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# When Defining Agriculture and Science, Explicit is not a Bad Word

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## Abstract

***Agriscience*** *is an emerging field at the intersection of recently separate fields of* ***agriculture*** *and* ***science****. For meaningful communication with and engagement of public audiences around agriscience, researchers, educators, and the public must have a consensus definition. We used personal meaning mapping to collect public audience understandings of the individual terms agriculture and science to find spontaneous overlap. We qualitatively coded them and compared them to each other. Very few participants explicitly included "agriculture" on science maps and vice versa. However, many maps included terms that related to the other topic; for example, on agriculture maps, many participants included "biology." Agriculture maps used more terms related to tangible products, while science maps contained more terms related to intangible results and specific disciplinary areas. We found some overlap of categories with both sets of standards but in differing amounts, reflecting the career emphasis of agricultural programs. The lack of consensus definitions of agriculture and science confound our efforts to support both public engagement with agriscience and literacy efforts in both science education and agricultural education. This research could form the basis for larger, broader quantitative public surveys and comparisons across geographic areas*.

**Keywords:** Definitions of terms; agriscience; public understanding of science; public engagement with science; science literacy; agricultural literacy

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## Introduction

Communicating the results and impacts of agricultural and scientific research and public engagement with science research is widely accepted as a societal need (Doerfert, 2011; Feinstein, 2011; Frick, Birkenholz, & Machtmes, 1995; Frick & Kahler, 1991; Gregory & Miller, 1998; Lundy, Ruth, Telg, & Irani, 2006; J. D. Miller, 2010; Roberts, Harder, & Brashears, 2016; Terry & Lawyer, 1995). *Agriscience* is an emerging field at the intersection of recently separate fields of *agriculture* and *science*. In the early 1900's in the United States, the Smith-Lever and Smith-Hughes Acts of legislation separated agricultural education from science education in secondary schools, with the aim of preparing students for careers (Lynch, 2000). However, an unintended consequence has been a resulting unnatural divide between the two fields, with agricultural

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education focusing mainly on the application of the science of cultivation, and science education focusing mainly on the theoretical foundations and core knowledge. As researchers and educators begin to adopt the term agriscience to re-emphasize the connections between the two fields, education researchers must ensure that our public audiences define the field in the same way in order for us to communicate with one another.

Words can mean different things to people based on their personal experiences (Aldrich, 1980). Yet successful communication and education both rely on shared meaning-making for faithful transmission of information (Lotman, 1988). Often, terms are assumed to have a single universal meaning; with science, at least, we suspect professional and public definitions differ (Quinn, 2009). Agriscience educators and professionals need agreed-upon, empirically based operational definitions of agriculture and science in order to engage stakeholders better. Apart from one focus group report (Roper, Irani, & Rumble, 2013), we have been unable to identify research examining public definitions of agriculture and science or perceptions of the relations between the two terms, let alone those with open-ended methods allowing the participants to explain their meanings without other researcher-imposed context. Therefore, we began an investigation into the spontaneous conceptions of agriculture and science in public populations in order to determine those definitions and ascertain whether the public explicitly connects these conceptions to each other in their minds.

## Literature Review

At first glance, one may think of agriculture as the applied domain of many of the disciplines of science, typically taught as more abstract, fundamental topics. However, it seems artificial to try to divorce these topics completely (Enderlin & Osborne, 1992; Hillison, 1996; Rivet & Krajcik, 2008; Thoron & Myers, 2008) and to remove the underlying knowledge-generation process and ongoing advancement from either. Agricultural education and communication fields for a long time targeted well-defined, but often narrow, sectors of the public such as industry members or agricultural producers. This focus began to shift with the re-organization of Cooperative Extension in the 1980s to focus on issues rather than audiences and has most recently been institutionalized in the American Association of Agricultural Educators' National Research Agenda (Doerfert, 2011; Roberts et al., 2016) with a focus on public audiences. Science, on the other hand, has been treated as a core subject for all Americans since the late 19th century (Rudolph & Meshoulam, 2014).

