Making Sense of the Buzz:
A Systematic Review of "STEM" in AFNR Education Literature

Hannah H. Scherer
Kelly Robinson
Virginia Tech

Aaron J. McKim
Michigan State

Hui-Hui Wang
Purdue

Catherine DiBenedetto
Clemson

Foundational Information

Background

Current models for STEM education call for interdisciplinary approaches in which learners address real-world challenges (NAE & NRC, 2014; NGSS Lead States, 2013).

Current need

Growing demand for AFNR graduates with a combination of technical AFNR, STEM, and leadership skills and knowledge (Andenoro, Baker, Stedman, & Weeks, 2016).

Call for more research

AFNR appears to be a valuable context to teach STEM, however systematic efforts to understand what models are effective are needed (Stripling & Ricketts, 2016).

Roadblock

Once again, the education community has embraced a slogan without really taking the time to clarify what the term might mean when applied beyond a general label. When most individuals use the term STEM, they mean whatever they meant in the past.

(Bybee, 2010, p. 30)

Study Goals

What does previous work tell us about how STEM learning in AFNR occurs?
- frameworks and models for STEM education and/or integration
- identify "effective models for science technology, engineering, and math (STEM) integration in school-based agricultural education curriculum" (Stripling & Ricketts, 2016, p. 31).

What are the entry points to collaboration between AFNR and STEM education communities?
- context and target audience for interventions, goals for teaching STEM

Are we collectively ready to move into this new collaborative, interdisciplinary space?

(Dierking & Falk, 2016; NAE & NRC, 2014; NRC, 2015)

Study Overview

Purpose

Articulate the state of the field for STEM in AFNR education to inform future research, innovations in practice, and interdisciplinary collaborations.

Approach

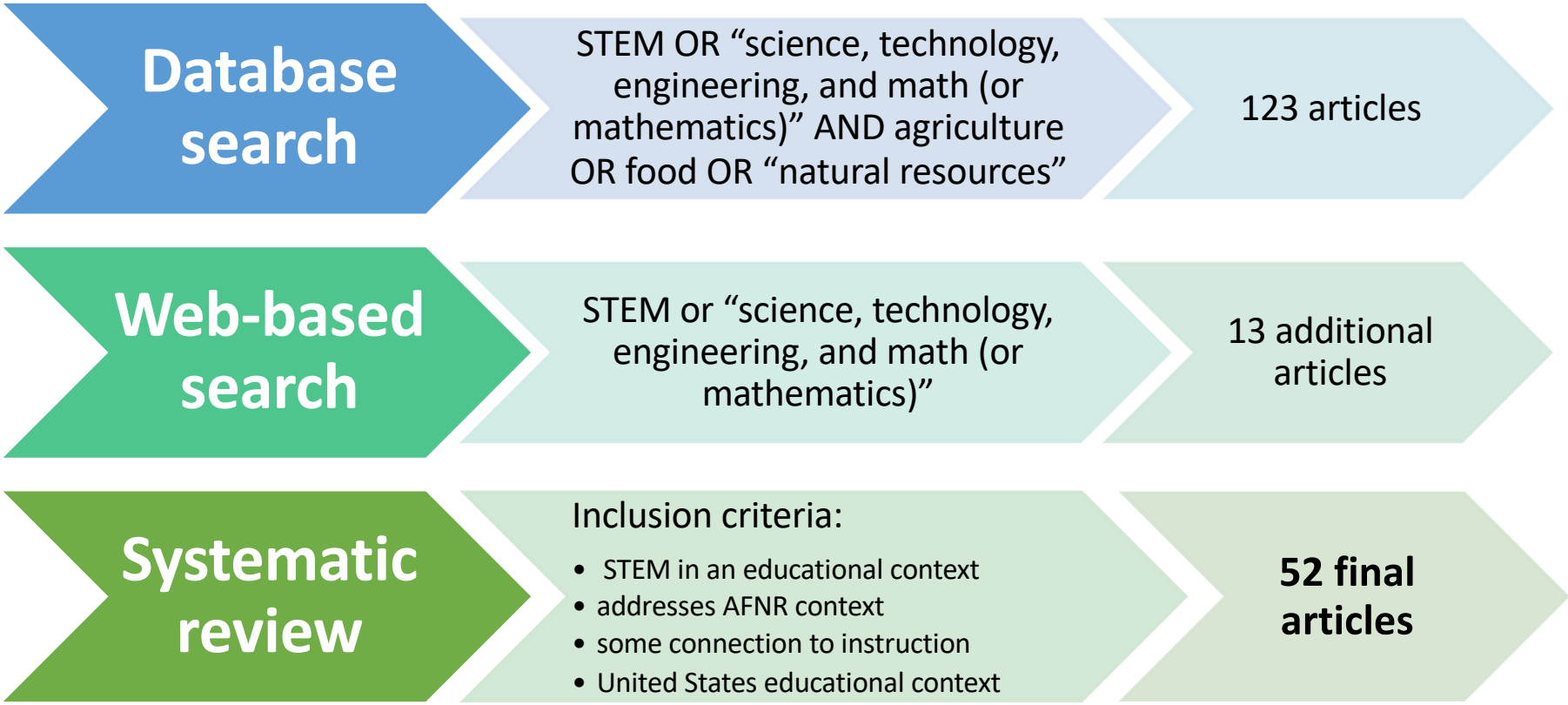
Through a systematic review of STEM in AFNR education literature, we developed a framework to be utilized to help provide structure and guidance for research and teaching.

