A Framework for Invention Education

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Contents

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A Framework for Invention Education

Introduction

Using their imagination and creativity, inventors have made significant contributions to our world throughout the course of human history. In recent times, a growing community has responded to the need for more intensive research on Invention Education[1] and within the last several years has begun organizing itself around collaborative action that will accelerate the uptake and practice of Invention Education.

The purpose of this document is to provide a comprehensive community-driven framework and set of principles for Invention Education that can support its growth within formal and informal learning environments from K-12 through higher education.

This effort has resulted in a growing inclusive community of practitioners and advocates, who have joined together to formalize and spread ways of supporting all people to develop an inventive mindset and become inventors. In response to community interest, in 2017 The Lemelson Foundation hosted individuals representing a broad cross-section of the educational ecosystem to deepen relationships between organizations and develop a shared vision for the future of Invention Education.

More than three dozen interviews and conversations with more than one hundred community stakeholders beginning in Fall 2018 contributed to the development of this document (see Appendix A). This engagement provided a clear indication of the interest among the participants to develop a common definition and framework for Invention Education.

The community believes that this resulting document has the potential to:

- Help all practitioners better communicate the value of Invention Education to others;
- Provide a core building block of a research agenda to further inform practices and policies for Invention Education;
- Promote consistency and rigor in Invention Education curricula through a common definition and framework;
- Foster the formation of new partnerships by helping more organizations see the value Invention Education adds to their work.

The community strongly believes the capacity to invent is inherent in every individual, and that we have a social responsibility to create equitable access to opportunities for all to learn how to invent.

[1] Plucker and Gorman (1999) reported the lack of intensive research on Invention Education, and little was found in the literature [about Invention Education] in the following two decades. Plucker (2002) individually noted the same lack of attention to invention in science curricula in the United States.

Why Invention Education

Technological advances in artificial intelligence, human speech recognition, and computer vision are advancing to the degree, and at such rapid rate, that they threaten to make aspects of the current education system increasingly obsolete. The promise of Invention Education is its focus on ways of thinking, engaging, and learning from one another that inherently define us as humans such as empathetic problem identification, innovative problem solving, and tolerance for operating in ambiguity or without instructions. The Invention Education community believes it is uniquely positioned to prepare the next generation to leverage fast-approaching technological advances that have and will continue to dramatically change our economy and society.

The benefits of Invention Education are increasingly recognized by individuals across every sector of our society. The community directly involved with Invention Education is growing, and includes both in- and out-of-school-time educators, business leaders, education researchers, nonprofits, policy makers, inventors, and the philanthropic community. Throughout the process of creating this document, representatives from these groups offered evidence of the value of learning opportunities that are inherent to the invention process. These measures correlate directly to the attributes that will be needed to stay relevant in our future economy, and to enhance our quality of life while preserving our ecosystems and natural environments.

Invention Education has demonstrated the ability to increase student engagement and participant interest in STEM[2] education, to promote knowledge acquisition, and to develop characteristics, skills, and mindsets that are needed not just for the future economy[3] but for our increasingly connected world. Invention Education can effectively engage learners from diverse backgrounds in collaborative projects, and develop the confidence in problem solving that empowers individuals to productively contribute to their local and global community. Many members of the Invention Education community expressed a desire to actively promote equity by both fostering and celebrating local community-generated problem solving.

Invention Education helps prepare students to become problem solvers with the interest and capacity to address issues facing humankind at

Technological advances are taking place at a rapid rate, creating a need for new knowledge and capabilities that exceed the traditional objectives of education.

[2] Please note that while STEM is used in this document, the authors see the applicability to any of the variations on the acronym such as STE(A)M.

