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ENGAGING LATINA STUDENTS IN THE INVENTION ECOSYSTEM

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Researchers who focus on innovation and invention provide empirical evidence for the benefits of drawing on diverse ideas throughout the invention process; however, the majority of inventors in the United States are White, middle-aged males with advanced science, technology, engineering, or mathematics degrees. By relying primarily on the ideas and inventiveness of homogenous groups, the United States is losing out on diverse and valuable funds of knowledge, which could contribute to groundbreaking innovations to improve peoples' everyday lives and the nation's global competitiveness. Considering that one in four students in the U.S. school system identifies as Latinx, and by 2050, one in three U.S. Americans will identify as Latinx, drawing on the rich cultural knowledge found within Latinx communities is essential for fostering innovation and invention in the diverse U.S. society.

In this conceptual paper, we focus specifically on engaging Latina students in the innovation ecosystem while emphasizing the importance of including the varied perspectives and diverse skill sets of all students. We propose the funds of knowledge theory as a helpful perspective for exploring the ways and reasons for including Latinas (and other diverse students) in inventing. We make the connection between funds of knowledge and invention education (IvE) and argue that one of the most productive ways to engage Latinas and other under-represented students in inventing is to embed IvE within the school day. By including diverse groups in the invention ecosystem, U.S. society and industry can benefit from rich funds of knowledge, which can contribute to solving the complex problems diverse communities face.

Key words: Invention education; Latina inventors; Funds of knowledge

INTRODUCTION

> *"I think to be an inventor you just need to make something better. It can literally be fixing something, as small as it may be, any little adjustment. I guess just noticing the details and making it better."*- Isabel, 18-year-old inventor

Recent scholarship argues that in order for the United States to remain competitive in the global economy, more people from diverse backgrounds need to become inventors (1-3). Invention and innovation require new ideas and different ways of thinking. In order to solve the complex problems communities face in an increasingly diverse country, it is necessary to draw on the valuable skills and knowledge of individuals with varied perspectives and backgrounds (4-6). Researchers who focus on innovation provide empirical evidence for the benefits of drawing on diverse ideas throughout the invention process (7-9); however, to this day, the majority of inventors are White, middle-aged males with advanced science, technology, engineering, or mathematics (STEM) degrees (1,2). Very few women or Black, Latinx, or Native American individuals hold U.S. patents, which is one of the measures of diversity in invention and innovation (7,10,11). Most of the diversity that does exist among patent holders comes from innovators born abroad (2).

Drawing on the knowledge and skills of homogeneous groups is problematic for multiple reasons. Scholars who study diversity in the innovation ecosystem argue that diverse teams consistently

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outperform homogeneous teams (8,10,11). For example, Gratton and colleagues found that diverse teams were more likely to develop innovative products (8). Additionally, by relying primarily on the ideas and inventiveness of specific groups, namely White and Asian males, the United States is losing out on valuable cultural capital and funds of knowledge, which could contribute to groundbreaking innovations to improve peoples' everyday lives in diverse communities (6,12). Cultural capital is traditionally defined as the assets and resources that one accumulates that are deemed valuable by White middle-class society (6). However, Yosso challenges this dominant conception and posits that communities of color possess assets and valuable cultural capital, which have been long overlooked and undervalued (6).

In addition to cultural capital, the U.S. economy is also missing out on economic capital. Authors report that if the United States successfully engaged women and under-represented groups as innovators, the gross domestic product would increase between 2.6% to 3.3% (7,13,14). Those best suited for identifying and solving the most critical problems communities face are individuals from those same communities, who have an indigenous understanding of the problem and those affected (15,16). Cook explains the innovation ecosystem has three levels. The first is preparation and education, the second is invention, and the third and final step is innovation, which involves the commercialization of inventions (10). Gaps based on gender and ethnicity occur at all three levels of the innovation ecosystem (15).

While recognizing the need for the varied perspectives of all diverse students, we focus specifically on engaging Latina students in the innovation ecosystem because Latinas have been one of the key groups long overlooked in the innovation and STEM pathways. In this conceptual paper, we introduce funds of knowledge as a theoretical framework for approaching the inclusion of Latinas in inventing. We then make the connection between funds of knowledge and invention education (IvE) and argue that one of the most productive ways to engage Latinas and other under-represented students in inventing is to embed IvE within the school day. We conclude by presenting organizations that support current IvE initiatives.

