



Invention education guides students to approach problem finding and problem solving with practices used by accomplished inventors.¹ In recent years, this type of learning has become an increasingly popular way for educators to inspire students and prepare them to tackle complex problems.

At its most effective, this pedagogy invites participants to invent solutions to real-world challenges by engaging in hands-on activities. In contrast to more passive forms of learning that embrace lectures and traditional classroom methodologies, Invention education excels in helping students document their learning and make it visible.

Helping Students Document Their Learning

One of the universal concerns shared by many educators is whether their students are demonstrating the newfound knowledge that they are learning. While there exist plenty of grade- and age-related learning benchmarks and standardized tests that do their best to provide an objective measure of a student's understanding, these do not always account for each child's ability to problem solve in a real-world setting.



A Camp Invention camper enthusiastically presents his invention prototype.

In fact, when it comes to the subject of standardized testing, studies have shown that performance on these assessments can often “tell more about the community in which a student lives than the amount the student has learned or the academic, social and emotional growth of the student during a school year.”²

Though many modern critiques of an overreliance on testing are largely in response to national educational policies enacted in 2002³ in efforts to close student achievement gaps, the desire to discover more authentic ways of measuring student thinking has a long and well-researched history.

In 1967, while studying at the Harvard Graduate School of Education, philosopher Nelson Goodman founded “Project Zero,” a research group that focused on the analysis of artistic expression as a valid and authentic expression of learning.⁴ Over the following decades, the group expanded its scope to explore the importance of students documenting their learning by “observing, recording, interpreting and sharing through the process and products of learning in order to deepen learning.”⁵



A team of three Camp Invention campers test their hydraulic arm prototype design.

Mara Krechevsky, senior researcher at Project Zero, explains that what makes this definition of documentation different from others is that it does not make a distinction between a finished product and something that is in progress.

“One thing we are doing in this definition is making the claim that you do not need to wait until the learning process is over—and there is a final product or an exam score—in order to know that learning is taking place,” Krechevsky said in an interview with Art Play Children Learning. “Rather, you can see learning happening during the process itself. Documentation is one way to make this learning visible, which can also inform future learning.”

1. Skukauskaite, A., Couch, S., & Flynn, L. (2019, November 1). *Researching invention education: A white paper*. ResearchGate. Retrieved from https://www.researchgate.net/publication/339526003_Researching_Invention_Education_A_White_Paper
2. Tienken, C. (2017, July 5). *Students' test scores tell us more about the community they live in than what they know*. The Conversation. Retrieved from <https://theconversation.com/students-test-scores-tell-us-more-about-the-community-they-live-in-than-what-they-know-77934>

3. Strauss, V. (2020, June 21). *Analysis | it looks like the beginning of the end of America's obsession with student standardized tests*. The Washington Post. Retrieved from <https://www.washingtonpost.com/education/2020/06/21/it-looks-like-beginning-end-americas-obsession-with-student-standardized-tests/>
4. Harvard Graduate School of Education. (n.d.). *Our first 50 years: Project Zero*. Our First 50 Years | Project Zero. Retrieved November 1, 2021, from <http://www.pz.harvard.edu/50th>

Developing an Inventive Mindset

One of the great benefits of invention education is that it enables students to develop creative identities that embrace exploration and the type of authentic learning celebrated by the researchers at Project Zero.

At the National Inventors Hall of Fame® (NIHF), we too are committed to advancing educational research. For more than 30 years, we have developed hands-on K-12 education programs and ensured their effectiveness and impact. In keeping with our commitment to furthering educational scholarship, in August 2021, researchers from NIHF and researchers from Old Dominion University teamed up to publish an article in the peer-reviewed publication *Journal of STEM Outreach* titled “Invention Education as a Context for Children’s Identity Exploration.”⁶

Findings from Invention Education as a Context for Children’s Identity Exploration

- Camp Invention generated a quantifiable measure of inventive mindset development, which was stable over time but largely independent of children’s identification with three STEM subjects typically encountered in school.
- During Camp Invention, children’s preferred activities supported perceived confidence, task novelty and task utility.
- Experiences at Camp Invention and in other invention education programs help shape the way children see themselves.
- Children rarely self-identify as “inventors” on their own. Invention education programs should therefore target many of the subcategories of invention (making, creating, building, etc.) to authentically engage children.
- Children should have a framework to see themselves with the identity of “inventor” or “innovator.”
- It may be 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 help children reflect on this in reference to their current and future selves.

In this study, researchers analyzed the pre- and post-program questionnaire responses of 108 upper elementary and middle school-aged children who attended Camp Invention®, NIHF’s K-6 STEM (science, technology, engineering and mathematics) program. In addition to developing a new, reliable measuring tool for scholars to assess inventive mindset development, the researchers uncovered several important findings.

Designing STEM Programs That Make Learning Visible

At NIHF, we have the privilege of both honoring the world’s most revolutionary inventors and integrating their stories and words of wisdom in our education curricula, giving children the opportunity to find an inspiring STEM role model. As research from Opportunity Insights⁷ has shown, when children are introduced to innovators, they are more likely to invent as they age. Early exposure to this style of invention education can significantly impact students throughout their lives.

Much like the learning documentation promoted by researchers at Harvard University’s Project Zero, the process of brainstorming, sketching and prototyping inventions is emphasized throughout all NIHF education programs, resulting in tangible representations of children’s ideas. Often, their prototypes look much different from their original descriptions and sketches. By comparing their sketches and prototypes, educators can see children’s thinking develop over time.



A girl at a NIHF afterschool program proudly shares a sketch and prototype of her invention.

NIHF programs offer children the opportunity to express their ideas in several different ways, from creating sketches and writing descriptions similar to inventors’ detailed explanations of patented work, to collaborating with peers and using upcycled materials to build functioning prototypes. Finally, children are encouraged to share their ideas by either discussing them

5. Penfold, L. (2020, January 13). *Harvard Project Zero’s Mara Krechevsky talks about making learning visible*. Art. Play. Children. Learning. Retrieved from <http://www.louisapenfold.com/making-learning-visible/>

6. Garner, J., Matheny, E., Rutledge, A., & Kuhn, M. (2021, August 11). *Invention education as a context for children’s identity exploration: Published in Journal of STEM Outreach*. *Journal of STEM Outreach*. Retrieved from <https://www.jstemoutreach.org/article/27331-invention-education-as-a-context-for-children-s-identity-exploration>

7. Bell, A., Chetty, R., Jaravel, X., Petkova, N., & Reenen, J. V. (2019, May). *Who Becomes an Inventor in America? The Importance of Exposure to Innovation*. Retrieved November 1, 2021, from https://opportunityinsights.org/wp-content/uploads/2018/03/inventors_summary.pdf

informally or presenting a thoughtful and persuasive pitch. Especially valuable is seeing how children's thinking evolves from the initial formation of the idea to its final expression.



“We are sensitive to meeting children where they are and making sure that invention education gives them the freedom to express their ideas as they feel comfortable. For some that means writing or sketching ideas in an Inventor Log, while others are comfortable sharing in small groups or pitching to the whole class. Flexibility is key to developing and maintaining a sense of psychological safety for children to explore their identity as inventors and makers. So, while invention education is helping children to create physical forms out of their hopes and dreams, it is also helping to protect those hopes and dreams so they can continue to strengthen and grow them until they are ready to bring them to fruition.”

— Erica Matheny, Curriculum Writer and Researcher at the National Inventors Hall of Fame