SCIENCE LITERACY:

AN UNDERGRADUATE ALTERNATIVE TO TRADITIONAL

INTRODUCTORY SCIENCE COURSES

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ASHLEY PAVEY

DR. JOSHUA GRUVER - ADVISOR

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ABSTRACT

THESIS: Science Literacy: An Undergraduate Alternative to Traditional Introductory Science Courses

STUDENT: Ashley Pavey

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This study utilized qualitative research methods to explore the attitudes, understanding, and professional opinions of Ball State University science instructors on science literacy. In-depth, semi-structured interviews with 8 introductory science professors of various departments were recorded, transcribed, and coded using content analysis to understand their relationship to science literacy and the role it plays within the traditional introductory science courses. Professors were asked a series of questions separated into four sections which addressed the following: Ball State's core curriculum, expectations within the classroom, perceived differences in student groups, and science literacy. Several themes emerged including: addressing scientific fundamentals, recognizing credible scientific sources, students fulfilling the core requirement, and relevancy to student lives. An additional section is included, which discusses the difficulties and potential for the development of a new course in science literacy. Implications and recommendations for Ball State University are discussed.

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INTRODUCTION

In the United States, despite a majority of the public beginning to recognize the importance of science in their daily lives, there is a political and cultural misunderstanding of science and the scientific process (Pew Research Center, 2015). The current administration has made it a point to impede research and erode public confidence in the scientific community, forcing political agendas into scientific exploration (Plumer and Davenport, 2019). This has further influenced the acceptance of science as a political position rather than as an understanding of science as a basis for informed decision making. The task of effectively communicating science is one which has been explored and developed by scientists of all disciplines, and which has historically been approached with an attitude of trial and error. This is due largely to the ever-growing gap between those who practice and study science, and others who rely on those practitioners to effectively communicate and advance scientific themes for the larger societies within which they exist. With the rate of scientific advancement ever increasing, it is vital that the methods used to communicate science be honed. Scientists must not only be efficacious within the context of speaking to peers, but also when discussing scientific issues with the general public. This is an especially important aspect to consider when training students to work within an increasingly connected world in which science is a vital tool for both academic and cultural advancement (Liu, 2009). Science has been so thoroughly assimilated into the culture of our global society that the social context of research can no longer be ignored; science must be understood not only by its practitioners but by the general public. The scientific community cannot disregard the increasing scholarly and ethical demands of society for academic accountability, public participation, education, and cross-cultural exchange of knowledge which affect the acceptance and assimilation of science (Bielawski, 1984). The focus of this thesis is a specific aspect of the broad idea of science communication: the attitudes and perceptions of university science educators.

The heightened impact of the layperson on the assimilation and advancement of scientific knowledge due to ever-increasing global connectivity, highlights the essential nature of effectively communicating science to the general public. This global state of affairs necessitates a shift in the practical role of the scientist, which becomes not only to seek knowledge, but also to impart it in such a way that they are able to cross cultural boundaries and effectively communicate discoveries (Bielawski, 1984). The responsibility for the level of science literacy found among the general public falls in the space between scientific discovery and the methods by which these discoveries are communicated. Perhaps the most important aspect of effectively communicating science lies within the academic relationship between practicing scientists and students of all ages. The goal of science education is generally understood to aim toward the development of a scientifically literate populace (NRC, 2013). This has been defined as "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (NRC, 1996). Effective science education is a crucial step toward effective acceptance of science by the general public, as more educated individuals have been shown to have a more positive attitude toward and understanding of science (National Science Board, 2018). This increased understanding can enable individuals to participate in decision making having to do with the application and assimilation of science knowledge and processes which affect their daily lives (Miller, 1993). Recent political and media debate in the United States concerning science concepts and issues exemplifies the need for more research in the development of a scientifically literate populace (Liu, 2009), the first step being the education of individuals as they prepare to enter adult society.

