Perspectives on Solution Diversity and Divergent Thinking in K-12 Engineering Design Learning Experiences

Kristen Wendell, Tufts University
Aaron Johnson & Chris Rogers, Tufts University
Ethan Danahy, Tufts University
Christine Cunningham, Museum of Science Boston
Megan Wongkamalasai & Richard Lehrer, Vanderbilt University
Jennfier Chiu, University of Virginia

Award 1253344 & 1623910

Tufts UNIVERSITY | Center for Engineering Education and Outreach

Solution diversity

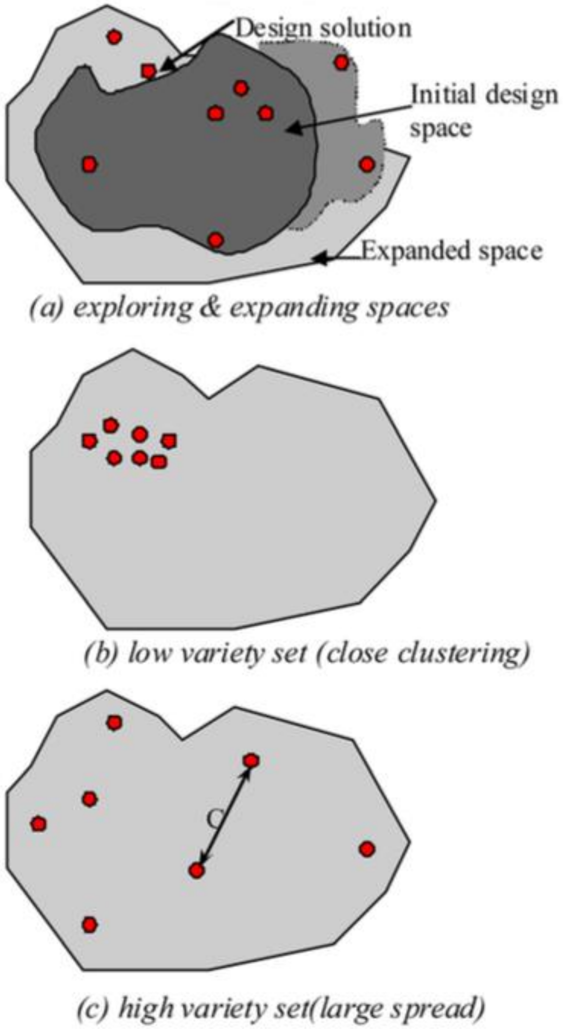
Multiple, meaningfully different solutions created by multiple designers or design teams for a single design problem;
A diverse set of outcomes to a common task

Divergent thinking

Cognition that broadly explores the design space and generates alternative solutions
(Crismond & Adams, 2012; Shah, Millsap, Woodward, & Smith, 2012)

Conceptual Blockbusting (Adams, 1986)
Lateral Thinking (de Bono, 1970)
The Complete Problem Solver (Hayes, 1989)
Experiences in Visual Thinking (McKim, 1980)

Diversity of solutions by design practitioners



Idea Fluency

An “abundance of ideas”
(Crismond & Adams, 2012)

