Claims, Evidence, and Reasoning in Middle School Science: A Mixed-Methods Study

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Background and Context – Ashley

- Prior science teaching experience in Washington D.C. and Thailand
- Now: 7th Grade Science Teacher at Hector P. Garcia Middle School
- Instructional Goals:
  - Accessible learning for all students
  - Authentic scientific argumentation tasks
  - Deep understanding of science concepts

Background and Context – Jeanna

- Elementary teaching experience (STEM-focused) in Minnesota
- Now: Assistant Professor of STEM Education at SMU
- Research interests
  - Equity in STEM education
  - STEM integration
  - Teacher and student practices in STEM
- Overarching goal of supporting teachers and improving science/STEM education

Claim

Evidence

Reasoning

Literature Review - Argumentation

- Scientific argumentation (McNeill et al., 2006)
  - Claim: addresses a question of interest
  - Evidence: scientific data
  - Reasoning: justification for using the data in relation to the claim
- Learning progression (Berland & McNeill, 2010; Osborne et al., 2016)
- Shortcomings in student argumentation common (Lemke, 1990; Krajcik et al., 1998; McNeill & Knight, 2013; Sadler, 2004)
- Challenges addressing argumentation in the classroom (Driver et al., 2000; McNeill & Berland, 2017; McNeill et al., 2016; Osborne et al., 2003)

Literature Review - Argumentation

- Targeted interventions effective (Chen et al., 2019; McNeill, 2011)
- Explicit instruction key (Kuhn, 1991; McNeill & Krajcik, 2009; Osborne et al., 2004)
- Fading of instructional scaffolds over time (McNeill et al., 2006)

Theoretical Framework - Translanguaging

- Historical deficit perspectives of multilingual students (e.g., Cummins, 2000; Probyn, 2019)
- Translanguaging: students use full range of linguistic resources (García & Sylvan, 2011; Li, 2018; Otheguy et al., 2015)
- Translanguaging can make learning more equitable (García & Wei, 2014)
- Translanguaging associated with improvements in students' understanding of science concepts (Karlsson et al., 2019; Poza, 2018) and argumentation (Licona & Kelly, 2020)

Research Questions

1. How does the quality of students' written arguments change over the course of a school year?
2. How do emergent bilingual students draw upon language resources from English and Spanish in their written arguments?

Research Methods

- Design-based implementation research (DBIR)
  - Collaborative design, testing, and improvement of classroom interventions (Penuel et al., 2011)
  - Responsive to classroom context (Cobb et al., 2003)
- Mixed-methods analysis
  - Quantitative: rubric-based scores of argument quality
  - Qualitative: use of English and Spanish resources

Context and Participants

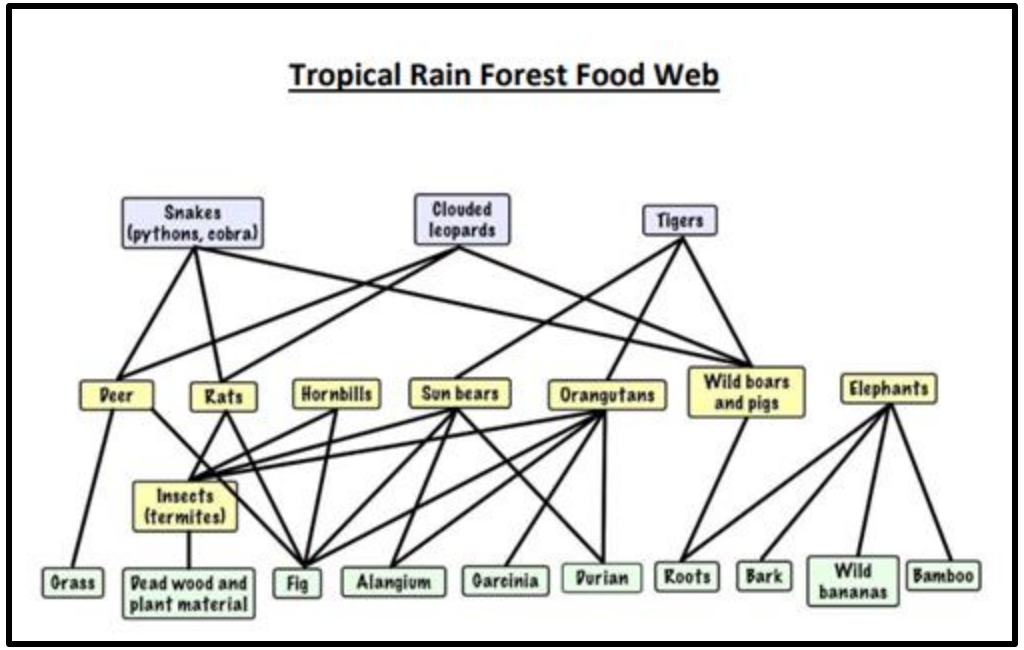
- 77 students in grade 7
- Single middle school
  - 96% of students identify as Hispanic
  - Approximately 68% considered emergent bilingual
- Three sub-populations
  - On-level science (*n* = 35)
  - On-level science with additional language supports (*n* = 16)
  - Honors science (*n* = 26)

