Imagination in STEM:
A Synthesis of Lessons Learned through Research and Professional Convenings
Museum of Science, Boston (2022)

The Museum of Science, Boston received funding from the National Science Foundation to carry out a Conferences project exploring connections between research and practice at the intersections of imagination, STEM (science, technology, engineering, and mathematics), and ISL (informal STEM learning). The major focus of this project was a series of virtual convening events (held from September 8-17, 2021) that involved over 160 researchers, educators, and practitioners from ISL and K-12 institutions, academia, community-based organizations, arts and STEM industries, and governmental organizations. Through a systematic literature review, professional survey, compilation of project exemplars, a series of three virtual panels and four virtual workshops, and in-person dissemination efforts (e.g., conferences), this project built and shared knowledge among professionals in ISL and contingent fields. Project activities synthesized what is known about how imagination is defined in STEM, its role in STEM education and practice, and strategies to foster imagination in STEM.

The project resulted in several products, including Convening Proceedings, resources describing results from the Literature Review (an Executive Summary, a Framework for Defining Imagination in STEM, and resources summarizing Imagination's Role in STEM, Imaginative Ways of Thinking, and Strategies for Supporting Imaginative Thinking), a report of survey results describing Professional Perspectives on Imagination in STEM, a Project Index, and a professional impacts report. Products are available at the project's page on InformalScience.org. As of December 2022, the team has also disseminated results at two professional conferences: the 2022 Association of Science and Technology Centers Conference (May, Fyler, et al., 2022) and the 2022 Association of Children's Museums Conference (May, Folks, et al., 2022).

The project's activities fostered cross-sector conversations about the role of imagination in STEM, prepared and disseminated products intended to help professionals take action from such conversations, and identified areas for future collaborative efforts that might leverage research-based knowledge about imagination to improve STEM outcomes in ISL. These efforts confirmed that intentionally attending to imagination in ISL experiences has the potential to improve STEM education, impact public perceptions of STEM as imaginative, and shift individual learners' ideas about their own relationship with and place within STEM. However, project activities also indicate there is much work to be done to achieve these ends. In synthesizing what was learned, the team identified several key "imagination problems" worthy of future exploration.

Problem Areas & Key Findings:

Defining Imagination: Imagination's scope is potentially too large, scattered, and unfocused to be leveraged productively. Through compiling and categorizing definitions of imagination from our literature review and professional survey, we found that imagination has been defined in a potentially overwhelming number of ways. However, through our work we were able to develop an organizational framework for developing and categorizing more actionable definitions, breaking them up based on their essence (what imagination is), ways of thinking (the processes that take place when imagination is happening), and contexts (where imagination emerges or is oriented).

Intentionally Addressing Imagination: Imagination is often essential, but not often enough intentional. Convening participants at our workshops indicated that in many of their projects, imagination is often essential to the work, but not necessarily intentionally addressed. Relatedly, through our survey we found that professionals are curious about and comfortable with addressing imagination in their work, but are not all purposefully doing work that addresses imagination. Further, through the course of our literature review, we found many articles and pieces of literature that addressed imagination in some ways, but did not include it as an explicit focus of the work.

Fostering Imagination: There is a lack of awareness or implementation of strategies that foster imaginative thinking. In the survey and through workshops, we often heard the same related questions: *How can we foster imagination? What strategies work to encourage imaginative ways of thinking?* While some studies we reviewed did embed experimental methods to measure strategies to foster imagination, most work has been descriptive or theoretical. By summarizing some of these strategies emergent in our literature review and by producing a Project Index, we aim to spark new conversations and work to explore these strategies and apply them in future initiatives.

Addressing the Myth that STEM is Not Imaginative: The myth that "*imagination is not a critical resource for STEM*" impacts practice. Few professionals believed this myth when they rated their agreement with this statement in the survey. Nearly everyone agreed that it is important to communicate publicly that STEM is imaginative. But in workshops and conversations, people repeat this myth – that there might be something about the word *imagination* that feels too fuzzy or soft, that we should use other words instead (like hypothesizing or visualizing). By maintaining this perspective, by backing down on our visceral beliefs in the importance of imagination, how might we be perpetuating this myth?

Buying-in to Imagination in STEM: It is difficult to gain buy-in that imagination is worth prioritizing. Survey and workshop participants reflected on the difficult nature of trying to gain buy-in to address imagination in their work in meaningful ways. For example, in the survey, some wanted "proof" through the ability to measure imagination or describe its outcomes (like how imagination impacts learning or other outcomes). Future work should continue to explore these metrics, but we also argue that imagination can be affirmed in learners *in its own right*.

(Un)-Privileging Certain Imaginative Ways of Thinking: Certain imaginative ways of thinking have historically been privileged over others that might be as important or impactful. Through our literature review and professional survey, we found a very large number of "imaginative ways of thinking" that are addressed in STEM contexts. Some ways of thinking emerge more often than others, which could indicate that certain kinds of ways of thinking are privileged over others. For example, in our Project Index, we discovered that across a range of exhibits, programs, research studies, and in- and out-of-school time projects, "problem solving" emerged as a common imaginative way of thinking, while "moral thinking" was less common. How might ISL contexts benefit from addressing less emphasized or less common imaginative ways of thinking?

Inclusion and Imagination: Individual, institutional, and societal barriers exclude some from *being able to freely* imagine, to *feel* imaginative, or to *be perceived as* imaginative. Our survey showed that people want to leverage the imaginative nature of STEM to broaden participation. Some of the literature we reviewed suggested that there are historically-built barriers to break down in order to fully see all learners as imaginative. Further, some of our workshop participants indicated that they feel there is privilege built around who gets to imagine or not. Excitingly, several entries in our Project Index explicitly address inclusion and equity and how imagination can shift practices and perspectives in these areas.

Conclusion and Thoughts on Future Work

Through this work, we have come to understand the state of imagination in STEM and ISL contexts, and we want to posit some areas for future work. Imagination can be overlooked or only passively acknowledged in STEM practice, and there can be limited buy-in for leveraging imagination in STEM education. Even when imagination is conjured, learners are not always equipped to engage with it. Equipping learners (both members of the public *and* professionals) to identify STEM as imaginative – and *themselves* as imaginative – has the potential for great impact in STEM education. Future research and development on the role of imagination in STEM should address any of the problem areas posed above if we are to embrace the power imagination holds.

References

InformalScience Project Page: https://www.informalscience.org/conference-interdisciplinary-perspectives-imagination-informal-stem-environments

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