Agriculture and science both have experienced extensive changes in the United States over the last 60 years. In the 1920's, nearly 30 percent of Americans lived on farms (Kalbacher & DeAre, 1988). Today, however, only about nine percent of Americans are in agricultural-related occupations ("USDA Economic Research Service - Ag and Food Sectors and the Economy," n.d.), and less than two percent live on farms; the population has shifted to be predominantly urban rather than rural (Environmental Protection Agency, 2013). Rapid innovation through the Space Race, the Human Genome Project, and the advent of the Internet and mobile eras have brought forth an array of scientific and engineering subdisciplines and interdisciplinary work. In fact, STEM, some combination of science, technology, engineering, and math, is in some circles replacing a narrow conception of science as the future field of U.S. competitiveness. Employment in STEM and STEM-related fields has paralleled increases in complexity as the underlying disciplines, moving from primarily government-funded research and development activities to a post-Cold War model that is inextricably tied to, and driven by, the global economy and innovation (Carnevale, Smith, & Melton, 2011).

However, it is unclear whether public or professional definitions of these concepts have explicitly changed as well, as these groups have rarely established definitions. Yet neither field suggests the sufficiency of dictionary definitions. Science has been declared difficult, if not impossible, to define (Boulter, 1999; Eto, 2008; Gieryn, 1999; Yeo, 2003); indeed few professional definitions are widely available. Similarly, agriculture has been defined in terms of subfields such as *sustainable* or *organic agriculture* or *agricultural literacy* but not more broadly (Bareja, 2014; Frick & Kahler, 1991; National Agricultural Library, 2014). While several definitions of scientific *literacy* have been offered that do reference both content knowledge and the processes associated with producing that knowledge (e.g. Bybee, McCrae, & Laurie, 2009; DeBoer, 2000; J. D. Miller, 2004), these have been criticized as inadequate, especially as concerns evidence-based decision-making (Crowell & Schunn, 2014; Feinstein, 2011; Kahan et al., 2012). Finally, in our literature search we did not find any empirical or other public definitions of science, aside from Quinn's (2009) suppositions that the public views science as an authoritative body and likely has a different conception of science than experts do.

There are several ways of constructing definitions: propose a definition philosophically or for use in one's own research or writing (eg. Agutter & Wheatley, 2008; Arseculeratne, 2009; Peregrine, Moses, Goodman, Lamphere, & Peacock, 2012; Quinn, 2009; Siepmann, 1999); form a consensus from a literature review (Darling-Hammond & Youngs, 2002; Epstein & Hundert, 2002; Eto, 2008); build a definition empirically through quantitative surveys (Harlow, 1976); generate a definition based on use in the case of device-driven technology (Steuer, 1992); or use a Delphi technique (Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003). Yet there are limitations to each of those methods for forming a definition upon which multiple stakeholders agree, by, for example, focusing on tasks or effects rather than fundamental purposes (Gordon, 1997; Hutton, 1999) or focusing on providing examples or stereotypes (Putnam, 1996). Definitions derived from these methods may also end up normative and prescriptive rather than descriptive (Hutton, 1999) or U.S.-centric (Verčič, van Ruler, Bütschi, & Flodin, 2001). Definitions based on research publications by professionals and even dictionaries may fail to consider public stakeholders, vernacular, and actual use of the words. Finally, quantitative methods presume some sort of existing definition in order to form questions necessary to gather data for statistical analysis.

Several national surveys demonstrate lower than desired levels of understanding among U.S. adults of both agriculture (Frick et al., 1995; Lundy et al., 2006) and science (J. D. Miller, 1998, 2004, 2010; J. D. Miller & Pardo, 2000; S. Miller, 2001; The Pew Research Center for People & the Press, 2013). On the other hand, while perceptions of science are generally positive (Pew Research Center, 2015; "Public Praises Science; Scientists Fault Public, Media," 2009), perceptions of agriculture may not always be (Goodwin, Chiarelli, & Irani, 2011; King, 2012; Rumble, Holt, & Irani, 2014). However, none of these studies actually defines either science or agriculture for participants, nor do they ask the participants to offer their own definitions to ensure shared meaning or compare, for example, to professional or dictionary versions. Even Rumble et al. (2014), one of the few studies using the overarching term agriculture rather than a more specific *sustainable agriculture, organic agriculture*, or the like, did not ask their focus group participants for or offer them a definition of agriculture from which to work.

Therefore, here, we undertake the first step toward defining agriscience by investigating open-ended public conceptions of its constituent terms agriculture and science. The long-term aim of this work is to be able to create instruments assessing perceptions of the relations between the terms and the understanding of the term agriscience quantitatively and across large populations. Our results here suggest that there are underlying areas of overlap in public conceptions of agriculture and science that can serve as a starting point for such work.

