The State of Computing in Introductory Statistics

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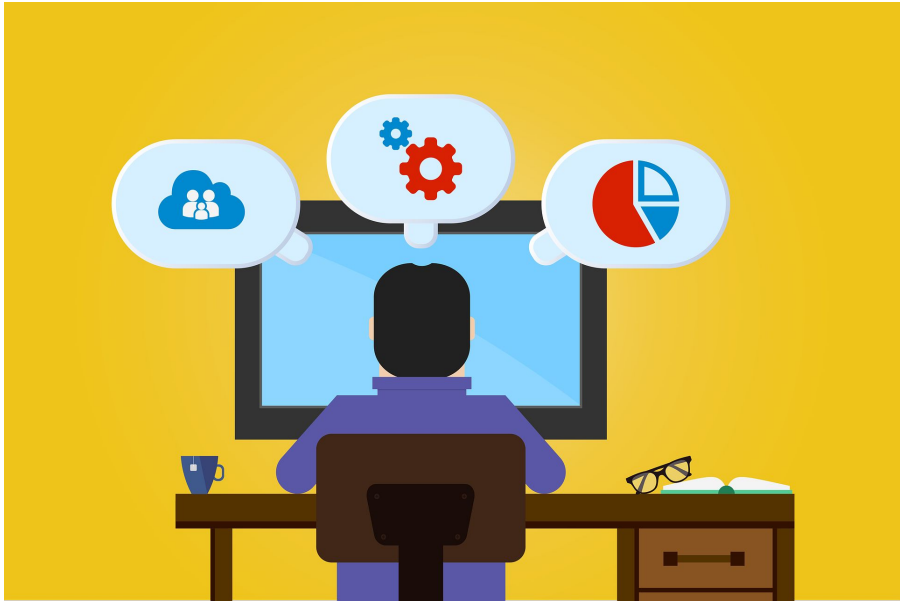
Introduction

Computing with data is fundamental to contemporary statistical practice and scientific inquiry.

(ASA, 2017; Horton, 2015; NASEM, 2018; Nolan & Temple Lang, 2010)

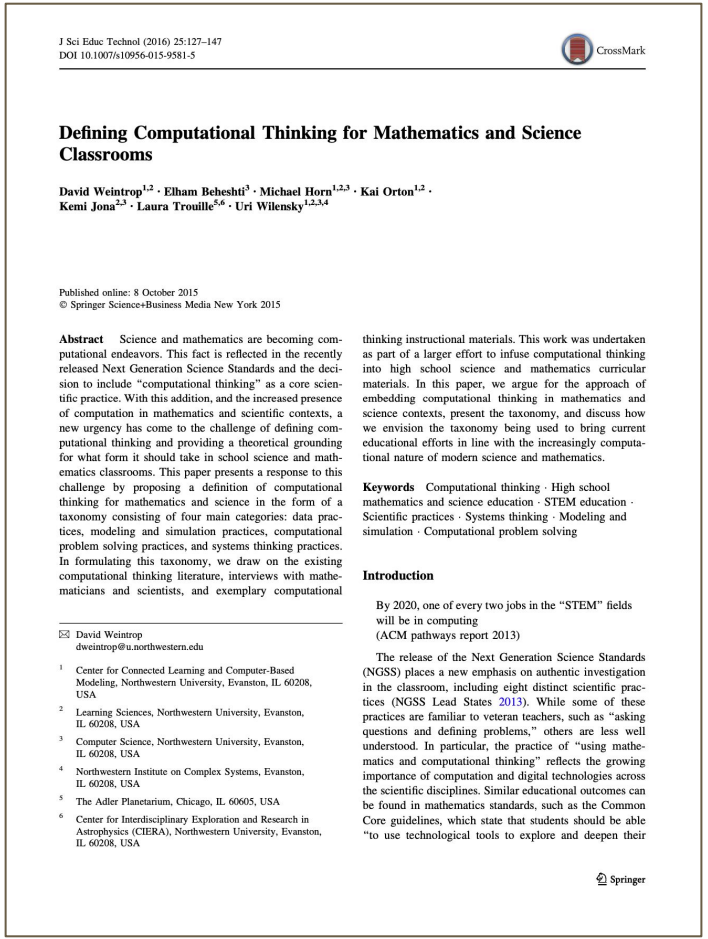


Instrument

Items to measure the extent to which computing and ideas of computational thinking (COMPUTES) were being embedded in the introductory statistics curriculum were included on the **Statistics Teaching Inventory**.

