

A Student Groupwork Spectrum for Engineering Design Collaboration

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Dr. Katey Shirey's work stems from her combined interests in science, art, and education. Dr. Shirey graduated from the University of Virginia with bachelor's degrees in physics and sculpture. She received her master's in secondary science education, also from Virginia, and taught Physics at Washington-Liberty High School in Arlington, VA. Dr. Shirey received her Ph.D. in 2017 from the University of Maryland in Curriculum and Instruction with a focus on teacher challenges and productive resources for integrating engineering design into high-school physics. Through her work as a Knowles Teacher Initiative Senior Fellow and founder of eduKatey, Dr. Shirey helps high-school science and math teachers leverage engineering-design instruction for content learning and increased student problem-solving agency.

A Spectrum of Engineering Design Groupwork Options

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Engineering design teams are a hallmark of learning to engineer¹, but students working in the online space may perceive groupwork to be more difficult than in person². High-school teachers working in online and hybrid spaces need distributed groupwork options that will engage students in collaboration to develop cooperative skills. The Engineering Group Work Spectrum was developed drawing from diverse real-world collaborations. The Spectrum offers seven tiers of student interdependence from complete interdependence (a “three-legged race”) to completely independent work. The purpose of this spectrum is to provide practical choices for teachers to continue to use groupwork in engineering design instruction even as normal classroom routines and settings are disrupted by distance learning online or socially distanced learning in the classroom.

THE ENGINEERING GROUP WORK SPECTRUM		
From more to less dependence on other group members		
Level of Dependence	Group Work Practice	Example
MORE DEPENDENT	WE MAKE ALL DESIGN DECISIONS AND PROJECT PROGRESS TOGETHER. IT'S A 3-LEGGED RACE.	ALL HANDS ON THE SAME TASK AT THE SAME TIME. WHEN ONE PERSON IS MISSING, ALL PROGRESS STOPS.
	WE WORK TOGETHER & SUPPORT EACH OTHER ON ONE DESIGN WITH SOME DISTRIBUTION.	USING GROUP ROLES i.e., "DRIVER AND NAVIGATOR" IN PAIR CODING
	WE TAKE UP VARIOUS INDIVIDUAL STAGES OF ONE DESIGN AND COMPILE AT THE END.	FABRICATING PIECES OF A ROVER THEN ASSEMBLING
	WE CREATE A SUITE OF DESIGNS THAT COHERE IN A GROUP-CREATED VISION.	RESTAURANT WARS MENU, COHESIVE PRODUCT COLLECTIONS
	WE CO-CONSTRUCT THE PROBLEM DEFINITION AND SUPPORT ONE ANOTHER TO INDIVIDUALLY MEET OUR INDICATORS OF SUCCESS IN SEPARATE DESIGNS.	YOUR SUCCESS IS MY SUCCESS I.E., SPRINTERS TRAINING TOGETHER
LESS DEPENDENT	WE UNDERSTAND EACH OTHER'S GOALS AND CRITIQUE ONE ANOTHER'S INDIVIDUAL DESIGNS.	PEER CRITIQUE OR FISHBOWL IN DESIGN REVIEW
INDEPENDENT	STUDENTS WORK ALONE WITHOUT ASSISTANCE FROM PEERS.	INDIVIDUAL DESIGN PROJECTS AS SUMMATIVE ASSESSMENT

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¹ Dym, C. L., Agogino, A., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering design thinking, teaching, and learning. *Journal of Engineering Education*, January, 103–120. <https://doi.org/10.1109/EMR.2006.1679078>