Methods: Article Selection

Search within title, abstract, and subject/keyword

2010-2017

Peer-reviewed publications



Methods: Article Analysis

First cycle - Initial coding based on research objectives

- each member of the research team coded a subset of papers on all questions
- debriefing by the entire research team
- questions guiding the coding process were refined
- final coding

Second cycle - Theme development

- codes within each research question were analyzed to develop themes
- themes debriefed with the entire research team
- theme descriptions and characteristics finalized
- Final coding with 85% interrater agreement

Findings

Appendix

Characteristics and Themes for Peer-reviewed STEM in AFNR Education Literature

Article	Type of article	Participants[a]	Context/ Topic	Instructional approach[b]	STEM subjects	STEM relationship[b]	AFNR/STEM relationship[b]	Justification[b]	Article focus[b]	Oper. Def. of STEM[b]
Akins, 2013	expert	MS/ HS	Ag careers	-	S,T,E,M	Interrelated	Applied	Recruitment	STEM program or curriculum	-
Balschweid et al., 2014	cohort	u-grad	Life science course	-	S,T,E,M	Disciplinary silos	Naturally occurring	Recruitment	Teacher practices & characteristics	Single
Birney et al., 2017	case	MS teachers	Harbor restoration	hands-on	S	n/a	Applied	STEM Learning	Teacher practices & characteristics	Single
Brandt et al., 2017	cohort	ES	Ag literacy	-	S,T,E,M	Interrelated	External	STEM Learning	STEM program or curriculum	2 or more
Campbell et al., 2014	pract-itioner	ES	Ag awareness day	hands-on	S	n/a	Applied	STEM Learning	STEM program or curriculum	-
Campbell et al., 2015	pract-itioner	ES	Ag day program	hands-on	S,M	Interrelated	Applied	STEM Learning	STEM program or curriculum	-
Chumbley et al., 2015	cohort	HS	Ag science	-	S	n/a	Applied	Recruitment	Perceptions of STEM	Single
Costas et al., 2017	case	HS	Soil microbiology	inquiry	S,T	Real-world	Naturally occurring	STEM Learning	STEM program or curriculum	Single
de Koff, 2017	expert	K-12	Drones in Extension	multiple	S,T,E,M	Interrelated	Naturally occurring	STEM Learning	STEM program or curriculum	-
Despain et al., 2016	cohort	HS	Ag biology	-	S	n/a	Applied	STEM Learning	Standardized testing	Single
DiBenedetto et al., 2015	case	HS	Ag in general	inquiry	S	n/a	Applied	Recruitment	Student career choice	Single + unspecified
Dodd et al., 2015	pract-itioner	4-H	Food challenge	competition	S,M	Interrelated	Naturally occurring	STEM Learning	STEM program or curriculum	-

Findings - Characteristics - Highlights

Objectives 1-3: *Characteristics, such as educational context, target population, and type of research; instructional approach, STEM subjects*