[3] World Economic Forum. (2018). The Future of Jobs Report 2018. Retrieved from http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf

the community level or globally. These problems include local needs or global concerns such as those articulated in the Sustainable Development Goals (a collection of 17 global goals set by the United Nations General Assembly in 2015)[4] or as described in the dozen or so Problem Profiles outlined in a collaboration between the University of Oxford's Global Priorities Institute and the Open Philanthropy Project.[5]

Fostering invention, innovation, and an entrepreneurial mindset directly supports the development of learners' self-determination and helps learners develop ways of exerting greater control over their future. It increases the spectrum of opportunities by developing the capacity for each individual to create new approaches, products, services, and then take them to market. These capabilities add value whether working within an existing company or creating a new one, and can benefit individuals and society in more ways than just financially. Invention Education provides a set of experiences that increase both capacity and confidence within the learner.

Invention Education also can build collaboration and communication skills. Research shows that while inventors can work individually or in teams with co-inventors, they are most successful when they pursue invention as a deeply collaborative process.[6] At their core, inventors display many of the following traits and dispositions (listed below), which can benefit all individuals in our society and are highly sought-after[7]:

INVENTOR TRAITS & DISPOSITIONS

» Empathy
Listens to viewpoints other than just their own, understands variety of perspectives, the ability to understand the challenges or needs of others

» Creativity
Ability to pair things in an unanticipated way to reveal untapped potential

» Curiosity
Alertness to practical problems and opportunities; intentional focus on both large overarching system and on small micro-components

» Resilience
Embraces failure as a learning experience, ability to work towards delayed gratification, critical stance toward their own work

» Calculated Risk-Taking
Conservation of energy where possible in order to minimize unnecessary exposures

» Passion
Optimistic commitment to vision coupled with flexibility to contemplate novel ways to achieve desired end result

» Resourcefulness
Seeks solutions with available resources, seeks ways to increase available resources

» Tolerance for Ambiguity & Complexity
Comfort working on the margins of established knowledge, willingness to become immersed in multi-layered problem set

[4] The United Nations. (2018). Sustainable Development Goals: 17 Goals to Transform Our World. Retrieved from https://www.un.org/sustainabledevelopment/

[5] Centre for Effective Altruism. (2018). List of the most urgent global problems. Retrieved February 26, 2019, from https://80000hours.org/problem-profiles/

[6] Fleming, et al. (2004). Enhancing inventiveness for quality of life, competitiveness, and sustainability. Retrieved from https://lemelson.mit.edu/sites/default/files/content/images/InventionEducation/Invention%20Assembly%20Report%20Exec%20Summary.pdf.

[7] Berger, Guy. (2018). LinkedIn 2018 Emerging Jobs Report. Retrieved February 12, 2019, from https://economicgraph.linkedin.com/research/linkedin-2018-emerging-jobs-report

Invention Education builds collaboration and communication skills.

Many teachers have seen first-hand how the open-ended project-based work required by Invention Education impacts the lives of their students. Invention Education's transdisciplinary nature brings value to both formal and informal classrooms. As education stands at a crossroads today, Invention Education is well positioned to help prepare today's learners for the uncertainties of the future while meeting students where they are academically and behaviorally. Invention Education will ensure the continued relevance of our education system by helping prepare today's learners for the economy of the future.

Process of Developing Definition & Framework

While efforts to inspire young people to invent have been developing for a long time, the recent focus on establishing a community definition and framework for Invention Education is a new initiative that grew out of a convening in Alexandria, Virginia, in November 2017 hosted by The Lemelson Foundation. During this gathering, the Invention Education community (including many practitioners, funders, inventors, and policy makers) expressed interest in more clearly defining the field and establishing a written summary of what the community has learned to date about developing the creativity and inventiveness of young people. To that end, in Summer 2018, The Lemelson Foundation engaged Initial Velocity on behalf of the Invention Education community, led by Andrew Coy, a former Senior Advisor on the Tech & Innovation Team in the White House Office of Science and Technology Policy during the Obama Administration. In Fall 2018, Initial Velocity engaged dozens of community members through one-on-one video and phone interviews, email outreach, and surveys. Additional information was collected during the 2018 K-12 Invention Education Convening. The information was compiled into a draft document and distributed among a few hundred stakeholders for comments and suggested edits. After this period of input, this document was released as Invention Education Framework.

