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Knowledge, Skills, or Attitudes/Beliefs: The Contexts of Agricultural Literacy in Upper-Elementary Science Curricula

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Abstract

Agricultural literacy connects knowledge, skills, and attitudes/beliefs (KSABs) about agriculture to KSABs in environmental education, education for sustainable development, and science education identified in recent reform initiatives. This study conducted a content analysis of 12 current upper-elementary U.S. science textbooks and curriculum programs to examine the representations and contexts of agricultural concepts. The findings revealed the reviewed materials did not include thorough representations of agricultural concepts or a wide distribution of KSABs and lacked systematic development of agricultural concepts. Implications for integrating agriculture into the elementary science curriculum to promote environmental, agricultural, and scientific literacy are discussed, as well as recommendations to guide developers to redesign science curriculum and promote agricultural literacy.

Keywords: agricultural literacy; agricultural education; environmental education; science curriculum; education for sustainable development; elementary

Introduction

During a recent summer tour of a local agricultural education center, a young boy of about 12 visiting from a large urban school district proposed to me a startling question. When the group was asked to note some of the visible and tactile differences between a small, brown chicken egg and a large, white duck egg, the young man inquired, "What's in them?" I thought for a moment as to how I should answer the question, not quite sure how to explain "an egg", while lamenting my own assumption that everyone knew what was inside those thin multi-colored shells. After my feeble attempt to explain the cuticle, shell, yolk, and white, he nodded in acknowledgement, "Oh, like in an Egg McMuffin!" His response confirmed what had long been troubling me; U.S. citizens lack sufficient agricultural literacy (Doerfert, 2011; Kovar & Ball, 2013; National Research Council [NRC], 1988).

U.S. citizens hold misconceptions about agriculture that are often led by stereotypical perceptions, such as farmers wearing straw hats and overalls working in barnyards full of clucking chickens, cows, and tractors (DeWerff, 1989; Frick, Kahler, & Miller, 1991; Leising, Igo, Heald, Hubert, & Yamamoto, 1998; Trexler, Johnson, & Heinze, 2000). Elementary school children have been found to interpret agriculture as the farmer, the cow, the tractor, and the rancher (DeWerff, 1989). Unfortunately, teachers' lack of agricultural knowledge and media-derived stereotypes often match their students' and have changed little over the last several decades (Anderson, Thompson, & Velez, 2010). This is particularly problematic, since agriculture impacts all of our lives in relation to food and fiber production, the resources and environmental implications involved in their production, and global trade. Introducing agricultural literacy initiatives early in

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life can create globally competent consumers who are aware of the countless interconnections within the physical world and help people make better decisions regarding their health, the environment, and the future (Frick et al., 1991).

Agricultural literacy, which differs from agricultural education, includes knowledge, skills, and attitudes/beliefs (KSABs) *about* the field of agriculture similar to those in science, environmental education, and education for sustainable development (henceforth, ESD; see Figure 1). Although agriculture has largely been removed from U.S. school curricula over the last century, recent science and environmental education reform documents – e.g., *A Framework for K-12 Science Education* (henceforth, *Framework*; NRC, 2012), *Next Generation Science Standards* (henceforth, *NGSS*; NGSS Lead States, 2013), *Excellence in Environmental Education – Guidelines for Learning* (North American Association for Environmental Education [NAAEE], 2010) – have reintroduced it in an attempt to create conscientious citizenry and lifelong learners who understand important interdisciplinary concepts (NRC, 2012).

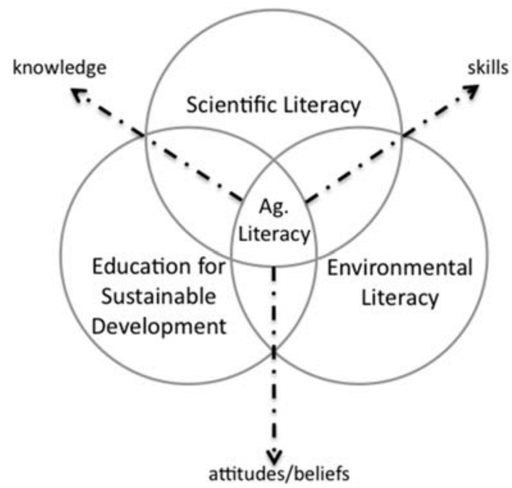

Figure 1. Agricultural (Ag.) literacy's integration within scientific literacy, environmental literacy, and education for sustainable development.

