her to want to be an example for other minorities in STEM.

3.4.2 The InvenTeam™ experience reinforcing the importance of representation in STEM for Lesly

Lesly continued pursuing engineering opportunities through MESA and other organizations while she attended McKay. At the end of her first year of high school, she was introduced to the possibility of McKay receiving an InvenTeam™ grant from LMIT. Lesly was the only one of the three participants in Saenz's study who knew about MIT when Katrina, her math teacher and MESA instructor at the time, first introduced the idea. Lesly described MIT as her dream school. She recalled Katrina announcing McKay was selected as one of the 15 teams to receive the InvenTeam™ grant at the end of her first year of high school. Lesly described how she cried tears of joy upon finding out.

It was Lesly's idea, an adaptive cup for individuals who suffer from dysphagia, which became the invention the McKay InvenTeam™ developed during the 2018–2019 school year. Lesly first conceptualized the idea as part of a project for MESA during her first year of high school. A healthcare professional who worked with geriatric patients at a nursing home visited MESA and explained the various needs of the patients based on their conditions. The healthcare professional introduced the students to dysphagia and the effect it has on an individual's ability to swallow. She also shared about a lack of cups available for individuals who suffer from the condition. Based on the presentation, Lesly decided to focus on inventing a new cup for individuals with dysphagia. While she did not make it to developing a prototype for a cup in her first high school year in MESA, she introduced the idea to the InvenTeam™ as they were applying for the InvenTeam™ grant and were trying to decide which invention to focus upon.

Lesly played an integral role on the team because of her experience and passion in engineering, yet she was always humble when discussing the InvenTeam™. When the researcher asked her what she learned through her experience on the InvenTeam™, she explained:

> I learned how to share my story, not to benefit me, but to, this is going to sound braggy, but to become an inspiration to others. I understood the importance of representation in the STEM world and what I want to do with that in the future. It opened my eyes again to what I want to do with community involvement for minorities in STEM.

Through the InvenTeam™ experience, Lesly "learned to share her story" in order to "benefit others." In the above quote, Lesly positioned herself as someone who has a story that may inspire other minorities in STEM. As a result of her participation on the InvenTeam™, Lesly "understood the importance of representation in the STEM world" and this understanding shaped her future.

Participating on the InvenTeam™ also reinforced Lesly's desire to work to engage more minorities in STEM. Lesly continued:

> I saw the importance of representation through the Recycl3D guys and now I understand that my story hopefully will serve a similar purpose, where I am somebody who looks like them and if this encourages the next generation of Latinas to continue engineering, I really, I really want that to happen.

Through her experiences on the InvenTeam™, Lesly strengthened her identity as a Latina in engineering and inventing who can encourage the "next generation" of Latina students. Lesly continued to discuss the need for representation of Latinx individuals in STEM:

> They are a big part of the population, and we cannot ignore it. They need to be represented in these subjects. I think that it just opened my eyes and made me understand that my perspective is also important, and it made me comfortable knowing that my perspective is different, and it made me understand that there are different opinions and I'm always going to have that one sticking out, and I am not embarrassed or shy to talk about it.

Lesly began by referencing the large Latinx population in the United States and said, "we cannot ignore it." She again stated the InvenTeam™ experience "opened my eyes" and added it "made her understand" the value of her perspective in STEM. Lesly acknowledged she was not the norm in engineering when she positioned herself as always having the opinion and perspective which is "sticking out." She continued by asserting she was not "embarrassed or shy" to share her perspective and ideas with others, because she knows there is value in her perspective. Lesly understands the value she brings to engineering as an underrepresented student and wants to help other Latina students to see the valuable assets they can also contribute to engineering and invention.

In the above section, we described how Lesly's understanding of the importance of representation in STEM fields contributed to the development of her identity as an inventor. Seeing herself and her story reflected in the Recycl3D team encouraged her to continue in engineering and helped her understand the value of her own experience. As a result, she wanted to become an inspiration for younger Latina students pursuing invention and engineering. In the final section of Lesly's narrative, we discuss her continued involvement in engineering at the university level as a theme which contributed to the development of her inventor's identity.

