Using Design-Based Research to Develop and Disseminate Strategies and Materials to Support STEM Interest, Relevance, and Self-Efficacy

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Design strategies framework overview

CONTENT STRATEGIES Content should include:	FORMAT STRATEGIES Format should:	OUTCOMES / IMPACTS Public participants will have:
• Applications or uses • Chemistry concepts • Connections across STEM topics • Connections to everyday life	• Allow for experimenting with variables • Allow for observation of phenomena • Allow for use of tools and materials • Be hands-on and interactive • Evoke familiar experiences	increased **interest** in the field of chemistry
• Applications or uses • Chemistry concepts • Connections across STEM topics • Connections to everyday life • Societal issues	• Allow for observation of phenomena • Allow for use of tools and materials • Evoke familiar experiences	increased understanding of the **relevance** of the field of chemistry to their lives
• Chemistry concepts • Connections to everyday life	• Allow for experimenting with variables • Allow for observation of phenomena • Allow for use of tools and materials • Be hands-on and interactive • Be simple to do and easy to understand • Evoke familiar experiences	increased feelings of **self-efficacy** about chemistry (ability to do chemistry activities and participate in converstaions about chemistry)

Note: The strongest factors in stimulating specific outcomes are highlighted by boxes in the table above.

Facilitation framework overview

Invite Participation	Support Exploration	Deepen Understanding
• Provide an introduction or activity overview • Introduce and model tools • Build rapport with participants • Learn what participants have experienced or know about chemistry • Encourage everyone to participate • Aid in transitions between different portions of an activity • Encourage participants to stay, but give them the option to stop	• Offer positive feedback • Provide basic information and vocabulary • Give step-by-step instructions • Ask participants to make observations and predictions • Encourage iteration and continued experimentation	• Describe why or how something is happening • Provide information and support making connections beyond the activity • Encourage participants to apply something they learned during the activity • Encourage participants to explain why or how something is happening

Public learning outcomes:
Positive attitudes towards chemistry, including:

- Increased **interest** in the field of chemistry
- Increased understanding of the **relevance** of chemistry to their lives
- Increased feelings of **self-efficacy** about chemistry

The starting Facilitation framework was adapted from work by the Exploratorium in their Tinkering Studio maker space

While this research focused on chemistry, the findings can be applied to STEM topics more broadly, including nanomanufacturing. The findings are summarized in frameworks for designing and facilitating educational activities in informal settings with public audiences.

Museum of Science collaborated with American Chemical Society, National Informal STEM Education Network, Science Museum of Minnesota, Sciencenter, and University of Wisconsin-Madison to conduct design-based research to develop strategies for stimulating **interest, sense of relevance, and feelings of self-efficacy.**

Research subjects were general public museum visitors in Boston and St. Paul, mostly in mixed generational groups including children eight years old or older, and adults online.

Testing found [1] that:

- **using hands-on and interactive methods of engaging audiences is the strongest strategy for stimulating interest and feelings of self-efficacy.**
- **connections to everyday life is strongest at stimulating a sense of relevance, more so than addressing broad societal issues.** [This proved true for the UWisc-Madison online adult public audience as well as for the in-museum audience.[2]]

While the research focused on hands-on chemistry activities, the framework strategies found to be successful are broad. Learner activities encouraged may be **as important for engaging young learners in finding interest, relevance, and feelings of self-efficacy with nanomanufacturing as they are for chemistry.**

Links to training and professional development resources for informal educators and researchers doing public outreach are here: **https://www.nisenet.org/chemattitudes**

1. Anderson, A., Kollmann, E.K., Beyer, M., Weitzman, O., Bequette, M., Haupt, G., & Velázquez, H. (2021). Design strategies for hands-on activities to increase interest, relevance, and self-efficacy in chemistry. Journal of Chemical Education, 98(6), 1841–1851. DOI: 10.1021/acs.jchemed.1c00193

2. Howell, E., Yang, S., Holesovsky, C., & Scheufele, D. (2021). Communicating chemistry through cooking & personal health: Everyday applications increase perceived relevance, interest, & self-efficacy in chemistry. Journal of Chemical Education, 98(6), 1852–1862. DOI: 10.1021/acs.jchemed.1c00125

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