- *55% in AFNR educational settings, 45% other*
- *29% addressed science only*
- *Instructional approach not sufficiently described in 67%*
- *15% employed problem-based learning*

Findings - STEM Relationships

Objective: *Distinguish the relationship between STEM subjects*

Category	Definition	Frequency Observed
Interrelated STEM subjects	Two or more STEM subjects were discussed in combination within the context of AFNR.	20 of 35 manuscripts (57%)
Real-World Problem Solving	STEM is an integrated approach used to address complex problems.	8 of 35 manuscripts (23%)
Disciplinary Silos	No relationship between STEM subjects articulated.	7 of 35 manuscripts (20%)

Note. 35 of the 52 manuscripts addressed more than one STEM discipline.

Findings - STEM/AFNR Relationship

Objective: *Distinguish the relationship between AFNR education and STEM learning*

Category	Definition	Frequency Observed
Applied STEM	AFNR education is an appropriate context for STEM learning.	29 of 52 manuscripts (56%)
STEM is Naturally Occurring	STEM learning happens as students engage in AFNR education.	18 of 52 manuscripts (35%)
STEM is External	STEM learning outcomes can be incorporated into AFNR education.	5 of 52 manuscripts (10%)

Findings - Justifications

Objective: *Determine how research and teaching of STEM was justified*

Category	Definition	Frequency Observed
STEM Learning	STEM learning outcomes can be achieved or enhanced through AFNR education.	29 of 52 manuscripts (56%)
Recruitment	More professionals are needed in STEM and/or AFNR.	13 of 52 manuscripts (13%)
Career Readiness	STEM learning is needed for success within professional careers.	8 of 52 manuscripts (15%)
Problem Solving	STEM learning is needed to solve complex problems.	4 of 52 manuscripts (8%)
Interdisciplinary Connections	AFNR and STEM learning are mutually reinforcing.	1 of 52 manuscripts (2%)

Note. Multiple justifications were used within some manuscripts.

Findings - Article Focus

Objective: *Describe the primary focus or objective*

Category	Definition	Frequency Observed
STEM Program or Curriculum	Evaluating or describing a program or curriculum to engage students in STEM.	33 of 52 manuscripts (63%)
Teacher Practices and Characteristics	Identifying or describing characteristics and approaches of STEM among AFNR educators.	9 of 52 manuscripts (17%)
Student Career Choice	Evaluating STEM career choice.	4 of 52 manuscripts (8%)
Perceptions of STEM	Interested in how individuals conceptualize STEM.	3 of 52 manuscripts (6%)
Emergent STEM	STEM was not the initial focus, however, STEM emerged through data collection.	3 of 52 manuscripts (6%)
Standardized Testing	Evaluating results from standardized assessments of STEM knowledge.	2 of 52 manuscripts (4%)

Note. Multiple objectives were used within some manuscripts.

Findings - Operationalization

Objective: *Identify how STEM was operationalized in the intervention and/or research design*

Category	Definition	Frequency Observed
Single Subject	One STEM subject within the intervention and/or research design.	17 of 52 manuscripts (33%)
Two or More Disciplines	Two or more STEM subjects within the intervention and/or research design.	11 of 52 manuscripts (21%)
Unspecified Disciplines	Intervention and/or research design involves an undescribed subset of science, technology, engineering, and/or mathematics.	7 of 52 manuscripts (13%)
n/a	Not research or STEM was emergent in the study.	19 of 52 manuscripts (37%)

Note. Multiple operationalizations were used within some manuscripts.

Applying a new proposed language

- Aim of study was to determine how STEM has been framed in literature.
- Common framework not identified for STEM and AFNR
- **Themes identified provide <u>options</u> to consider relationship between STEM and AFNR**
- Proposed common language to communicate and build new knowledge