Latinx in Inventing and Engineering

The Latinx community is the fastest-growing minority group in the United States (17). Considering one in four students in the U.S. school system identifies as Latinx, and by 2050, one in three Americans will identify as Latinx, drawing on the rich cultural knowledge found within Latinx communities is essential (17). While Latinx students are entering higher education at increasing rates, they continue to be under-represented in earned STEM degrees and in the STEM workforce (17). This is problematic given that gaps in patenting based on gender and ethnicity correlate with the lack of diversity in STEM disciplines, specifically engineering and technology, the two fields that generate the most patents (10,11). Latinx individuals currently constitute 17% of the U.S. population yet account for only 3% of Ph.D. degrees earned in STEM fields and 3% of the innovators in the United States (2).

Given the overlap between invention and engineering and the fact that more than 50% of patent holders have degrees in engineering, understanding Latinx participation in engineering is necessary (2). As an aggregated group, Latinx are slowly increasing their involvement in engineering. Between the years 1995 and 2014, the representation of Latinx engineers increased from 5.76% to 9.56%. At 10% of earned bachelor's degrees, Latinx are the largest minority group within U.S. engineering schools (18). However, Rincon and Lane report that male Latino students are twice as likely to receive engineering degrees as their Latina counterparts (19). Latina students are awarded only one out of every five engineering degrees received by the Latinx population (18). While there is a growing body of literature that addresses the experiences of all Latinx students in engineering, Rodriguez and colleagues call for the experiences of Latinas in engineering to be examined independently from male Latino students (20). Recognizing the unique challenges Latinas in engineering face based on the intersectionality of ethnicity and gender, an increasing number of scholars focus specifically on understanding the experiences of Latinas in engineering (21,22).

Latinas as Inventors: Intersectionality of Ethnicity and Gender

Many of the studies that disaggregate Latina and Latino students focus more broadly on Latinas in STEM, as they are the least represented group in STEM fields (23). A recent report found the majority of Latinas who do participate in STEM earned degrees in biology or biomedical science. The same report indicated that only 18% of Latinas participating in STEM fields hold degrees in engineering (24). Additionally, only 2% of working engineers in the United States are Latina (18). Latinas in engineering are under-represented as engineers, just as they are under-represented as inventors. The under-representation of Latinas in engineering has prompted scholars to study the experiences of Latinas who have persisted in engineering to better understand how to increase participation (20).

Citing the increasing Latinx population in the United States, Camacho and Lord explain that involving Latinas in engineering has the potential to solve problems within communities throughout the United States (25). The authors also explain that because engineering settings are typically dominated by White, male elites, the presence of Latinas in engineering challenges the status quo. Currently, the lack of Latinas in engineering professions leaves their knowledge and perspectives out of the field. Engaging Latinas in engineering and the invention ecosystem facilitates opportunities to draw on the funds of knowledge Latina students possess and gives institutions the opportunity to understand how and in what ways Latina students have the potential to discover and develop solutions to problems that women encounter in their daily lives (26).

While there is little scholarship that explicitly focuses on Latinas within the invention ecosystem, Camacho and Lord make the case for increasing Latina participation in engineering as a means to address the complex problems communities face (25). Camacho and Lord draw on the work of Mackenzie and Wajcman, who argue that too often technological advancement and innovation are conceptualized as a process separate from everyday social interactions (25,27). The authors note that the majority of attention and research is dedicated to examining how people adapt to technological advancement and innovation as opposed to how people shape it. This scholarship points to the need for including diverse perspectives and know-how in the innovation pathways, thus shaping technological advancements and inventions that address local and global problems of increasingly diverse and interconnected societies. Considering the assets Latinas bring to society and the increasing numbers of the Latinx population, Latinas have the potential to contribute and shape innovation through the rich assets they bring to invention and engineering.

Asset-Based Approach to Engaging Latinx in Invention

There is a growing body of literature that focuses on the experiences of Latinas in STEM; however, until recently, much of the literature approached the topic from a deficit-based perspective. Deficit-based approaches focus on what Latinas in STEM lack when compared to the standard White, male majority (6,28). Deficit framings focus on what students do not know and must learn to meet externally defined standards of knowledge, such as state tests in discrete subjects of math or science. With the focus on what students lack based on particular standardized assessments, the knowledge, perspectives, and interdisciplinary know-how of many students are overlooked.

