Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #46824

Investigating Perceptions of Inventiveness and Entrepreneurial Mindsets in Late Elementary School Students

Jasmine N Patel, Georgia Institute of Technology

Jasmine Patel is a Research Associate at Georgia Institute of Technology's Center for Education Integrating Science, Mathematics, and Computing (CEISMC). She specializes in invention education and informal STEM learning within K-12 settings. Her work involves research into the implementation and effects of educational interventions. In her role, Jasmine collaborates with a diverse group of K-12 students, educators, and administrators to develop and execute research and evaluation strategies focused on invention and science education.

Alaina Lee Rutledge

National STEAM, Innovation and Creativity specialist. Led the development and research of OST programming for the world's premier Invention Education program. Focused on current educational trends and deeply understands the STEAM market. Led the development of STEAM programming that engaged thousands of educators and millions of children in large-scale national dynamic, high-quality, transformative learning experiences.

Current research focus areas: Invention Education, Equity, Identity, OST, SEL

Jayme M. Cellitioci

Jayme Cellitioci is the Director of Creativity and Innovation at the National Inventors Hall of Fame (NIHF). She leads vision and strategy for the development of educational programming that is centered around insights from the NIHF Inductees. Jayme curates content for NIHF museum located at the United States Patent and Trademark Office; events and ceremonies; and other outreach initiatives. She also oversees research partnerships and the application of findings to curricula. Jayme holds a bachelor's degree in psychology/biology, a master's in creativity and change leadership, and a professional certificate in free-choice learning.

Ashley Giordano

Ashley has an M.A. in History and a Museum Studies Certificate from the University of Delaware. Her career at the National Inventors Hall of Fame began as a curriculum writer, but quickly evolved to reflect her passion for supporting the tactical details of large-scale programs and product development and dissemination. Ashley is currently engaged in research on behalf of NIHF as a member of the Strategic Data Project Fellowship, a program of the Center for Education Policy Research at Harvard University.

Roxanne A. Moore Ph.D., Georgia Institute of Technology

Dr. Roxanne Moore is currently a Principal Research Engineer at Georgia Tech with appointments in the Center for Education Integrating Mathematics, Science, and Computing (CEISMC) and Mechanical Engineering. She has spent her 12+ year research faculty career focusing on broadening participation in STEM and creating novel learning experiences for students all over the world. Dr. Moore focuses on empowering students with a STEM toolbox so they can design their own future. She has served in leadership roles on over $17M in grants from sponsors including the National Science Foundation, National Institutes of Health, Economic Development Agency, the Lemelson Foundation, Amazon, and Google and has co-authored over 70 peer-reviewed publications.

Investigating Perceptions of Inventiveness and Entrepreneurial Mindsets in Late Elementary School Students

Abstract

Invention education promotes the development of critical thinking, creativity, and communication skills essential for success in science, technology, engineering, and math (STEM) fields. Cultivating an entrepreneurial mindset encourages students to explore ideas, iterate solutions, take risks, and embrace experimentation. Research shows that students who actively engage in hands-on invention activities are more likely to develop skills such as collaboration, resourcefulness, and resilience. These skills empower them to tackle complex problems with confidence and fosters a deeper connection to STEM learning. Prior studies have explored how attitudes toward STEM influence persistence, but more research is needed to examine how inventiveness and students' perceptions of using science and math in creative contexts drive deeper engagement and innovative thinking.

Quantitative data has been analyzed and published in an earlier paper. Here, we will discuss the findings from the qualitative data collected and analyzed. Focus groups were conducted to investigate students' perspectives regarding camp activities and content included in the program. Participants included lower and upper elementary students from 3rd to 6th grade, with a total of six focus groups held in Georgia and Ohio.

This paper will address two key research questions:

1. How do participants define inventiveness and entrepreneurial thinking, and how do they apply these concepts both within Camp Invention and in real-world settings?
2. How do participants' favorite activities at Camp Invention foster inventiveness and entrepreneurial thinking, particularly through the integration of science and math?

Qualitative data from the focus groups were analyzed using thematic analysis to identify themes related to participants' perceptions of inventiveness and their favorite activities during Camp Invention focusing on their engagement with science and math. The analysis revealed that collaboration, creativity, and hands-on STEM activities helped students develop critical thinking, resilience, and an entrepreneurial mindset, while also deepening their understanding of scientific principles and financial literacy. By understanding how students define and experience inventiveness and entrepreneurial thinking through engaging activities, educators can provide students with the skills they need to thrive in STEM fields and pursue future entrepreneurial opportunities.

