Tinkering in STEM Education

Overview

As high-stakes testing and rote memorization command a disproportionate amount of time in schools—particularly in schools with students from low-income communities and communities of color—tinkering offers educators a playful, collaborative, and inquiry-based approach to engaging youth in STEM-rich learning. Tinkering places a low barrier for exploring STEM phenomena because projects use everyday materials, educators welcome playful and collaborative designs, and the whole community can connect everyday interests and experiences from in-school and out-of-school environments in surprising and unexpected ways. Encouraging creativity and critical thinking in STEM education can happen in many ways and tinkering provides a powerful venue to support imaginative and diverse ways of engaging with STEM phenomena and practices.

Learning Goals

The persistent problem we explore in this collection is how to create imaginative and open-ended STEM-rich tinkering experiences in classrooms and afterschool settings. The first brief defines tinkering and reviews the literature on learning through tinkering. The next three briefs discuss case studies of learning through tinkering. The Blikstein brief reviews the history of science and engineering education through fabrication and discusses how tinkering and making can be implemented within school setting. The Vossoughi et al. brief explores the dimensions of equitable afterschool STEM-rich tinkering including the importance of teaching, noticing with students, and pedagogically connecting ideas from tinkering to home practices and school practices. The Petrich et al. piece outlines the design and research principles associated with creating a tinkering space on the museum floor. The final brief provides educators with a theoretical basis for supporting tinkering-based collaborative projects and STEM inquiries that promote hybrid language practice, multiple ways of knowing, and multiple pathways into design processes.

Research about TINKERING IN STEM EDUCATION

(Visit the links below to see a two-page brief of each summarized research article.)

1 An Overview of Learning through Making and Tinkering

Vossoughi and Bevan conducted a literature review of educational research on making and tinkering. Specifically they reviewed the historical roots of making, the emerging design principles that characterized tinkering and making programs, the pedagogical theories and practices that lead to supportive and collaborative learning environments, as well as the possibilities and tensions associated with equity-oriented teaching and learning. This brief provides a definition of tinkering and an overview of what is known about learning through tinkering.

http://www.exploratorium.edu/sites/default/files/pdfs/brief_OverviewOfLearning.pdf

2 How "Making" Projects can Promote Deep Learning

Blikstein et al. review the history of science and engineering learning through fabrication and then discuss how to design fabrication spaces within school settings. The field of informal science education has embraced "making" and design activities as a powerful approach to engaging learners, but questions remain about how such programs support deep STEM learning. This paper provides theoretical background and concrete cases that illuminate program design and implementation issues related to making.

http://www.exploratorium.edu/sites/default/files/pdfs/brief_MakingProjects.pdf

3 Tinkering, Learning, and Equity in an Afterschool Setting

This paper draws on ethnographic data to bring equity to the fore within discussions of tinkering and making. Vossoughi,Escudé, Kong & Hooper argue that equity lies in the how of teaching and learning through specific ways of: designing making environments, using pedagogical language, integrating students' cultural and intellectual histories, and expanding the meanings and purposes of STEM learning. The authors identify and exemplify emergent equity-oriented pedagogical principles within an afterschool tinkering program that predominantly serves African American, Latino/a and Asian-American youth (K-12) from low-income, marginalized communities.

http://www.exploratorium.edu/sites/default/files/pdfs/brief_TinkeringLearningEquity.pdf

4 Having Fun and Learning through Tinkering

Petrich et al. explore three areas of design principles related to tinkering in a museum setting: activity design, environmental design, and facilitation practices. The authors detail their approach to supporting a tinkering environment and connect these principles to conceptions of learning in general and engineering practices more specifically.   This paper provides a detailed illustration of design choices in the creation of tinkering programs and spaces.

http://www.exploratorium.edu/sites/default/files/pdfs/brief_HavingFun.pdf

5 Rethinking Learning with Hybrid Language Practices

Tinkering dispositions can be built in multiple kinds of settings, however, educators and students need to be able to have fluid activities where multiple ways of knowing can inform each other. Gutiérrez et al. describe how teachers can engage children's talk and welcome diverse activities and linguistic practices to deepen learning and participation. This article explores how teachers allow students to offer local knowledge, reorganize activities, and make meaning that can connect to the official curriculum in unexpected ways. These nuanced pedagogical practices should help new educators consider how facilitation and fluid language practices could shift students' engagement and experience with STEM-rich tinkering.

http://www.exploratorium.edu/sites/default/files/pdfs/brief_RethinkingLearning.pdf

WHAT DO YOU THINK?

How do the briefs define tinkering and making? In addition to playing with familiar and complex materials, what are some other important aspects of creating rich learning environments for tinkering?

Discuss how to support young people take intellectual risks, create original projects, and make creative connections to other settings like home, school, etc.

Discuss how educators can more explicitly connect the science students experience in tinkering projects without diminishing their playful inquiries.

How can tinkering support more equitable learning environments in STEM education? What are the challenges?

RELATED RESOURCES

Learning STEM Through Design: Students Benefit from Expanding What Counts as "Engineering"
http://stemteachingtools.org/brief/7

Making and Tinkering: A Review of the Literature
http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_089888.pdf

Equity in Out-of-School STEM Learning
http://www.exploratorium.edu/sites/default/files/pdfs/IG_Equity_Final_Report.pdf

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