A crucial step toward addressing the science literacy gaps among students of all disciplines and age levels lies with addressing professorial assumptions of the kind of scientific knowledge students have and the resources made available to them prior to beginning their post-secondary education (Glaze, 2018). These assumptions have translated into disadvantaging those students lacking in that prior knowledge. The often unspoken but pervasive culture of a highly research-based curriculum found in most science departments results in a pigeonholed pathway to science education via traditional introductory lab courses. These lab courses often fail to provide all students an equal chance for success in terms of science literacy, because the potential gains are lost on many who lack the basic understanding of many of the scientific principles that are part of the common human experience. This contributes to the current public and political aversion to science literacy and its importance. Therefore the addition of a course specifically designed to address these issues may be a highly effective way to include non-science major students in the growth of the sciences.

Deficiencies

Most science literacy research up to this point has been focused on defining and expanding the concept of science literacy and what it means for science education within the context of a responsible and educated citizenship (Harring and Jagers, 2018). Science literacy aimed education methods have been explored and shown to improve both science literacy and process skills over traditional lab courses (Gormally et al, 2009), however these studies have been limited to single classrooms and have not explored possible differences, which could be found between different student groups or different branches of science. Recent political and media debate in the United States concerning science concepts and issues (e.g., Climate Change) exemplifies the need for more research in the development of a scientifically literate populace (Liu, 2009). This research was intended to fill some of these research needs through an exploratory study of Ball State science educators, who ostensibly use the University Science Core Curriculum to help enable students to become responsible and engaged citizens.

Research Questions

Broadly speaking, this study sought to explore the attitudes and potential assumptions of Ball State science educators concerning science literacy. Several research questions included: What role do professors believe the introductory science courses serve within the Ball State core curriculum? Do they have a familiarity with the term 'science literacy' and how is it integrated into their courses? Are their expectations of students within the core science courses affected by perceived differences in student groups? Should a new option for science education be explored within the core curriculum science courses at Ball State? The interviews served to address these questions and provide insight into educator's perspectives.

Statement of Purpose

This study explored faculty's expectations of their students and the role science literacy plays in the classroom. This included investigating faculty perceptions of science literacy levels among students taking these courses and the role of science literacy within the university core curriculum. Addressing gaps in science literacy found in the general student population is the responsibility of both secondary and post-secondary educators, and this study aimed to expand the current body of literature available by exploring possible perceived differences between student groups (such as science vs non-science majors), and between different branches and departments of science education. This study will complement and expand the existing body of work on this subject by providing a more in-depth analysis of professorial attitudes on science literacy within specific core science courses. This was achieved by completing semi-structured interviews with professors of different departments who have recent experience teaching the introductory science courses which fulfill the Ball State core curriculums science credit requirement.

LITERATURE REVIEW

Defining Science Literacy

Since the 1920's, as technology and society have advanced, so too has the "goal" for science education shifted over time. As culture and global political awareness have fluctuated, the definitions of scientific literacy have grown and changed along with them. In 1963, the Executive Secretary of the National Science Teachers Association (NSTA) surveyed a number of scientists and educators, asking them to describe what science literacy meant to them. Most of them focused on the idea of greater content knowledge in a variety of fields, rather than speaking of the intersection between science and society at large (Carlton, 1963). The NSTA also defined a scientifically literate person in their 1971 position statement *School Science Education for the 1970's* as one who "uses science concepts, process skills, and values in making everyday decisions as he interacts with other people and with his environment [and] understands the interrelationships between science, technology, and other facts of society, including social and economic development" (NSTA, 1971). According to the National Science Education Standards (NSES), science literacy is "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (Glaze, 2018). However, this broadness is most probably a necessary part of the nature of scientific literacy, as there is no single correct way to be educated on the matter. In fact, science literacy may be less of a finale and definitive state of being and more of a mode of thinking in which students can be trained (DeBoer, 2000). That is to say, science literacy will be different for each student and educator as the issues teachers find most relevant to discuss will be different depending on their lives and the lives of their students; where they live, and what issues are most relevant to their daily lives.