Introduction

Being inventive is a quintessentially human trait that is universal and vital for societal progress. Humans are wired to solve problems and create new technology, and with each new advancement comes new challenges and opportunities for further invention and innovation [1]. With the complexity of today's problems due to an expanding global economy, rapid technological advancement, limited natural resources, healthcare challenges, and racial and ethnic divides, employing the same thinking and methods as in the past will not be sufficient. Increasing diversity in the STEM workforce has historically been a national priority [2]; however, there is less discourse around creating a more inventive workforce and how to teach inventive skills and mindsets [3]. Inventiveness transcends pure STEM or engineering, and it is not just strictly about patenting inventions, either. Inventiveness is what enables us to look at something in a different way, to apply analogies from other disciplines to new problems, sometimes it is simply about finding a quick solution to a challenge, with or without formal STEM or engineering content knowledge. Focusing purely on the analytical aspects of STEM without highlighting the inventive aspects, combined with a lack of inclusive culture, has contributed to slow progress with respect to diversity in STEM education and workforce [4].

Inventive habits and mindsets can be taught, practiced, and nurtured when prioritized. However, most traditional STEM courses, even engineering design-focused lessons, leave little room for invention and inventiveness due to: ready-made projects, pre-established objectives, turn-key/cookie cutter experiments, lack of clear applications, and a heavy focus on solving well-constrained problems. More specifically, most STEM and engineering curriculum, including higher education engineering degree programming, relies on problems with known solutions and clearly-defined solution pathways [5]. Invention education pedagogy empowers children to ideate, create, and solve challenges, including at times, defining their own challenges. It guides students through the practices of innovation. It builds the mindset and skills that support children in the complexities of designing tangible solutions, from concept ideation to product development and business practice.

Invention education programs, including invention-focused curricula, competitions, and summer programs, engage children in hands-on, experiential learning. This methodology bridges the gap between theory and practice. These experiences support young innovators in developing creative and practical solutions to real-world challenges, preparing children for the challenges of tomorrow and inspiring them to contribute their ideas to the world [6]. Understanding how children conceptualize inventiveness and entrepreneurial thinking is critical, as these early constructs shape and define how they may engage with innovation, entrepreneurship, and STEM.

Invention education nurtures creativity and innovation by emphasizing inventiveness, entrepreneurial thinking, and problem-solving techniques [3]. Rather than assuming that inventiveness is innate, we support its development through pedagogy grounded in the invention process, which includes empathy, identifying problems, ideating solutions, designing prototypes, testing models, and effectively communicating ideas to an audience [6]. This approach encourages children to think critically and independently and empowers them to identify and solve problems that are relevant and meaningful to their backgrounds and experiences.

Invention education practices foster teamwork, confidence, and resourcefulness, creating a meaningful connection to STEM learning [7], [8], [9]. Prior studies have shown that invention education promotes collaboration, creativity, and adaptability - key attributes for thriving in STEM disciplines [7], [9], [10]. Both STEM and invention education emphasize the importance of incorporating children's perspectives into the learning process. However, despite the growing research in the fields of STEM and invention education, there is limited understanding of how children define inventiveness and entrepreneurial thinking.

Evaluation studies have demonstrated notable improvements in children's creativity, problem-solving abilities, and interest in STEM shortly after participating in Camp Invention, a long-running summer program focused on inventing for grades K-6 [11], [12], [13]. Further evidence from a 2018 study by the Institute for Learning Innovation (ILI) highlighted long-term impacts, with effects persisting up to four years after the program [14]. Repeated STEM challenges help develop children's problem-solving skills while enhancing their capacity for innovative thinking and entrepreneurial problem-solving.

Many schools and educators are seeking to equip and empower the next generation of problem-solvers to be the protagonists of their own learning and ignite the practice of innovation. This research aims to provide insights for educators seeking to inspire students to ideate, innovate, and take their ideas to market through entrepreneurial practice.

Background

Camp Invention is the flagship program of the National Inventors Hall of Fame. For 35 years, the National Inventors Hall of Fame has promoted invention, entrepreneurship, intellectual property (IP) literacy, and STEM interest while building 21st-century skills such as creativity and problem-solving through in-school, out-of-school, and summertime educational experiences. Camp Invention has served over 3.7 million children, educators, and college students to date.