Organizations such as Farm Bureaus, 4-H, cooperative extension agencies, and organizations such as Agriculture in the Classroom have developed scores of instructional materials in response to recommendations for agricultural reintegration. However, most resources are offered as enhancement materials to supplement existing basal textbooks and curricula and have not been aligned to national standards or designed to be integrated coherently into existing instruction, leaving agriculture's systematic presentation potentially obstructed. Coherent, systematic presentation of curriculum "means that for teachers and students, the learning goals, activities, and assessments align with each other" (Drake & Burns, 2004, p. 19), which can address misconceptions and stereotypical thinking to improve students' agricultural literacy. Thus, the issue does not stem from a dearth of agricultural materials (Bellah & Dyer, 2009), but in how agriculture is currently embedded in general education. Teachers' own lack of knowledge, interest, or time may also inhibit agricultural instruction (McReynolds, 1985). To understand students' exposure to agriculture, this content analysis of upper-elementary U.S. science curricula is the first to examine the representation and contexts of agricultural concepts.

Agricultural Literacy

Agricultural literacy differs from agricultural education in that its focus is on educating students *about* the field of agriculture rather than preparing students for work *within* the field of agriculture. According to the NRC's (1988) report, *Understanding Agriculture: New Directions for Education,* "Agriculture is too important a topic to be taught only to the relatively small percentage of students considering careers in agriculture" (p. 1) and should be integrated into all grade levels and fields of study. Agricultural literacy encourages understandings about food and fiber systems, global economies, nutrition, and environmental conscientiousness (NRC, 1988). Agricultural educators have constructed definitions necessitating literate students be able to "synthesize, analyze, and communicate" about agriculture (Frick et al., 1991, p. 54), as well as appreciate the values and beliefs within the system to become fully engaged, literate students (Meischen & Trexler, 2003).

(Re)Integration of Agriculture

Historically, agriculture was introduced to all students in all grade levels as a study in science education, appearing in schools in the late 1700s (Dabney, 1904). Its familiarity to students allowed for authentic contexts and experiential learning opportunities (Knobloch & Martin, 2002) and was considered an important topic in all schools – rural, suburban, and urban alike (Hillison, 1998). Over time, however, agriculture became a vocational study no longer integrated into general education. In the 1980s, agricultural literacy efforts emerged and advocated its integration into science and environmental education (Leising, Pense, & Portillo, 2003). According to agricultural educators, agriculture should be integrated into existing K-12 math, science, engineering, technology, and literature curricula (Balschweid, Thompson, & Cole, 2000; Trexler et al., 2000) because its relevance can enhance learning experiences by encouraging students to think deeply about the real world and construct their own knowledge with authentic, tangible examples (Bellah & Dyer, 2009; Knobloch, Ball, & Allen, 2007; Lockwood, 1999).

Science, Environmental Literacy, and Education for Sustainable Development Initiatives

Recent educational reform initiatives within science, environmental education, and education for sustainable development discussed integrating disciplines (including agriculture) to minimize the breadth of disjointed facts and increase the depth of understanding by incorporating crosscutting concepts, practices, and core ideas shared by several fields (NAAEE, 2010; NRC, 2012). Each initiative overlaps with the others, converging on advocacy for the development of citizens who are aware of their impacts on the natural world. Becoming "literate" in each of these fields encourages individuals to make informed decisions regarding important personal and societal issues. Unfortunately, none of the discipline-based literacy definitions has encouraged becoming literate in the other fields as well, which would help individuals grasp the interconnectedness between the disciplines. For instance, to be considered scientifically literate (NGSS Lead States, 2013; Bybee, 1997), students should respect and understand how resources influence their environments, such as "…maintaining supplies of clean water and food, and solving the problems of global environmental change" (NRC, 2012, p. 9). However, being scientifically literate does not mean students are equally environmentally literate. To be environmentally literate (McBeth & Volk, 2010; Roth, 1992), students must develop scientific skills, such as observing and investigating environmental issues experienced in the natural and man-made worlds (NAAEE, 2010); yet becoming environmentally literate does not mean students are also scientifically literate. To understand sustainability (Scott & Gough, 2003; Sterling, 2001), students should plan for a sustainable future, while respecting and preserving the past; but similarly, that does not mean students are scientifically and environmentally literate. However, it is important for students to become literate in each of the fields to make wiser choices as lifelong consumers and recognize their own impacts on the environment and in the world.

