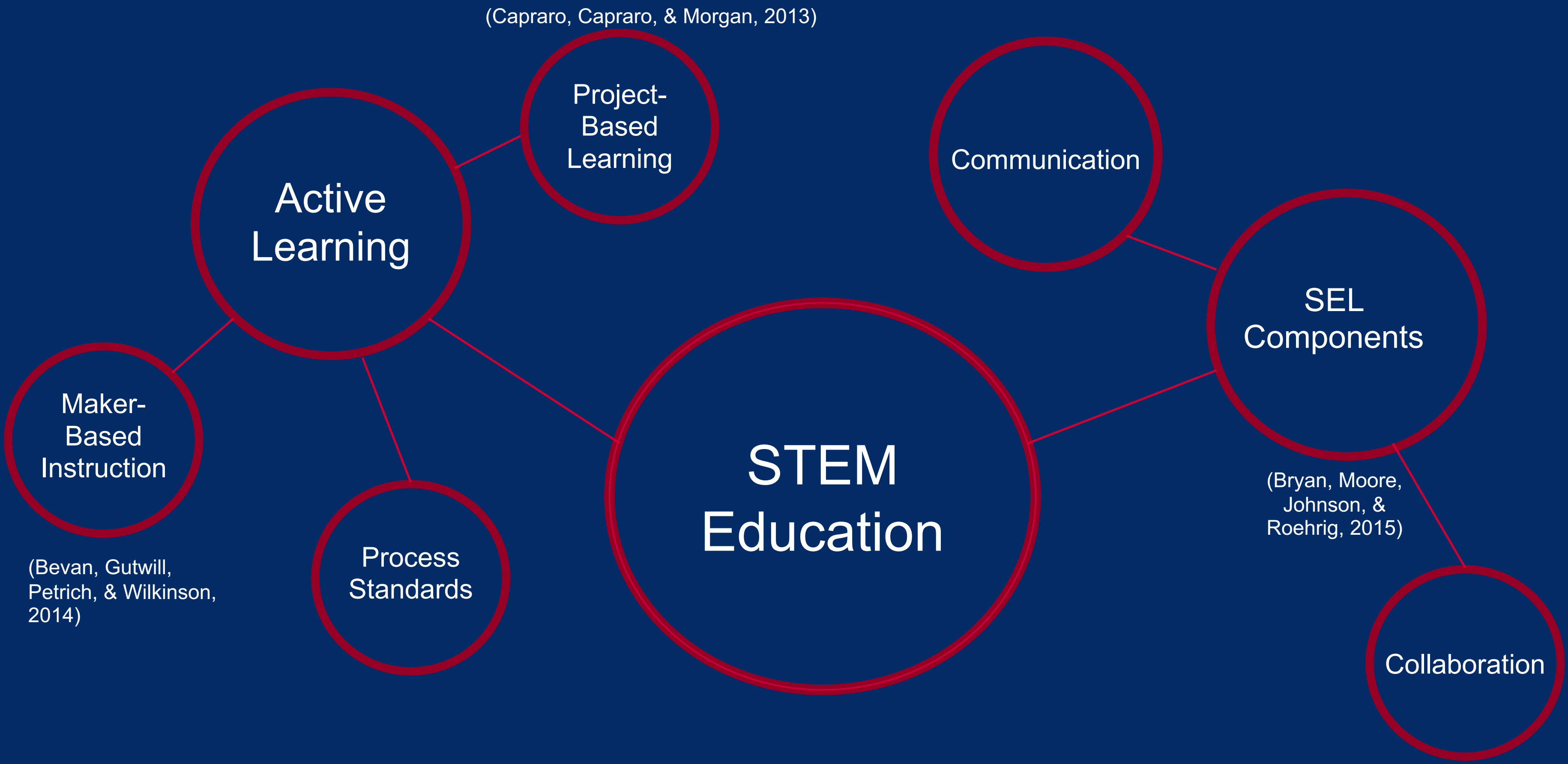
The Development of an Instrument to Measure Teachers' Perceptions of STEM Practices

ANTHONY SPARKS, ELIZABETH ADAMS, &
LEANNE KETTERLIN-GELLER

World Changers Shaped Here SMU

Background

- Exposure to STEM education influences students' career trajectories (Wang, 2013)
- Few instruments available to measure teachers' perceptions towards STEM practices
  - Extant research utilized modified versions of published instruments
- To measure teachers' perceived importance, confidence, and frequency of implementing STEM practices


(Capraro, Capraro, & Morgan, 2013)
Project-Based Learning
Active Learning
Maker-Based Instruction
(Bevan, Gutwill, Petrich, & Wilkinson, 2014)
Process Standards
STEM Education
Communication
SEL Components
(Bryan, Moore, Johnson, & Roehrig, 2015)
Collaboration

STEM Perceptions, Practices, and Culture

- The scale was developed over the course of the last ten years across multiple projects
  - Consulted experts with experience with classroom instruction in STEM
- Includes 27 commonly adopted STEM practices
  - Survey measures three aspects of these STEM practices
    1. Importance of practice
    2. Confidence of practice
    3. Frequency of implementing practice

