



As part of our mission to advance the spirit of innovation across the country, not only have we at the National Inventors Hall of Fame® (NIHF) developed invention education curricula for over 30 years, but we also remain committed to advancing the study of this pedagogy through continuous research.

Made possible by the generous support of the Burton D. Morgan Foundation, Lemelson Foundation and Overdeck Family Foundation, NIHF partnered with The Center for Educational Partnerships at Old Dominion University to conduct groundbreaking research that explores inventive mindset development and how such a mindset can help a student identify as an “innovator.”

This research resulted in an article titled “Invention Education as a Context for Children’s Identity Exploration.” Published in August 2021 in the *Journal of STEM Outreach*, one of the most well-respected academic journals of its kind, the article is an important contribution to the burgeoning field of invention education.



Two campers comparing the musical instruments they built at Camp Invention to explore the science of sound.

For Alaina Rutledge, vice president of educational research and development at NIHF and one of the article’s co-authors, the research unearthed key insights into how features of invention education programming support creative identity exploration. It also resulted in the development of a tool to measure a child’s perception of their own “inventive mindset.”

“The research showed us that participating in Camp Invention® supports identity exploration, including entrepreneurship

through the lens of invention, which can be thought of as ideating, making, creating, iterating, pitching,” Rutledge said. “We developed a stable measure of ‘inventive mindset’ in children consisting of two factors or subscales, which we called ‘solution-seeking,’ or ‘stick-to-itiveness’ and ‘ingenuity.’”

Rutledge added that this type of research helps NIHF better understand and advance the field of innovation, and helps the organization continue designing engaging education programs that are inherently collaborative and meaningful to participants.

What is Invention Education?

As the challenges faced by our society grow ever more complex, so too does the need for innovative ideas and creative solutions. This need is relevant for students as well as for professionals. Employers have highlighted the importance of invention and innovation skills, including problem finding, creative thinking, teamwork and persistence.

Due to these present and growing needs, educators, nonprofit and government agencies, and social science researchers have worked together to develop ways of teaching these skills at the K-12 level. Invention education, therefore, represents a cross-sector movement that seeks to “explicitly teach the novel application of ideas, objects and tools that mimic the practices and habits of the mind of accomplished inventors.”¹

NIHF aligns with this understanding of invention education, and believes this pedagogy is able to leverage children’s natural inclination to create and guide them through the act of hands-on invention to build the mindset and skills they need to navigate their lives.

The Frontier of Invention Education Scholarship

At the heart of all scholarship exists a body of peer-reviewed research that acts as the foundation from which the field in question can grow and evolve. However, because the study of invention education is in its relative infancy, these analyses, tools and benchmarks are still being developed and tested.

The authors of “Invention Education as a Context for Children’s Identity Exploration” sought to address this challenge directly by examining how children perceive particular aspects of

1. Lemelson Foundation, (2019). Researching Invention Education: A White Paper. Retrieved from <https://lemelson.mit.edu/node/2511> ; Lemelson Foundation, (2020). A Framework for Invention Education. Retrieved from <https://www.lemelson.org/our-work/education/>

invention education pedagogy and developing “a high-quality tool for measuring students’ perceptions of their own proclivities towards invention” that could both guide the development of future invention education programs and evaluate their impact.²

To do this, the researchers examined Camp Invention Connect®, a K-6 STEM (science, technology, engineering and mathematics) summer education program developed by NIHF, for its potential and “context for inventive mindset development,”³ meaning that it can support children’s long-lasting learning about their own inventive capacities as well as new skills.

In the process, they also developed and validated “inventive mindset scale” including nine assessment items related to creativity and inventiveness, and using a four-point, Likert-type scale with “strongly disagree,” “disagree,” “agree” and “strongly agree” response options.⁴

Using this inventive mindset scale and a set of additional questions “designed to reveal children’s identification with particular STEM subjects,” the team analyzed the pre- and post-camp survey responses from 108 upper elementary and middle school-aged children and sought to answer three primary research questions:



Two campers building their own fish tanks to learn more about marine biodiversity at Camp Invention Connect.

Research Question 1:

What are the invention-related self-perceptions of upper elementary and middle school-aged children participating in an out-of-school time (OST) invention education program and to what degree do these overlap with their identification with STEM subjects?

After analyzing the pre-and post-camp questionnaire results, the researchers found that the questions relating to identification with science, technology and mathematics “demonstrated independence” from the other inventive mindset items. Additionally, relations among these three items (“I am a math person,” “I am a science person” and “I am a technology person”) were low.

According to the authors of the study, these findings suggest

that the “STEM identification items should be considered separately from the inventive mindset measure,” and, further, that the children in the study did not respond in a consistent way across the various STEM identification items presented.