Common Definition

As Invention Education efforts multiply, it is critically important to maintain a clear view of the essential elements. While definitions for *invention*[8] and *education*[9] exist and while various scholars and practitioners have created related working definitions previously[10], prior to this document, no common definition or framework for *Invention Education* exists. The following common definition, reached through numerous community calls and a collaborative editing processes, is intended for widespread use:

Invention Education /in·ven·tion-'ed·u·ca·tion/ *noun*

- A pedagogical approach focused on problem identification through empathy and collaborative problem solving that results in novel solutions by integrating the process of invention into teaching and learning.
- Key components include collaboration, empathy, problem identification and refinement, research, accessing sources of expertise and capacities, continuous learning including self-directed study, prototyping, user input, iteration, intellectual property literacy and its application to the creation and protection of inventions, community engagement, entrepreneurial exploration, go-to-market evaluation, and consideration of sustainability.
- Interdisciplinary, and therefore often team-oriented, with a focus broad enough to be responsive to the ever-changing and increasingly interconnected world that demands complex solutions which draw on more than one academic discipline.
- Often encompassing computational thinking, entrepreneurship, the maker mindset, human-centered design, and design thinking; includes an application of Science, Technology, Engineering, and Math (STEM) education principles as well as creative practices and processes common to the arts and

Additionally, many members of the Invention Education community express values that include striving to be socially inclusive and environmentally conscious in the service of creating a viable citizenry of and for everyone.

While it is not anticipated that every program will concentrate on all aspects of Invention Education as defined in this document, nor that the elements that are part of the invention process will occur in any specific order, clearly stating the ideal components provides a starting place for growth and continuous improvement of Invention Education offerings in ways that foster substantive impact.

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[8] For purposes of a working definition of invent, please see the Merriam-Webster Dictionary entry, which states (in part), "to produce (something, such as a useful device or process) for the first time through the use of the imagination or of ingenious thinking and experiment" https://www.merriam-webster.com/dictionary/invent

[9] For the purposes of a working definition of educate, please see the Merriam-Webster Dictionary entry, which states (in part), "to develop mentally, morally, or aesthetically especially by instruction" https://www.merriam-webster.com/dictionary/educate

[10] Flemings, M. C. (2004). Invention: Enhancing inventiveness for quality of life, competitiveness, and sustainability (Report of the Committee for the Study of Invention, sponsored by the Lemelson-MIT Program and the National Science Foundation) Cambridge, MA: MIT.

Framework

In establishing the framework, we recognize that while invention has existed in every culture, time period, and geographic location, the formal articulation of Invention Education as an educational approach is still an emerging field. In this early stage, there are a wide array of program offerings and few will include every component enumerated in the definition or framework articulated in this document. The community, however, recognizes the importance of each one of the aspects enumerated in the Common Definition presented in this document while providing space for valuable variations.

This document is intended to be used as a tool for organizing existing materials and supporting the creation of additional resources that will assist programs seeking to develop and integrate Invention Education according to their educational systems and learning environments.

It is anticipated that the exact format and implementation of Invention Education experiences may vary and may not touch on every aspect articulated in this framework. It would be expected, however, that Invention Education program providers would have considered the applicability of each of the elements described in the following sections and be able to provide a clear rationale for those instances when they might not include some aspect of Invention Education as articulated in this document.

The framework set forth in this document is designed to serve as:

- A guide for program development that can support organizations that want to integrate Invention Education into their educational offerings.
- A way to organize resources to help content providers and program providers find and share materials that address specific Invention Education tenets.
- An eventual framework for program comparison and evaluation either informally or through a formal, and community-accepted, structure (note that this document itself does not create any proposed structure or mechanism to do so currently).