Practice	Importance of practice 0 = Not important at all 1 = Not important 2 = Important 3 = Very important					Confidence in implementing practice 0 = Not confident at all 1 = Not confident 2 = Confident 3 = Very confident					Frequency A: Less often than 1 time per month B: 1 time per month C: 2-3 times per month D: 1 time per week E: 2-3 times per week F: Everyday					
Learning experiences encourage student ownership.	0	1	2	3		0	1	2	3		A	B	C	D	E	F
Learning experiences foster a maker mindset (e.g., curiosity, resilience, and an eagerness to collaborate and share).	0	1	2	3		0	1	2	3		A	B	C	D	E	F
Students have opportunities to showcase their achievements.	0	1	2	3		0	1	2	3		A	B	C	D	E	F
Instruction calls students' attention to the mathematics concepts that they may have learned in their math class.	0	1	2	3		0	1	2	3		A	B	C	D	E	F
Lessons utilize informal learning spaces.	0	1	2	3		0	1	2	3		A	B	C	D	E	F
Lessons utilize curricular materials developed by industry (e.g., TI, NASA).	0	1	2	3		0	1	2	3		A	B	C	D	E	F
Students' cultural and ethnic backgrounds inform instructional planning.	0	1	2	3		0	1	2	3		A	B	C	D	E	F
Lessons incorporate community building activities.	0	1	2	3		0	1	2	3		A	B	C	D	E	F
Teachers collaborate during professional learning community (PLC) meetings.	0	1	2	3		0	1	2	3		A	B	C	D	E	F

Context of Study

- Forty-six middle-school science teachers recruited for a multi-year professional development project
    - Up to three intensive summer academies focusing on implementation of active learning strategies
    - Routine coaching throughout the school year
- Teachers surveyed up to seven time points $N = 172$ observations
    - Surveyed before the academies, once in the fall, and once in the spring

Demographics

Characteristic		# of Teachers	% of Teachers
Gender	Male	14	30%
	Female	32	70%
Race	Black	24	52%
	White	17	37%
	Asian	2	4%
	Two or More	3	7%
Ethnicity	Hispanic	7	15%
	Not Hispanic	39	85%

Method

- Scale descriptive statistics
- Complex Survey Confirmatory Factor Analysis
    - Three hypothesized factors: Importance, Confidence, and Frequency
- First fit model without accounting for observations nested within individuals, then accounting for the nesting
- Because we do not hypothesize a different structure within individuals compared to between, we specify a complex data structure
- Analyses conducted in Mplus with a weighted least squares estimator

Method cont.

- Analyzed fit indices for both models (Hu & Bentler, 1999)
  - Comparative fit index (CFI)
    - Reasonably specified models with CFI $> .90$
  - Tucker-Lewis index (TLI)
    - Reasonably specified models with TLI $> .90$
  - Root mean squared error of approximation (RMSEA)
    - Reasonably specified models with RMSEA $< .08$

Scale Descriptive Statistics

Scale	Mean	SD	Min	Max
Importance	3.54	0.17	3.16	3.77
Confidence	3.13	0.20	2.78	3.49
Frequency	3.99	0.62	2.87	4.88

Results

Model	CFI	TLI	RMSEA
Without Clustering	0.893	0.890	0.06 (0.056, 0.063)
With Clustering	0.889	0.885	0.04 (0.036, 0.045)

- Accounting for clustering within individuals leads to better RMSEA
- Slightly worse CFI and TLI when accounting for clustering

- Loadings all statistically significant
- Greater variability in loadings with frequency scale

Scale	Avg. Loading	Range
Importance	.772	(.641-.859)
Confidence	.757	(.620-.849)
Frequency	.646	(.282-.823)

Discussion

- Initial steps in validation of the STEM PPC for measuring teachers' perceptions of STEM practices
    - Potentially useful for measuring perceptions during intervention work
- Some items related to frequency of practice may depend on contextual factors (e.g., resources available to implement STEM practices)
    - Evidenced by lower average loading on the frequency scale and larger range of loadings

Next Steps

- Items on school culture may impact overall fit of the model
  - Consider removing items before additional analyses
- Analyze the appropriateness of the response scales
  - Study the response patterns to ensure full use of scales
- Study relations to similar constructs (e.g., self-efficacy)

Thank You

- asparks@smu.edu
- Special thanks to the Texas Instruments Foundation and the O'Donnell Foundation

Item Loadings for Model Accounting for Clustering of Observations Within Teachers

Item	Importance	Confidence	Frequency
Students engage with one another in small groups to accomplish assigned tasks	.701	.670	.407
Instruction includes open-ended questions that encourage different approaches	.772	.709	.620
Instruction allows students to connect science concepts to real-life situations	.671	.734	.656
Students engage with hands-on materials	.735	.718	.598
Students engage with technology during lesson	.678	.759	.509
Learning experiences foster students' personal interest in science	.808	.809	.719
Activities allow for multiple solutions or representations	.753	.801	.673
Formative feedback is provided to students	.659	.743	.486
Lessons connect to students' prior knowledge and experiences	.853	.784	.634
Lessons explicitly connect to mathematics ideas and terminology	.832	.766	.672
Lessons explicitly connect to engineering ideas and terminology	.822	.706	.703
Lessons explicitly connect to technology ideas and terminology	.822	.797	.737
Lessons expose students to information about STEM careers	.855	.745	.823
Learning experiences encourage student ownership	.754	.849	.723
Learning experiences foster a maker-mindset (e.g., curiosity, resilience, and an eagerness to collaborate and share)	.766	.841	.793
Students have opportunities to showcase their achievements	.868	.830	.748
Instruction calls students' attention to the mathematics concepts that they may have learned in their math class	.786	.739	.691
Lessons utilize informal learning spaces	.823	.798	.703
Lessons utilize curricular materials developed by industry (e.g., Texas Instruments, NASA)	.788	.620	.732
Students' cultural and ethnic backgrounds inform instructional planning	.765	.761	.767
Lessons incorporate community building activities	.789	.826	.753
Teachers collaborate during professional learning community (PLC) meetings	.641	.661	.282
Learning experiences foster students' motivation to learn science	.859	.788	.619
Teachers review assessment data with other teachers	.723	.714	.446