In contrast to the focus on lack in deficit-based views of education and minority groups, asset-based approaches emphasize the value and skills diverse students bring to the learning environment. Asset-based education encourages teachers to learn about their students' life experiences and draw on such experiences to enhance the learning opportunities for all students. Asset-based education still values and prepares students for standardized tests, but the teaching and learning foregrounds students' knowledge and experiences as foundations for developing new knowledge and connecting community-based values and skills to the curriculum. Contrary to the deficit-based explanations of Latinas' under-representation in STEM, asset-based approaches position the valuable and rich cultural capital and funds of knowledge Latinas bring to inventing and STEM as the foundation for their contributions and achievement in STEM and innovation. In the following section,

we focus on one asset-based framework that could be applied to the study of Latina inventors.

Funds of Knowledge

> *"I guess it comes from my family. We're pretty quick learners and we catch on quick to something that interests us."*- Isabel

Scholars argue that drawing on the ideas of diverse groups of people has the potential to solve complex social problems because of the varied perspectives and funds of knowledge different groups can bring to problem solving (10,12,15,16). Funds of knowledge is a theoretical lens that acknowledges the assets and skills students from under-represented communities bring to their classrooms and schools (12,29). Moll and colleagues define funds of knowledge as "historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning or well-being" (12). Authors who developed the concept explain that funds of knowledge theory is based on the simple premise that communities of color have valuable and rich life experiences through which they have gained knowledge and developed competence (29). These experiences and knowledge constitute the assets members of the diverse communities bring and create as they participate in their local and global social networks.

The authors who coined the term funds of knowledge studied the households of Mexican American students living in the border region between Mexico and the United States (12). Moll and colleagues identified different funds of knowledge that students developed within their homes and communities and then used to inform their formal learning experiences (12). Examples of various forms of knowledge were ranching and farming skills, business skills, material and scientific knowledge, and knowledge of contemporary and folk medicine, among others. The authors found the households they studied had "ample, cultural, and cognitive resources with great potential for utility in classroom instruction" as opposed to lacking social organization or being intellectually "less than" the White majority, as they have been typically portrayed in deficit-based approaches (12).

Since Moll and colleagues' introduction of the funds of knowledge framework, much of the research that incorporates funds of knowledge has traditionally included working-class Latinx students as participants (26,30,31). Researchers have found that many funds of knowledge that students develop are vital to their well-being and can be critical in maintaining a family's stability and vitality (12,26). Wilson-Lopez and co-authors explain that funds of knowledge can be intergenerational and that, many times, skills can be developed and shared by parents and grandparents as well as members of the community (26). These funds of knowledge become instrumental in Latinx student participation in school, professional worlds, and innovation.

Funds of Knowledge in Science and Engineering

Funds of knowledge as a framework has been applied to the study of Latinx students in science and, more recently, engineering (26,30,32). In a recent literature review, Denton and colleagues explain that by offering connections to students' lives, funds of knowledge theory provides an opportunity to address equity issues in formal STEM settings (31). Additionally, Verdin and colleagues argue that by recognizing the funds of knowledge students possess, educators provide opportunities for students to connect the resources and knowledge developed out of school in students' families and communities to formal engineering settings (32).

Calabrese-Barton and Tan posit that valuing funds of knowledge "positions minority students as rightful experts of certain knowledge directly related and applicable to school science" (30). One study that focused on middle school students who experienced problem solving and engineering design embedded within their school day found the work gave students an opportunity to engage their "lived lives" and draw on their own cultural capital and funds of knowledge (16). The authors also argued that these opportunities provided students with a sense of belonging in their STEM classroom.

In a 2016 ethnographic study, Wilson-Lopez and coauthors explored connections between Latinx high school students' funds of knowledge and engineering practices (26). The authors illuminated Latinx students' abilities to integrate their everyday funds of knowledge, developed through cultural, familial, and recreational practices, into problem solving

and engineering activities within the classroom. Furthermore, the authors made visible the ways in which Latinx students' funds of knowledge aligned with the foundational tenets of engineering and problem solving (26). When engaged in identifying problems and the engineering design process, students demonstrated their ability to work in teams and apply scientific and mathematical knowledge while displaying ethical and empathetic reasoning. One group of students designed an improved headrest on shower chairs for individuals in need of head support. Students drew on their funds of knowledge related to health by applying what they knew from their own family experiences to their design. For example, a student who had a sibling with a degenerative muscular disease chose to take on the perspective of a user with disabilities throughout the invention process.