Most often these subjects are taught in isolation with minimal integration. Agriculture can link these topics by providing relevant, authentic, and familiar examples and connections students recognize by acknowledging the resources and products people consume involve (preferably) sustainable scientific processes with environmental impacts (Blum, 1973; Powell, Agnew, & Trexler, 2008), such as studying organic farming methods and how our food gets to our tables. Integrating science into vocational agriculture improved scientific literacy "owing to the synergistic connections between the disciplines" (Rosentrater, 2005, p. 323). Others contend the reverse to also be true: By infusing agriculture into other disciplines, agricultural literacy will likely increase (Conroy & Sipple, 2001; Vahoviak & Etling, 1994). While familiarity does not imply literacy, agricultural literacy contains crosscutting concepts, core ideas, and ties together KSABs about agriculture to those in science, environmental education, and ESD.

Purpose of Study

Teachers use adopted textbooks and curricula, particularly when they are unfamiliar with content knowledge (Driscoll, Moallem, Dick, & Kirby, 1994; Stern & Roseman, 2004). Curricula designed well can enhance knowledge acquisition, and those designed poorly can promote misconceptions or stereotypes (Ball & Cohen, 1996). If teachers use adopted materials that lack systematic development of agricultural concepts, agricultural literacy efforts will likely not be achieved. Identifying the extent of agricultural representation and the contexts in which agricultural concepts appear in current materials can provide support and evidence for curriculum reform initiatives' calls for integrated materials, increased student literacy, science for all, and the leveling of inequality in general education. Such discoveries can also help curriculum and instructional designers locate appropriate places for agricultural integration into new basal textbooks and curricular programs that could be adopted by several states and districts.

The purpose of this content analysis of widely adopted upper-elementary U.S. basal science textbooks and curriculum programs was to determine the representation and context in which agricultural literacy concepts are presented to students in primary education. According to McReynolds (1985), "[t]he earlier in life that we present information [about agriculture] to children, the more receptive they are to accepting and applying wholesome concepts about the topic for the rest of their lives" (p. 17). This study explored the following research questions:

(1) To what degree (frequency) are agricultural literacy concepts embedded in upper-elementary science textbooks and curriculum programs?

(2) In what contexts (knowledge, skills, or attitudes/beliefs) do agricultural literacy concepts appear within the materials?

Methods

Since agriculture has historically been a part of science education, it was fitting to explore its current presence in science curriculum materials. This study employed content analysis of current science materials to provide a systematic and objective examination of agriculture's presence, as well as to make qualitative inferences about the embedded contexts in which agriculture appeared (Krippendorf, 2004). In this investigation, curriculum was defined as having a scope and sequence of learning activities designed around a science topic that included traditional basal textbooks and other curriculum programs not centered on a primary textbook.

Sample

The textbooks and curriculum programs in this study were gathered by first identifying U.S. "textbook adoption states" (Education Commission of the States [ECS], 2005). Then, the most current lists of *approved* curriculum materials from the 20 adoption states were reviewed, since no lists of actual *adopted* science curricula exist. The 12 most frequently identified science textbooks and curriculum programs on the approved lists for 4th and 5th grades were collected and analyzed (see Table 1). These grades were selected since children are in the concrete operational stage of development where they begin using logic and reasoning to understand multiple parts of problems and systems (Piaget, 1983), which is important when beginning to understand agriculture's many connections to science, environmental education, and other fields of study, so these grades were appropriate. The materials included in the study were published between 2003 and 2007; and while some materials have more current editions available, states often keep materials in schools up to 10 years since curriculum review cycles, adoption cycles, publisher contracts, and budget cycles vary (ECS, 2005). Regardless of reform initiatives encouraging science for all, many states, districts, and schools are unable to provide students with materials that can meet these needs and reduce inequalities due to the lack of resources to adopt newer materials (Hug, Krajcik, & Marx, 2005; Lynch, 2000), so using versions likely to still be in the classrooms across the country was intentional.

Table 1

Frequency of Most Approved Science Curricula by Textbook Adoption States

Publisher/Title/Copyright	Abbreviation	4th Grade	5th Grade
MacMillan/McGraw-Hill Science (2005)	MMH	16	17
Houghton Mifflin Science-California (2007)	HMS	13	13
Scott Foresman Science (2006)	SFS	13	13
Full Option Science System (2005) [a]	FOS	11	11
Harcourt School Publishers Science (2003)	HSP	10	10
Delta Science Modules (2004) [b]	DSM	6	8

[a]Grade four: Earth Materials, Human Body, Matter and Energy, Structures of Life, and Water. Grade five: Environments, Food and Nutrition, Landforms, Living Systems, and Water Planet.

[b]Grade four: Food Chains and Webs, Electromagnetism, Earth Movements, and Dinosaurs and Fossils. Grade five: Cells and Classification, Energy, Erosion, and Our Solar System and Beyond.