The camp is tailored for rising K-6 students, providing them with an engaging and educational summer experience centered on innovation and problem-solving. Camp Invention collaborates with educators, schools, districts, and community organizations to expand the program's reach to different communities nationwide, ensuring all children have access to the tools of innovation, entrepreneurship, and intellectual property. Camp Invention is offered through a mix of parent-paid, full scholarship, and partial scholarship models. Consequently, the program has gained widespread recognition as a leading summer enrichment experience focused on STEM. In 2023, a total of 361,000 children, including 258,000 underserved children, and 2,500 school and district partners were served in all 50 states. The program continually designs new curricula and activities to align with current educational trends and advancements in innovation, STEM, and best practices.

During 2023, children experienced all new programming. The "Wonder" program, featuring four engaging modules designed to inspire creativity and innovation among children, included the following modules:

Catching Air™: Participants designed and built their own mini skate parks, complete with ramps, halfpipes, and rails. They personalized mini skateboards and practiced tricks, exploring principles of physics, engineering, and art.

Invention Celebration™: Campers took on the role of event planners to organize a celebration of creativity and innovation. They invented a Party Assistant, engineered light-up party hats, explored color psychology through bubble art banners, and experimented with sound by creating their own musical instruments.

MimicBot™: Participants investigated the inner workings of a robot that mimics sounds and transformed it into a unique animatronic stuffie. They explored concepts from the natural world and learned about intellectual property to protect their creations from idea theft.

Pop-Up Venture™: Campers became innovative entrepreneurs by designing their own mini pop-up businesses. They developed business plans, managed startup funds, created marketing strategies, and launched their businesses during a culminating pop-up event, gaining valuable entrepreneurial experience.

By delivering authentic invention education, National Inventors Hall of Fame programs aim to build the I Can Invent® Mindset - essential skills and traits that will empower children to invent. With these activities in mind, an evaluation of Camp Invention was developed to explore student outcomes related to their engagement with science, math, and inventiveness, highlighting the role of engaging activities in developing entrepreneurial and invention-related exposure.

Methods

Research Design

A mixed-methods approach was used for this study, combining quantitative data from paper surveys with qualitative data collected through focus groups and interviews. The quantitative findings have been published previously, and this paper focuses on the insights drawn from the qualitative data.

The research was guided by the following questions:

1. How do participants define inventiveness and entrepreneurial thinking, and how do they apply these concepts both within Camp Invention and in real-world settings?
2. How do participants' favorite activities at Camp Invention foster inventiveness and entrepreneurial thinking, particularly through the integration of science and math?

The research study received approval from the Institutional Review Board (IRB). To support data collection, all research personnel, including camp facilitators, completed certification through the Collaborative Institutional Training Initiative (CITI).

Participants

The study took place at 20 locations across Georgia and Ohio, with six sites - three in each state - selected for focus group sessions which occurred toward the end of the summer camp. The participants included 3rd – 6th grade students, representing lower and upper elementary school aged groups who attended the week-long invention education camp, Camp Invention, during the summer of 2023. Parents and guardians of enrolled students received an email containing information about the study and a link to the informed consent form.

The demographic data provided reflects the entire research study, which included a total of 940 children. Among those, 875 completed the matched post-survey. Of the matched sample, 51.3% were male, 46.5% were female, and 2.2% chose other or preferred not to say. In terms of race, 63.7% of participants identified as White, 6.1% as Black or African American, and 8.3% were considered underrepresented based on race or ethnicity. These numbers include the focus group participants as part of the overall sample.

Data Sources

Focus Group Discussion Protocols
All sessions were conducted in person by a member of the research team in a quiet area of the school, with each lasting approximately 30 minutes. Interviews were recorded with the students' consent and transcribed for analysis. All interviewers followed the same guided protocol, incorporating follow-up questions designed to gather more in-depth responses.

The focus group participants were asked questions such as their favorite activities during the camp and whether they used science or math in those activities, inquiring to see if they made connections between the interactive experiences and the application of STEM. They were also asked to define what it means to be inventive, share examples of when they demonstrated inventiveness both during and outside of camp, describe the process of inventing, explain what being an inventor means to them, and discuss their career goals for the future.

Data Analysis

Qualitative data from the focus groups were analyzed through thematic analysis to identify key themes. This process involved initially coding student interviews, followed by grouping similar codes to form broader themes for each set of combined codes.