The framework is organized hierarchically in the following ways:

- **Tenets** — broad areas directly tied to the common definition of Invention Education
- **Clusters** — divisions within a given domain that organize articulated statements
- **Articulation** — statements of specific values

Invention Education has demonstrated the ability to increase student engagement and participant interest in STEM education, to promote knowledge acquisition, to develop characteristics, skills, and mindsets that are needed not just for the future economy but for our increasingly connected world.

Invention Education consists of the following six tenets by which gold-standard programs will be articulated, understood, and evaluated.

INVENTION EDUCATION FRAMEWORK TENETS

The framework is not intended to dictate a specific evaluation process or tool. The primary function is to articulate a shared set of values that can serve as the basis for evaluating programs for consistent outcomes. We imagine that programs can use the framework to evaluate program designs, the impact of programs on participants, or that content providers can use the framework to organize or categorize offerings.

1

Context

Invention Education Philosophy

Invention is not a singular act or "ah-ha" moment but is the result of an ongoing creative process. This process can sometimes be very informal and without overt steps, or it can be highly structured and the result of deliberate actions that create optimal circumstances for inventiveness. In both extremes, however, similar elements exist and are essential for the ultimate invention learning experience.

Invention Education is unique from the invention process in that the measure of success is not the actual invention, but the learning and mindsets connected to the process of invention. As such, despite the highly variable nature of an invention outcome, the learning outcomes can be predicted and evaluated. To achieve this, the values of invention should be integrated directly into the structure of the learning opportunity and explicitly stated as learning objectives.

Invention is not a singular act or "ah-ha" moment but is the result of an ongoing creative process.

As community members become more articulate about the tenets that drive their philosophical approach to Invention Education, a broader conversation can emerge in which the underlying educational approach is debated and improved. Programs which develop strong articulations of their core philosophy will be best positioned to also have a high degree of impact.

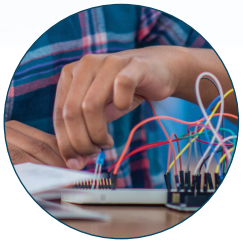
Cluster Heading		Articulation
1.a	**Education Philosophy Framing**	1. Description of historical context and dominant educational philosophy influences. 2. Exploration of unique approaches and views (if applicable). 3. Description of view on how and where Invention Education fits into the context of current education system narratives/trends.
1.b	**Educational Theory of Change**	1. Articulate an organized theory of change that describes how the planned resources for a specific program or offering will result in specific outcomes.
1.c	**Age-Appropriate and Culturally Competent Application**	1. Articulation of plans for addressing specific needs of the ages/grades that will be served. 2. Articulation of approaches that recognize some populations may have been actively discouraged from developing attributes identified as critical for invention.
1.d	**Measurement Plan**	1. Description of validated tools or ways of making warranted claims that will be used for internal evaluation.
1.e	**Larger Educational Ecosystem Context**	1. Relevance and relationship to existing educational initiatives.

2

Empathy

Real-World Problem Identification, Definition, & Collaboration

The most critical and a highly distinguishing aspect of Invention Education is the strong focus placed on the process of empathetic problem identification. Repeatedly, community members from within the field have stressed that the majority of their time and attention is dedicated to a rigorous process of teaching problem identification.[11] *This process sometimes focuses on generating a high number of identified problems and at other times focuses on delving deep to articulate thoroughly a single problem. Regardless of the unique techniques or approaches, Invention Education programs should continue to place heavy emphasis on this key component and not be afraid of devoting significant blocks of instructional time to it, ensuring that this step supports solving with, not for, specific communities.*



A majority of time and attention is spent on a rigorous process for problem identification.

It is important to note that the authors of this definition and framework do not see inventing as being limited to a specific course or content area, but rather as having the potential and imperative to cut across disciplines as students work to create solutions that connect with the human experience.[12]

Cluster Heading	Articulation
2.a Selected Domain of Applied Invention	1. Best practices for determining the focus or category for exploration. 2. Creating a network of on-demand domain experts.
2.b Alignment to External Frameworks, Standards, or Indicators	1. Naming of program's sanctioned and/or dominant standards. 2. List of specific standards aligned to selected applied Invention Education domain.
2.c Statement of Work Across Disciplinary Boundaries	1. Description of how Invention Education draws on different academic disciplines or enhances existing content areas.

