A Quasi-experimental Study of NGSS Curriculum and PD on Three-dimensional Learning Outcomes

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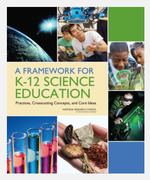
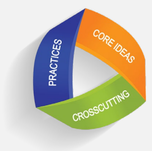
Next Generation Science Standards (NGSS)



NGSS calls for integration of **curriculum**, **professional development**, and **assessment**.

Curriculum Designed for NGSS

- Focuses on a central phenomenon.
- Includes a coherent storyline from the student perspective (Reiser, 2014).
- Engages students in three dimensions *simultaneously*:
  - Science and engineering practices
  - Crosscutting concepts
  - Disciplinary core ideas



Online, Video-Based Analysis-of-Practice PD

- 50 hours of online PD
  - 2-hour weekly synchronous sessions
  - 3 hours of asynchronous work weekly in the summer
- PD spread across 5 months (summer and fall 2018)
- Teachers analyze their own and others' videos.
- Applied the *Science Teachers Learning from Lesson Analysis,* or **STeLLA** PD model (Roth et al., 2011; Roth et al., 2019; Taylor et al., 2017).

Distal Three-dimensional Assessment

Performance Expectation MS-LS1-3: Use argument supported by evidence for how the body is a system of interacting sub-systems composed of groups of cells.

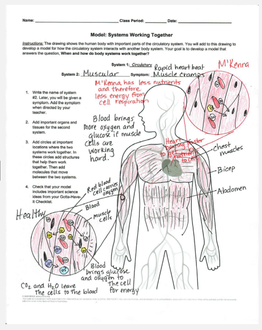
In the unit, students **develop a model explaining how body systems work together.**

On the assessment, students **use their model to and argue from evidence to explain** why some athletic students on a hiking trip in the mountains have sore muscles and other athletic students don't (Harris et al., 2016).

Phenomenon for Unit
What's wrong with M'Kenna, and how can symptoms in one part of her body lead to symptoms elsewhere?

Phenomenon for Assessment
Why do some athletic students have sore muscles after hiking and others don't?

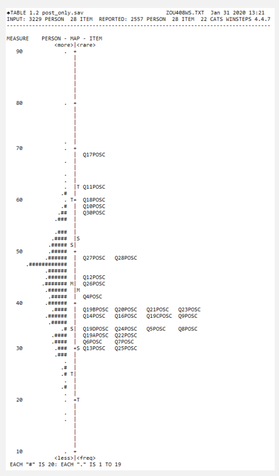
Students develop model to explain M'Kenna's symptoms.



Students apply model to explain hiking-at-high-altitude phenomenon.

Rasch person measures (scaled to 100 points)
Person reliability = 0.80
Person separation = 1.98

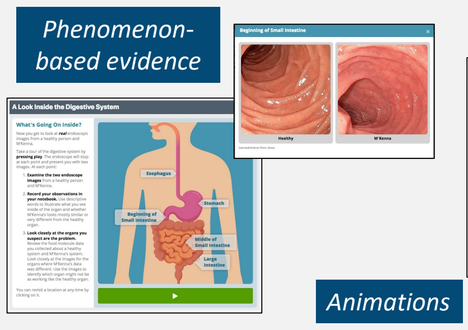
- Person separation is at low end of acceptability.
- Several items provide redundant information, particularly at low end of scale.



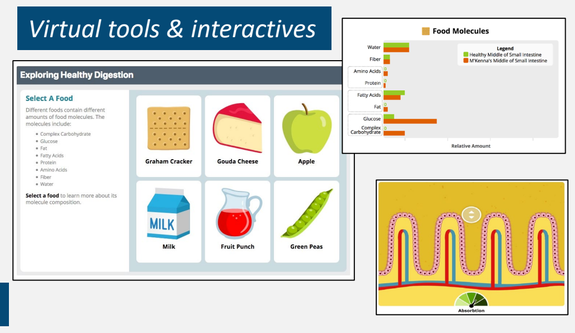
Media-enhanced digital materials for face-to-face classroom

A Medical Mystery
Body Systems Unit for Middle School

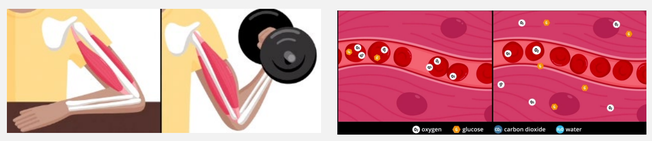
Phenomenon-based evidence



Virtual tools & interactives



Animations



Research Questions

To what extent does the package of curriculum and PD

1. enhance teacher instructional practice?
2. enhance teacher three-dimensional science content knowledge?
3. enhance student three-dimensional science achievement on a distal assessment?