Results and Discussion

Analysis of the qualitative data revealed how creativity, problem-solving, and engagement contribute to students' understanding and application of inventiveness and entrepreneurial thinking. This section outlines the themes identified from the data, providing a deeper exploration of each theme, along with student quotes that illustrate their perspectives.

Collaboration, Teamwork, Empathy

Many of the participants expressed how sharing their ideas and collective efforts can lead to innovative solutions. One student described the process as "sharing your ideas and having your

ideas combined with other people to make it," highlighting how collaboration can enhance individual contributions and lead to innovative outcomes. This collaborative approach not only sparks new ideas but allows the development of solutions that can "make life easier" and help improve the world. Many students highlighted the importance of empathy in invention, with one stating, "being an inventor, some inventors find ways to make the world a better place," while another reflected, "I think it also means to help the world in a way that some people think impossible." The students' perspectives reflect a sense of responsibility and a desire to solve problems that may appear difficult, from health issues to improving quality of life. Empathy is also evident in the students' desire to help others, with one noting that "it just makes me feel good to help people," and another saying, "I'm just gonna help the world." These reflections suggest that inventing is not just about technical skills, but also about the emotional satisfaction of contributing to the greater good. Additionally, one student described inventing as a chance to "create new things with your own ideas" and bring "new stuff to the new world," demonstrating how eager the students are to shape the future with their creativity and compassion. Ultimately, these perspectives reveal that collaboration, teamwork, and empathy not only enhance the inventive process but also motivate the development of solutions that can have lasting, positive impacts.

Additional quotes:

> "Maybe I can invent something to help people from sicknesses and disease."

> "It means to collaborate with other people and have different ideas."

Creativity, Personal Expression, and Excitement

Several of the camp activities were a blend of creativity, personalization, and excitement allowing the students to bring their imagination to life. One activity that the students provided a lot of feedback on was the MimicBot™, a module where students explore nature, genetics, and adaptive innovation. With the freedom to design and customize their bots however they liked, students created everything from furry characters and polar bears to canaries and monsters, with many students saying, "you can customize it in your way and make it yours." This open-ended design process gave students the space to express themselves and transform their ideas into something tangible. One student noted how "it gave you a time just to put your personality out and let you do whatever you want with it." For the students, the activity wasn't just about the final product but also about the process, where they could use their imagination and explore how the bots worked internally. One student shared that they enjoyed the "thrill of like, to see how it works and just using it."

The sense of accomplishment gained from completing various camp activities served as a strong motivator leaving students feeling proud of what they had achieved. One student remarked, "When you accomplish something, you feel good about yourself," capturing the self-confidence that developed throughout the creative process. The excitement of watching their creations take shape was clear, with another student mentioning, "I get that feeling of success and happiness" after seeing their hard work come together. These activities provided students with the

opportunity to express their creativity and celebrate their hard work, allowing them to see their ideas come to life and test their creations.

Additional quotes:

> "I liked the MimicBot™ because you can create whatever you want and you can be creative and it inspires you and you can use your imagination."
>
> "I really liked that (MimicBot™) because when we did it, I thought it was really cool unscrewing it to see what was inside of it. I got to see how it actually worked."
>
> "The Reveal."
>
> "I think inventing is cool because, it is very like, you have to work hard on it and if you like give up, it's never gonna work. The ending is the best part."
>
> "Seeing how it works and how far your imagination continues."
>
> "Cause you get to see how it looks like, how it works. Like after all that hard work, you finally see what it looks like, test it out, and you can just be amazed. You can be proud of yourself. That is the best part."

Engagement with STEM Concepts and Innovation

At Camp Invention, students participated in a variety of hands-on activities that integrated STEM concepts, helping them connect their experiences to science and math. Through projects like those featured in Catching Air™, students explored miniature, finger-sized skateboards known as fingerboards, and designed a skatepark from them. They explored the application of fundamental scientific principles such as force, motion, friction, and gravity to design functional products. As one student explained, "In skateboarding, we used force, motion, and gravity," highlighting how physics can be applied to design decisions and product development. In their work on fingerboards, students combined creativity with careful measurement and accuracy to ensure their designs were functional and effective. As one student explained, "I measured everything to create the fingerboards. The size, the length, the width to make sure everything would fit in its right place."