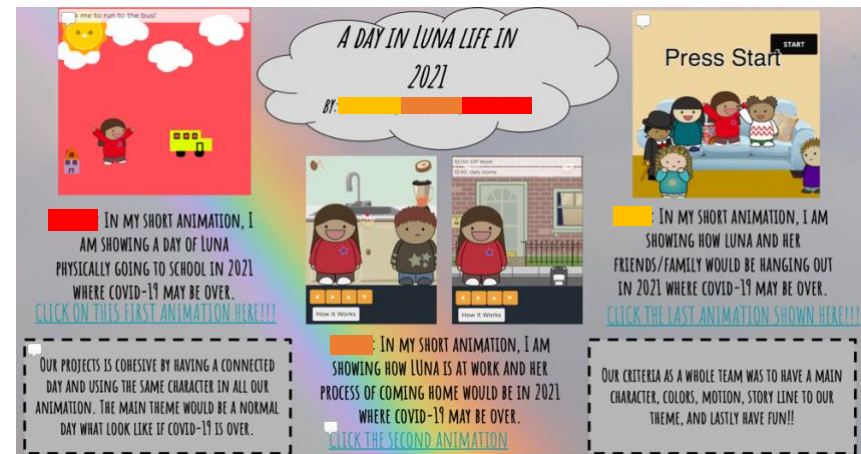
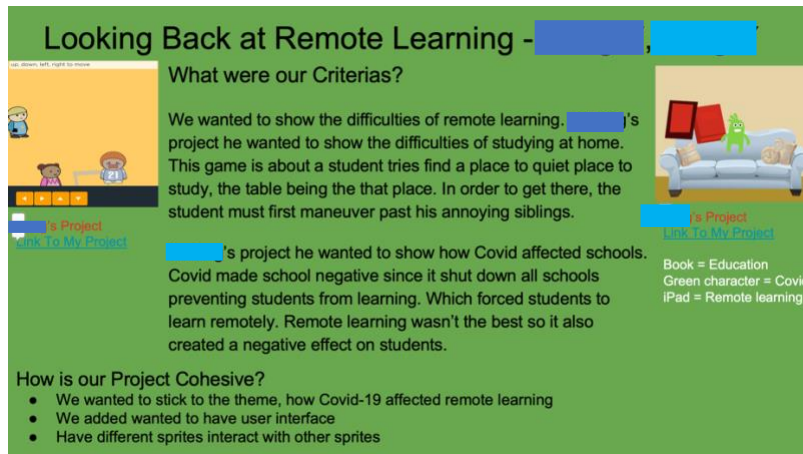
² Koh, M. H., & Hill, J. R. (2009). Student perceptions of groupwork in an online course: Benefits and challenges. *International Journal of E-Learning & Distance Education/Revue Internationale Du e-Learning et La Formation à Distance*, 23(2), 69–92.

EXAMPLE: Cohesive Collections of Coded Personal Reflections

The fourth line in the spectrum is: “We create a suite of designs that cohere in a group-created vision.” Examples of discrete designs cohering to one vision include fashion collections, an artist’s body of work, a coherent restaurant menu made up of various chef’s creations such as in *Top Chef’s Restaurant Wars*, or an advertisement campaign. This option is nicknamed, “Cohesive Collections.”

This approach was piloted in an online summer camp for low-income first-generation students during the summer of 2020 (47 rising 9th to 12th graders from two Midwest states, three teachers across the country, meeting synchronously one hour per day for 10 days). Students were tasked with coding apps and games to describe their personal experiences in 2020 or an optimism for 2021. This option was chosen so that students could cooperate in learning about engineering design and coding, but code individually from home.

Each group was collectively responsible for defining a single design problem by coming to consensus on their stakeholders, criteria, and constraints. Each student produced an individual coded design evaluated individually for meeting the project and the group’s stated requirements. Each group presented together and was evaluated for coherence among the designs and articulation of themes.



AFFORDANCES

- Students shared personal feelings in individual designs.
- Students thought deeply about problem definition with other students.
- Assessment boundaries between individual and group work were clear and easy to assess.
- The method gave “hope for pandemic group work” to a participating educator.
- “The coding assignment it was a fun way to cooperate it into our learning”

LIMITATIONS

- Thematic unification was weak (e.g., topic, colors, actions.)
- Seven students chose to work alone.
- There was no other option for student expression besides coding made available.

