A Gap Analysis of Noncognitive Constructs in Evaluation Instruments Designed for Computing Education

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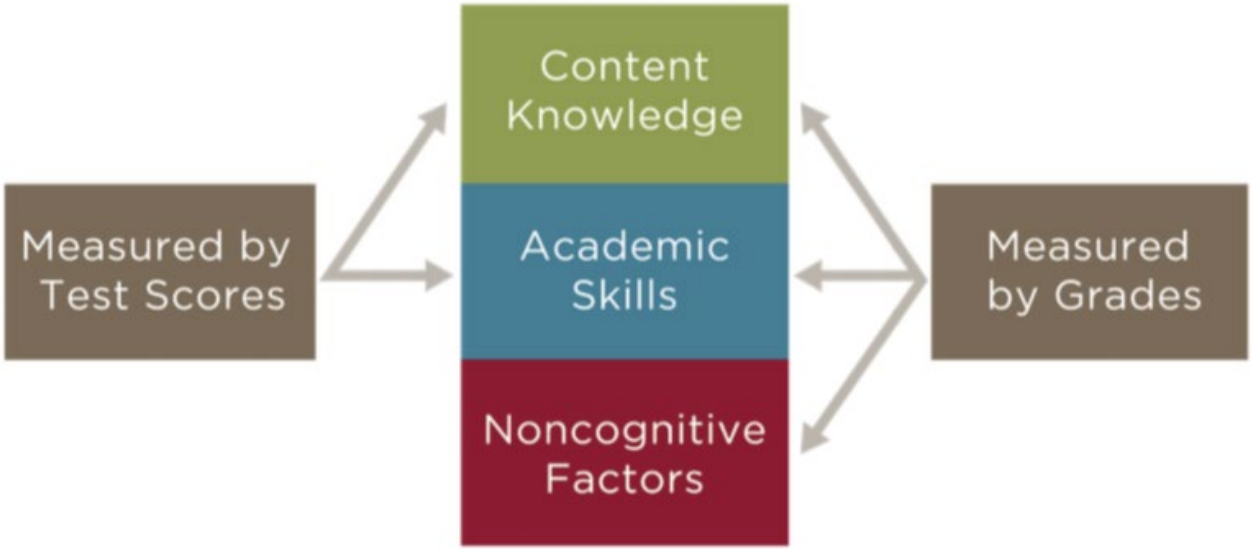
What are “noncognitive” factors?

- "...any skills, behaviors, habits, tendencies, traits, and disposition that are typically not measured by tests" Farkus [10]. For example:
  - Self-efficacy
  - Study skills of students
  - Support of family and friends
  - Sense of belonging
- In psychology, education and economics, cognitive and noncognitive factors are currently understood as **interdependent**
- In research, maintaining a distinction between the two can shed further light on research-based factors within the field of educational psychology [10]

Noncognitive factors affect academic achievement



Research Question

Which noncognitive constructs are (and are not)

currently being measured in instruments

specifically designed for evaluating the

impact of computing education?

Choosing a model – Farrington et al

Farrington et. al. (2012) identify five categories of noncognitive factors as well as their interdependencies:

- Academic behaviors (attending class, doing homework, etc.)
- Academic perseverance (e.g. grit, self-control, self-discipline)
- Academic mindsets (e.g. positive or negative mindsets related to belonging, abilities, competencies)
- Learning strategies (e.g. study skills, metacognitive strategies, self-regulated learning), and
- Social skills (e.g. interpersonal skills, empathy, cooperation)

Choosing a model - Marzano

Acknowledges the breadth of variables outside students' control that have been shown to impact achievement. Based on effect size from meta-studies:

- Student-level
- Teacher-level
  - Individual teacher effects, instructional strategies, curriculum design
- School-level
  - Guaranteed/viable curriculum, challenging goals, effective feedback,
  - Parental/ community involvement, safe/orderly environment, and
  - Collegiality/ professionalism

Choosing a Framework – Lee and Shute (2010)

Acknowledges breadth of variables outside students' control shown to impact achievement. Based on meta-studies measuring effect size.