Beyond the physical applications of STEM, the camp also encouraged entrepreneurial thinking, allowing students to explore the intersection of innovation and business. In Pop-Up Venture™, students explored how to manage finances, budget, and make strategic decisions, with one student pointing out, "The pop-up shops teach you about how to spend money and what you need and really what you don't need." This hands-on introduction to economics showed them that innovation is not just about creating something new, but also about understanding the market and managing resources effectively. The camp also helped students recognize the value of intellectual property and the importance of protecting their ideas. As one student stated, "We're gonna patent them. I've already patented it so they can't try to steal it," showing an understanding of how patents protect innovative ideas.

Through their study of sound waves and light during the Invention Celebration™ activity, students explored how science and creativity come together. One student reflected, “We learned about how lights work, LED lights, and we learned about the negative and the positive,” referring to the flow of electrical current in the light. These activities helped students understand the practical applications of ideas, how they drive innovation, and how they relate to science and math principles.

Additional quotes:

> “You start off with a thousand dollars but then eventually you have to pay off the loan.”
>
> “Some things are free, and some things cost money.”
>
> “You had to spend different money, and you had to budget and manage.”

Perceptions and Engagement with Inventiveness

The students' perceptions of inventiveness highlight creativity, independence, and imagination. Many expressed the idea that inventiveness involves creating something original and unique, often starting from an individual idea. One student shared that inventiveness involves “being original,” where individuals start with their own ideas and work independently, even without outside help. This viewpoint was reflected in other statements that described inventiveness as “creating something new” and “doing what you design and want to build.” Some students compared the process to art, describing it as a form of personal creation on a larger scale, with one saying, “Kinda like art but bigger.”

The role of imagination and creativity is central to how students engage with inventiveness. Phrases like “use your imagination” and “think outside the box” are commonly used in their description, emphasizing that inventiveness is seen as a process of expanding the mind and seeing beyond traditional boundaries. For many students, being inventive involves imagining possibilities and bringing them to life through design and construction. As one student explained, “We don’t have to copy something, we just think it, we sketch it, we model it, then we make it.” This demonstrates their confidence in their ability to develop original solutions, turning abstract ideas into real-world solutions.

In addition to creativity and independence, students also identified the importance of the practical impact of their inventions. For several, inventiveness was closely connected to the idea of creating something that can contribute to the future. Statements like “creating something new that can change the future” and “you can bring your ideas to life” reflect an awareness that their inventions have the potential to shape the world around them. Moreover, the idea of success was closely linked to the tangible result of their creations. One student described the “feeling of success when you make something that’s successful and actually serves a purpose,” suggesting that inventiveness is not just about the act of creating but also about making sure the final product has a meaningful and functional impact.

These quotes imply that students perceive inventiveness as a journey, where they have the freedom to explore, sketch, and build to bring their ideas to life. This also reflects ownership, with students fully responsible for their designs and outcomes or solutions.

Additional quotes:

> "Inventive is like, you have to think outside a box and use what you already have and use the supplies you already have. And you can find in boxes, anything that you don't use and then combine something that's large."
>
> "You have to have hope."

Problem-solving, Iterative Learning, and Hands-on Learning

The program provided students with an opportunity to explore innovation and entrepreneurship through hands-on learning activities. They recognized that invention is not about instant success but a deliberate process of overcoming challenges. As one student observed, "being inventive doesn't mean that you make the thing in one day." This highlights the importance of determination and breaking problems one step at a time. Problem-solving in this context allows students to develop critical thinking and apply their knowledge of science, math, and creativity to real-world challenges.

During the camp, failure was not seen as a setback, but as a crucial part of the innovation process. One participant expressed joy in "messing up and then seeing from your mistakes to improve it." This iterative process of trial-and-error builds resilience and shows the importance of learning and improving. The process of rethinking ideas and designs, and exploring failures, resulted in the students feeling pleased with the outcome of their projects. Another student shared, "I think the part when it actually succeeds because it makes you think about all the trial and error and how long it took you, that you finally made something, and the hope that you can make it even better." These insights show how iterative learning turns challenges into valuable opportunities, helping students develop the mindset needed to invent.

The camp's hands-on approach further increased students' engagement by allowing them to interact directly with materials and tools. One student shared their excitement about "messing with the wires because it's fun to put stuff together," and another student said in relation to one of the activities, "we could use clay, we could use cardboard pieces, straws, and pipe cleaners." Students shared how they expressed their inventiveness and creativity beyond camp, often using materials they found at home to create the things they imagined. They demonstrated resourcefulness by identifying what they needed and figuring out how to make it work. For example, one student used cardboard and wheels to build a sliding bed for their dolls, while another crafted animal shapes from paper and cotton balls.