While funds of knowledge theory focuses on the skills and experiences of historically minoritized groups, all students bring a variety of assets and skills to innovation and inventing. The foundation of asset-based perspectives, such as funds of knowledge, is an understanding that under-represented groups, in this case Latina students, have been overlooked and that their skills and perspectives could enhance opportunities for all. There is no common set of skills Latina students bring to inventing; however, by noticing and valuing what students bring individually and collectively, educators can identify the skills and knowledge Latinas can contribute to learning opportunities that benefit all students in the classroom. For example, Wilson-Lopez and colleagues provide an example of a student who has lived in Mexico and the United States and brought a transnational experience to a high school engineering design challenge. The Latina student had worked both in Mexico City and her small U.S. town helping her father lay shingles on roofs. She drew on her experience in roofing to add weather and population density considerations to her school engineering design challenge (12). This example demonstrates how one Latina student's prior experience became a fund of knowledge in an engineering design and problem-solving setting. By displaying the connection between her out-of-school experience and engineering design, this one student illuminates how considering a student's out-of-school experiences may inform learning and innovation within school. Educators and other students could draw on examples such as this to explore the experiences, knowledge, and skills diverse students bring and how those diverse funds of knowledge may contribute to innovation and learning for all.

Scholars have also found that valuing funds of knowledge in the classroom has the potential to promote equity in engineering and invention (31,32). By intentionally drawing on the funds of knowledge students bring to the classroom, educators provide opportunities to generate multiple perspectives throughout the engineering design and invention process (16). Educators can accomplish this by learning about students' life experiences and elevating those experiences as assets in the classroom. When teachers understand the diverse skills and knowledge students bring to the classroom, they can draw on the expertise of the student, their family, and their community to make connections between funds of knowledge and the processes of engineering design and invention. Including the varied funds of knowledge of all students creates opportunities for more equitable education and the participation in invention of those who have been under-represented in the field. Equity can be enhanced when IvE is included in the school day. IvE offers equitable opportunities for all students to draw on their funds of knowledge in identifying complex problems and developing innovative technological solutions relevant for local communities and society at large.

Invention Education (IvE)

What is IvE?

IvE is an educational approach that teaches students how to identify and solve problems within their communities (15). IvE calls for early and frequent exposure to the iterative and recursive process of inventing (33,34). A fundamental principle guiding the IvE movement is that inventiveness can be developed (1,15,35). Additionally, supporters of the IvE movement believe that individuals from varied backgrounds have valuable skills and knowledge to contribute to the invention ecosystem (15,36). IvE draws on the knowledge of the community by involving various stakeholders, including mentors from the community, to assist in the invention process and

provide expertise when needed (15).

IvE is interdisciplinary, open-ended, and learner-centered. It provides students with the opportunity to learn through hands-on content knowledge application (38) from multiple subject areas or fields of study. The goal of IvE is for students to engage in the process of invention and see their own potential as problem solvers and inventors. Rather than implementing a specific method or focusing on a marketable product, IvE offers ways of thinking about the world through problem seeking and solving. In IvE settings, students not only draw on their diverse funds of knowledge but also develop new knowledge and skills as they solve problems and develop their inventions (15). Students also learn how to think like inventors by engaging in the practices of invention. Because invention education is interdisciplinary, it provides multiple entry points for students from varied backgrounds and with diverse skill sets.

Currently, there are no specific standards that guide IvE; however, content from multiple fields of study, including English language arts, science, arts, technology, engineering, and math (15) are incorporated into IvE. While IvE can be taken up individually, it is typically team-based and takes place in small groups. Open-ended learning, such as IvE, which focuses on solving problems students have identified in their everyday lives, has proven effective in engaging students who are traditionally marginalized by formal science settings (16). Examples of related initiatives that draw on the skills and knowledge of diverse groups with many of the same fundamental guiding principles of IvE can be found in the maker movement and in the work of authors who call for STEM-rich making as a means to achieve equity in innovation (16,37).

Connecting Funds of Knowledge and Invention Education

Invention education enacts diversity, equity, and inclusion by valuing and drawing on the skills and knowledge of varied members of diverse communities. It also does so by teaching children to identify problems within their own communities, which simultaneously empowers students as problem finders and solvers and as capable catalysts for change within society (15). The funds of knowledge framework complements the fundamental principles of IvE because both recognize the valuable skills and assets that diverse individuals from under-represented groups possess and can bring to learning and problem-solving situations (12,34). IvE provides opportunities for students to share the funds of knowledge and problem-solving skills they have developed in their own homes and communities (33). Both IvE and funds of knowledge elevate groups who have been minoritized or overlooked and demonstrate the value and potentials of different kinds of knowledge stemming from individuals and groups of varied backgrounds. As members of diverse communities, Latina students have access to funds of knowledge that may be critical to identifying and solving problems that Latinx communities throughout the United States face (25,26).