- Student Personal
  - Student Engagement
    - Behavior, Cognitive, Affect
  - Learning Strategies
    - Cognitive, Meta-Cognitive, Behavioral
- School-level
  - School Climate
    - Academic Emphasis, Teacher Variables, Principal Leadership, Other
  - Social-Familial Influences
    - Parental Involvement, Peer Influences

Personal and Social Contextual Factors in K-12 Ed

Student-Personal

Student Engagement

- Behav-ioral
- Cog-nitive
- Affect

Learning Strategies

- Cog-nitive
- Meta-Cogniti ve
- Behav-ioral

Social Contextual

School Climate

- Acad-emic Emph-asis
- Teach-er Vari-ables
- Princ-ipal Leaders hip
- Other

Social-Familial Influences

- Parent-al Involve ment
- Peer Influ-ences

Methodology

- **csedresearch.org** houses all of the instruments in this study
  - Reviewed 297 articles published from 2012 to 2016 in **csedresearch.org**
  - Searched online databases for instruments
    - American Evaluation Association, STELAR, The Pear Institute, Institute for the Integration of Technology into Teaching and Learning, MSPNet, Engineering is Elementary
  - Searches based on relevant keywords (e.g., computer science, inventory, survey, instrument, evaluation, interest, self-efficacy, etc.).
- Asked CS ed community for additional instruments (SIGCSE-Members list-serv, computing ed social media)

Methodology

- 47 evaluation instruments specifically covering computing education
  - K-12, Undergraduate, Pre-service teachers, Teachers/PD, etc.
- We reviewed each instrument to determine if it measured cognitive or noncognitive factors or assessed programs, or a combination of these
- Resulted in 31 instruments measuring noncognitive factors

Our other SIGCSE 2019 paper

Table 3: List of Evaluation Instruments

Program Evaluation	Cog-nitive	Noncog-nitive	Evaluation Instrument Title	Appendix Citation
	X		Algorithm Analysis Concept Inventory	[A-11]
		X	BASICS Study Student Implementation Questionnaire	[A-32]
		X	BASICS Study Teacher Implementation Questionnaire	[A-33]
X			BASICS Study Teacher Interview Guide	[A-34]
X	X	X	CISE REU A La Carte Student Survey	[A-37]
		X	Cognitive Load Component Survey	[A-21]
	X		Commutative Assessment	[A-40]
	X		Computational Thinking Pattern Analysis (CTPA)	[A-17]
	X	X	Computational Thinking Survey	[A-44]
	X		Computational Thinking Test	[A-36]
		X	Computer Anxiety Scale	[A-43]
		X	Computer Attitude Questionnaire (CAQ 5.14)	[A-15]
		X	Computer Attitude Questionnaire (CAQ 5.22)	[A-15]
		X	Computer Attitude Scale	[A-19]
		X	Computer Programming Self-Efficacy Scale	[A-31]
		X	Computer Science Attitude and Identity Survey (CSAIS)	[A-38]
		X	Computer Science Attitude Survey (Hoegh and Moskal)	[A-14]
		X	Computer Science Attitude Survey (Weibe et al)	[A-42]
		X	Computer Science Interest Survey	[A-2]

Or…

Visit **csedresearch.org**

As new instruments are posted, we send notifications to twitter: @csedresearch

Want to learn more?

Visit us at the NSF Showcase at 3pm (immediately following this session!).

We would love to chat.