Design and Procedure

A Guide to Food and Fiber Systems Literacy (henceforth, *FFSL*; Leising et al., 1998) and the *Framework* (NRC, 2012) laid the foundation for the construction of a code-sheet containing agricultural topics, themes, and concepts loosely framed around Frick and colleague's (1991) "11 broad agricultural subject areas" (p. 54). The *FFSL* was developed and tested to provide a framework for agricultural literacy in K-12 education; however, no update has been released since its inception. Therefore, additional concepts were added to align to new agricultural topics included in the *Framework.* Ten overarching agricultural categories and 385 subsequent concepts were listed on the code-sheet, and a codebook was designed as a guide for coding the concepts (visit https://www.academia.edu/6817113/Science_Curricula_Codebook for a downloadable version). See Table 2 for select examples in each category of the code-sheet or visit https://www.academia.edu/6817188/Science_Curricula_Code_Sheet for the complete, downloadable code-sheet. Thoughtful *a priori* research design involving coding definitions and decisions is said to improve the reliability, validity, generalizability, and intersubjectivity of the constructs identified in science reform initiatives (Neuendorf, 2002).

Table 2

Categories with Concept Examples

Agricultural Category	Number in Category	Select Examples
General Agriculture	46	Agriculture; by-products; consumers; farmer; policy; wildlife
Food & Nutrition	48	Calories; diet; food; food chains; minerals; nutrition
Plants, Agronomy, & Horticulture	51	Bacteria; CO_2; crops; fertilizers; irrigation; plants
Livestock, Meat, & Poultry	31	Animals; birds; fish; livestock; migration; veterinarian
Dairy	23	Cheese; cows; dairy products; homogenization; pasteurization
Work Animals & Machines	19	Farm machinery; ox/oxen; plow; simple machines; tools; tractor
Fiber	22	Building structures; fiber; paper; shelter; timber/lumber; wool
Land & Natural Resources	48	Habitat; land/landforms; lakes/ponds; natural resources; erosion; water
Environment & Sustainability	47	Climate; conservation; ecosystem; energy; pollution; sustainable
Agriscience & Biotechnology	50	Agribusiness; biodiversity; biofuels; disease; pesticide; recycling
Summary	385	

The codebook and code-sheets were used to determine the frequency and contexts in which agricultural literacy concepts were embedded in the curricula materials. Each time a concept appeared on a page in the materials, it was entered on the code-sheet. If a concept appeared more than once on a page, it was recorded only once unless it appeared in more than one context (for example, as knowledge *and* a skill), then each context was recorded individually. Tables-of-contents, glossaries, vocabulary insets, overviews/reviews, and supplemental references were not included in the analysis. Illustrations of a concept, such as dog (*animal*) or kudzu (*plant*), were coded as the concept they represented. If similar illustrations appeared on the same page, such as wolf and dog, *animal* was counted only once. Concepts were then tallied to describe the frequency of each category's representation.

The materials were also reviewed to examine the context in which agricultural concepts were presented to either: 1) provide content *knowledge*, 2) teach a related *skill*, or 3) influence an *attitude* or change a *belief*. The definitions of KSABs were adapted from Bloom's taxonomy of learning domains and defined in the codebook using examples from the Association of Schools of Public Health's (2012) guiding documents for faculty and curriculum designers (see Table 3 below for select examples). These documents provided action verbs and examples to identify *knowledge* (usually as background content), *skills* (in labs/guided inquiries or critical thinking questions), and *attitudes/beliefs* (suggestions for altering opinions or behaviors) in the study.

Table 3

Select Definitions, Action Verbs, and Examples from NGSS of KSABs from the Codebook

	Knowledge	Skills	Attitudes/Beliefs
Definitions	complex process of learning concepts, principles, and information, and remembering, relating, and judging ideas or abstract phenomenon	the ability to use one's knowledge effectively and readily in execution or performance; a learned power of doing something competently : a developed aptitude or ability	conviction of the truth of some statement or the reality of some being or phenomenon especially when based on examination of evidence
Action Verbs	analyze, classify, compare, describe, differentiate, explain, generate, identify, interpret, justify, prioritize, recognize, summarize, understand, use, verify	adapt, assess, categorize, clarify, communicate, construct, cooperate, demonstrate, detect, develop, document, employ, evaluate, organize, prioritize, propose, recommend, utilize	appreciate, assume responsibility, assure, be conscientious, be ethical, demonstrate composure, develop, endorse, express, justify, maintain awareness, resolve, respect, value
NGSS Examples	Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space.	Obtain and combine information about ways individual communities can use science ideas to protect the Earth's resources and environment.	Individuals and communities are doing things to help protect Earth's resources and environments.