## Conceptual Framework

The overarching framework for this study is a pragmatic approach to investigating social constructivism. "The formations of definitions are social processes that shape reality" (Gordon, 1997, p. 58), an activity designed to advance a mission. Professional definitions formed the basis for many of the operational definitions described above, rather than laypersons' existing understanding. Here, we want to form definitions based on public understanding in order to advance our education and Extension missions of public agriscience literacy and engagement.

This study is based primarily upon social constructivist theory (John-Steiner & Mahn, 1996). Individuals construct their own knowledge through life experiences and especially through interactions with others (John-Steiner & Mahn, 1996; Vygotsky, 1978). People use prior experiences and knowledge to comprehend new experiences, create mental models, and construct new knowledge, actively interacting with the data of our experiences, selectively filtering and framing that data learned socially (Greca & Moreira, 2000; Rapp, 2005).

Ours is also a pragmatic approach, as we chose our method based on how well it answers our questions (Thayer, 1982). Blumer (1986) sums up his own pragmatic stance on meaning as: "respect the nature of the empirical world and organize a methodological stance to reflect that respect" (p. 60). As we wanted to explore public definitions without imposing any predetermined concepts of our own, we wanted a method to collect data quickly from a group of people to whom we could offer little incentive. Therefore, we chose to examine public meaning-making using personal meaning mapping (Falk, Moussouri, & Coulson, 1998).

Personal meaning mapping grew out of concept mapping developed by Novak (Cañas et al., 2003; Markham, Mintzes, & Jones, 1994; Novak, 1990; Novak & Cañas, 2008). The technique as we use it here differs from Novak's positivist-behaviorist concept mapping in that it is from a relativist-constructivist tradition and does not assume any level of initial participant knowledge (Falk et al., 1998). Researchers typically use concept maps or personal meaning maps to measure an individual's change in knowledge (Cañas et al., 2003; Falk et al., 1998; Falk & Storksdieck, 2005; Hay, 2007; Kinchin, Hay, & Adams, 2000; Lim, Lee, & Grabowski, 2009; Nesbit & Adesope, 2006; Novak, 1990; Rollins, 2010). These methods particularly capture complexity and extent of learning (Falk et al., 1998) without imposing limits on *what* learners were expected to learn. However, concept mapping can also be used to explore and ensure shared cognition (Stoyanova & Kommers, 2002). This type of tool becomes important to use with public audiences and in generating definitions, for it allows us to use qualitative methods to explore and capture complexity and extent of participant understanding and meaning to generate hypotheses (Auerbach & Silverstein, 2003), rather than imposing a predefined definition or set of concepts. Several researchers advance the use of PMMs as a workable research method and see the method as important within research in informal learning settings (Falk et al., 1998; Falk & Storksdieck, 2005; Judson, 2012; Lelliott, 2014).

## Purpose and Objectives of the Study

The purpose of this study was to explore how public populations spontaneously conceptualize the terms agriculture and science*,* and whether and how they characterize the relationship between the terms. This work is intended to be the first step in designing reliable, valid instruments to assess public meanings of agriculture and science and their coherence with researchers' and other experts' definitions and standards for education. From the concepts and meanings identified here, we will refine or build assessment instruments to explore public perceptions with a national audience. The objectives of this study are:

1. Describe the specific topics, overarching categories, and themes reported in the personal meaning maps of public participants about agriculture and science.
2. Compare the resulting topics, categories, and themes, looking for explicit and implicit connections between agriculture and science by participants.

## Methods

### Data Collection

We collected personal meaning maps from visitors to a local natural history museum and a local library headquarters on five weekdays and Saturdays in Fall 2013, between the hours of 10 am and 3 pm. We selected two public settings, a local museum and the public library headquarters, in order to sample a public audience. Based on previous personal meaning map studies with public participants (Falk et al., 1998), we aimed for a minimum data collection of 40 maps, with an equal number of maps from each data collection site.

We asked groups or individuals to create a map of one of the topics *science* or *agriculture,* alternating topics by group. We used systemic probability sampling to select and recruit participants for this study, which gives each individual an equal chance of being selected (O'Leary & Israel, 2013). The *a priori* criteria for participation was age (i.e., adults at 18 years or older) or parental consent for minors (i.e., 17 years and younger). We recruited for participation every second group or individual who crossed a particular point as they entered or exited the venue and appeared to meet the *a priori* criteria. If a group or individual refused to participate, we did not count them in the sampling and asked the next visitor to participate. When two researchers were present for data collection, we recruited new groups or individuals using the sampling method while current participants were still completing their maps. If only one researcher was present, recruitment stopped while participants worked on their maps. We gave no incentive for participation.