Using a framework from Weintrop et al. (2016), items were written to address:

- Data Practices
- Simulation Practices
- Coding Practices



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Defining Computational Thinking for Mathematics and Science Classrooms

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Abstract Science and mathematics are becoming computational endeavors. This fact is reflected in the recently released Next Generation Science Standards and the decision to include "computational thinking" as a core scientific practice. With this addition, and the increased presence of computation in mathematics and scientific contexts, a new urgency has come to the challenge of defining computational thinking and providing a theoretical grounding for what form it should take in school science and mathematics classrooms. This paper presents a response to this challenge by proposing a definition of computational thinking for mathematics and science in the form of a taxonomy consisting of four main categories: data practices, modeling and simulation practices, computational problem solving practices, and systems thinking practices. In formulating this taxonomy, we draw on the existing computational thinking literature, interviews with mathematicians and scientists, and exemplary computational thinking instructional materials. This work was undertaken as part of a larger effort to infuse computational thinking into high school science and mathematics curricular materials. In this paper, we argue for the approach of embedding computational thinking in mathematics and science contexts, present the taxonomy, and discuss how we envision the taxonomy being used to bring current educational efforts in line with the increasingly computational nature of modern science and mathematics.

Keywords Computational thinking · High school mathematics and science education · STEM education · Scientific practices · Systems thinking · Modeling and simulation · Computational problem solving

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Introduction

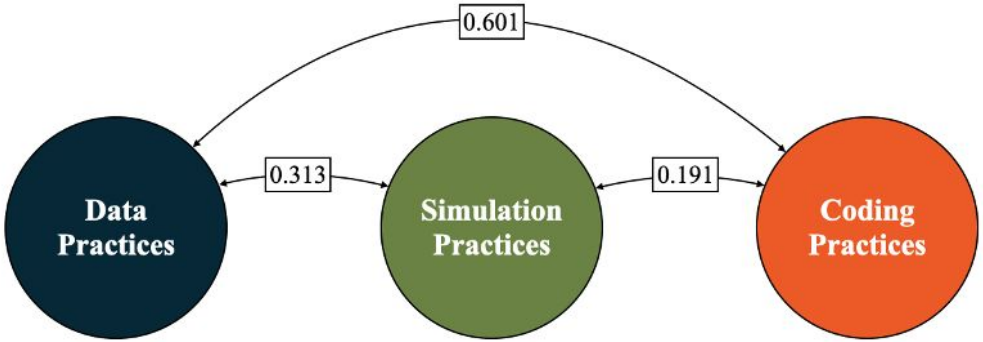
By 2020, one of every two jobs in the "STEM" fields will be in computing
(ACM pathways report 2013)

The release of the Next Generation Science Standards (NGSS) places a new emphasis on authentic investigation in the classroom, including eight distinct scientific practices (NGSS Lead States 2013). While some of these practices are familiar to veteran teachers, such as "asking questions and defining problems," others are less well understood. In particular, the practice of "using mathematics and computational thinking" reflects the growing importance of computation and digital technologies across the scientific disciplines. Similar educational outcomes can be found in mathematics standards, such as the Common Core guidelines, which state that students should be able "to use technological tools to explore and deepen their

Methods

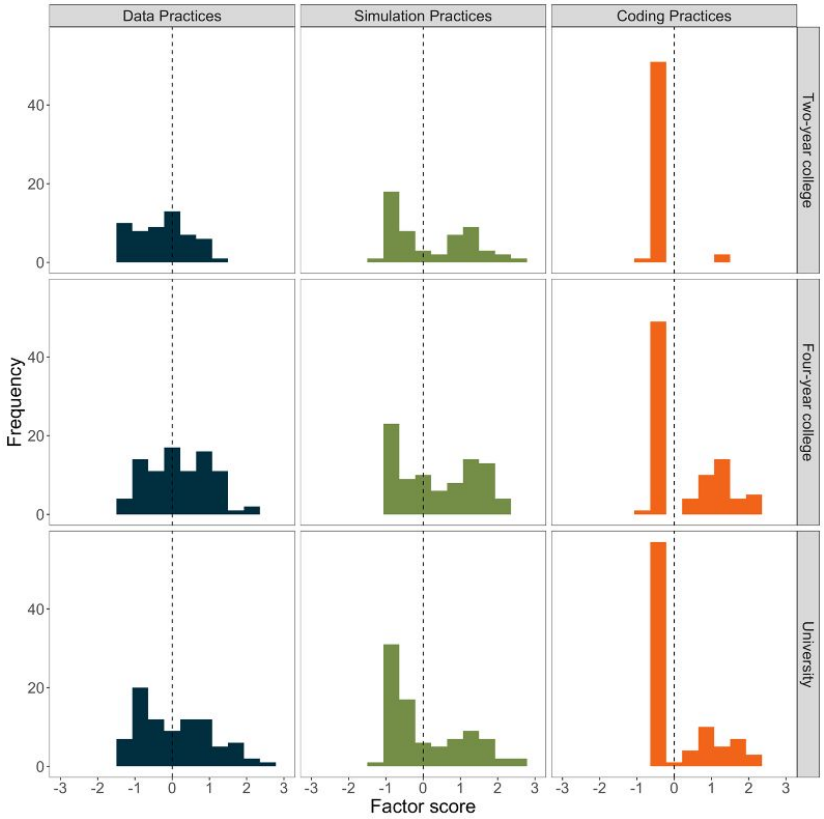
- Email invitations sent to five statistics education listservs in Fall 2019.
- Administered via Qualtrics.
- 293 respondents