A History of Science Education

Scientific literacy as a concept has been in the lexicon since the 1950s, although it is only fairly recently that its definition and status as an emerging focus in science education have begun to be studied and pursued in-depth. For most of the history of higher education in America, the humanities were the subjects most firmly entrenched in the culture of the public and of education; they were thought to be the most useful and worthy subjects (DeBoer, 2000). Science at the upper levels shifted the traditional deductive logical approaches used by the humanities to an inductive process which involved the observance of the natural world followed by formulating conclusions based on that evidence. It quickly adopted an attitude of fostering independent thought, and of cultivating citizens who would be better equipped to more fully and knowledgeably participate in civic matters. In other words, it would create an increasingly scientifically literate populace (although the phrase would not be used until much later in the history of higher education) (DeBoer, 2000).

Currently in the United States, the main measuring tool in terms of scientific education are standardized tests, which highlight the constraining nature of some of the content standards enforced. Because science literacy is such a broad term, rigid definitions and testing dates cause educators to reduce science instruction to a literal understanding of fact and definition rather than the development of critical inquiry skills necessary to facilitate long term scientific literacy. The result is an influx of underprepared students into post-secondary education, and it falls to both secondary and post-secondary educators to help bridge those gaps. The role of the professor in addressing these short-comings is paramount, as they are often the only practicing scientists students are likely to encounter. Yet these problems are also often compounded by educators' assumptions, including expectations of what students should know before entering given courses. The dangers of these assumptions exist not only for non-science majors, but future scientists as well. Because science majors are assumed to possess the understandings, which make up basic science literacy, they too often receive little to no background on the realities of the scientific process; this in turn produces scientists and educators who continue the proliferations of these misconceptions (Glaze, 2018). In the words of Dr. Amanda Glaze of Georgia Southern University, filling these gaps in student knowledge ensures that "we are not merely correcting the mistakes of others but are ensuring future success and strength in our fields" (Glaze, 2018, p.4).

Teaching Science Literacy

It must be addressed that the broad nature of the term science literacy prevents standard assessment of such a course; in other words, there can be no test of scientific literacy because there is no body of knowledge than can legitimately define it (DeBoer, 2000). Very few attempts have been made to assess scientific literacy, with the most in-depth form currently developed being an environmental literacy assessment specifically designed for a single college campus (Lloyd-Strovas et al, 2017), which could not necessarily be extrapolated to include other campuses or student body compositions. However, science literacy aimed education methods have been shown to be effective forms of instruction which positively influence the development of students. For example, the guided-inquiry approach has been shown to improve science literacy among non-science undergraduate students (Gormally et al, 2009); this suggests that approaching science education with science literacy as the main focus improves both science literacy and science process skills as compared to traditional laboratory methods.

It has also been argued that it may be naïve to expect students to think like scientists, and that instead there should be a focus on scientific awareness rather than scientific literacy; that students should be taught about technology rather than the abstractions of science, leaving the responsibility for science-based decision making to the experts rather than the general public (DeBoer, 2000). If we were to subscribe to the inherent naivety of students, it could further be argued that this trait paired with the broad and inherently difficult nature of a science literacy content course presents an option which would be bereft of the benefits of traditional laboratory courses which provide an important glimpse and gateway into the world of scientists.

However, advanced science literacy education as an alternative to traditionally required lab-based courses such as biology, chemistry, and physics would prove to be a positive influence on students and the general public in several dimensions. Not only would an emphasis on scientific literacy in the core science curriculum promote the growth of informed students within the traditional liberal arts education framework of our schools (Eslinger and Kent, 2018), it may also provide further influence causing more students to pursue careers in science (DeBoer, 2000). Individuals with higher levels of education have been shown to be more environmentally literate, which supports the claim that environmental education should be integrated throughout higher education in order to develop an environmentally literate citizenry (Lloyd-Strovas et al, 2017); this can be reasonably extrapolated to include general science literacy, as it is often made up of environmental issues. Further, familiarity with science would positively affect public support of science and prepare students to participate in human and civic affairs; citizen participation in these societal scientific issues is a key component to the success of a democratic society (DeBoer, 2000). A citizenry with a sympathetic attitude toward science and the willingness to make use of scientific expertise is one which is familiar with the concepts of science literacy and understands the societal issues which are enveloped under these terms.