We explained how to construct a PMM to the participants, in which they were asked to write all words, phrases, or sentences that came to mind when they thought of the topic; responses could be facts or feelings (Rollins, 2010). Researchers walked the participants through construction of a PMM on books (see Supplemental Online material, http://ufdc.ufl.edu/IR00009175/00001/downloads) and pointed out specifically the individual nodes, the connecting lines, and the descriptions on the connecting lines (Novak, 1990; Novak & Cañas, 2008). Following the presentation of the sample map, we instructed participants to complete their own map, working together on one topic if they were a group. When participants indicated they were finished, they completed a short demographic questionnaire requesting gender, race/ethnicity, zip code, frequency of visits to the venue, education level, career, and hobbies related to agriculture, science, technology, or math, to ensure our sample was representative of the local population and that participants at each location and on each visit were similar. We did not collect personal identifiers to ensure participant anonymity. Time to complete a PMM varied from approximately five to fifteen minutes depending on the participant.

**Analysis.** We counted each response, namely a word or phrase, on the map connected to the topic or to another response as a node. See an example map in Figure 1. We first listed all the individual nodes from both maps and tallied their frequency. In this count, we counted nodes repeatedly for the same map if participants connected them via branching to more than two other nodes. For an example, see Figure 2. In this chain, we counted the node "research" twice because participants connected it from "science" to both "new" and "technology," forming two separate chains of thought.

