

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

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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

### **Scoring Rubrics** (NGSS Performance Expectation: MS-PS4-2) **CCC: Structure & function** How these properties are affected when the

- wave interacts with an object or material 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

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

Kne	owledge Integrat	vledge Integration: Linking DCI and CCC ideas		
	Descriptor	Category of Response		
1	l 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 conclusion about pitch linked to two accurate ideas about mechanism or property		

of sound wave

accurate ideas

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,  $\infty$ ]. 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		Initial TAP Design		Revised TAP Design	
assess	ment prompt	All Periods 👻	88%	All Periods 💌	33%
and NG	SS alignment	Description: The question for this milestone is located in <b>Step 5.1</b> and i	s aligned with the MS-PS4-2 NGSS performance expectation.	Description: The question for this milestone is aligned with the MS-PS4-2 NGSS perform Students should be able to explain (a) how the properties of a sound wave (frequency,	mance expectation. wavelength) correspond to an observable phenomenon (pitch), and (b) how these
		Students should be able to explain (a) how the properties of a sound wa (pitch), and (b) how these properties are affected when the wave intera	cts with an object or mater <b>Fxample student</b>	Item Location: 7.8: Milestone 3: Revise your frequency explanation! (Step Info)	Graphe show class
	Key Insights:	Item Location: 5.1: Physics of sound waves Milestone (Step Info)	responses indicative	CLASS REPORT	progress from initial to
	the class' average	CLASS REPORT	of the average score	Key In	revised explanations
		Key Insights:	composition	To check your students' progress, compar If you see more students receiving higher scores, they imp	re score distributi
thev	anderstanding	1. Analysis of student responses indicate that less than 65% of students are making at least one valid connection about sound	"I chose the the <u>full one is higher&lt; because anything with water</u> would be higher somewhat, so with out the water it would sound a	If you do not see increases in scores for DCI, CCC, and/	/or KI, your students need your help gaining more ideas.
		waves (neither their properties nor their interactions with different materials).	<u>little deeper</u> but not super deep but you can still tell the difference."	DCI: Frequency & Pitch CCC: Density of Medium	■ KI: Linking density of medium to properties of resound wave =
	Recommended	2. Over 50% of students need help gaining ideas about how	"I think the pitches would <u>be different</u> because it traveling through a denser medium than air."	62%         80%         40%         34%         32%           37%         20%         0%         0%         11	28% 54% 48%
	actions suggest an	objects to produce sound.	"The <u>frequency of a pitch in water</u> is hardly <u>loud</u> because it slowly generated."	1         2         3         1         2           7.6: Milestone 3: Frequ         7.6: Milestone 3: Frequ         7.6: Milestone 3: Revis           7.8: Milestone 3: Revis         7.8: Milestone 3: Revis	3 1 2 3 4 5 7.6: Milestone 3: Frequ
und	activity with			DCI score: CCC score: 1 = inaccurate idea or no mention of frequency or pitch 1 = inaccurate idea or no mention of mass or o	Knowledge Integration (KI) measures how well students are identifying and linking density key ideas when explaining the different sounds made by tapping an empty versus a
unu	implementation	RECOMMENDATIONS STUDENT WORK		2 = accurate idea about either pitch or frequency       2 = accurate idea about mechanism (vibration         3 = accurate link between pitch and frequency       properties of medium (mass, density)         3 = linking mechanism (vibrations) to property	y of medium <b>"Student Work"</b> shows
ro thay	options. Adaptive	Help students acquire ideas about <u>frequency, vibrations, and mass</u> . Have students revisit the oscilloscope (Step 3.3) and consider these	Implementation Options:     Write these guiding guestions on the board and have students	(mass, density) to property of wave (pitch, free wavelength)	Initial and revised
d liev	from the classroom	"Test a frequency of 100 and observe what happens. How many crests	<ul> <li>answer them while they revisit Step 3.3 (individually or in pairs)</li> <li>Guide a whole-class discussion using the oscilloscope on Step 3.3</li> </ul>	RECOMMENDATIONS STUDENT WORK	students
u tand"	target ideas	do you see? Are the waves long or short? Do you hear a low pitched or a high pitched sound?"	<ul><li>(show on screen)</li><li>Create a worksheet for student pairs using these guiding</li></ul>	The report above gives you an overview of the progress students made using the activity	vity in Step 7.7 to revise their explanation.
lanu .	students are	<b>Targeted idea:</b> Lower frequency sound waves have longer waves and lower pitched sounds.	questions (or use ours)	If the analytics show that only a few students advanced their score through revision, the knowledge they gained or revised only superficially.	ney may have either not known how to efficiently revise their explanation with the new
haut	confused about.			Suggested Process for Developing Integrated Science Knowledge:	
DOUL		"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		1 Reveal Current Ideas     2 Discover New Ideas	3 Distinguish Among Ideas 4 Connect Relevant Ideas
		Targeted idea: Higher frequency sound waves have shorter waves	teachers choose what	to Step 7.8 with the class or with a peer or group of students in a break	encourage them to contrast their explanation and the evidence they
	Empty Glass Full glass	and higher pitched sounds.	works best in their	OR 7.1 OR Guiding question: What	<ul> <li>When in groups: Let each</li> <li>student explain to their partner</li> </ul>
		"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 <u>would be different</u>	which new idea they will incorporate or which idea they
sed Kl		vibrations, and mass."		because it is traveling through a denser medium than air." Note: It is important to start with Because it is traveling through a 100Hz versus 40 students draw w	mmended actions guide throug
				ideas your students expressed when supporting them to gain a better understanding! CCC focus (Density of • As a class or in t	sequence activity. Leachers car
.89).		,,		revisit Step 5.1 a • Guiding question medium sound t	ort teachers to build instruction
3);		I eacher designed support	Teacher designed support activity:		around student ideas.
prior	✓ Correct	<ul> <li>Discover ideas in unit</li> </ul>			
es	Less mass More mass Correct Correct	<ul> <li>Write initial milestone expl</li> </ul>	anation		

"I think that first time I didn't really even look that much at the numbers scores I just

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

• 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**

fter 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 meters longer than the indicating evolution happens over generations grown up to about 13 centimeters long, which is almost five cen ning length of the lizards' back legs (about eight centimeters long). I believe that the + description of natural selection bearance of the snakes caused the Anolis Lizard species to evolve and develop longe legs. 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 environment that is now snake-infested. This concept relates to natural selection

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 the predator was introduced to the environment. This is proof of natural selection because the Anolis nerations 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 prease 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			
	know"		KI 2 because no evidence from graph and no reference to	
ybe the short legs were to help climb up rocks, because their bo	natural selection (survive because of favorable trait)			

Well they survive more if they can run farther faster KI 2 because no evidence from graph an o reference to natural selection (survive because of favorable trait)

- 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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