Data Analysis

- Once surveys were identified, we reviewed each construct according to the formal definitions provided by Lee and Shute
- If the evaluation instruments states "Self-Efficacy" but constructs measured fall into different categories as defined by Lee & Shute
  - We place those constructs not under Self-Efficacy, but in the proper buckets

Constructs Found via the Lee and Shute model

Component	Total Constructs	Unique Constructs
Student Engagement	82	65
Learning Strategies	8	8
School Climate	36	36
School-Familial Influences	6	6
Total	132	115

Personal and Social Contextual Factors in K-12 Education

Student-Personal

- Student Engagement 82/65
- Learning Strategies 8/8

Social Contextual

- School Climate 36/36
- Social-Familial Influences 6/6

Student Engagement (Table 1 Summary)

Subcomp-onent	Includes constructs such as	Total	Unique
Behavior	Contributions to small group work, Engagement in cognitively demanding work, Engagement in discussion	6	6
Cognition	Attribution for success/failure, Confidence, Goal Orientation, Outcome Expectancy, Self-efficacy, Self-concept. Self-discipline,	33	30
Affect	Feeling towards school/learning, Feeling proud of academic accomplishments, Sense of belonging/identification, Interest/curiosity	43	29
Subtotal		82	65

Learning Strategies (Table 2 Summary)

Subcomp-onent	Includes constructs such as	Tota l	Unique
Cognition	Instances and sources of repairs (State mentor question correction by teacher or student)	1	1
Meta-cognition	Is focus of learning on the "how" or the "why", Knowledge Transfer, Perception of impact of a computer game on learning, Problem solving strategies, Self-assessed level of technological adoption	5	5
Behavior	Help-seeking, Homework Management, Study Habits *NOTE: No instruments measure Time Management, Test-taking and Note-taking Strategies*	2	2
Subtotal		8	8

School Climate (Table 3 Summary)

Subcomp-onent	Includes constructs such as	Total	Unique
Academic Emphasis	Like/dislike of school	1	1
Teacher Variables	Motivation, Affect, Cognition, Meta-cognition	28	28
Principal Leadership		0	0
Other School Variables	Parental Involvement, Peer Influences	7	7
Subtotal		36	36

Social-Familial Influences (Table 4 Summary)

Subcomp-onent	Includes constructs such as	Total	Unique
Parental Involvement	Importance of learning computing, Perceptions of careers in computing, Perspective on computing, Support for pursuit of computing careers	4	4
Peer Influences	Friends/family in CS, Friends/family interest in CS	2	2
Subtotal		6	6

Evaluation Instruments in Computing Education

- Our Strengths (kind of….)
  - Student Engagement - Cognition (30)
  - Student Engagement - Affect (29)
  - School Climate - Teacher Variables (28)

- Our Weaknesses
  - School Climate -> Principal Leadership (0), Academic Emphasis (1)
  - Learning Strategies -> Cognition (1), Behavior (1)
  - Social-Familial Influences -> Peer Influences (2), Parental Involvement (4)
  - Learning Strategies -> Meta-cognition (5)