Emergent Theme	Description
Relationship between STEM Subjects	
Interrelated STEM Subjects	Two or more STEM subjects were discussed in combination within the context of AFNR.
Disciplinary Silos	No relationship between STEM subjects articulated.
Real-World Problem Solving	STEM is an integrated approach used to address complex problems.
Relationship between AFNR and STEM	
Applied STEM	AFNR education is an appropriate context for STEM learning.
STEM is Naturally Occurring	STEM learning happens as students engage in AFNR education.
STEM is External	STEM learning outcomes can be incorporated into AFNR education.
Primary Justification for STEM in AFNR	
STEM Learning	STEM learning outcomes can be achieved or enhanced through AFNR education.
Recruitment	More professionals are needed in STEM and/or AFNR.
Career Readiness	STEM learning is needed for success within professional careers.
Problem Solving	STEM learning is needed to solve complex problems.
Interdisciplinary Connections	AFNR and STEM learning are mutually reinforcing.
Article Focus	
STEM Program or Curriculum	Evaluating or describing a program or curriculum to engage students in STEM.
Teacher Practices and Characteristics	Identifying or describing characteristics and approaches of STEM among AFNR educators.
Student Career Choice	Evaluating STEM career choice.
Perceptions of STEM	Interested in how individuals conceptualize STEM.
Emergent STEM	STEM was not the initial focus, however, STEM emerged through data collection.
Standardized Testing	Evaluating results from standardized assessments of STEM knowledge.
Operationalization of STEM in Research	
Single Subject	One STEM subject within the intervention and/or research design.
Two or More Subjects	Two or more STEM subjects within the intervention and/or research design.
Unspecified Subjects	Intervention and/or research design involves an undescribed subset of science, technology, engineering, and/or mathematics.

Implications for AFNR educators

- STEM or S-T-E-M? Interdisciplinary or four distinct disciplinary silos
- Lack of focus on Engineering and Technology highlights growth opportunity and rethinking of agricultural mechanics/ engineering courses in relationship to NGSS
- Opportunity to collaborate with STEM educators supported by our findings
- Consider learning opportunities across the lifespan
- How do you articulate the relationship between AFNR and STEM within your own teaching? How does it align with our themes? Are you intentional about your approach?

Implications for researchers

- Key deficit in depth of descriptions of instructional approach limits development of theoretically and empirically supported frameworks and models → **case studies in collaboration with educators**
- Common language can allow for aggregation of findings → **meta-analyses**
- Researchers should critically review how they operationalize each characteristic in their work → **alignment between justifications, interventions, and research design in the literature**

NAE & NRC, 2014

Final thoughts

Teaching STEM through AFNR contexts allows us to prepare students to learn about, address challenges within, and be employed in AFNR.

What does previous work tell us about how STEM learning in AFNR occurs?

What are the entry points to collaboration between AFNR and STEM education communities?

Are we collectively ready to move into this new collaborative, interdisciplinary space?

Scherer, H., McKim, A. J., Wang, H.-H., DiBenedetto, C. A., & Robinson, K. (in press). Making sense of the buzz: A systematic review of "STEM" in agriculture, food, and natural resources education literature. *Journal of Agricultural Education*.

Hannah H. Scherer
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References

Andenoro, A. C., Baker, M., Stedman, N., & Weeks, P. P. (2016). Research priority 7: Addressing complex problems. In T. G. Roberts & M. T. Brashears (Eds.), American Association for Agricultural Education national research agenda: 2016-2020. Gainesville, FL: Department of Agricultural Education and Communication. Retrieved from http://aaaeonline.org/resources/Documents/AAAE_National_Research_Agenda_2016-2020.pdf.

Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher, 70*(1), 30-35.

Dierking, L. D., & Falk, J. H. (2016). 2020 Vision: Envisioning a new generation of STEM learning research. *Cultural Studies of Science Education, 11*(1), 1-10. doi:10.1007/s11422-015-9713-5

National Academy of Engineering (NAE) & National Research Council (NRC). (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research*. Washington, DC: The National Academies Press.

National Research Council. (2015). *Identifying and supporting productive STEM programs in out-of-school settings.* Washington, DC: The National Academies Press.

NGSS Lead States. (2013). Next generation science standards: For states, by states. Retrieved from http://www.nextgenscience.org/next-generation-science-standards

Stripling, C., & Ricketts, J. C. (2016). Research priority 3: Sufficient scientific and professional workforce that addresses the challenges of the 21st century. In T. G. Roberts, A. Harder, & M. T. Brashears (Eds.), *American Association for Agricultural Education national research agenda: 2016-2020*. Gainesville, FL: Department of Agricultural Education and Communication.