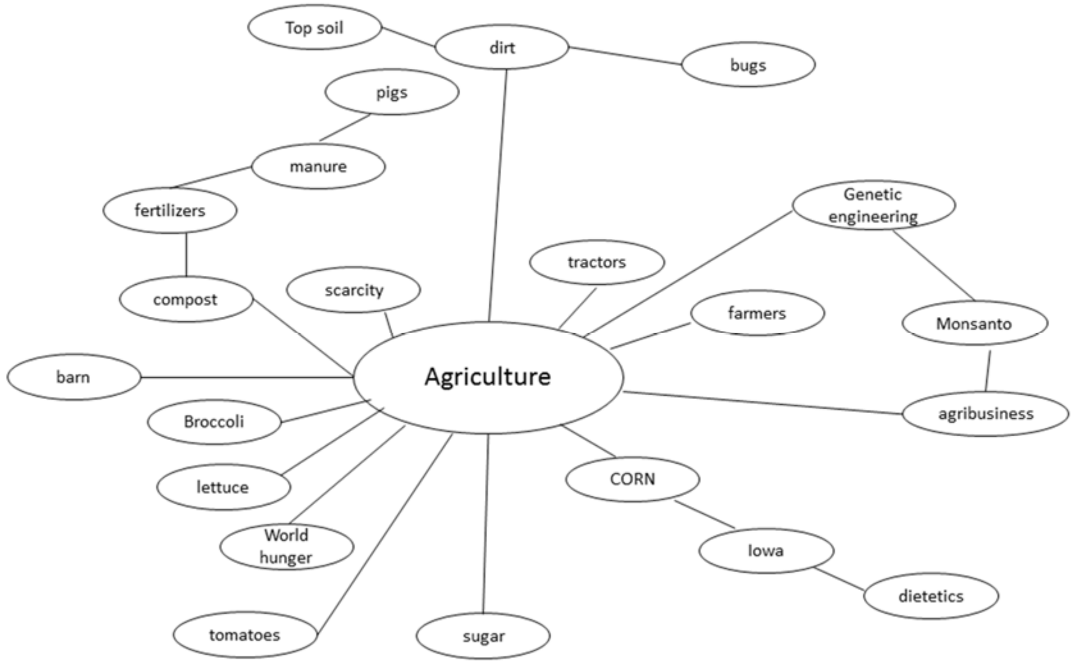


*Figure 1*. Example digital re-creation of personal meaning map for agriculture

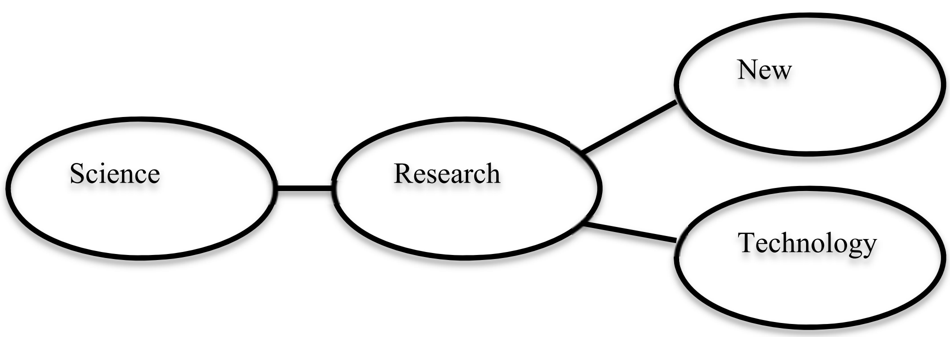


*Figure 2.* Example of Branching Node

To address our first research question, we counted occurrences of any nodes of agriculture explicitly appearing in science maps and vice versa. To address our second research question, the authors together coded the nodes into codes, categories, sub-categories, and meta-categories using constant comparative analysis (Glaser, 1965; Glaser & Strauss, 1967). Once the authors prepared the codebook, a third qualitative researcher applied the codes to a random subset of 10% of the nodes to provide further reliability. We resolved discrepancies in coding through discussion among the three researchers, and updated the codebook indicate the final code and category descriptions and revised coding as necessary.

The researchers used member checks with participants at the time of data collection, triangulation of investigators, and persistent observations to ensure credibility of the research study (Dooley, 2007). We provide thick descriptions of our research context to ensure transferability

(Dooley, 2007). The researchers both have experience working in informal and formal learning settings with myriad audiences. The second author worked in nature centers and environmental education centers for over seven years, and the first author worked in science museums for over 10 years. Both of their work experiences involved learning concepts in science and/or agriculture and conducting evaluations on the experiences of audiences in these settings.

To avoid researcher bias, the researchers consistently explained how to construct a PMM for participants. To avoid social desirability bias, researchers instructed participants to use their own definition of the terms, that there were no "correct" PMMs, and that their responses were valid.

## Results

Across the 89 group and individual participants, 85 were adults and four were children, in 54 groups (*M* = 1.64 people per group). Two-thirds of the adults self-identified as female (*n* = 57, 67%), and two-thirds self-identified white (*n* = 56, 66%), with multi-racial as the next-largest race/ethnicity category (*n* = 14, 16%), followed by Asian (*n* = 9, 11%), Hispanic (*n* = 4, 5%), Black (*n* = 3, 4%), and Middle Eastern (*n* = 2, 2%). This is a somewhat lower percentage of white participants based on county demographics from the most recent census, but roughly equivalent to that for the city based on 2014 estimates (U.S. Census Bureau, n.d.). However, the number of white participants in this study exceeds the percentage of the state (56%) and U.S. citizens (62%) self-identifying as white, non-Hispanic (U.S. Census Bureau, n.d.). Three-quarters of the participants were almost equally divided among those with high school diplomas (*n* = 23, 27%), four-year degrees (*n* = 23, 27%), and master's degrees (*n* = 19, 22%) as their highest level of education, with the remaining quarter split between two-year degrees (*n* = 7, 8%) and PhD or equivalent degrees (*n* = 8, 10%).

Slightly more science (n = 30) than agriculture (*n* = 24) maps were collected overall and at each location, and a few more maps were collected at the museum (*n* = 29) than the library (*n* = 25). See Table 1. In total, we identified 759 specific nodes in 54 maps (*M* = 14 nodes per map), combined into 17 categories and seven meta-categories. We coded 20 percent of nodes with more than one code for a total of 932 codes, 370 on agriculture maps (40%, *M* = 15 codes per map), and 562 on *science* maps (60%, *M* = 19 codes per map). We categorized some nodes in multiple categories due to lack of context (3% of the total sample of codes). We aggregated nodes coded either animals or plants into both the input and product categories when it was unclear whether the participant responded with a raw material used as part of a process or with a result of an agricultural or scientific process. For example, we coded the node "chicken" as animal but categorized it as both input and product as it could be raw material in an agricultural process or it could be the result. Therefore, we categorized such nodes as both. On the other hand, we coded "crop" as *plant* and only categorized it as product due to its specificity. Due to the lack of context at the code level leading to such a large percentage of dual-categorized items, we used category and meta-category levels for the main analysis for Objective 2. See Table 2, Table 3, and the full codebook in Supplemental Material, http://ufdc.ufl.edu/IR00009175/00001/downloads.