3.5 How continued involvement in engineering at the university level contributed to Lesly's identity work

In the fall of 2021, Lesly began her first year at Oregon State University (OSU). Upon moving onto the OSU campus, Lesly immersed herself in the engineering community. She lived on a dormitory floor with other female engineering students and joined identity specific engineering organizations, such as the Society of Hispanic Engineers.

> Right now, I'm surrounded by a community of people of color who are pursuing their degrees in STEM and I tell people, you need to talk about your experiences because your experiences are so unique. I feel so inspired by them because some of them, although they did not have the same opportunities as me, the amount of work and grit they put into their education. I feel so impressed and so good because, my friend did all of these things. A lot of people need to hear it. It can help so many girls continue in STEM and continue going in their engineering path.

At OSU, Lesly was "surrounded by a community of people of color" in STEM. Lesly reflected on her own experiences as a Latina who saw herself and her story in the Recycl3D team, which led to her envisioning herself as a Latina in STEM. Through her own experience, Lesly saw the importance of exposing younger generations to the stories and experiences of Latinx individuals in STEM. She encouraged her friends to "talk about your experiences because your experiences are so unique" which signals her understanding that people of color have unique experiences in STEM and those perspectives need to be heard. Lesly also stated she is inspired by "the amount of work and grit" her friends have put into their education. Lesly "feels so impressed and so good" having friends who "did all these things." She explained that by hearing the stories of other people of color in STEM, it can "help" other girls to persist in STEM and engineering.

Lesly also worked with an engineering professor on research improving power grids. She describes the experience:

> I am now doing research with one of the professors here in the electrical and computer engineering department. I do research on that and we are learning about microgrids and how we can improve power grids and just all of that research, which again, you never think of doing that your first year. It's just been surreal, and it's just been amazing.

Lesly shared she never thought she would be participating in research her first year of college. She described the experience as "surreal and amazing." During her first year of college, Lesly was "doing research" with a professor in the electrical and computer engineering department and continuing to learn about engineering, in this case, researching how to improve power grids. By engaging in the practices of inventing and engineering, Lesly continued to take part in identity work on both ontological and epistemological levels which provided opportunities for her identity as an inventor and an engineer to develop and thicken.

Lesly made specific choices to surround herself with aspiring female engineers and people of color in STEM. Lesly's continued engagement in engineering at the college level contributed to the

development of her identity as an inventor because she was surrounded by other people of color in STEM. Through her involvement in engineering in college, she continued to take part in formal engineering practices, which gave her the opportunity to apply her knowledge of problem solving and inventing.

Lesly *knows* she is an inventor because she had been surrounded by the word since middle school through her participation in MESA. Lesly's narrative provides evidence of the benefits of participating in multiple cycles of the invention process. The early and consistent support of Lesly's family also contributed to the development of her identity as an inventor. Additionally, Lesly continued to strengthen her inventor's identity through continued participation in engineering at the university level.

4 Discussion

By examining the narratives of one young Latina inventor, we offer a fresh perspective in understanding the life experiences of Latina students who have participated in invention education. We illuminated the contextual elements one young Latina inventor evoked throughout her identity work. Drawing upon the work of Calabrese-Barton et al. (2013), we followed Lesly's journey from someone who saw engineering and invention happening around her to someone who saw herself as an inventor and an engineer. This journey of becoming is consistent with how Kelly (2017) conceptualizes identity work as taking place on both ontological and epistemological levels. We also identified four unique themes within Lesly's narrative to determine which life experiences contributed most directly to the development of her identity work to see herself as an inventor. Lesly's educational and developmental journey offers valuable insights into how these themes intersect to shape her identity. Her experiences reflect a nuanced and multi-faceted process that not only highlights personal growth but also the broader societal and cultural influences that impact how people engage in identity work. The results of this narrative study indicate the development of an inventor's identity takes place over time, reflecting the inductive nature of identity work.