RQ#1: What is the latent structure underlying introductory statistics instructor's responses to the COMPUTES items?



The best fitting model included three correlated domains.

RQ#2: Does the degree of curricular emphasis vary by institutional setting?

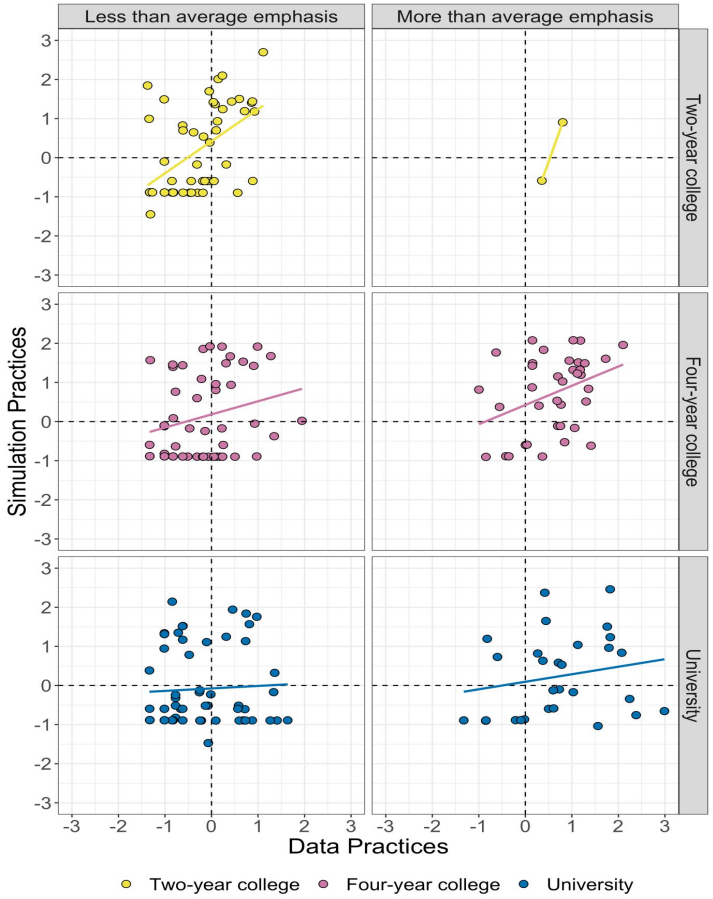


- There is variation in the instructional emphasis across institution type.
- Across all institution types, there are teachers that are emphasizing simulation practices in the curriculum and those that aren't.
- This bimodality is also seen in emphasis on coding practices, but is more pronounced.
- There is almost no variation in emphasis of coding practices for two-year college instructors.

RQ#2 (continued)

- Higher levels of emphasis on data practices also seem to have higher levels of emphasis on simulation practices, regardless of whether or not they emphasize coding practices.

- The magnitude of this relationship seems to be higher for instructors who have above average emphasis on coding practices for both four-year college and university instructors.



Limitations

Generalizability:

- Voluntary, convenience sample primarily of members of the statistics education community.
- Respondents mainly from the United States.

Bias:

- Results may be positively biased as a result of the sampling frame

Future Work

- Some items need to be further refined (coding practices items in particular).
- Additional items need to be written to differentiate at lower levels of computing emphasis in each domain.
- Coding practices items too closely aligned with practices that are more prevalent in syntax-driven software.
    - Need to measure coding practices that are more likely to be included in courses that use software with a GUI (e.g., applying data moves; Erickson et al., 2019).
- Broaden sample to include instructors from other countries, and those teaching secondary and graduate level courses.
- Compare results over time to gain insight into how curricular emphasis have changed over time.

Future Work (continued)

- Understand why instructors are *not* including computational practices for particular audiences or in certain courses would help teachers and curriculum designers think about whether and how to include additional computational practices.
    - Might help inform how ideas/concepts from computation might be introduced in courses that do not emphasize computation.
- Study the efficacy of the teaching of computational and data practices
    - Including computational and data practices in the curriculum is a necessary, but not sufficient, condition for effective teaching of these ideas.

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