The feedback from students shows how hands-on learning supported active problem-solving, as students built, tested, and iterated on their projects. Overall, the responses from students illustrate the value of problem-solving, iterative learning, and a hands-on approach, as they test ideas, troubleshoot issues, and discover new ways to tackle challenges.

Real-world Applications and Future STEM Aspirations

When asked about their future goals, the student responses revealed a wide variety of aspirations, demonstrating the broad impact STEM education has on the next generation. Many students expressed the desire to become professionals who integrate STEM in real-world settings. For example, several students were drawn to fields like mechanical engineering, biology, and dermatology, where they aim to apply scientific principles to solve problems and improve lives. One student's goal of becoming a "kids' therapist" reflects an interest in understanding human behavior and helping others, aligning with STEM disciplines like psychology and healthcare. Another student, interested in pursuing zoology or veterinary science, emphasizes the value of studying animals, which shows a growing interest in environmental and biological sciences and demonstrates invention's connectedness to nature.

Additionally, several students expressed an interest in innovation and entrepreneurship, a reflection on the hands-on nature of the camp activities. One student who aspires to be a baker wants to invent new food types, showcasing the creative potential of STEM in culinary fields. Another student's dream of becoming an inventor or artist points to the intersection of creativity and engineering, central to many STEM fields. Another student expressed a desire to become a farmer, understanding that farming relies on science, math, and technology for crop production and sustainability. The desire to explore space or the ocean, as shown by students interested in astronomy, marine science, and paleontology, speaks to the curiosity that drives scientific research and exploration. The variety in students' future goals showcase the importance of exposing them to a wide range of STEM disciplines, helping them recognize how different fields intersect and lead to exciting career opportunities.

Below is a word cloud representing the students' future aspirations in the focus groups.

Conclusion

The results from the student focus groups reveal how Camp Invention encourages creativity, problem-solving, and engagement in students, shaping their understanding and application of inventiveness and entrepreneurial thinking. Key themes emerged, such as the importance of collaboration, teamwork, and empathy, where students recognized the value of combining ideas and working together to solve problems and improve the world. Open-ended activities allowed students to express their creativity and showcase their individuality. Moreover, hands-on activities integrating STEM concepts, such as building skateparks or engaging with the business module, deepened students' understanding of scientific principles, financial literacy, and innovation. Students embraced iterative learning, where trial-and-error and problem-solving enhanced their resilience and critical thinking. The focus on real-world applications inspired diverse future aspirations, from engineering and biology to culinary arts and entrepreneurship, demonstrating the broad impact of STEM education. Collectively, these insights underscore the importance of experiential learning in cultivating inventiveness, practical skills, and an entrepreneurial mindset in young learners.

Based on the findings from this study, several aspects of the camp experience should be maintained, while others could be refined to enhance future evaluations. The hands-on, inventive activities effectively engaged students and encouraged problem-solving, making them a valuable component to retain. Additionally, the camp fostered entrepreneurial mindsets by promoting creative thinking and risk-taking. Post-camp reflections provided useful insights into students' experiences and should continue to be part of the assessment process.

Although the focus groups provided positive feedback, there are certain limitations to consider. The research was conducted in a specific context - a summer camp focused on invention-related activities - making it distinct from typical in-school settings. This raises questions about how the findings might translate to regular school environments. Additionally, the study focused on late elementary school-aged students (grades 3-6), and expanding the participant pool to include other grade bands could provide insights into whether perceptions and experiences differ for older students.

Currently, there are no established plans to assess the long-term impact of the camp on participants. However, conducting longitudinal studies could help determine whether students continue to apply these skills and concepts in their academic and personal pursuits over time. Data collection for this part of the study was conducted only at the end of the camp. To better measure the camp's impact, refining data collection methods - such as incorporating pre-camp assessments - would allow for a clearer comparison of students' inventive and entrepreneurial mindsets before and after participation.

Future work could explore a broader range of learning environments to better understand students' experiences with invention education and entrepreneurship, such as in-school settings or other educational programs. Expanding to diverse geographical locations would also help assess how these activities impact a wider variety of students. Future research could also explore the experiences of lead facilitators, the camp instructors, to better understand the challenges and successes of implementing invention-based learning for younger students. Their perspectives could provide guidance for professional development and curriculum design, helping to improve the effectiveness of invention-based learning across diverse educational settings.

