Developing and Assessing Critical Thinking and Conclusion-Making through Science Outreach

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Introduction

What is SciTrek?
SciTrek is a science outreach program that engages 1st-6th grade students in hands-on, mentored experiments to improve their scientific reasoning and conclusion-making skills through guided discovery instruction and assessments.

I. Drawing valid conclusions is central to scientific reasoning and linked to improved science achievement.
II. Students often struggle with reasoning and experimental design, particularly the Control of Variables Strategy (CVS; can only change one variable at a time to make a conclusion), which is key for making valid causal claims.
III.The Claim-Evidence-Reasoning (CER) framework, which focuses on argumentation from data as a core activity of science, supports students in structuring scientific explanations but is most effective when paired with an understanding of experimental design.

SciTrek strives to teach fifth graders scientific thinking, using scaffolded, interactive modules to teach experimental design and conclusion-making. Our research shows early science education builds strong domain-specific skills, but also promotes broader critical thinking essential for evidence-based claims (CER) and informed citizenship–showing that conclusion making can be taught as a standard skill.

Methods

- Data from the 5th-grade classrooms that consisted of 758 students who participated in two modules throughout the school year; each module delivered in a different semester separated by the new year.

- To evaluate the impact of SciTrek on students' ability to draw scientific conclusions, a pre- and post-assessment was administered seven days before and after each module.
- Paper assessments were collected from the classrooms and were graded and/or coded, and analyzed.
- The assessments measure improvement in students ability to draw valid scientific conclusions and identify which foundational skills (e.g., identifying variables, interpreting data, understanding experiment structure) were the most influential in contributing to that growth.
- The primary focus assessed was on students' ability to retain key scientific reasoning skills, aiding in their ability to create a conclusion, and whether SciTrek participation contributed to their development.

Results

- Using R, we ran Pearson's correlations to inform our analysis (Figure 3).
- In SPSS, we ran a mediation analysis on the two distinct dimensions that we theorize contribute to student's ability for *Holistic Conclusion Making*, specifically, **control of variables strategy (CVS)** and the ability to **write a conclusion given data**. As part of our mediation analysis we calculated multiple regressions, to test the pathways between our hypothesized two pathways that may contribute to holistic conclusion making.
- These findings indicate **partial mediation for the first pathway** below, indicating that being able to evaluate the validity of claims partial mediated the relationship between knowing conclusions and holistic conclusion making (Mastery; Figure 1). that there was **no evidence of mediation in the second mediation pathway** below (evaluating data did not significantly mediate the relationship between knowing CVS and holistic conclusion making.(Mastery Figure 2).

Conclusions

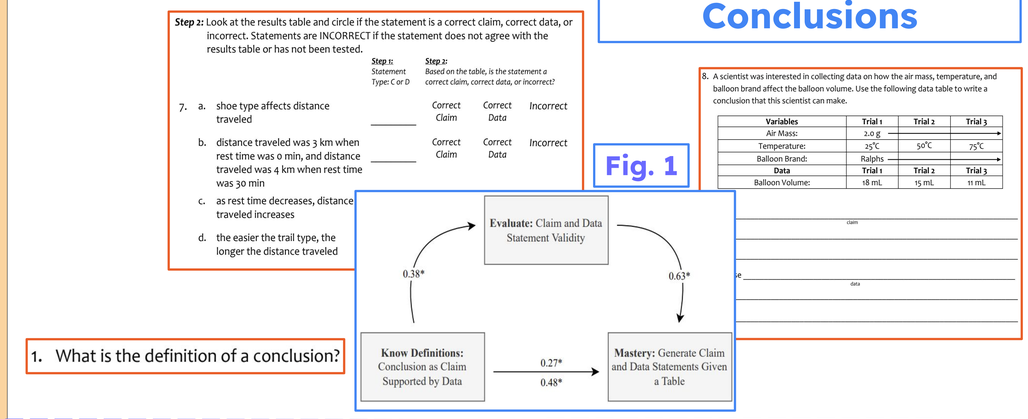


Fig. 1

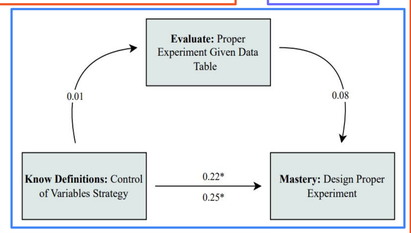
1. What is the definition of a conclusion?

Designing Experiments w/CVS

Variables	Trial 1	Trial 2
Shoe Type:	Walking	Running
Trail Type:	Easy	→
Rest Time:	0 min	30 min
Running Time:	1 hr	→
Data	**Trial 1**	**Trial 2**
Distance Traveled:	3 km	4 km
Runner's Socks:	Dirty	Clean

6. Can this group make a claim/conclusion? Yes No I Don't Know

Fig. 2



2. When conducting an experiment, how many changing variables can you have in order to make a claim/conclusion? _____

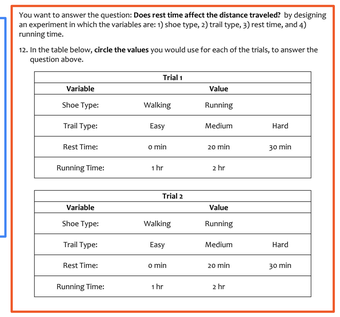
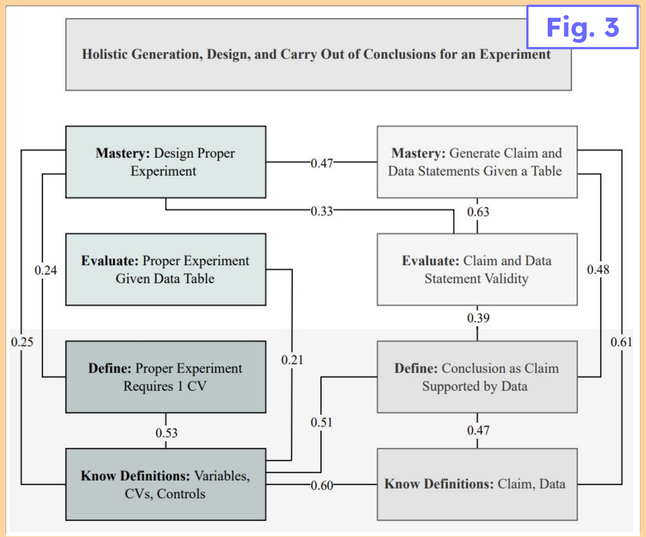


Fig. 3



Discussion

• Generally, as students progressed through modules, their knowledge of conclusion making holistically increased, as evidenced by the significant correlations between the lower levels skills (e.g., knowing the definitions of claim and data), and higher level ones (e.g. synthesizing claim and data statements given data tables).

• Our mediational analyses confirmed our hypothesis that the fundamental *Know Definition* assessment questions' relationship to *mastery of conclusion making skills* was partial mediated by student's ability to evaluate claim and data statement's validity.

• Evaluate: Proper Experiment Given Data Table was not a significant mediator of the path between the ability to define conclusions and the mastery of conclusion making skills.

• It could be that our measure of evaluation in the second mediation did not accutarely capture the conceptual constructs or that it isn't really a necessary step in gaining mastery of the ability to draw conclusions from data.
• Future research will explore if framing assessments as data tables or as graphics will lead to better performance for the 5th grade students.

References

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