Upon completion, the data from the code-sheets were analyzed to address both research questions. Frequencies of each concept and the contexts of agricultural literacy in each science curriculum were computed. To ensure inter-rater reliability, an undergraduate student coder also examined one textbook and curriculum program from each grade level, for a total of four sources. Coding agreement occurred for the majority of items (91%), and when disagreements occurred, discussions took place until consensus was reached.

Findings

Table 4 contains a list of the frequencies that the agricultural categories appeared, and Table 5 showcases the distribution of the categories' contexts. None of the materials included all 385 subsequent concepts from the 10 created categories. On average, the materials contained between 19% (*general agriculture*) and 60% (*plants, agronomy, and horticulture*) of the subsequent concepts in each category. Equally notable, not all of the concepts were presented as knowledge, skills, *and* attitudes/beliefs.

Frequencies of Agricultural Representation

The number of page occurrences for each concept was analyzed to determine the frequencies agricultural categories appeared in the materials (see Table 4). *Land and natural resources* (N=5,703), *plants, agronomy, and horticulture* (N=4,677), and *environment and sustainability* (N=3,521) appeared regularly in all materials; however, some concepts appeared substantially more often than others, which resulted in a higher frequencies of certain categories. For instance, in the *land and natural resources* category, many materials cited *water's* (N=1,746) importance as a natural resource, but did not include concepts such as *overgrazing* and *deforestation*. Similarly, in the *plants, agronomy, and horticulture* category, *plants* (N=1,025) appeared frequently as part of the food chain, ecosystem, or whose structures and functions were described and analyzed; however, concepts such as *agronomy* and *cultivation* were seldom mentioned. In the *environment and sustainability* category, *energy* (N=672) was mentioned frequently in the materials; however, concepts related to *stewardship*, *climate change*, and *sustainability* rarely appeared.

Food and nutrition (N=2,113), *livestock, meat, and poultry* (N=2,081), *fiber* (N=1,028), and *agriscience and biotechnology* (N=884) were moderately represented in the materials; and again, some concepts were mentioned more often than others. All used the term *food* (N=619) regularly; however, concepts such as *calories*, *hunger/starvation*, and *preservatives* rarely appeared. The *livestock, meat, and poultry* category appeared regularly simply because it contained the term *animal* (N=1,120), which seldom related to agriculture.

General agriculture (N=466), *work animals and machines* (N=152), and *dairy* (N=168) were not mentioned significantly in any of the materials. Several used *horses* to describe fossils, bones, and evolution, but offered little more about their agricultural uses, save for one discussing *crossbreeding* and *hybrids* (both in *agriscience and biotechnology*). Other materials offered lessons on *simple machines,* demonstrating their mechanics and physics rather than their importance in agricultural production. *Dairy* concepts appeared most often when illustrating *digestion*.

While many agricultural concepts appeared in the materials, many concepts were often disconnected from the agricultural literacy standards defined in *FFSL* and the *Framework*. Conceptual ideas pertaining to particular agricultural concepts were not developed. Topics were primarily presented as isolated facts or examples illustrating separate, non-agricultural ideas in science education.

Table 4

Frequencies of Agricultural Literacy Concepts in Upper-Elementary Science Curricula

		4th Grade						5th Grade					
Agricultural Category	Total	MMH	HMS	SFS	FOS	HSP	DSM	MMH	HMS	SFS	FOS	HSP	DSM
General Agriculture	466	45	62	52	15	36	8	71	34	36	41	58	8
Food & Nutrition	2,113	150	136	198	125	97	19	298	214	219	461	169	27
Plants, Agronomy, & Horticulture	4,677	465	320	598	225	308	59	833	296	491	447	516	119
Livestock, Meat, & Poultry	2,081	283	194	209	112	202	56	286	75	216	193	214	41
Dairy	168	15	6	12	9	8	0	33	13	10	49	11	2
Work Animals & Machines	152	21	2	22	12	18	1	24	9	22	5	10	6
Fiber	1,028	132	117	140	49	91	9	152	71	94	69	94	10
Land & Natural Resources	5,703	627	460	592	276	485	72	823	453	615	568	622	110
Environment & Sustainability	3,521	364	265	467	96	201	42	493	325	450	313	427	78
Agriscience & Biotechnology	884	93	84	112	37	52	17	126	45	127	80	103	8
Summary	20,793	2,195	1,646	2,402	956	1,498	283	3,139	1,535	2,280	2,226	2,224	409