Table 1

*Total Personal Meaning Maps Collected by Venue and Topic*

| Number of Maps | Agriculture | | | Science | | |
|---|---|---|---|---|---|---|
| | Number | Percent of Venue Sub Total | Percent of Total ($N = 54$) | Number | Percent of Venue Sub Total | Percent of Total ($N = 54$) |
| Library | 11 | 46 | 20 | 14 | 47 | 26 |
| Museum | 13 | 54 | 24 | 16 | 53 | 30 |
| Grand Total | 24 | - | 44 | 30 | - | 56 |

Table 2

*Coding for Personal Meaning Maps on Agriculture and Science*

| Meta-category | Categories | Codes | Sub-codes |
|---|---|---|---|
| Artifact | Input | Animals[a] | Livestock |
| | | Plants[a] | |
| | | Plant Producer[b] | |
| | | Water | |
| | | Ingredients | |
| | Product | Animals[a] | |
| | | Plants[a] | |
| | | Human Food | |
| | Equipment | | |
| | Tool | | |
| Intangible | Factor | | |
| | Outcome | | |
| | Process | Technique | Research |

Table 2 (continued)

*Coding for Personal Meaning Maps on Agriculture and Science*

| Meta-category | Categories | Codes | Sub-codes |
|---|---|---|---|
| | | | Technology |
| Location | Location[c] | School | |
| Attribute | Attribute | Attribute[c] | |
| People | People[c] | Specific Person | |
| Humanities | Religion | | |
| | Ethics | | |
| | Art | | |
| Career | Discipline | Topic | |
| | Plant Producer[b] | | |
| | Business | | |
| | Job | | |

[a] Codes for *animals* and *plants* occurred in both *input* and *product* categories due to lack of context. [b] *Plant Producer* nodes lacked context as to whether they were primary producers in a food web or the people who produce plants. [c] We did not combine *Location* or *People* categories with any other categories, so we carried them over to meta-category. We did not combine *Attribute* code with any other codes or categories, so we carried it over to both category and meta-category.

For Objective 1, we found "science" was an explicit node in only a single agriculture map ($n$ = 24 maps, 4%), with "plant science" as an additional node on one other agriculture map. "Agriculture" was an explicit node in only two science maps ($n$ = 30 maps, 7%). For Objective 2, we found all seven meta-categories in both types of maps, but the distribution of categories varied by topic. For example, though we found the humanities meta-category on both maps, we found business nodes within that meta-category almost exclusively on agriculture maps, while we found *religion* nodes only on the science maps. Under the artifact meta-category, equipment category nodes only appeared on agriculture maps ($n$ = 14). See Table 4.

Table 3

*Example Codebook for the Meta-Category* Artifact

| Label | Level | Definition |
|---|---|---|
| ARTIFACT | Meta-Category | Tangible inputs, outputs, or assistance |
| Input | Category | What goes in to science or agriculture, raw materials |
| Animals | Code | Specific animals or just generic "animals" |
| Livestock | Sub-Code | Animals that specifically are cultivated for science or agriculture purposes |
| Plants | Code | Specific plants or just generic "plants" |
| Ingredients | Code | Item that is potentially used in a science/agriculture process as an input, but also could be used as human food |
| Plant Producer | Code | Reference to something that could be a "primary producer" in the food web that is not otherwise categorized as plant or ingredient |
| Water | Code | Related to water |
| Product | Category | Result of science or agricultural practice |
| Human Food | Code | References to "food" in generic, or specific products that could be used for human food as-is |
| Equipment | Category | Larger than handheld or larger than personal object that assists in performing activities of science or agriculture |
| Tool | Category | Handheld object that assists in performing science or agriculture |

The most frequent category on science maps was discipline (35%), twice as frequent as the next largest category, outcome (16%). No other category had more than a 9% share. The category outcome, describing intangible results, was twice as frequent (16% vs. 7%) on science maps than agriculture. On agriculture maps, however, the three most frequent categories occurred more evenly: product (25%), followed by discipline (21%) and input (16%). On all the maps combined, discipline accounted for almost one-third (30%) of the total responses. Overall, the three most frequent meta-categories were career (32%), artifact (30%), and intangible (20%). However, agriculture maps heavily favored artifact (47% of nodes were in this meta-category), followed by career (24%), while science maps more heavily weighted career (37%), then intangible (25%).