Continued on back.

[11] National Academies of Sciences, Engineering, and Medicine. 2019. *Science and Engineering for Grades 6-12: Investigation and Design at the Center.* Washington, DC: The National Academies Press. https://doi.org/10.17226/25216.

[12] Fleming, et al. (2004). Enhancing inventiveness for quality of life, competitiveness, and sustainability. Retrieved from https://lemelson.mit.edu/sites/default/files/content/images/InventionEducation/Invention%20Assembly%20Report%20Exec%20Summary.pdf

Empathy (Continued)

Cluster Heading	Articulation
2.d Selected Approach(es) to Real-World Problem Identification	1. Articulation of the approach deployed by a program to foster empathetic real-world problem identification and definition, especially focused on how to support or encourage learners for empathetic discovery through empowering those who are most directly served by a potential invention to be full collaborators throughout the process. 2. Describe plan for pushing beyond initial idea generation to uncover unanticipated problem identification. 3. Plan for individual documentation of problems identified. 4. Intention and platform for sharing identified problems with broader community (if applicable). 5. Early-stage feedback and participation from community of individuals served through the defined problem statement.
2.e Time and Space Allocation Plan	1. Percentage of time reserved for problem identification, exploration, documentation, clear articulation, and proposed solution generation.

3

Problem Solving

Prototyping, Tools, Techniques, & Documentation

The act of invention requires the creation of something specific and novel. While there is no minimum expected level of sophistication, there is always an expectation in Invention Education of some form of prototype development. It may be as simple as cardboard and tape, or as complex as machined parts with electronic components. For the purposes of digital inventions, this could involve screen-based experiences. Additionally, prototyping tools and techniques may involve indigenous knowledge approaches that look different than commonly recognized or promoted practices and which highlight the global manifestations of invention throughout time.

There is always an expectation in Invention Education of some form of prototype.

Cluster Heading	Articulation
3.a Problem Solving	1. Plan to support the learner through their own problem solving process. 2. Preservation of appropriate amount of time for multiple problem solving cycles including response to failed attempts.
3.b Process and Justification for Prototyping Approach	1. Overview of approach to prototyping support. 2. List of selected prototyping tools and techniques for explicit support.
3.c Safety Procedures	1. Description of safety protocols for use of above tools.
3.d Fabrication Support Plan	1. Description of instructional and on-demand support for use of tools to make and refine prototypes.
3.e Fabrication Documentation Plan	1. Plan for learner documentation of the various steps and iterations of the prototype creation process for the benefit of future replication.
3.f Intellectual Tools and Approaches	1. Application of concepts and bodies of knowledge from various fields of education including Science, Technology, Engineering, Math, Art, Social Studies, and other fields of study.

4

Continuous Learning

Characteristics, Skills & Mindsets

Before, during, and following the process of clearly identifying a problem and creation of a proposed solution, Invention Education relies on access to a learning network of experts, mentors, and the development of additional core skills. Programs should situate skills in a socio-cultural context while encouraging continual learning and further development as needed by the unique circumstances relating to both the individual and the project. Areas of development may include technical knowledge, physical prototyping, interpersonal, or behavioral. Providing space and time for the learner to actively seek out resources to develop their knowledge and skill sets is a best practice and core to the educational objectives of Invention Education.

Invention Education relies on access to a learning network of experts, mentors, and the development of additional core skills.