How Integrating IvE in School Can Reach Diverse Students

Scholars examining who becomes an inventor in the United States provide evidence that exposure to innovation and practices that contribute to inventiveness during childhood increases the likelihood that an individual will become an inventor (1,35). Given the under-representation of women and minority groups as inventors, scholars argue more attention and effort must be placed on increasing invention initiatives and education at the K-12 level (34). In the following section, we discuss why embedding IvE within the school day could be effective in democratizing access to IvE and increasing the number of inventors from varied backgrounds (15).

The United States is becoming increasingly diverse, and students around the nation bring rich funds of knowledge to their classrooms. Schools are institutions with the potential to affect a large number of individuals from varied backgrounds across many age ranges. IvE could be embedded within the school day starting in the early elementary years because scholarship indicates that a student's inventiveness can begin to develop at any age and that consistent exposure from an early age results in lasting impacts (30,33,34,38). Studies that have explored early exposure to invention activities support Bell and colleagues' findings that inventiveness can be developed (1). For example, in a recent study,

Root-Bernstein and colleagues examined the early lives of successful STEM professionals and found that art, design, and craft activities played a fundamental role in contributing to their inventiveness (35). These findings suggest that the ability to invent is not inherent but rather developed through repeated engagement in the iterative and recursive process of inventing.

Perry and Estabrooks argue that invention is a process that must be practiced and developed. If students practice developing their abilities to find and solve problems at a young age, they will be better equipped to take on complex issues that require innovation within their communities (39). As multiple scholars reason, if students are exposed to IvE in the elementary grades, they have more opportunities to develop the skills necessary for problem solving and inventing while simultaneously bringing their funds of knowledge to academic settings (6,15).

Implementing IvE in the school day calls for teachers and administrators to explore how IvE processes may align with their districts' standards and how the existing curricula may be adjusted to become more relevant and equitable to the diverse students within their schools. Given that IvE is an emerging field, to date there are limited examples of how IvE has been successfully implemented into the school day. One example is captured by Zhang and colleagues in their 2019 case study of a middle school classroom that incorporated IvE into the STEM curriculum of a 7th grade science class (38). The teacher modified an out-of-school IvE curriculum known as the Junior Varsity (JV) InvenTeams™ to meet the needs of the class. Drawing on the curriculum designed by the Lemelson-MIT (LMIT) Program, the students were tasked with converting shoe boxes into lunch boxes that would keep cold food cold and warm food warm. The challenge required an understanding of heat transfer, radiation, convection, conduction, thermal energy, and insulation. When asked about the experience by the research team, the teacher who adapted and implemented an IvE curriculum in his classroom cited high levels of student engagement and the multiple ways of presenting information to the students as positives from the experience. The teacher also expressed that the students benefited from the hands-on learning experiences. Challenges included the management of the different skills each student brought to the project (38). Nevertheless, this example demonstrates how IvE implemented in a classroom creates opportunities for all students to develop new knowledge together while sharing the varied funds of knowledge and problem-solving skills brought from their own homes and communities. Offering invention opportunities throughout the school day provides students with an opportunity to share their ways of knowing and rich funds of knowledge with their peers and teachers. The benefit is multidirectional. Society benefits by gaining access to the funds of knowledge developed by diverse communities while the students benefit by participating in the invention pathways. The vast disparity among patent holders in the United States and the empirical research that calls for early and frequent invention education exposure support the argument for embedding invention education within the school day (15). Implementing IvE would require changes in the current K-12 school system, which, in turn, would require policy shifts and interdisciplinary collaboration across siloed subjects in school (15,34).

Recent Programs, Projects, and Initiatives in Invention Education

Building on the literature that presents evidence that inventiveness can be developed through early and repeated exposure, there has been an increase in K-12 innovation programs (1,15). In addition to the federal National Science Foundation (NSF) grants that address engineering or STEM more broadly, there is a growing movement in the United States that focuses on providing students with IvE experiences. For example, prolific inventor Jerome Lemelson founded the Lemelson Foundation, which funds invention-focused programs throughout the United States, including the LMIT Program and the Smithsonian (3).