Table 4

*Frequency of Meta-Categories and Categories on Agriculture, Science, and All Maps*

| Meta-Category | Agriculture Percent | Science Percent | All Maps Percent |
|---|---|---|---|
| Artifact | 47 | 19 | 30 |
| Intangible | 13 | 25 | 20 |
| Location | 5 | 8 | 7 |
| Attribute | 5 | 8 | 7 |
| People | 3 | 2 | 3 |
| Humanities | 2 | 1 | 2 |
| Career | 24 | 37 | 32 |

*Note.* Percentages may not sum to 100 due to rounding.

## Discussion, Conclusions, Recommendations, Implications

We see from the results that the spontaneous occurrence of the explicit terms science and agriculture in the personal meaning maps of the other topic was virtually non-existent. Yet almost all categories appeared on both agriculture and science maps, and terms related to agriculture appeared on science maps and vice versa, suggesting that at some less conscious level, people do recognize relations between these topics. Science in particular was associated most frequently with particular disciplines of science, as well as intangible outcomes such as benefits to society in a more abstract sense. On the other hand, participants often tied agriculture to particular physical inputs and products. This abstract versus concrete divide is not surprising given the current setup of the curricula in secondary schools, and mirrors the reasons given by advocates for more integrated, contextualized curricula (Rivet & Krajcik, 2008; Thoron & Myers, 2008). This divide echoes but is not identical to differences among existing professional definitions of the two terms and warrants further study.

The three most frequent meta-categories were the same on both sets of maps, though their frequencies differed. This provides additional evidence that while participants relate these concepts to each other, at least some of our public participants still perceive science and agriculture somewhat differently. Few participants included words describing the links among nodes they drew on their personal meaning maps, which made it difficult to distinguish the context of some nodes. In particular, we had to categorize animals and plants that could be either inputs or outputs of agriscience processes into both. Better instructions with example maps might help clarify context in the future, as nodes in the maps tended to be single words as opposed to phrases and statements coded in other qualitative studies, such as interviews or even open-ended survey responses. Certainly also this study could be replicated in other areas of the state as well as throughout the country and the rest of the world for comparison based on regional contexts.

Given the small scale and qualitative nature of this study, we must exercise caution in generalizing our results. However, given the lack of accepted national professional definition of agriculture or science, let alone agriscience, it seems reasonable to suggest that both research and Extension, education, and outreach efforts need to be explicit about the connections they imply when talking about agriscience. Priority 1 of the American Association for Agricultural Education's 2016-2020 National Research Agenda is "Public and Policy Maker Understanding of Agriculture and Natural Resources," directly supporting the need for research that addresses meaningful engagement with these groups (Roberts et al., 2016). Given the variety of types of agriscience research, products, and ventures that can exist within an individual state let alone region of the United States, these particular results may prove fairly location-specific, but researchers are unable to know whether this is the case without assessing the definitions through research.

For educational research, the results presented here will guide the design of larger-scale, quantitative studies to assess both public and educator or professional meaning making about the differences and similarities in agriculture and science envisioned by these groups. Surveys could directly offer items explicitly comparing dimensions of agriculture and science revealed through these meaning maps that are not part of other definitions. Respondents can be asked to rate how related to each term the dimension is could also reveal which elements are more closely identified with agriculture or science. Researchers may establish a professional definition using Delphi studies, especially with further guidance drawn from work conceptualizing Ag-STEM Disciplinary Core Ideas (Barrick, Heinert, Myers, Thoron, & Stofer, 2017). For public audiences, national surveys of different stakeholder publics, including policymakers, adult voters, and primary household purchasers, can be developed offering statements asking for agreement or disagreement with characteristics of agriculture and science uncovered here in our themes. Once researchers and professionals establish these definitions independently using such representative methods, we may examine the differences among the various publics and professionals.

More broadly throughout educational research, the findings presented here suggest a need to define or measure definitions of terms used in research instruments. Without such assurance of shared meaning, measurement of literacy and perceptions around broad concepts of agriculture and science may actually tell us little. Given a potential variation among adults' definitions of agriculture based on not only personal educational and socioeconomic background but also geographic location (Roper et al., 2013) and other cultural aspects, it is even more important to define terms up front or ask for participants' definitions as a course of the research. An absence of proper operational definitions of the broader terms may lead to researchers not accurately measuring knowledge, attitudes, or perceptions of the public. As products, tools, and processes in agricultural and scientific areas expand rapidly, clearly understanding definitions of terms becomes increasingly necessary.