Cluster Heading		Articulation
4.a	**Map of Applicable Skill Development, Domains, and Fields**	1. Enumeration of anticipated domains and fields of study likely to be of use and explored by students in an Invention Education experience. 2. Map of specific soft skills anticipated to be developed over course of program.
4.b	**Educational Support Strategies for Skill Development**	1. Description of instructional methods, tools, access points, and other program plans focused on development of the above referenced knowledge, skills, domains, and fields of study.
4.c	**Documentation of Individualized Student Learning Outcomes**	1. Plan for demonstrating student learning outcomes. 2. Student learning outcome evaluation method and plan for providing formative and summative feedback to learners.
4.d	**Self-Directed Learning Experiences**	1. Space or structure for supporting students in process of continuous and often self-directed learning.
4.e	**Teamwork, Collaboration, Leadership, and Communication**	1. Describe on how students' invention has supported teamwork and collaboration. 2. Describe students' leadership qualities exhibited in the process of inventing.
4.f	**Reflection, Self-Assessment, and Continuous Improvement**	1. Strategies or rubrics for evaluating student written or oral self-reflections (e.g., student's fabrication may have failed, but they gained real insight in problem-definition, collaboration, or redesign). 2. Using the steps of the design process as points of focus for assessment.

5

Iteration

Community of Feedback & Culture of Iteration

Once an initial prototype has been created, the invention process should incorporate testing or feedback by potential users. It is important to note here that programs should evaluate best practices regarding anticipated testing with human or animal subjects and, when or where appropriate, obtain appropriate consent and Institutional Review Board (IRB), or equivalent, approval. The feedback collected from use could be observed, oral, written, or otherwise documented, but should always include opportunities for students to revisit their initial design.

Once an initial prototype has been created, the invention process should incorporate testing by potential users.

Additionally, all inventors should develop the ability to succinctly describe and demonstrate their work to an audience, with an age-appropriate understanding of intellectual property processes including what measures may be appropriate prior to publicly disclosing an invention. The process of feedback and iteration should be front-and-center in Invention Education programs.

Cluster Heading	Articulation
5.a Development of User Feedback Procedure Plan	1. Overview of organization's policies for testing inventions with human or animal subjects (such as Institutional Review Board or equivalent, when and where appropriate). 2. Ensuring that all user feedback adheres to the community value of inventing with, not just for, others. 3. Process in which students create, present, and receive approval for plans to test and document use of prototype with human or animal subjects.
5.b Feedback & Review	1. Plan for reporting on prototype feedback and planned iterations on prototype. 2. Early-stage and initial go-to-market evaluation.
5.c Concept Iteration	1. Reflective documentation of evolution of invention over the course of user feedback and prototype creations (such as in an Inventor's Notebook and portfolio).

Continued on back.

Iteration (Continued)

Cluster Heading	Articulation
5.d Logistics and Planning of Community Showcase Events	1. Best practices relating to showcase event hosting or participation, including resources for a wide range of types of showcase activities (including but not limited to competitions, showcase, or presentations). 2. Articulation of ways to support the full range of community stakeholders to participate and overcome implicit bias inherent against lower socioeconomic learners that exists in some forms of competitions.
5.e Hosting and Documentation of Community Showcase	1. Overview of plans for a community showcase event. 2. Specific plan for documenting the community event, such as event attendance and/or other metrics, photography, video, etc.
5.f Celebration of Historical and Modern Inventors	1. Plan for integrating recognition of diverse examples historical and/or modern inventors. 2. Plan for any mentorship, including opportunities for learners to engage with a diverse set of contemporary inventors in their local communities.

6

Sustainable Innovation

Entrepreneurial Exploration, Go-To-Market Evaluation, Intellectual Property, Economic Impact, & Sustainability

Entrepreneurship is key in the context of Invention Education as it is the vehicle through which a new idea reaches an expanded audience. Programs should provide space and preparation for learners to make decisions about their desired engagement in the entrepreneurial endeavors that stem from their invention.

Regardless of the individual inventor's interest in exploring entrepreneurship opportunities, a reflective evaluation should be made for each new invention regarding the value of bringing it to market and the best pathway to do so. While programs serving different age groups should approach this in an age-appropriate manner, all programs should consider the best ways to address questions of entrepreneurship, intellectual property protection, go-to-market, and sustainability.