The theme of *Early and Consistent Family Support* reflects the pivotal role Lesly's family played in her education and the impact that familial encouragement and support can have on a young Latina's identity as an inventor, which reflects similar findings of Verdin and Godwin (2018) about the identity development of Latina engineers. While Rincón and Rodriguez (2021) explain that young Latina engineers may experience conflict between stereotypical gender roles in their families and engineering identities, Lesly never verbalized having experienced those conflicts. In contrast, Lesly described the critical role her parents played in supporting the engineering and invention experiences that allowed her to engage in inventor identity work.

The theme of *Participation in Extracurricular STEM Activities* illustrates the importance of repeated exposure to STEM and invention in cultivating an inventor's identity. This theme also highlights the significance of experiential learning in shaping how a young Latina embraces her identity as an inventor. This further reinforces the work of Carlone and Johnson (2007), Kelly (2017) in engineering and Couch et al. (2020) in invention. Because identity work is ongoing, repeated exposure to STEM and invention allowed Lesly to do identity work on both an epistemological and an ontological level through the scaffolding of knowledge and practice involved in engineering and invention projects.

Lesly's Understanding the Importance of Representation in STEM serves as a critical theme which reinforces the essential role that representation and visibility play in shaping young people's identities, especially within the STEM and invention fields. This theme highlights the importance of fostering a sense of community among underrepresented groups as Calabrese-Barton et al. (2013) have discussed in their work. Lesly's exposure to the Recycl3D team was a pivotal moment for her to begin her identity work. Seeing others who looked like her doing engineering projects provided her with a sense of belonging and possibility as a Latina in STEM, reflecting the work of Rodriguez and Blaney (2021).

Continued Involvement in Engineering at the University Level emerges as a concluding theme in Lesly's narrative. Her transition to college further exposed her to a supportive community of people of color pursuing STEM degrees, providing more opportunities for her to see others like her in STEM spaces. The environment reinforced her decision to pursue engineering as a field of study and reminded her of the importance of representation for other young Latinas interested in engineering and invention (Rodriguez and Blaney, 2021). This theme underscores the importance of fostering supportive environments and continuing engagement to sustain inventor identities beyond high school.

Lesly's story serves as a testament to the transformative potential of invention education in shaping the trajectories of underrepresented individuals in the fields of STEM and invention, inspiring a call to action for educators, institutions, and policymakers to foster environments that empower and elevate young inventors throughout their educational and professional endeavors. Through the narrative analysis of Lesly's journey to developing her identity as an inventor, we have illuminated the dynamic process of identity construction through repeated identity work, reaffirming the insights from prior research (Calabrese-Barton et al., 2013; Cunningham and Kelly, 2017; Couch et al., 2018). The significance of capturing diverse perspectives on invention education from underrepresented students further deepens our understanding of the broader implications of invention education in the lives of young people of color.

4.1 Implications for educators

Educators have the potential to influence the development of an inventor's identity in their students by reinforcing the understanding that students are inventors who can solve complex problems within their communities. Lesly identified as an inventor because she was accustomed to hearing the word inventor starting in middle school with MESA and continued to hear the word in high school through her involvement with the InvenTeam™. Lesly "knew" she was an inventor because she was a part of a community of people who defined inventors as individuals who identify and solve problems. By providing outside recognition to students who participate in invention education, educators may support the development of an inventor's identity particularly for diverse, first-generation students like Lesly (Rodriguez et al., 2019a,c). For example, telling students that they are inventors and that they belong in invention could contribute to students seeing themselves as inventors and as people who bring valuable perspectives to invention.