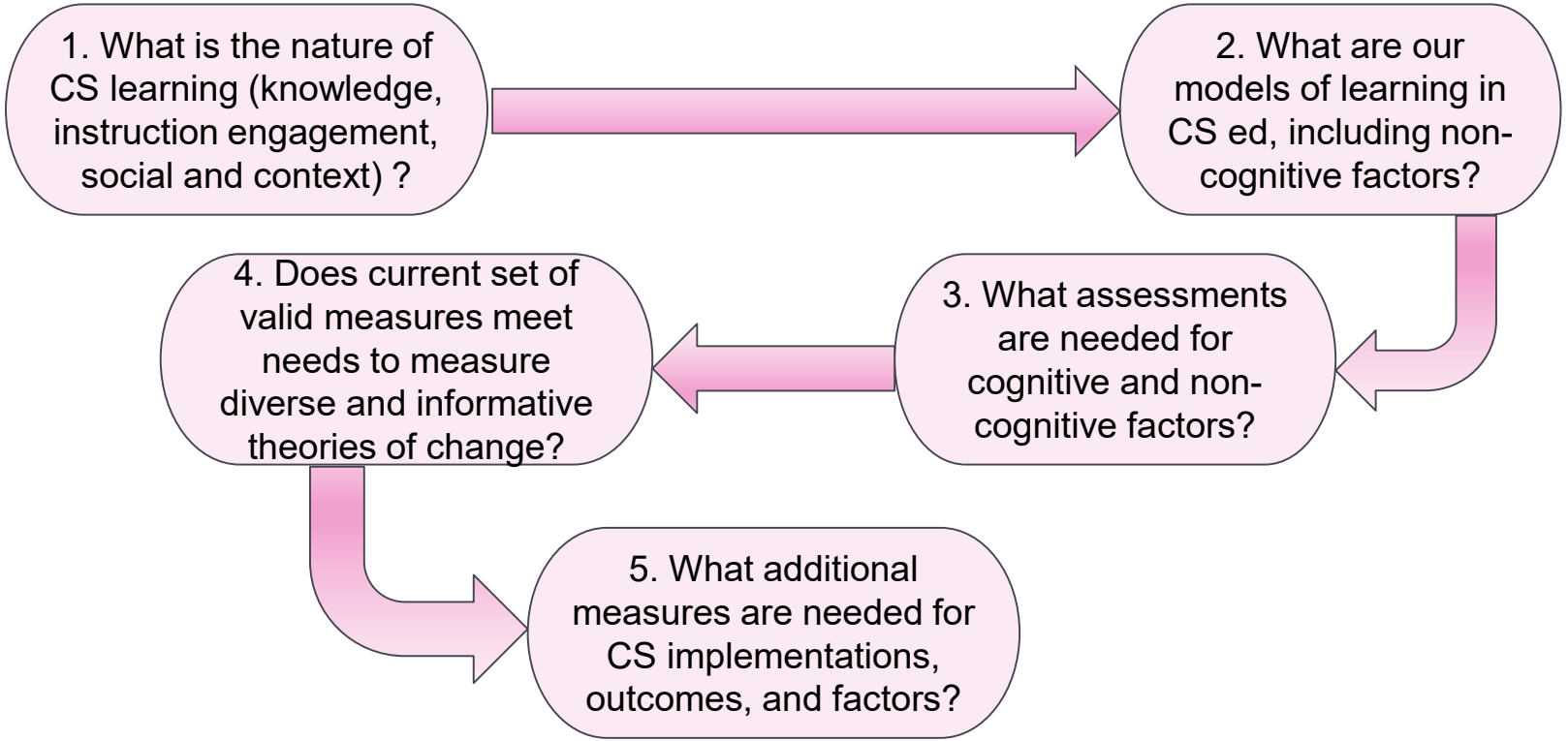
Discussion and Implications

- Taxonomy of noncognitive factors in K-12 learning (Lee & Shute) that reveals:
  - Currently, what we found primarily measures students' cognitive-motivational and emotional engagement
  - Lacking valid measures of student learning strategies, school, and social-familial variables
- Limitations
  - Framework is based on studies from K-12 and limited set of evaluation instruments
  - May miss higher education contributions
  - Does not fully reflect recent CS education research (e.g., elementary and middle schools)

Larger Questions this Study Raises

- Which constructs and components contribute most to student success? Effect sizes?
- Is there currently enough data on women and underrepresented populations?
- Do we know, adequately, which constructs predict success among these populations?
- And….

Drive Measures Development for CS Ed Research



Conclusion and Next Steps

- Consider this a draft periodic table - a landscape of constructs informing student success
- Reveals the strengths and gaps of our existing toolbox of measures
- Could be reviewed "periodically" (1x year?)
  - Does it reflect and support best theories of learning for all grade levels and all underrepresented populations?
  - Does it help researchers select the most sensitive, valid, reliable measures for interventions?

We are inviting you to join this dialogue!

Thank you!

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