

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 researchbased 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

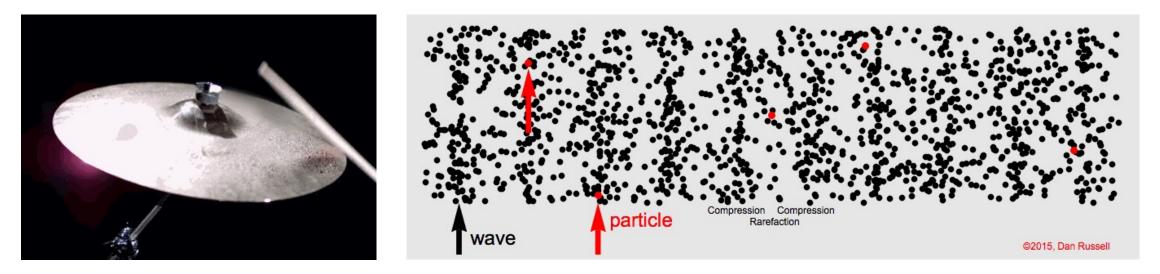
Unit design follows **Knowledge Integration (KI)** pedagogy:

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

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.



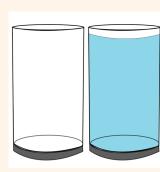
on and connect ideas.



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



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

Arlene has two glass cups. She

- 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.

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

Holistic score KI = 5

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

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

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."

because 3 ideas are linked

CCC: Structure & function How these properties are affected when the Descriptor wave interacts with an object or material Difference of material/ medium or mass topic is not mentioned or inaccurate Mechanism is inaccurate or not 2 Irrelevant, mentioned inaccurate or vague **2** *Emerging understanding:* Differences of material/ medium are explained (density, mass/volume) 3 Partial link: 1 Accurate mechanism is described: full glass is more difficult to vibrate accurate idea **3** Full understanding (2 linked ideas); Linking either density, mass, volume, pitch 4 Full link: 2 linked

Linking density of the medium and vibrations, \square CCC = 3

Knowledge Integration: Linking DCI and CCC ideas Category of Response I don't know or off Off topic, blank, repeats prompt, or "I don't know" 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.) 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.) Accurate conclusion about pitch linked to accurate idea about mechanism or property accurate ideas of sound wave

5 Complex link: 3 or Accurate conclusion about pitch linked to two more linked accurate ideas about mechanism or property of sound wave accurate ideas

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

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

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.

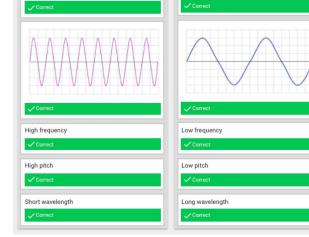
What progress did students make?

- 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

Embedded assessment prompt and NGSS alignment		All Periods Meriods M			All Periods Description: The question for this milestone is aligned with the MS-PS4-2 NGSS performance expectation. Students should be able to explain (a) how the properties of a sound wave (frequency, wavelength) correspond to an observable phenomenon (pitch), and (b) how these properties are affected when the wave interacts with an object or material.			
	written overview of	Key Insight						
	the class' average understanding	Key Insights:		composition			ed their explanations with help of the sorting activity.	
, they		1. Analysis of student responses indicate that less than 65% of students are making at least one valid connection about sound waves (neither their properties nor their interactions with different	would be higher somewhat, so	ner< because anything with water with out the water it would sound a p but you can still tell the difference."	If you do no DCI: Frequency & Pitch	et see increases in scores for DCI, CCC, and/or Ki	I, your students need your help gaining more ideas.	
	[]	materials).	"I think the pitches would <u>be different</u> because it traveling through a denser medium than air." "The <u>frequency of a pitch in water</u> is hardly <u>loud</u> because it slowly generated."		62% 80%	54% 54% 34% 32% 200		
	Recommended actions suggest an	 Over 50% of students need help gaining ideas about how frequency relates to pitch <u>and</u> how vibrations interact with different objects to produce sound. 			20% 0% 0% 1 2 3 7.6: Milestone 3: Frequ 7.8: Milestone 3: Revis	7.6: Milestone 3: Frequ 7.8: Milestone 3: Revis	36% 36% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 37% 3	
	activity with				DCI score: 1 = inaccurate idea or no mention of frequency o	CCC score: pritch 1 = inaccurate idea or no mention of mass or densit	Knowledge Integration (KI) measures how well students are identifying and linkin	g
ound	implementation	RECOMMENDATIONS STUDENT WORK			2 = accurate idea about either pitch or frequency 3 = accurate link between pitch and frequency	2 = accurate idea about mechanism (vibrations) or properties of medium (mass, density)	"Student Work" shows	d
	options. Adaptive	Help students acquire ideas about <u>frequency, vibrations, and mass</u> . Have students revisit the oscilloscope (Step 3.3) and consider these	 (show on screen) Create a worksheet for student pairs using these guiding 			3 = linking mechanism (vibrations) to property of m (mass, density) to property of wave (pitch, frequenc wavelength)		
fore they	based on analytics	guiding questions:					scores for individual	
nd	from the classroom;	"Test a frequency of 100 and observe what happens. How many crests do you see? Are the waves long or short? Do you hear a low pitched or			RECOMMENDATIONS STUDENT WORK	+	students	
stand".	target ideas students are	a high pitched sound?" Targeted idea: Lower frequency sound waves have longer waves and lower pitched sounds.			The report above gives you an overview of the progress students made using the activity in Step 7.7 to revise their explanation. If the analytics show that only a few students advanced their score through revision, they may have either not known how to efficiently revise their explanation with the new knowledge they gained or revised only superficially.			
about vised Kl	confused about.				Suggested Process for Developing Integrated Science Knowledge:			
		"Test a frequency of 400 and observe what happens. How many crests do you see? Are the waves long or short? Do you hear a low pitched or a high pitched sound" Targeted idea: Higher frequency sound waves have shorter waves and higher pitched sounds.		tation options: choose what	1 Reveal Current Ideas	DCI focus (Frequency & Pitch): • As a class or in breakout rooms, rouisit the Oscillescence in Step	Distinguish Among Ideas 4 Connect Relevant Ide	e ir
	Empty Glass Full glass			works best in their		 7.1 Guiding question: What happens to pitch when the 	When in groups: Let each student explain to their partner	
		"Discuss how sound is generated when a full and an empty glass is tapped to make sure students integrate their ideas about frequency,	classroom.		Show this example response to your students and discuss the ideas: "I think the pitches would be different	frequency increases? Predict the wave <u>pattern when</u> you set the Oscil	which new idea they will incorporate or which idea they	
		vibrations, and mass."			because it is traveling through a denser medium than air." Note: It is important to start with	100Hz versus 40 students draw w	mended actions guide thro	
					ideas your students expressed when supporting them to gain a better understanding!	 CCC focus (Density of • As a class or in t revisit Step 5.1 a CCC focus (Density of • As a class or in t revisit Step 5.1 a CCC focus (Density of • As a class or in t revisit Step 5.1 a 		
0.89).						Cuiding quantier	rt teachers to build instruct	
13);		 Teacher designed support activity: Discover ideas in unit 			in the empty/full glass is heavier?		around student ideas.	
r, prior	✓ Correct							
ures	Less mass More mass Correct	 Write initial milestone expl 	anation					
ed	Less dense More dense Correct Correct	 Sorting tack to distinguish 		Think that first tim	e i didn't really ev	en look that mucl	h at the numbers scores I ju	st