The Lemelson Foundation also supports the InventEd™ community, which spearheads the IvE initiatives both nationally and internationally. InventEd™ is a community of supporters of IvE launched by The Lemelson Foundation. Through partnerships with organizations such as PBS Newshour, Henry Ford, and the United States Patent and Trademark Office, InventEd™ members believe that solving the

complex problems communities face will require diverse perspectives from individuals with varied life experiences. InventEd™ explains that IvE has the potential to bridge the increasing gap between the U.S. educational system and the needs of the workforce (40).

One of the programs funded by the Lemelson Foundation is the LMIT invention education program. The LMIT Program provides curriculum, professional development, and grants to increase access to IvE for students throughout the United States. One of their most notable programs is their InvenTeam™ grants initiative, which each year provides funding and support for up to15 high school invention teams nationwide (41). Over the past two decades, LMIT has also provided JV InvenTeam™ grants for middle school students and invention prizes for collegiate and mid-career inventors (41).

LMIT is also responsible for producing a growing body of literature that examines who participates and supports IvE and in what ways (15). Studies supported by LMIT have been primarily conducted with high school students who participate on InvenTeams™ although there is a growing body of research conducted at the middle school level (16,36,38). Research conducted by LMIT and affiliated scholars has called for embedding IvE into the school day (38). Studies involving high school InvenTeams™ found that when female students received support in IvE, even with little background in STEM, they were more likely to consider choosing a STEM career path (36).

Addressing the gender disparity among patent holders, IvE scholars have also explored the supports and constraints young women participating in the year-long invention projects experienced and how those experiences shaped the students' affiliation with an inventor identity (36). Young female inventors cited personal values, various relationships/resources, and the structure of the invention project as supports. The girls shared that their constraints included time, lack of prior experience with invention activities, and stereotypes. Based on their findings, Couch and colleagues called for policy initiatives that specifically address the need to engage more females and people from diverse backgrounds in the invention ecosystem (34,36).

Additional Supporters of Invention Education

Another national organization that supports IvE efforts is the STEM Innovator™ program at the University of Iowa. The STEM Innovator program assists educators in creating IvE activities and provides access to curriculum resources (15,43). The program also provides a portfolio assessment tool to assess students' (as well as educators') changes in knowledge, mindset, and skills over time (43). A research team from the University of Iowa recently conducted a longitudinal study with high school students who experienced IvE embedded in their school day through the STEM Innovator™ program. Flynn and colleagues found that IvE mindsets of non-dominant groups in STEM increased significantly throughout their participation in the program, providing further evidence that IvE should be embedded in the school day (15,43).

Georgia Tech is also actively involved in the invention education movement. The university hosts an annual Invention Convention, which awards a K-12 InVenture™ Prize (15,44). Studies that have examined teachers' perceptions of students' learning and growth through participation in the K-12 InVenture™ program indicate that teachers find IvE to be positive for their students. Teachers in the study also indicated that students improved their abilities to work in teams and learned about entrepreneurship and its connection to engineering design (44).

The Henry Ford organization is another example of an entity that has invested in the IvE movement by providing programs for students in grades K-12 around the world. They facilitate the STEMIE Coalition, which teaches students problem-solving skills by linking IvE with entrepreneurship (45). The two main functions of STEMIE are providing a free curriculum and hosting an annual National Invention Convention. The Henry Ford also recognizes teachers who encourage students to take risks and learn from failure through their Teacher Innovator Award (45). IvE programs provide opportunities to expose students to the recursive process of inventing while drawing on the rich funds of knowledge and skills of students under-represented in inventing and STEM. IvE programs have the potential to increase the participation of under-represented groups in the innovation ecosystem. IvE also facilitates the

engagement of young Latina students, such as Isabel who is quoted above, and provides the opportunity for students from diverse backgrounds to draw on the assets they bring to invention from their homes and communities.

CONCLUSION

There are numerous, multi-directional benefits to increasing the number of diverse inventors in the United States (1,3,7). Individual inventors benefit by gaining access to economic capital, communities benefit from the innovation and improvements to daily life, and the United States benefits by continuing to be economically competitive in the global market (1,7). Considering the increasing numbers of the Latinx population and the valuable funds of knowledge Latinx students bring to society, it is important to engage Latina students in the invention ecosystem. By including diverse groups in the invention ecosystem, U.S. society and industry can gain access to the rich funds of knowledge that may solve the complex social, environmental, economic, technological, and other problems of the 21st century. IvE provides opportunities to engage students from under-represented groups by acknowledging their potential to solve the diverse problems communities face throughout the world. Embedding IvE in the school day would provide equitable opportunities for more, and more diverse, students to contribute to shaping the innovation processes and technological advancements in and for the rapidly changing U.S. and global societies.