Research Design

Comparison group	**Teacher PD**	**Treatment group**
Multiple classes/teacher	30 teachers	Multiple classes/teacher
1,652 students	Summer and Fall 2018	1,592 students
Business-as-usual body systems unit	pretest/posttest	*A Medical Mystery* body systems unit
2017-2018 school year		2018-2019 school year
pretest/posttest		pretest/posttest

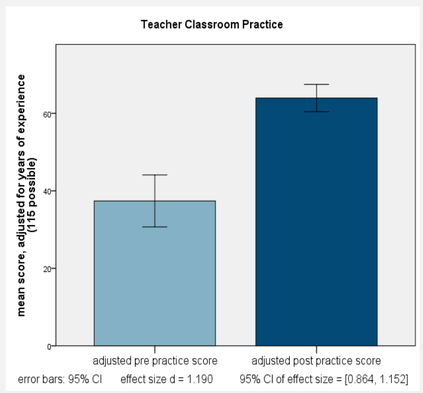
Analytic Models

Teacher Model
- ANCOVA
- Post scores predicted by pre scores and years of teaching experience

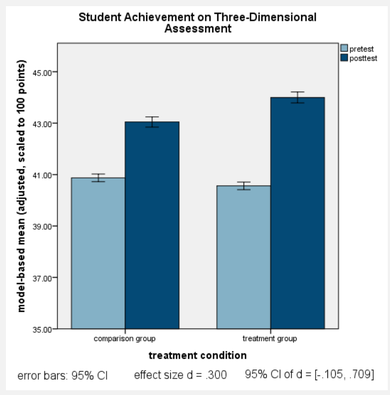
Student Model
- Three-level HLM
- Students nested in classes (treatment at class level)
- Classes nested in teacher
- Random slopes for treatment (average treatment effect across teachers)

Results

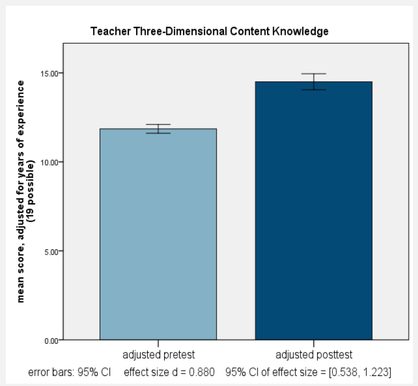
Sizable changes in teacher practice



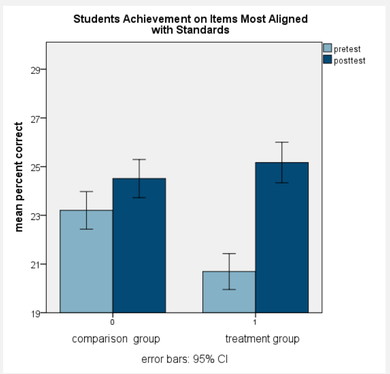
Modest impact on students



Modest changes in teacher content knowledge



Student impact is greatest on most challenging items



Proof of Concept

- This is one of the only studies that uses a quasi-experimental design to test the theory of action outlined in *A Framework for K-12 Science Education* (NRC, 2012).
- It is **possible to "move the needle"** on students' three-dimensional learning with an **integration** of
  - curriculum,
  - PD, and
  - assessment.

Challenges and Questions

- Effects were relatively small, particularly for students.
- Will a single unit ever show strong changes in three-dimensional learning?
- How will students perform after a full year of NGSS instruction? After multiple years?
- How are other researchers designing units, PD, and assessments? What improvements can be made on this model?

Limitations

- Teacher practice is measured with one video at pretest and one video at posttest. It is not clear if changes in practice are durable.
- Quasi-experimental design does not rule out all possible influences on teachers and students.
  - Results may show improvement in outcomes that are to be expected on a year-to-year basis (teachers just getting better naturally over time).
- There may be issues with the sensitivity of the assessment in detecting student impacts.
  - Is assessment over-aligned to instruction?
  - Are we seeing an opportunity gap?
  - Is it not sensitive enough to better reveal impacts on students?
  - Assessment with higher person separation would provide greater sensitivity.

Implications

- We provide initial evidence in support of the theory of action outlined in *A Framework for K-12 Science Education*. More evidence is needed.
- We need additional models of high-quality assessments for NGSS.
- Much research remains:
  - Additional units from other developers
  - Alternative assessment structures
  - Head-to-head comparison of units designed to address the same NGSS performance expectations

Citations

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