Agricultural Contexts

The contexts in which agricultural concepts appeared were not distributed evenly across KSABs (see Table 5). As mentioned, none of the materials included all of the concepts represented as knowledge, skills, *and* attitudes/beliefs; however, some materials did present a few concepts in all contexts (KSABs). For instance, one text discussed *farming's* future and *hydroponics* in great detail, offering facts (*knowledge*), questions for inquiry (*skills*), and the thought that such growing may be healthier and more environmentally friendly than traditional agricultural practices that produce runoff and pollution from pesticides and herbicides (*attitudes/beliefs*). A few described *plants* and their uses (*knowledge*), used them in labs to teach scientific processes (*skills*), and discussed how protecting them would reduce *soil erosion*, *carbon dioxide*, and promote healthy *ecosystems* to encourage students to be more conscientious about their impacts on the environment (*attitudes/beliefs*).

Most agricultural concepts, however, were presented as content knowledge (N=16,710) to illustrate non-agricultural topics, rather than teach related skills (N=3,255) or influence attitudes/beliefs (N=828). For example, a passage highlighting a chemist who studied fuel cells mentioned ethanol (a *biofuel* made from *corn*) as *renewable energy*; however, the occupation was the focus, not the processes involved (*skill*) or importance of developing biofuels for commercial use to conserve natural resources (*attitude/belief*). Another mentioned *land clearing* and *plowing* as human environmental manipulations that cause *habitat* and *ecosystem destruction*, which could generate negative attitudes about agriculture, but failed to mention agriculture's importance to the survival of the global population.

When concepts were used to teach skills, most used labs, demonstrations, or critical thinking questions involving *animals, plants*, *fruits* or *vegetables*, *soil*, *water*, *sunlight*, or *insects* to investigate *plant parts* or *growth*, *composting*, *environments*, *ecosystems*, or *pollution*. For example, onions were used in labs to teach students how to classify *plant* parts and view cells; however, not all labs were meaningfully tied back to knowledge of *growing plants* or plants' importance for survival and for *reducing carbon dioxide*. *Soil* was used in labs to encourage investigation about *erosion*, *soil composition*, and filtering *water*, but offered minimal suggestions for student action to conserve and protect it as a natural resource.

When concepts were presented to influence attitudes or beliefs, most materials described *pollution*, *conservation*, and *ecosystem, habitat,* and *environmental destruction*. Students learned through vignettes that *chemicals, fertilizers,* and *pesticides* caused *water, soil,* and *air pollution*, what individuals were doing to combat it, and what students could do to change their behaviors or help repair the *environment*. One textbook described a man who removed garbage along the Mississippi River because *pollution* and toxic *runoff* contaminate drinking *water* and encouraged students to find ways to help keep their own rivers clean. Another's passage offered suggestions for students to participate in Earth Day, but provided little background knowledge or further inquiry. Overall, these findings demonstrate a lack of agricultural literacy concepts and an uneven distribution of the concepts over the contexts of KSABs.

Table 5

Contexts of Agricultural Literacy Concepts in Upper-Elementary Science Curricula

		4th Grade						5th Grade					
Agricultural Category	Totals	MMH	HMS	SFS	FOS	HSP	DSM	MMH	HMS	SFS	FOS	HSP	DSM
Knowledge													
General Agriculture	362	36	46	33	15	32	8	55	25	34	32	39	7
Food & Nutrition	1,717	133	112	142	119	81	19	239	165	169	380	132	26
Plants, Agronomy, & Horticulture	3,871	402	253	445	220	268	59	677	248	392	386	419	102
Livestock, Meat, & Poultry	1,731	221	155	157	107	182	56	239	57	167	181	180	29
Dairy	135	12	4	3	9	7	0	28	11	9	42	8	2
Work Animals & Machines	132	18	2	19	11	18	1	22	7	17	5	7	5
Fiber	708	90	73	97	45	76	9	101	28	65	63	51	10
Land & Natural Resources	4,579	493	347	450	257	401	72	662	339	474	508	483	93
Environment & Sustainability	2,775	285	198	350	89	164	42	391	268	332	272	326	58
Agriscience & Biotechnology	700	70	64	82	35	43	17	99	34	92	72	85	7
Summary	16,710	1,760	1,254	1,778	907	1,272	283	2,513	1,182	1,751	1,941	1,730	339
Skills													
General Agriculture	49	2	6	10	0	2	0	11	7	1	4	6	0
Food & Nutrition	358	15	24	51	6	16	0	54	45	50	62	34	1
Plants, Agronomy, & Horticulture	667	50	44	128	4	34	0	132	39	94	46	86	10
Livestock, Meat, & Poultry	282	50	36	42	5	10	0	39	12	45	7	24	12
Dairy	31	2	2	9	0	1	0	5	2	1	7	2	0
Work Animals & Machines	20	3	0	3	1	0	0	2	2	5	0	3	1
Fiber	290	36	39	42	4	12	0	44	42	26	5	40	0