Given that an inventor's identity is developed over time through repeated engagement with invention, educators and administrators may consider implementing invention education in early elementary years. If invention education is implemented into the school day starting in the early grades, more students will have opportunities to take part in invention and develop identities as inventors, engineers and "STEM people." Educators may also consider facilitating opportunities for students who are marginalized in invention to meet and interact with older students or mentors in the field with whom the students identify. For example, Lesly discussed the power of seeing the Recycl3D team the all-Latino award-winning engineering team from McKay High School. She explained that seeing people who looked like her succeed in engineering motivated her to continue her trajectory and also seek out more opportunities. She also expressed the desire to be someone other Latinx students in invention and engineering look up to. By exposing students to inventors from marginalized populations, teachers affirm that all students can thrive as inventors.

4.2 Implications for researchers

Focusing on the narrative of one young Latina inventor who participated in invention education in a K-12 setting provided the opportunity to examine how identity is constructed over time through repeated identity work (Calabrese-Barton et al., 2013; Kelly, 2017; Couch et al., 2018). Exploring the life experiences of a young Latina inventor who participated in out-of-school invention education starting in middle school also allowed us to capture how early and consistent exposure to invention affects identity development (Couch et al., 2018). Additionally, gaining insight from an underrepresented student who has experienced K-12 invention education provided insight on how it connects to students' lives within and outside of school. If more researchers examine the narratives of underrepresented students in invention, the field could gain a deeper understanding of the unique ways diverse students develop identities as inventors and how those identities thicken over time. Future research could include ethnographic studies in spaces such as InvenTeams, engineering, clubs, MESA or other settings, in which students engage in identity work through interactions with others in the context of learning and problem-solving. Longitudinal, ethnographically-oriented, studies within schools, classrooms, and clubs could provide insights how the social environments and discourse shape student identity development and learning not only individually but also collectively. In depth case studies of students at different stages of identity development could also expand knowledge on the processes, practices, and contextual factors that support or constrain diverse students becoming inventors. While we focused on Latinas as one of the main underrepresented groups in invention education, other studies could study identity work among students of different backgrounds, including neurodivergent, ethnic, racial, or socioeconomic, among other backgrounds. Correlational quantitative studies exploring relationships among varied demographic factors, exposure to STEM and invention, and learning or career outcomes are also needed to document the expanding field and its impact. To bring clarity to overlapping concepts of inventor, engineer, scientist, mathematician, designer and other identities, systematic literature reviews could provide the grounding for understanding the intersections among the different perspectives and the roots of such differences.

4.3 Implications for policy makers

Our study contributes to the growing body of literature which calls for increasing access and opportunities for diverse students to participate in invention education. Researchers in the field have called for embedding invention education within the school day to increase access to invention and increase the number of diverse patent holders in the U.S. (Zhang et al., 2019; Couch et al., 2019a). By embedding invention education into the school day, policymakers may democratize access to invention education experiences, which are typically limited to after-school extracurricular activities, such as MESA and the InvenTeam™ and thus may not be accessible to all students.

By taking part in the iterative and recursive process of inventing, Lesly was given opportunities to engage in inventor identity work, which strengthened her self-identification as an inventor (Kelly, 2017). Lesly had the necessary support and understanding from her parents to engage in after school activities such as MESA and InvenTeams™, which helped solidify her develop and solidify her identity as an inventor. However, Saenz and Skukauskaite (2022) found that other Latina students without the same level of access to after school programming—whether due to other commitments or other reasons—did not develop inventor's identities in the same way. While the parents of the other Latinas Saenz interviewed were supportive of learning taking place within the school day, they were more hesitant to allow their daughters to participate in an after-school program. Literature on identity development and our study of Lesly's narrative provides evidence that participating in extracurricular invention education activities contributes to the development of an inventor's identity; however, limited opportunities are available to students within the school day, limiting access to participation, especially for those who have been historically underrepresented as inventors (Couch et al., 2018, 2019b). Therefore, in concert with other invention education scholars (Committee for the Study of Invention, 2004; Zhang et al., 2019), we argue for invention education to be embedded within the school day.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by University of Central Florida Institutional Review Board. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

CS: Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing. AS: Conceptualization, Methodology, Project administration, Supervision, Writing – review & editing. MS: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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