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REFERENCES

1. Bell A, Chetty R, Jaravel X, Petkova N, Van Reenen J (2019). Who becomes an inventor in America? The importance of exposure to innovation. Q J Econ. 2019;134(2):647–713.
2. Nager A, Hart D, Ezell S, Atkinson RD. The demographics of innovation in the United States. Washington (DC): Information Technology and Innovation Foundation; 2016.
3. Wisnioski M, Hintz ES, Kleine MS. Does America need more innovators? Cambridge (MA): The MIT Press; 2019.
4. Ashcraft C, Breitzman A. Who invents IT? Women's participation in information technology patenting, 2012 Update. Faculty Scholarship for the College of Science & Mathematics. 2012 [accessed 2021 Aug 7]. https://rdw.rowan.edu/csm_facpub/6.
5. Samuelson CC, Litzler E. Community cultural wealth: an assets-based approach to persistence of engineering students of color. J Eng Educ. 2016;105(1):93–117.
6. Yosso TJ. Whose culture has capital? A critical race theory discussion of community cultural wealth. Race Ethn Educ. 2005;8(1):69–91.
7. Couch S, Estabrooks L. Policy initiatives needed to foster female inventors' contributions to U.S. economic growth. Cambridge (MA): Lemelson-MIT Program. 2020 [accessed 2021 Aug 7]. https://lemelson.mit.edu/sites/default/files/2020-08/LMIT-FemaleInventorsResearch-WhitePaper-07.20.pdf.
8. Gratton L, Kelan, E, Voigt, A, Walker, L, Wolfram, HJ. Innovative potential: women and men in teams. Lehman Brothers Centre for Women in Business. London (UK): Working Paper Series; 2007.
9. Herring C. Does diversity pay? Race, gender, and the business case for diversity. Am. Sociol. Rev. 2009;7124(2): 208–224.
10. Cook LD. The innovation gap in pink and black. In: Wisnioski M, Hintz ES, Kleine MS, editors. Does America need more innovators? Cambridge (MA): The MIT Press; 2019. p. 221-247.
11. Sanders LM, Ashcraft C. Confronting the absence of women in technology innovation. In:

