Supporting Teachers in Responsive Instruction to Develop Expertise in Science (STRIDES)

Poster presented at 2021 DRK-12 PI Meeting

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STRIDES Progress

The **STRIDES** project uses state-of-the-art technology and **natural language processing** (NLP) models to provide teachers with detailed evidence of students' progress in achieving the multi-dimensional proficiency called for by the **Next Generation Science Standards** (NGSS). The **Teacher Action Planner** (TAP) in the STRIDES web-based curriculum environment presents **patterns in students' evolving understanding in real time** and provides research-based activities for the teacher to respond to students' ideas. **STRIDES professional development** activities guide teachers to **customize the curricula** to address diverse students' evolving ideas. Project video

- 7 inquiry units: Genetics of Extinction, Musical Instruments, Plate Tectonics, Thermodynamics, Photosynthesis, Global Climate Change, Solar Ovens
- 9 embedded assessments with associated Teacher Action Plan (TAP)
- 5 embedded assessments with TAP in development
- 23 teachers participating in professional development courses

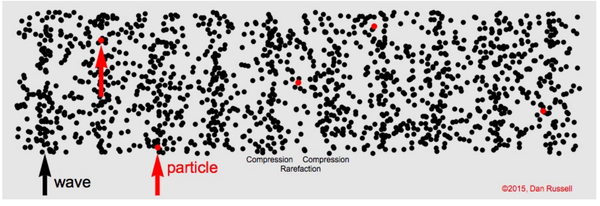
STRIDES Unit: Musical Instruments and Physics of Sound Waves

Unit design follows **Knowledge Integration (KI)** pedagogy:

Elicit student ideas, guide students to **discover** new ideas, encourage students to **distinguish** between prior and newly discovered ideas, and support students to **reflect on and connect** ideas.

Hands-on experimentation: Design a water xylophone

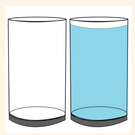
Students design, build, and experiment with a water xylophone to explore pitch and volume, how sound is created, and how sound travels. They use models and drawings to connect these ideas with ideas about wavelength, frequency, and amplitude.



Students explore how sound is vibrations and how vibrations travel through a medium. Students often have the idea that sound travels with the wave. This animation helps them discover that vibrations displace particles.

Scoring Embedded Assessments to Inform Teachers in Real Time + Creating Summaries to Guide Customizations

Embedded Assessment: Frequency



Arlene has two glass cups. She leaves one empty and fills the other one with water. She then uses a chopstick to gently strike each glass. What will she hear?

- There is no change; the pitch stays the SAME.
- The pitch of the tapped full glass is LOWER than the pitch of the tapped empty glass.
- The pitch of the tapped full glass is HIGHER than the pitch of the tapped empty glass.

Explain why you think the pitches of the sound waves generated by striking the two glasses will be the same or different.

Natural Language Processing (NLP) Model

- Item assessed on 3 dimensions: KI + NGSS sub-scores
- **c-rater** model: trained on 1313 human coded responses
- Human coder agreement (10% of the material): Cohen's Kappa DCI = .8; CCC = .8; KI = .7
- Human-machine agreement: Quadratically-weighted kappa (QWK) = .76 for DCI; .73 for CCC; .76 for KI
- Automated scoring model implemented in curriculum unit assesses student responses in real time

Scoring Rubrics (NGSS Performance Expectation: MS-PS4-2)

DCI: Wave properties
How properties of a sound wave (frequency, wavelength) correspond to an observable phenomenon (pitch)

1	No or incorrect conclusion about pitch or frequency or how pitch and frequency relate
2	*Emerging understanding:* Accurate conclusion about pitch or frequency
3	*Full understanding (2 linked ideas):* Accurate link between pitch and frequency in either the full or empty glass

CCC: Structure & function
How these properties are affected when the wave interacts with an object or material