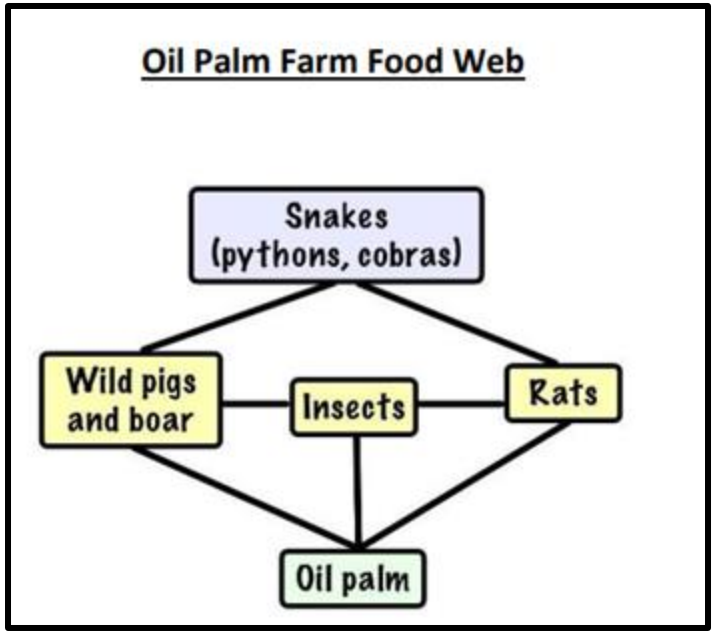
Data Collection

- Students completed 5-6 written arguments on science topics
- Explicit instruction and varying amounts of scaffolding over time and based upon student needs
  - Graphic organizers
  - Sentence frames
  - Materials in English and Spanish
  - Translation services
  - Audio-recording prior to writing

Example Scientific Argument

- Does the biodiversity of an ecosystem affect its ability to handle a disruption?