Wisnioski M, Hintz ES, Kleine MS, editors. Does America need more innovators? Cambridge (MA): The MIT Press; 2019. p. 323-344.
12. Moll LC, Amanti C, Neff D, Gonzalez N. Funds of knowledge for teaching: using a qualitative approach to connect homes and classrooms. Theory Pract. 1992;31(2):132–141.
13. Fechner H, Shapanka M. Closing diversity gaps in innovation: gender, race, and income disparities in patenting and commercialization of inventions. Technol Innov. 2018;(19)4:727-734.
14. Hunt J, Garant JP, Herman H, Munroe DJ. Why are women underrepresented amongst patentees? Res Policy. 2013;42(4):831–843.
15. Invention Education Research Community. Researching invention education. Cambridge (MA): The Lemelson Foundation; 2019 [accessed 2021 Aug 7]. https://lemelson.mit.edu/node/2511.
16. Calabrese Barton A, Tan E. A longitudinal study of equity-oriented STEM-rich making among youth from historically marginalized communities. Am Educ Res J. 2018;55(4):761–800.
17. Latinos in higher education: compilation of fast facts. Washington (DC): Excelencia in Education; c2019 [accessed 2021 August 12]. https://www.edexcelencia.org/research/publications/latinos-higher-education-compilation-fast-facts.
18. Science and engineering indicators. Arlington (VA): National Science Foundation; c2020 [accessed 2021 Aug 7]. www.nsf.gov/statistics/indicators/.
19. Rincon BE, Lane TB. Latin@s in science, technology, engineering, and mathematics (STEM) at the intersections. Equity Excell Educ. 2017;50(2):182-195
20. Rodriguez SL, Doran EE, Sissel M, Estes N. Becoming la ingeniera: examining the engineering identity development of undergraduate Latina students. J Lat Educ. 2019:1–20.
21. Banda RM. From the inside looking out: Latinas intersectionality and their engineering departments. Int J Qual Stud Educ. 2020;33(8):824-839.
22. Rodriguez SL, Blaney JM. "We're the unicorns in STEM": understanding how academic and social experiences influence sense of belonging for Latina undergraduate students. J Divers High Educ. 2021;14(3):441–455.
23. Pietri ES, Drawbaugh, ML, Lewis AN, Johnson IR. Who encourages Latina women to feel a sense of identity-safety in STEM environments? J Exp Soc Psychol. 2019;84.
24. Bachelor's degrees conferred by postsecondary institutions, by race/ethnicity and sex of student: selected years, 1976–77 through 2015–16. Washington (DC): National Center for Education Statistics; c2017 [accessed 2021 Jul 17]. https://nces.ed.gov/programs/digest/d17/tables/dt17_322.20.asp
25. Camacho MM, Lord SM. The borderlands of education: Latinas in engineering. Lanham, (MD): Lexington Books; 2013.
26. Wilson-Lopez A, Mejia JA, Hasbún IM, Kasun, GS. Latina/o adolescents' funds of knowledge related to engineering. J Eng Educ. 2016;105(2), 278–311.
27. MacKenzie D, Wajcman J. The social shaping of technology. London (UK): Open University Press; 1999 [2021 Aug 7]. http://eprints.lse.ac.uk/28638/.
28. Gonzalez E, Fernandez F, Wilson M, editors. An asset-based approach to advancing Latina students in STEM: increasing resilience, participation and success. Oxfordshire (UK): Routledge; 2021.
29. González N, Moll LC. Cruzando el puente: building bridges to funds of knowledge. Educ Policy. 2001;16(4):623–641.
30. Calabrese Barton A, Tan E. Funds of knowledge and discourses and hybrid space. J Res Sci Teach. 2009;46(1):50-73.
31. Denton M, Borrego M. Funds of knowledge in STEM education: a scoping review. Stud Eng Educ. 2021;1(2):557-580.
32. Verdin D, Godwin A, Capobianco B. Systematic review of the funds of knowledge framework in STEM education. Proceedings of the Annual Conference and Exposition of American Society of Engineering Education; 2016 Jun 26-29; New Orleans, LA. Washington (DC): American Society For Engineering Education; 2016.
33. Committee for Study of Invention. Invention: enhancing inventiveness for quality of life, competitiveness, and sustainability. Cambridge

(MA): Lemelson-MIT Program; 2004 [accessed 2020 Jul 18]. http://lemelson.mit.edu/search-resources/817.
34. Couch S, Skukauskaite A, Green JL. Invention education: preparing the next generation of innovators. Technol Innov. 2019;20(3):161–163.
35. Root-Bernstein R, Peruski A, VanDyke M, Root-Bernstein M, LaMore R, Schweitzer J, Roraback E. Differences in male and female arts and crafts avocations in the early training and patenting activity of STEMM professionals. Technol Innov. 2019;20(3):197–219.
36. Couch S, Estabrooks, LB, Skukauskaite, A. Addressing the gender gap among patent holders through invention education policies. Technol Innov. 2018;19(4):735–749.
37. Maaia LC. Inventing with maker education in high school classrooms. Technol Innov. 2019; 20(3):267–283.
38. Zhang H, Estabrooks L, Perry A. Bringing invention education into middle school science classrooms: a case study. Technol Innov. 2019;(20):235-250.
39. Perry A, Estabrooks LB. Let's invent!: using invention activities to integrate engineering design in the science classroom. Sci Teach. 2019;86(6):37–43.
40. Invention Education. Portland (OR): InventEd; c2021 [accessed 2021 Sep 9]. https://invention-education.org/.
41. Lemelson-MIT Program. Overview. Cambridge (MA): Lemelson-MIT; c2021 [accessed 2021 Aug 7]. https://lemelson.mit.edu/overview.
42. Couch S, Skukauskaite A, Estabrooks LB. Invention education and the developing nature of high school students' construction of an "inventor" identity. Technol Innov. 2019;20(3): 285–302.
43. Flynn L, Crady R, Trane G. Capturing problem-based learning critical competencies over time through portfolio assessment. Proceedings of the American Education Research Association Annual Meeting; 2021 Apr 8-12; virtual. Washington (DC): American Educational Research Association; 2021.
44. Moore RA, Newton SH, Alemdar M. K–12 InVenture prize: teacher reflections on educating K–12 inventors. Technol Innov. 2019;20(3):221–233.
45. The Henry Ford. Dearborn (MI): The Henry Ford; c2021 [accessed 2021 Sep 12]. https://www.thehenryford.org/.