Flexibility

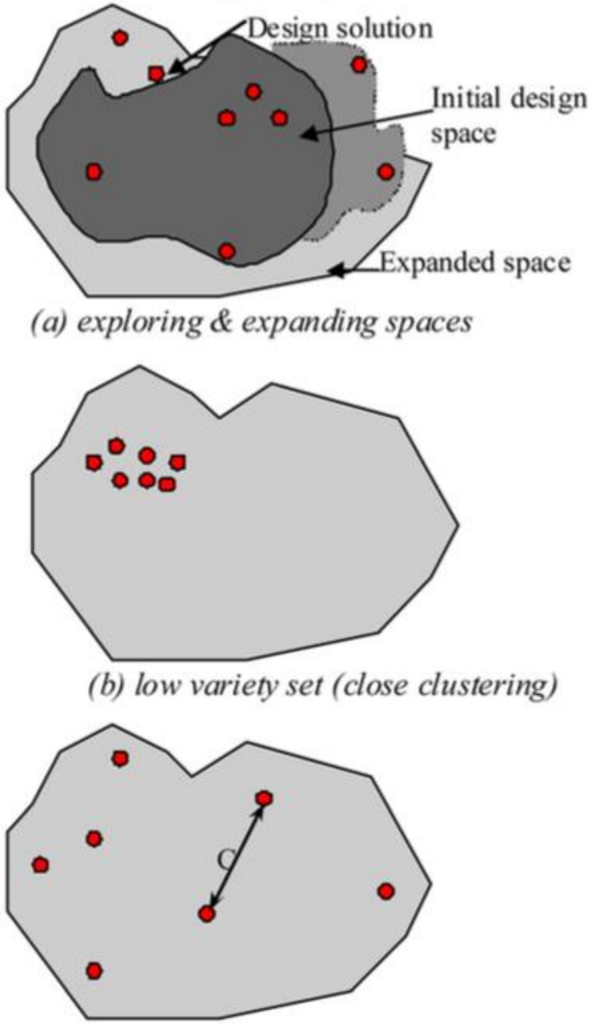
Variety in the categories being explored; distance between points in a design space
(Shah et al., 2012)

Originality (Novelty)

Consideration of solutions not originally perceived to be in the design space
(Shah, Smith, & Vargas-Hernandez, 2003)

Solution diversity among multiple design teams

Divergent thinking by an individual



(a) exploring & expanding spaces

(b) low variety set (close clustering)

(c) high variety set(large spread)

Why value solution diversity in K-12 engineering design?

In a K-12 classroom, what are the benefits of having a range of successful solutions to the same design problem? (And how much "conceptual distance" between solutions is necessary?)

→ A question for discussion in this session!

- To support a distributed cognition or knowledge-building learning environment?
- To generate productive between-team discourse?
- More productive disciplinary engagement?
- Students seeing their peers as a more legitimate audience for share-outs and critiques?
- More opportunities for reasoning about mechanisms?
- More phenomena to explore and mathematize?

Agenda

- 5-minute introductions to the projects and posters (~25 min)
- Small group discussion of projects with focus questions (~20 min)
- Assemble new small groups, report, and continue discussion (~20 min)
- Reflections by our discussant, Ethan Danahy, and final Q & A with presenters (~20 min)

Guiding questions

In what ways do researchers, teacher collaborators, or students value a diverse set of solutions to design problems? What does "solution diversity" look like in K-12 engineering experiences?

How does valuing solution diversity influence assessment, teacher professional development, and the design of instructional strategies and scaffolds?

Focus questions for small group discussions

TRADE-OFFS

Why and when would solution diversity NOT be desirable in a K-12 engineering experience?

What are the pros AND cons of developing and implementing engineering projects that generate/support students' solution diversity?

ASSESSMENT

How do you assess learning when each student team designs a different solution?

Where in K12 education is solution diversity already flourishing (e.g., fine arts)? What might engineering education learn from this?

Is solution diversity a measure of success?

DIMENSIONS

How can we characterize what solution diversity looks like during a K-12 engineering experience?

What are the dimensions of diverse solutions?

What makes two different ways to solve a design problem "diverse," or divergent?

TEACHER DEVELOPMENT

What professional development experiences or strategies help teachers prepare to facilitate solution diversity during engineering projects?

What do teachers need to know, do, and learn with respect to supporting solution diversity?

What instructional scaffolds are needed?

A thought exercise

Think of a familiar hands-on “making” task that is close-ended or well-structured, such that there is not much meaningful difference among different students’ creations? (e.g., mousetrap car kit, soda bottle rockets, solar-powered toy car)

Try to adapt that task into a more complex, ill-structured (Jonassen, 2006) problem that would allow for diversity of solutions across a class of students. What would need to be changed about the task, the context, the materials provided, the pedagogy of posing the task, etc.?

Presenters

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Discussant: Ethan Danahy, Tufts University