Especially in the United States, a compounding issue is the lack of consensus professional definitions of *agriculture* or *science*, let alone *agriscience*. Searches of government agency web sites for the U.S. Departments of Agriculture (including the National Agricultural Library), Interior, Labor, and Education, plus the National Science Foundation turned up no definitions. Definitions of sub-specialties or sub-domains such as *sustainable agriculture* or *organic agriculture* exist (National Agricultural Library, 2014), but definitions of the broader term agriculture do not. The federal government definitions vary in individual statutes and court cases (Bareja, 2014). Keyword searches of research databases and journals for the terms "agriculture" plus "definition of," "agriscience" plus "definition of," and "what is agriculture," revealed neither operational definitions put forth by researchers nor empirical studies that operationally defined agriculture or agriscience by any audience. Researchers do have an empirically derived working definition of agricultural literacy. In this definition, the word agriculture is used several times in various contexts, including setting out "basic agriculture information" for literacy (Frick & Kahler, 1991,

p. 52). Yet, a clear definition of agriculture is not included, making the definition of agricultural literacy circular.

Definitions of science have been under discussion since at least the Victorian Age (Yeo, 2003), though some scholars argue that a permanent fixed definition is impossible (Boulter, 1999; Gieryn, 1999) or that science does not define itself and it is up to philosophy to define everything (Eto, 2008), which rules out empirical definition. A keyword search of “science” plus “definition of”, or “what is science” through several databases, journals, and websites of federal agencies yielded limited literature that operationally defined science. Science fares slightly better than agriculture, perhaps, in that there is a U.S. government agency definition of the term; the U.S. National Academy of Sciences and Institute of Medicine (2008) provide a definition of science. Buried in a document on evolution, it defines science as, “the use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process” (National Academy of Sciences and Institute of Medicine 2008, p.10). The Ohio Academy of Science adopted a definition of science more strictly as a method, namely a systematic method of investigation leading to explanation (Shrake, Elfner, Hummon, Janson, & Free, 2006).

Overall, it seems the existing definitions of agriculture and science and their respective associated concepts of literacy mirror the application vs. knowledge-generation focus of formal school divides between the two in recent years. In contrast to agriculture, definitions of science make no mention of specific content of interest aside from “natural phenomena” or “the nature of the universe.” However, given the problems identified with the definitions of literacy, it is likely that none of these matches with general public meanings of the terms, and if we want to join the two terms as agriscience, the existing definitions do not immediately suggest their overlap.

In addition to examining agriscience definitions, researchers should also work to establish and examine public and professional definitions of all the Ag-STEM topics, namely technology, engineering, and math. This research may involve preliminary qualitative studies similar to the meaning maps investigated here, followed by Delphi studies and national surveys. Finally, researchers may examine commonalities among the groups on their perceptions of the five terms. Once researchers and educators know whether commonalities exist, they can focus efforts on building consensus or examining reasons behind differences or simply moving beyond disagreements over parts of definitions that may be irrelevant to problems of interest.

The research findings outlined here also point to a need for an explicit understanding of these terms among groups when communicating. Successful communication demands shared meaning making by all parties. Fundamentally, the content of messages sent back and forth must be transmitted faithfully before communication can forge new meaning among parties (Lotman, 1988). However, for this transmission to happen, the parties must agree on both the meaning of terms involved, especially ambiguous terms and terms crucial to the communication at hand. Words “are tools like a steamship, which require the cooperative activity of a number of persons to use” (Putnam, 1996, p. 146).

Therefore, simply assuming that educators and their audiences have the same understanding of the meanings of agriculture and science and failing to agree upon definitions hampers efforts to communicate from the beginning. Reaching common understanding up front can focus learners’ attention on the bigger messages, rather than distracting learners who may have questions about the research-basis of agriculture or the real-world applications of science, which may be less relevant to the communication at hand. In the context of communication, the lack of operational definitions of agriculture and science could spawn more issues as the public seeks research-based information. People with varying definitions of science and agriculture could continue to question the validity of the information delivered by scientists, educators, Extension specialists, or the media, despite the provision of facts, if they have varied definitions (Gregory & Miller, 1998). However, effective engagement may become increasingly difficult if researchers, scientists, and other professionals do not agree on definitions with stakeholders.

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