Incorporating more hands-on invention education activities into the curriculum for younger students can help increase student engagement and excitement in STEM. Educators can inspire a deeper interest in these subjects by providing students with creative problem-solving and experimentation opportunities, which may help students see their real-world applications. Additionally, students develop essential skills such as creativity, resilience, adaptability, and collaboration, which are important for success in both academic and professional settings.

For many students, Camp Invention provided an opportunity to explore their passions and express themselves through hands-on invention activities. The camp's approach sparked enthusiasm for STEM fields and entrepreneurial thinking, helping lay the groundwork for students to envision themselves as future inventors, engineers, doctors, scientists, and entrepreneurs. By examining how students define and experience inventiveness and entrepreneurial thinking, educators can equip students with the skills and mindset needed to excel in STEM fields and embrace entrepreneurial opportunities.

Acknowledgements

We would like to acknowledge United States Patent and Trademark Office for their generous support and contributions to this work. Additionally, we would like to express our gratitude to the Lead Research Facilitators (Camp Directors and Instructors) for their dedicated time and

effort in facilitating the Camp Invention program. Finally, we are deeply grateful to the participating students and their families.

References

[1] K. Ashton, *How to Fly a Horse*. Accessed: Jan. 13, 2025. [Online]. Available: https://www.penguinrandomhouse.com/books/234946/how-to-fly-a-horse-by-kevin-ashton/

[2] "Progress Report on the Implementation of the Federal STEM Education Strategic Plan [2021]," Executive Office of the President, Dec. 2021. Accessed: Jan. 13, 2025. [Online]. Available: https://eric.ed.gov/?id=ED625726

[3] R. Moore *et al.*, "Infusing Entrepreneurship into Engineering Design Curricula to Promote Inventiveness: A Student-Centered Approach to Inclusive Innovation," presented at the 2022 ASEE Annual Conference & Exposition, Minneapolis, MN: ASEE Conferences, Aug. 2022. doi: 10.18260/1-2--41609.

[4] K. Rooney and Y. Khorram, "Tech companies say they value diversity, but reports show little change in last six years," CNBC. Accessed: Jan. 13, 2025. [Online]. Available: https://www.cnbc.com/2020/06/12/six-years-into-diversity-reports-big-tech-has-made-little-progress.html

[5] J. W. Getzels, "Problem-Finding and the Inventiveness of Solutions," *J. Creat. Behav.*, vol. 9, no. 1, pp. 12–18, 1975, doi: 10.1002/j.2162-6057.1975.tb00552.x.

[6] The Lemelson Foundation, *A Framework for Invention Education*, 2020.

[7] K. Boice, C. Cappelli, M. Alemdar, J. Patel, and R. Moore, "Reinventing the InVenture Prize: Transforming a Year-long Invention Program into a Week-long University-based Summer Program," in *2020 ASEE Virtual Annual Conference Content Access Proceedings*, Virtual On line: ASEE Conferences, Jun. 2020. doi: 10.18260/1-2--35137.

[8] J. N. Patel, A. L. Rutledge, J. M. Cellitioci, and R. A. Moore, "The Impact of Invention Education Participation on Students' Confidence and Anxiety in STEM," presented at the 2024 ASEE Annual Conference & Exposition, Portland, OR, Jun. 2024. doi: 10.18260/1-2--48111.

[9] S. Newton, M. Alemdar, R. Moore, and C. Cappelli, "An Investigation of Students' Experiences in a K-12 Invention Program (Evaluation)," in *2018 ASEE Annual Conference & Exposition Proceedings*, Salt Lake City, Utah: ASEE Conferences, Jun. 2018. doi: 10.18260/1-2--29796.

[10] J. H. Falk, "Invention Education: Outcomes for STEM Learning. Camp Invention® 2017 Evaluation Summary," Institute for Learning Innovation, 2017.

[11] ChangeMaker Consulting LLC, "Camp Invention Evaluation Executive Summary," 2014.

[12] Kent State University, Bureau of Research Training and Services, National Inventors Hall of Fame, "Camp Invention Evaluation Report," 2004.

[13] A. Scarisbrick-Hauser and B. Hauser, "Camp Invention 2009 Program Evaluation," H.A. Praxis Solutions, Unpublished Technical Report, 2009.

[14] J. H. Falk and D. D. Meier, "Camp Invention Evaluation Report," Institute for Learning Innovation, 2018.