Entrepreneurship is key in the context of Invention Education as it is the vehicle through which a new idea reaches an expanded audience.

Additionally, the Invention Education community believes that the benefits of Invention Education extend into a wide variety of future pathways, careers, and endeavors as they serve to develop the capacity of individuals to work collaboratively to solve a problem in a unique or novel way.

Cluster Heading	Articulation
6.a Entrepreneurship Process Exploration	1. Plan through which students will better understand the scope of the entrepreneurship process, including but not limited to how ideas for new inventions are born, protected by intellectual property (such as patents, trademarks, copyrights, trade secrets), and are developed and evaluated for successful commercialization.
6.b Go-to-Market Evaluation Process	1. Process for supporting learners in developing increased customer empathy. 2. Identification of potential markets with accompanying research on market size, characteristics, and barriers to entry. 3. Process for evaluating the best approach to bring a given invention to market. 4. Identification of potential key performance measurements and selection of an appropriate business model.

Continued on back.

Sustainable Innovation (Continued)

Cluster Heading	Articulation
6.c Understanding Environmental Impact and Planning for Sustainability	1. Commitment to evaluating the environmental impact of each phase of the invention process, including problem solving, prototyping, material sourcing, production methods, disposal, and decomposition of component parts. 2. Exploration of inventions specifically designed to address issues relating to sustainability, such as those articulated in the Sustainable Development Goals.
6.d Support for Understanding Various Approaches to Intellectual Property	1. Age-appropriate overview of the concepts covered in learning modules related to the foundation of intellectual property creation, protection, and enforcement. 2. Description of how these modules will be integrated into the program in an age-appropriate manner, including utilizing existing inventions, research and/or intellectual property databases as inspiration for generating new ideas that can be developed into novel products and services. 3. Development of a plan for sharing, protecting, and/or commercializing the invention. 4. Description of how the program will support individual students interested in pursuing intellectual property protection, which could include understanding options such as Open Source. 5. Plans for recognizing those who file for as well as those who are granted formal intellectual property protection, e.g. a U.S. patent, U.S. trademark, U.S. copyright registration, or who fully publish Open Source.
6.e Economic Impact	1. Support for projections relating to the potential impact of an invention on various measures relating to economic activity.
6.f Next Step Planning and Support	1. Decision regarding student's specific intention to pursue further entrepreneurial activities and to go-to-market with a given invention.

Foundational Core for Implementations

Invention Education efforts will not fulfill full their potential without addressing the core questions of sustainability, equity, and inclusion. The following should be woven throughout the fabric of designing, implementing, or evaluating Invention Education programs.

Environmental Sustainability

The Invention Education community recognizes that human actions and the development of inventions have an impact on the environment. The Invention Education framework advocates to increase environmental responsibility and to inspire a sense of appropriate stewardship. While not all inventions are focused directly on issues relating to the sustainable development goals or the development of renewable energy, every invention should be evaluated for its net impact on our planet. The ideal scenario is for all inventions to have the smallest possible environmental footprint throughout the development process and beyond.

Diversity, Equity, & Inclusion

The Invention Education community fundamentally believes that every person can be an inventor and that as humans we are born with innate capacities to invent. It is incumbent on the Invention Education community of practitioners, funders, and policy makers to ensure that every learner has equitable access, and that historical and systemic disparities are addressed through intentional investments in underrepresented communities.

Invention Education is a unique engagement tool that has the potential to specifically serve underrepresented students through the belief advocated for by members of the community that everyone has the innate capacity to solve problems they directly see and experience. Many believe that this is best done through a learning approach that values and sees cultural differences as assets, and includes a direct focus on the contribution from diverse perspectives that is both inclusive and empowering.