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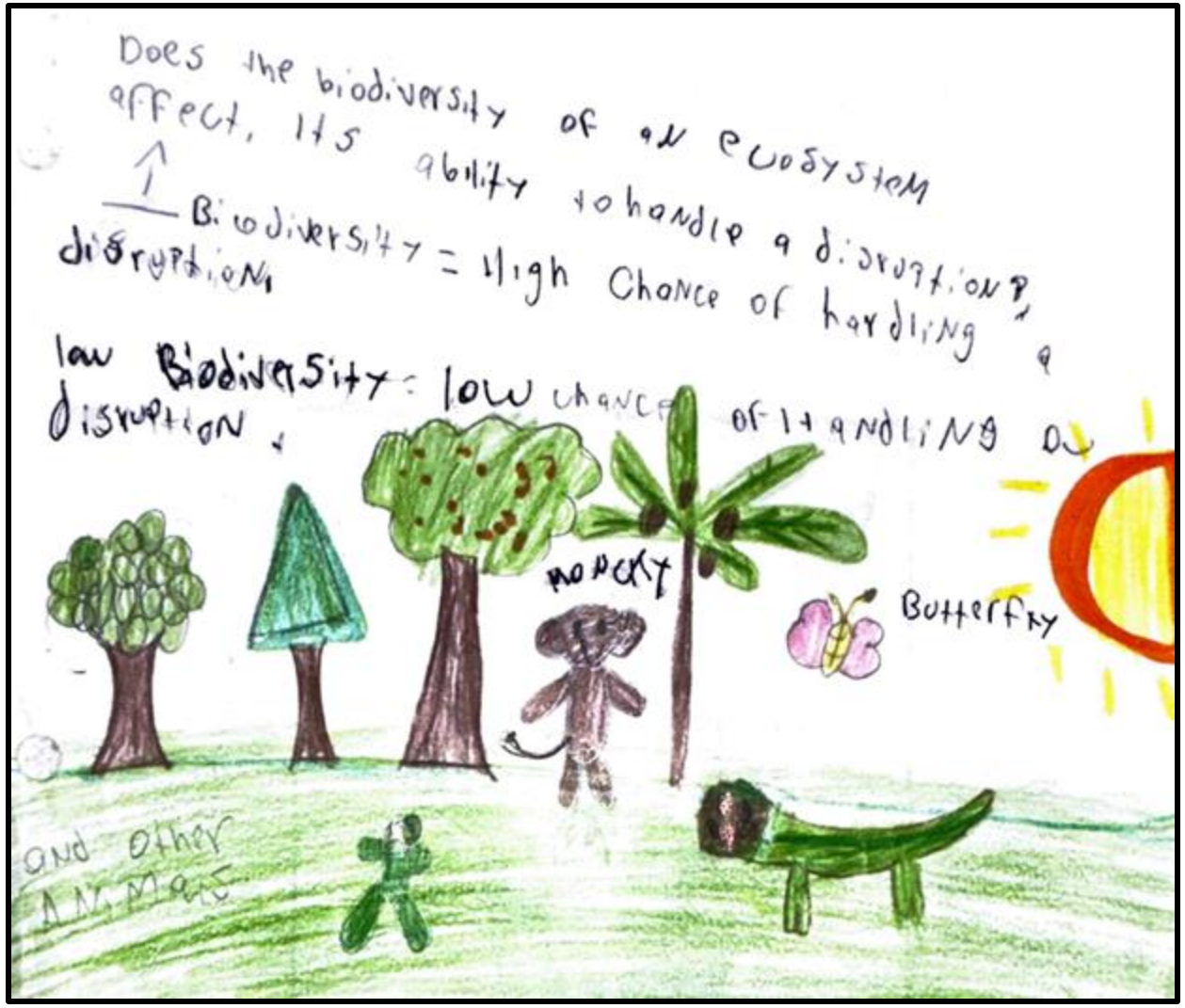


Data Analysis

- Quantitative:
  - Rubric to score written arguments (McNeill & Krajcik, 2008)
  - Maximum of three points for each element of argument (claim, evidence, reasoning)
  - Multilevel time series model with argument measurement occasion nested within individuals – student growth trajectories
  - Interaction effect for argumentation opportunity x class period
- Qualitative:
  - Patterns in use of Spanish and English in written artifacts
  - Use (or non-use) of provided scaffolds
  - Length of written arguments