1	Difference of material/ medium or mass is not mentioned or inaccurate Mechanism is inaccurate or not mentioned
2	*Emerging understanding:* Differences of material/ medium are explained (density, mass/volume) Accurate mechanism is described: full glass is more difficult to vibrate
3	*Full understanding (2 linked ideas);* Linking either density, mass, volume, pitch

Knowledge Integration: Linking DCI and CCC ideas

	Descriptor	Category of Response
1	I don't know or off topic	Off topic, blank, repeats prompt, or "I don't know"
2	Irrelevant, inaccurate or vague	*Inaccurate mechanism* (water blocks sound, less space to move in glass with water, etc.) *Inaccurate conclusion* (pitch is lower in empty glass; sound is louder or confusing pitch and volume, etc.)
3	Partial link: 1 accurate idea	*Accurate mechanism only* (water is denser than air, water is harder to vibrate, etc.) *Accurate conclusion only* (pitch is lower in glass with water, frequency is higher in empty glass, etc.)
4	Full link: 2 linked accurate ideas	Accurate conclusion about pitch linked to accurate idea about mechanism or property of sound wave
5	Complex link: 3 or more linked accurate ideas	Accurate conclusion about pitch linked to two accurate ideas about mechanism or property of sound wave

Accurate idea about pitch, DCI = 2

"the pitch of a full glass is lower because it is more dense, and harder for the sound to vibrate."

Holistic score KI = 5 because 3 ideas are linked

Linking density of the medium and vibrations, CCC = 3

Design and Test of the Teacher Action Plan (TAP) for Real-Time Use

Participants:

- One teacher, two 6th grade classes, 56 students
- School serving predominantly Hispanic students (94%),
- 74% qualify for free lunch

Results:

Are the DCI and CCC distinct?

- Initially they are slightly correlated (r = .26, p = .049). After instruction, they are more integrated (r = .5; p < .001).

What does the TAP reveal & How did the teacher respond?

- Students had accurate ideas about pitch; were confused about how sound travels.
- Teacher found the TAP informative: *"Last year without report, right before they made the water xy, felt pretty scattered what the students understand and nobody understood it all, was less clear what exactly they did not understand"*.
- Recommended actions aligned with the teachers' practice.
- Teacher designed **hands-on sorting activity** to help distinguish ideas about how sound waves travel through different media.

What progress did students make?

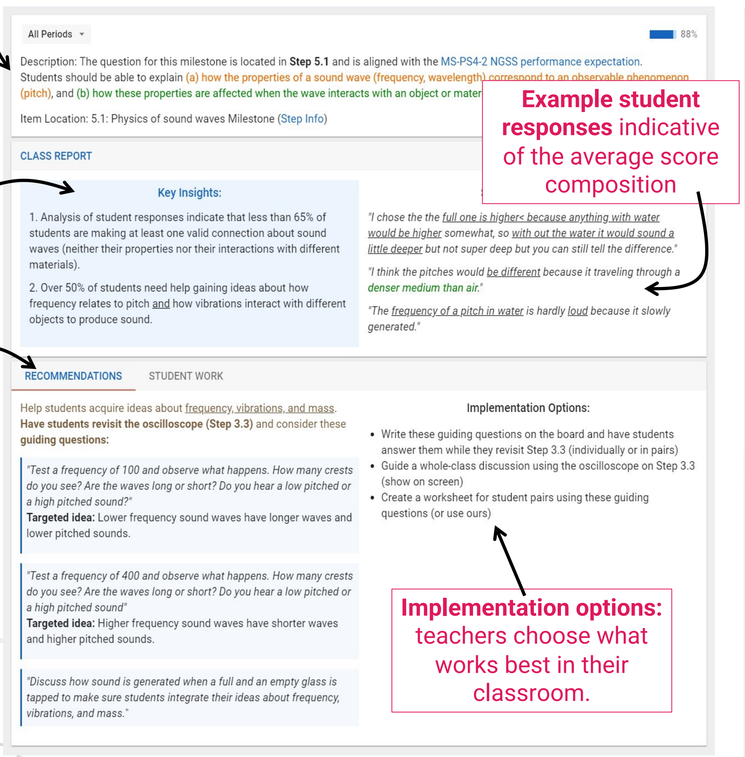
- Paired samples t-Test with initial KI score (before instruction) and revised KI score (after instruction) as the two measurements.
- Prior to TAP, students had incomplete understanding (M = 2.71, *SD* = 0.89). After TAP, they had more integrated understanding (M = 3.30, *SD* = 1.13); $t(55) = 5.45$, $p < .001$, $d = .73$, 95% CI for Cohen's d [0.48, ∞]. However, prior knowledge seems to explain this difference: One-way repeated measures ANCOVA (initial KI, revised KI and prior KI as control variable) indicated $F(1,49) = 0.50$, $p = .484$, $\eta^2_p = 0.01$.
- Students' understanding from before to after the unit improved: paired samples t-Test with prior KI (pretest score) was *M* = 2.37 (*SD* = 0.46) and post KI (posttest score) was *M* = 3.36 (*SD* = 0.75); $t(49) = 11.63$, $p < .001$, $d = 1.65$, 95% CI for Cohen's d [1.28, ∞].