Although children may perceive themselves as being creative, open to considering and sharing new ideas, imaginative and capable of problem solving, these are distinct from self-perceptions of being a math, science or technology person. While adults might tend to associate STEM and invention-related characteristics interchangeably, children might not.⁵ Additionally, children’s responses during the study were relatively stable over the duration of a one-week, at-home Camp Invention Connect experience.⁶



Two campers showing off their pop-up venture businesses they created at Camp Invention.

Research Question 2:

What features of an invention camp experience contribute to a context that is conducive for inventive identity exploration?

Identity exploration is a relatively new idea that incorporates explicitly learning about oneself in order to think about who one could become in the future.⁷ It is more likely to happen if the educational setting is perceived to be enjoyable, useful, of moderate challenge and emotionally safe.

Prior to asking participants about their most- and least-liked activities during their Camp Invention virtual experience, the researchers anticipated that the most-liked activities likely would align with statements related to invention-related tasks that support inventive identity exploration including problem solving, creativity, doing a relevant activity and finding out something new.⁸

After analyzing their 108 responses, the researchers found that children had a strong preference for hands-on activities. Highlights from the survey revealed:

- **85%** of the children listed “making/creating/building” as their most-liked activity

2. Joanna Garner, Erica Matheny, Alaina Rutledge, and Melissa Kuhn. 2021. “Invention Education as a Context for Children’s Identity Exploration.” *Journal of STEM Outreach* 4 (1). Retrieved from <https://www.jstemoutreach.org/article/27331-invention-education-as-a-context-for-children-s-identity-exploration>

3. Ibid.,

4. Ibid.,

5. Ibid.,

6. Ibid.,

7. Mirit Sinai, Avi Kaplan and Hanoch Flum (2012). Promoting identity exploration within the school curriculum: A design-based study in a Junior High literature lesson in Israel. *Contemporary Educational Psychology* 37 (3), 195-205. Ibid.,

8. Ibid.,

- **99%** of this group agreed that their most-liked activity involved designing something new
- **82%** of this same group believed their most-liked activity involved finding out something that was previously unknown

The children seemed to prefer hands-on, creative activities.

- **44%** of all participants listed coaching as their least-liked activity
- **46%** of all participants listed sharing ideas as their least-liked activity

When asked about their experience of Camp Invention as a whole:

- **54%** of children reported designing something new
- **44%** said they were able to problem solve
- **60%** said they worked on something new
- **73%** said they found out something previously unknown

For the researchers, the above findings show that even when reflecting on the activities they least enjoyed, “many children reported being engaged in behaviors that fostered inventive and innovative skills and habits of mind.”⁹



Two campers testing their hydraulic arm at Camp Invention Connect.

Research Question 3:

To what extent is gender associated with children’s responses to an invention mindset questionnaire, their identification with STEM subjects and their perceptions of the invention camp experience?

Prior to the one-week camp experience, the researchers did not find gender differences in inventive mindset scores. However, the pre-camp data revealed that both boys and girls “exhibited

self-perceptions congruent with an inventive mindset, with gender differences in the strength of the relationship between mindset and identification with invention-relevant subject areas of science, math and technology.”¹⁰ Whereas boys’ inventive mindset was correlated with being “a science person” and “a technology person,” this was not the case for girls who instead, as a group, correlated inventive mindset with being “a math person.” However, girls’ and boys’ connections between inventive mindset and identification with STEM also depended on which aspect of inventive mindset — ingenuity or solution-seeking — was being considered.

When educating children, it is important to note any differences among learners. Only a few students identified as non-binary or multi-gendered within the study, so the above findings represent differences between girls and boys. Knowing how different children identify what is invention can help practitioners design programming that considers these differences.

Conclusions

This study is one of the first of its kind to explore how invention education experiences can provide a context for identity exploration. While Camp Invention Connect was not intentionally designed using the principles of identity exploration, the researchers found that the program experience “elicited emotions and perceptions commensurate with conditions about learning about the self.”¹¹

The children in the study rarely self-identified as “inventors” on their own, and the researchers suggest that as a best practice, invention education programs should target many of the subcategories of invention (making, creating, building, etc.) that children express interest in while providing explicit support context and framework to help them see themselves with the identity of “inventor” or “innovator.” This could involve children bringing examples of inventiveness from their everyday lives or working together to solve a problem that is personally meaningful for them.

While the researchers behind this study concluded that invention education programs like Camp Invention can offer children a space and context for identity exploration, future curricula designers in this space should not assume these intended connections will occur spontaneously. Rather, it is beneficial for programs to include explicit references to principles associated with persistence in invention and innovation (such as tolerance for risk and failure), and to encourage children to reflect on these principles in relation to their current and future selves and their identification with STEM and invention.¹²

9. Ibid.,
10. Ibid.,
11. Ibid.,
12. Ibid.,