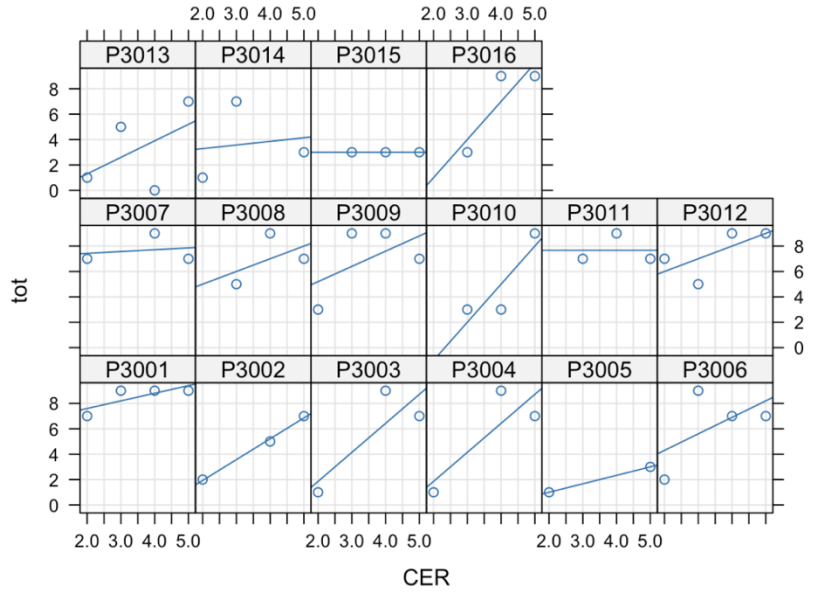
Findings - Quantitative

- Across individuals, increase in total argumentation score (out of maximum of nine points) for each progressive argumentation occasion was 0.70 points
  - Different across class periods
- Final argumentation occasion scores (maximum of 3 points each):
  - Claim: 2.78
  - Evidence: 2.74
  - Reasoning: 2.08

Findings – Quantitative – Emergent Bilingual

- Greatest growth of all class periods: average increase of 1.18 points in each progressive argumentation occasion
- Final argumentation occasion:
  - Claim: all 16 students received score of 3
  - Evidence: all 16 students received score of 2 or
  - Reasoning: 13 of 16 received score of 2 or 3

Individual Student Growth Trajectories in the Emergent Bilingual Class Period



Note. The x-axis represents the argumentation occasion (CER number), and the y-axis represents the total score out of a maximum of nine points. The numbers above each growth trajectory represent study ID numbers.

Findings – Qualitative – Emergent Bilingual

- Changes in relative use of Spanish and English
- Two cases (all names pseudonyms)
  - Highlight different use of language and instructional resources

Qualitative Findings – Case 1: Felipe

- Change in argumentation scores
  - Initial argument: 5 out of 9 possible points
  - Following three arguments: scores of 8-9
- Patterns in language use
  - Initial argument:
    - One sentence in English, remainder in Spanish
    - Total length: 104 words
  - Final argument:
    - All in English
    - Total length: 208 words
    - Review and revision evident
    - Did not use provided graphic organizer to structure argument

Qualitative Findings – Case 2: Alejandra

- Change in argumentation scores
  - Initial argument: 3 out of 9 possible points
  - Final argument: 8 out of 9 possible points
- Patterns in language use
  - More English over school year
  - Consistent use of drawings and visual representations
  - Fluid use of languages, without clear separation
  - Initial argument: 116 words
    - “The fire affect a bird, los árboles cambiaron y solo quedaba comida para bird small.”
  - Final argument: 225 words
    - “I can conclude the presence of vegetation sí affect...”

Discussion

- Unique mixed-method, longitudinal approach to studying students' written argumentation skills
- Reasoning is most challenging for students (e.g., Berland & McNeill, 2010; Osborne et al., 2016)
- Different approaches to leveraging language resources in creating written arguments
- At time of final argument, emergent bilingual class period met or exceeded the average performance of other on-level students on all argumentation elements, and met or exceeded the performance of honors students on all argumentation elements except reasoning

Implications and Next Steps for Teaching

- Overcoming challenges of argumentation instruction
- Importance of instructional supports
  - Translation services and language support tools
  - Collaborative student small groups
  - Teacher and peer feedback on writing samples
  - Developing culture of writing in science
- Instruction now
  - Prioritized scientific argumentation tasks based on key science concepts

Implications and Next Steps for Teaching

Personal Reflections on the Collaboration

- Informing practice while contributing to STEM education research
- Unwavering commitment of partner to student and teacher success
- Authentic professional learning community based on shared interests

Next Steps in Research

- Further qualitative analysis of additional students' arguments
- Conference proposal under review
- Developing full research manuscript for publication

Personal Reflections on the Collaboration

- Bridging gap between research and practice
- Importance of invested partners
- Organizational structures to support researcher-practitioner collaborations

Questions?

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Thank you!

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DALLAS INDEPENDENT SCHOOL DISTRICT

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