Table 5 (continued)

Contexts of Agricultural Literacy Concepts in Upper-Elementary Science Curricula

		4th Grade						5th Grade					
Agricultural Category	Totals	MMH	HMS	SFS	FOS	HSP	DSM	MMH	HMS	SFS	FOS	HSP	DSM
Land & Natural Resources	893	107	88	113	16	67	0	133	86	123	44	106	10
Environment & Sustainability	537	55	39	86	6	20	0	88	41	105	21	59	17
Agriscience & Biotechnology	128	14	13	25	2	2	0	20	8	33	2	8	1
Summary	3,255	334	291	509	44	164	0	528	284	483	198	368	52
Attitudes/Beliefs													
General Agriculture	55	7	10	9	0	2	0	5	2	1	5	13	1
Food & Nutrition	38	2	0	5	0	0	0	5	4	0	19	3	0
Plants, Agronomy, & Horticulture	139	13	23	25	1	6	0	24	9	5	15	11	7
Livestock, Meat, & Poultry	68	12	3	10	0	10	0	8	6	4	5	10	0
Dairy	2	1	0	0	0	0	0	0	0	0	0	1	0
Work Animals & Machines	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Fiber	30	6	5	1	0	3	0	7	1	3	1	3	0
Land & Natural Resources	231	27	25	29	3	17	0	28	28	18	16	33	7
Environment & Sustainability	209	24	28	31	1	17	0	14	16	13	20	42	3
Agriscience & Biotechnology	56	9	7	5	0	7	0	7	3	2	6	10	0
Summary	828	101	101	115	5	62	0	98	69	46	87	126	18

Discussion

This analysis revealed a lack of agricultural concepts in the widely adopted upper-elementary science curricula that were reviewed. The materials did not include thorough representation of agricultural literacy concepts or a wide distribution of KSABs. Most concepts were presented to promote knowledge acquisition of non-agricultural topics, rather than teach transferable skills or alter attitudes/beliefs related to agricultural literacy and environmental conscientiousness, thus not providing students with a comprehensive understanding of agricultural literacy. Assuming science curricula would present concepts primarily to provide content knowledge, also using agriculture to teach skills and address attitudes/beliefs would create comprehensive materials that support recent reform initiatives' hopes of producing knowledgeable, inquisitive, and conscientious students. Within the texts and curriculum programs, few terms rose to any level of emphasis (e.g., *water*, *plants*, *animals*); however, their agricultural importance rarely emerged. Also, agricultural KSABs were found more in fifth grade materials than fourth, providing younger students with less exposure to agriculture when their logic and reasoning skills may be more developmental. Regardless of agriculture's presence in national science and environmental education reform initiatives, it was not presented coherently in the science materials reviewed here.

New frameworks and standards (NRC, 2012; NGSS Lead States, 2013) are guiding decision makers and educational policy toward curriculum redesign; and this study reaffirms the critical need for curriculum reform with the systematic reintegration of agriculture, where agriculture can be integrated coherently into general education materials to serve as the keystone to minimizing the breadth of disjointed facts and increasing the depth of understanding through crosscutting concepts, practices, and core ideas shared by multiple fields (NRC, 2012). Identifying the frequency and contexts in which agricultural concepts appear in current materials can provide support and evidence for policy makers and stakeholders looking to further conversations about curriculum integration in science, environmental education, and ESD around relevant and authentic topics. Agriculture can become the uniting topic, as its presence is noted in each of the reform initiatives' guiding documents. Agricultural literacy can help students connect KSABs in science, environmental education, and ESD; and returning to agriculture's historic scientific foundation through integrated curriculum can increase literacy in these fields. While these subjects are generally taught in isolation with minimal integration, integrating agriculture can link them by providing relevant, authentic, and familiar examples and connections students recognize by acknowledging the resources and products people consume involve scientific processes with environmental impacts. Therefore, we contend that the next generation of basal science textbooks and curriculum programs should include agriculture as an integrating theme in the curriculum.

Recommendations for Future Research

As curriculum reform initiatives call for integrated materials, increased student literacy, science for all, and the leveling of inequality in general education, this study demonstrates a place to begin further research into the "how" after identifying "where" the lack of agricultural representation is. Curriculum and instructional designers can begin to locate appropriate places for agricultural integration into new basal textbooks and curricular programs, and developers can then redesign integrated curriculum that promotes agricultural literacy that could be adopted by states and districts. Similarly, if developing integrated curricula is the goal, studies such as this one should be replicated to determine the frequency and contexts of agricultural concepts in other subjects' basal textbooks and curriculum programs outside of science. The following are our recommendations for developing more coherent, integrated curricula.