 $F(1,49) = 0.50, p = .484, \eta_{p}^{2} = 0.01.$

• 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 $[1.28, \infty]$.



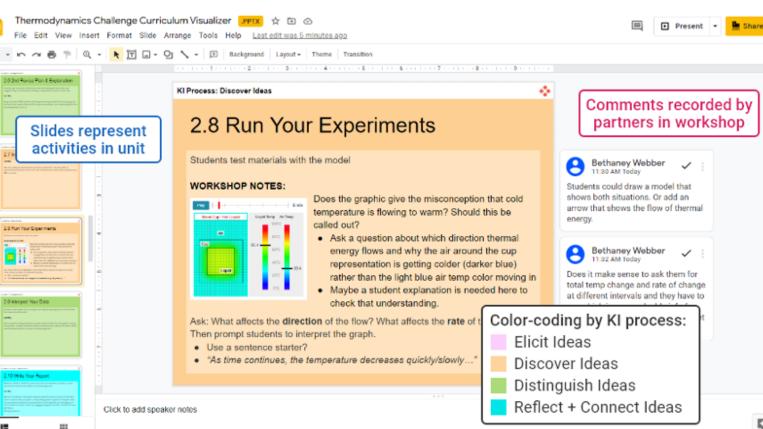
- Sorting task to distinguish ideas
- Revise explanation

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

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

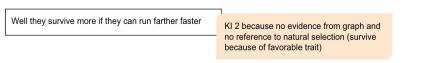
- Each slide represents an activity. Teachers can view full curriculum or zoom in to customize.
- Tool makes it easy to reorder, add, or
 - remove activities or lessons.
- Color-coded slides indicate the KI process activities support. Helps to reflect on the sequence of activities, identify which over-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

Review of Student Work

After the introduction of the snake predators. I observed that the length of the Anolis izards' back legs grew significantly longer over time. By the 40th generation, the back legs KI 5 because detailed evidence from graph neters longer than the indicating evolution happens over generations grown up to about 13 centimeters long, which is almost five cen ing length of the lizards' back legs (about eight centimeters long). I believe that the + description of natural selection earance of the snakes caused the Anolis Lizard species to evolve and develop longe s. This adaptation is more suitable for running from and escaping fast predator e new trait makes it a bit easier for the lizards to survive (and be able to reproduce) in vironment that is now snake-infested. This concept relates to natural selection

I 5 because natural selection explain graph shows a gradual increase in the average length of the back legs of the Anolis lizard directly orable trait passed on over predator was introduced to the environment. This is proof of natural selection because the Anolis enerations because those Lizards ds survival was favored towards the lizards with longer legs and so the lizards with slightly longer urvived and reproduced more) legs than the rest survived more often and got to reproduce more and pass on their traits. The gradual nce from graph crease in the graph shows the lizards with longer leas reproducing more while the lizards with shorte legs are dying of

KI 1 because "I don't						
now"		KI 2 because no evidence from				
aybe the short legs were to help climb up rocks, because their body would be angled up, or to be shorter and not sible to the snakes.						
10	W"	w"				



- 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.

We thank the National Science Foundation for their generous support. We thank all participating teachers and students for sharing their thoughts with us. We thank the WISE technology team for realizing the presented innovations.