Embedded assessment prompt and NGSS alignment

Key Insights: written overview of the class' average understanding

Recommended actions suggest an activity with implementation options. Adaptive based on analytics from the classroom; target ideas students are confused about.

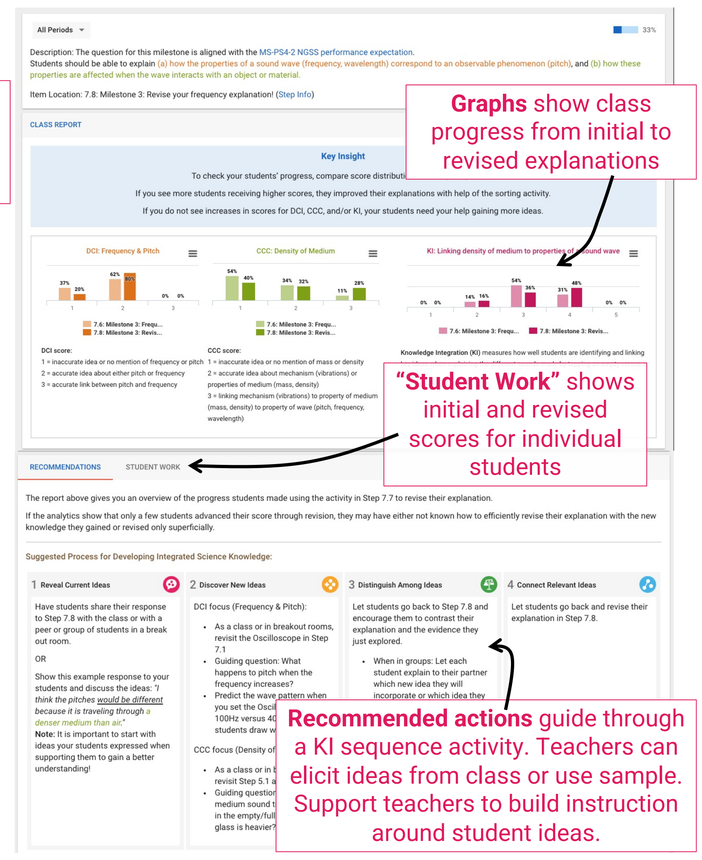
Initial TAP Design



Example student responses indicative of the average score composition

Implementation options: teachers choose what works best in their classroom.