First, comprehensive agricultural literacy curriculum should be developed that align to the *FFSL* (Leising et al., 1998), the *Framework* (NRC, 2012), *NGSS* (NGSS Lead States, 2013), *National Agricultural Literacy Outcomes* (henceforth, *NALO*; Spielmaker, 2013), and *Common Core Standards* (National Governors Association Center for Best Practices [NGACBP], 2010). However, agricultural curriculum materials should not be predominantly supplemental or curriculum enhancement materials, but systematically integrated with existing subject concepts (Shepardson, Niyogi, Choi, & Charusombat, 2009). Appropriate design should allow agricultural literacy topics to fit coherently into the adopted general education curriculum. Analysis of existing materials' tables-of-contents should be done to determine appropriate places for such inclusion.

Based on the findings from this study, we recommend that upper-elementary curriculum include a sequence of agricultural literacy topics derived from *FFSL* (Leising et al., 1998), *NALO* (Spielmaker, 2013), and the *Framework* (NRC, 2012). Curriculum and instructional designers should use agriculture as a unifying topic for science, environmental education, and ESD to encourage literacy through the development of KSABs embedded in crosscutting concepts, core ideas, and practices found in all the subjects. Students can learn about the processes foods and fibers pass through before reaching consumers. These processes can be connected to science lessons on ecosystems, living things, weather, and the human body, providing a basis for understanding the need for global trade, producing certain products in certain places, and how to make healthy lifestyle choices. By studying agricultural systems in detail, students can distinguish between sustainable practices and the environmental impacts of irresponsible practices, and eventually come to appreciate their responsibilities as informed citizens by participating in discussions and decisions regarding public policy.

Secondly, agricultural literacy assessments should align to frameworks and standards and measure science and environmental literacy through multiple approaches and instruments (NRC, 2014). Providing several methods of summative and formative assessment, checks-for-understanding, and authentic performance tasks incorporating agricultural literacy KSABs will help students gain scientific knowledge and skills, learn to question and investigate environmental issues, and plan for a sustainable future (Wiggins & McTighe, 2005).

Finally, in order to implement new curricula, teacher professional development should be designed to integrate agricultural KSABs as an important component of teachers' pedagogical content knowledge (Balschweid et al., 2000). The inclusion of authentic agricultural experiences would also address stereotypes and misconceptions and improve educators' agricultural literacy as well.

Limitations

There were some limitations with this study that involved material selection. While the sampling procedure included materials approved by adoption states, it did not include all basal textbooks or curriculum programs available to teachers and districts. While it is safe to assume many non-adoption states use these materials, curricula not included in this study may have resulted in higher agricultural content frequencies. Additionally, materials that did not appear on approval lists may be more widely used by schools in non-adoption states. Furthermore, some programs used in this study have more recent editions available for schools. These newer editions may have already been revised to include additional agriculture concepts.

Additionally, this study only looked at science basal textbooks and curriculum programs. Agricultural literacy KSABs may be presented in other subject areas' materials in a more thorough and integrated fashion. Similarly, analyzing materials from more grades than 4th and 5th may have produced more comprehensive results. Further research can improve and expand upon the findings mentioned here.

Conclusion

Identifying the need for revised curricula that align to current standards from *NGSS* (NGSS Lead States, 2013) and *Common Core Standards* (NGACBP, 2010) to promote agricultural literacy is timely. Even though studies have found that teachers had favorable impressions of agriculture, recognized it would enhance their curriculum, and believed agriculture could be integrated into any subject (Knobloch & Martin, 2002), it is still not present in classrooms (Bellah & Dyer, 2009; Leising et al., 2003) and materials. Agricultural literacy instructional resources are available, but teachers' lack of knowledge or interest, their stereotypes, or their lack of time due to "over-stuffed" curriculum and high-stakes testing may drive their decisions to not include agriculture in their classes (McReynolds, 1985).

In the development of the next generation of U.S. science curriculum, it is important that curriculum developers design programs to incorporate agriculture in a coherent, systematic fashion, rather than leaving it to vocational study alone. We encourage agricultural and environmental experts to work with science curriculum developers to address the deficiencies found in this study to build a more agriculturally integrated curriculum. Future research might include investigation into other discipline-based fields to support these findings regarding agriculture's absence in elementary curricula; however, science seems the most likely place to begin agriculture's reintegration into general education.

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