The current efforts to take up Invention Education present an important opportunity to design for equity as practitioners increase student access to Invention Education experiences. In order to support problem identification, inventiveness, and entrepreneurial skills in all young people, however, it is critical that educators are engaged in the work of unlearning implicit biases and gaining more understanding of the systemic, interpersonal, and cultural barriers to participation for youth. The approach outlined in this framework can serve to advance equity and inclusion based on the

community's shared belief that:

1) The education system is stronger when more diverse voices and people are involved.
2) Inequalities in the status quo will continue unless the community deliberately seeks to discuss issues of equity and inclusion, and receives training and support on how educational systems can better address and undo existing disparities.
3) In order to widen access for youth from traditionally marginalized groups, the community needs to better understand existing systemic barriers, particularly those around intersectionality[13], and then take action to undo lingering effects of these inherited systems that prevent any group's full participation.
4) Educators who are working to embody equitable practices have a responsibility to explore how their lived experience, power, and privilege impact learning experiences they design or deliver.
5) The inherent potential and characteristics of Invention Education requires a deliberate approach to improving equity and inclusion as practitioners continue to explore and create best-practices for the field.

We recognize that invention aptitudes can either be nurtured through opportunities to engage directly in invention or atrophy through neglect. They can also be discouraged, either unintentionally or intentionally, and, tragically, sometimes as the result of prejudicial bias. In too many instances our current educational system often suppresses creativity and inventiveness in favor of rote learning and compliance; which appears to disproportionately affect lower socioeconomic communities. This focus contributes to documented disparities across race, gender, and socio-economic backgrounds. Creating meaningful opportunities for all youth to invent and apply entrepreneurial thinking to the identification of problems and solutions is of the utmost importance and benefit to both individuals and society as a whole.[14]

Invention aptitudes can either be nurtured through opportunities experiencing invention or atrophy through neglect.

[13] Intersectionality refers to situations in which there are two or more aspects of diversity present in a given situation. See Kimberlé Crenshaw, a law professor at Columbia (https://www.law.columbia.edu/faculty/kimberle-crenshaw) who has written and taught about intersectionality. The topic is talked about in fairly broad circles, and is making its way into more education conversations. An overview of intersectionality can be found here: Boston YWCA (2019). What is intersectionality, and what does it have to do with me? Retrieved February 17, 2019 from https://www.ywboston.org/2017/03/what-is-intersectionality-and-what-does-it-have-to-do-with-me/

[14] Bell, A. M., Chetty, R., Jaravel, X., Petkova, N., & Van Reenen, J. (2017). Who becomes an inventor in America? The importance of exposure to innovation (No. w24062). National Bureau of Economic Research. *National Bureau of Economic Research.*

Call to Action

We call upon individuals, organizations, and governments everywhere to make investments in our future and the future of our children by investing in

Invention Education.

Appendix:

Collaborators, Contributors, Interviewees, and Advocates

(Sorted alphabetically by last name)

- **Maya Ajmera**
  Society for Science & the Public
- **Lola Aleru**
  Global Minimum Inc.
- **Kate Anderson**
  Beyond Benign
- **Stephanie Bailes**
  The Cade Museum for Creativity and Invention
- **Gregg Behr**
  The Grable Foundation
- **Dawn Bowlus**
  Jacobson Institute, The University of Iowa
- **Danny Briere**
  The Henry Ford Invention Convention
- **Amy Cannon**
  Beyond Benign
- **Dwight Carr**
  Maryland MESA
  Johns Hopkins Applied Physics Lab
- **Cindy Cooper**
  The Lemelson Foundation
- **Kyle Cornforth**
  Maker Ed
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The Lemelson Foundation uses the power of invention to improve lives, by inspiring and enabling the next generation of inventors and invention-based enterprises to promote economic growth in the US, and social and economic progress for the poor in developing countries.

The Lemelson Foundation sees its role as a convener and collaborator in helping to create a new generation of inventors and problem solvers. Together with a growing community of individuals and organizations, The Lemelson Foundation works to support having every child experience Invention Education and develop the critical mindsets and skillsets to make change through invention.

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