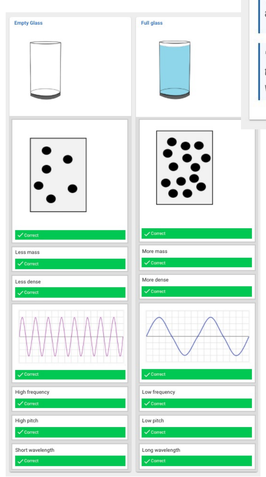
Revised TAP Design



Graphs show class progress from initial to revised explanations

"Student Work" shows initial and revised scores for individual students

Recommended actions guide through a KI sequence activity. Teachers can elicit ideas from class or use sample. Support teachers to build instruction around student ideas.



Teacher designed support activity:

- Discover ideas in unit
- Write initial milestone explanation
- Sorting task to distinguish ideas
- Revise explanation

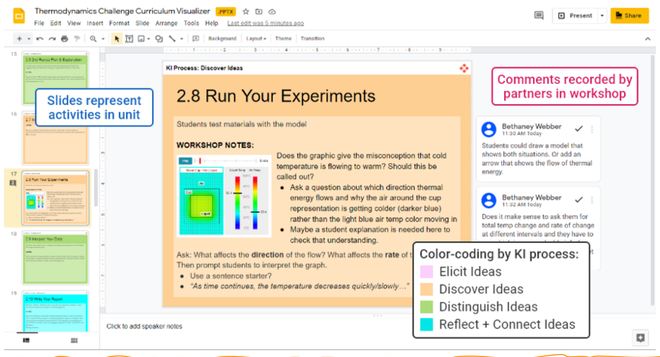
We implemented a digital version of this sequence during remote instruction because of COVID-19.

"I think that first time I didn't really even look that much at the numbers scores I just looked at the overall patterns as a class but I think in the second report the individual scores are super helpful so I can think more about it in terms of intervention who are students that I need to just have a conversation with and say like but I thought you can tell me more about and like just push their thinking 'cause for some of these 2's I think that's what it is."

Curriculum Customizations During Professional Development Courses

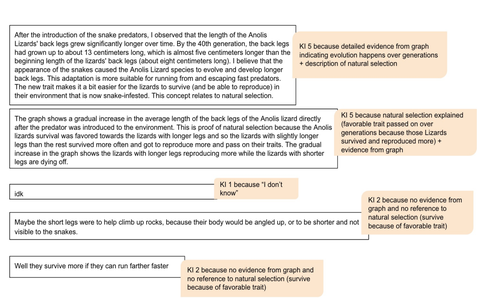
- During PD, teachers use the TAP and additional logged student work to plan customizations to refine the unit.
- They explore the **KI rubric** to deepen their understanding of the impact of their guidance and the unit.
- They use **Curriculum Visualizer** to plan customizations.

Curriculum Visualizer



- Each slide represents an activity. Teachers can view full curriculum or zoom in to customize.
- Tool makes it easy to reorder, add, or remove activities or lessons.
- Color-coded slides indicate the KI process activities support. Helps to reflect on the sequence of activities, identify which over- or underrepresented processes.

Review of Student Work



- Teachers categorize small sample of student responses using the KI rubric.
- Compare their scores to those of a trained scorer.
- Sparks discussion of NGSS assessments among teachers and researchers.

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- Bichler, S., Gerard, L., Bradford, A., & Linn, M. C. (2021). Designing a remote professional development course to support teacher customization in science. *Computers in Human Behavior, 123*, 106814. https://doi.org/10.1016/j.chb.2021.106814
- Gerard, L., Wiley, K., Bradford, A., Chen, J. K., Lim-Breitbart, J., & Linn, M. (2020). Impact of a Teacher Action Planner that Captures Student Ideas on Teacher Customization Decisions. In Gresalfi, M. and Horn, I. S. (Eds.), The Interdisciplinarity of the Learning Sciences, 14th International Conference of the Learning Sciences (ICLS) 2020, Volume 4 (pp. 2077-2084). Nashville, Tennessee: International Society of the Learning Sciences.