METHODOLOGY

Study Area

Ball State University was chosen as the study area for several reasons. The depth and breadth of available science departments and scientific majors indicates that science education is an important aspect of the university's design. In addition to this variety of scientific education experiences, I am personally familiar with the design and classroom dynamics of several departments. This familiarity enabled me to navigate the research process most effectively within the context of this particular university.

Semi-Structured Interviews

Semi-structured interviews with participants were conducted online, audio-recorded via WebEx, and transcribed. The interview instrument addressed topics such as: what role science literacy plays in the classroom, professorial expectations of students, and their professional opinions on the addition of a non-content specific core curriculum science course (Appendix A). Interviews took approximately 45 minutes to complete. Professors were contacted via email (Appendix B) and asked to read a consent form (Appendix C) and provide their verbal confirmation that they were willing to participate in the interview and allow their comments to be used. This was done in compliance with Internal Review Board standards following IRB approval.

Participants

Potential interviewees were recruited based on their recent history with teaching at least one of the following core science courses offered by Ball State: Anthropology 105, Astronomy 100/120, Biology 100/111/112, Chemistry 100/101/111, Geography 101, Geology 101, Health Sciences 160, Natural Resources 101, and Physics 100/101/110/120. Respondents were given the option to remain anonymous, and although several declined, pseudonyms will be used to protect their identities resulting in the following list of completed interviews: Dr. A (Physics 110/Astronomy 100), Dr. B (Biology 100), Dr. C (Chemistry 111), Dr. D, (Geography 101), Dr. E (Health Sciences 160), Mr. F (Natural Resources 101), Dr. G (Health Sciences 160), and Dr. H (Geography 101).

Analysis

Interviews were transcribed verbatim, following which content analysis was used to code transcripts to determine individual units of meaning concerning science education and science literacy within the classroom. The individual codes were then organized into relevant themes to identify commonalities and differences within and across interviews. Direct quotations were used to provide support for theme development. Peer debriefing with my advisor (Dr. Joshua Gruver) was also employed to enhance trustworthiness and credibility of findings (Lincoln & Guba 1985; Creswell 1998; Spall 1998; Spillett 2003). Peer debriefing reduces the risk of researcher bias by providing a second perspective in the analysis. Finally, thick description and direct quotations accompanies theme analysis to illustrate the themes and provide external validity in the final report.

RESULTS/DISCUSSION

Professors were asked a series of questions separated into four sections which addressed: Ball State's core curriculum, expectations within the classroom, perceived differences in student groups, and science literacy. Three overarching themes emerged from the interview data: addressing scientific fundamentals, perception of student differences, and relevancy to student lives. An additional section is included which discusses the difficulties and potential for the development of a new course in science literacy, which had unique sub-themes involving concerns about academic resources, and the suggestion of integration rather than fresh course development. The reported number of students in each course ranged from 30 to approximately 120, and the reported length of time the professors had been teaching at Ball State ranged from one year to 32 years. The purpose of these interviews with Ball State professors teaching these courses was to explore their thoughts and attitudes related to these courses with regard to science literacy, their place within the core curriculum, their perceptions and assumptions of students taking these courses, and to discuss their opinions on science literacy and the potential for a new course designed to address science literacy directly rather than as a secondary aspect of content-specific introductory courses.

Addressing Scientific Fundamentals

The Ball State University official website states that the core curriculum is meant to enable students to "undertake the broad responsibilities of citizenship in a free society" (BSU, 2019). As science literacy is a key aspect of this citizenry (NRC, 2013), the core science courses offered should address this issue and provide students with the knowledge to be considered scientifically literate. Because professors are the functional instruments entrusted to implement the stated university mission, understanding their opinions and actions is a key aspect of determining the efficacy of their courses. To that end, professors were asked what role they believed their courses served within the Ball State core curriculum. All stated in some way that the introductory courses are meant to provide some sort of broad or fundamental training and foundation of scientific understanding.

> "Well to me the core curriculum is largely about breadth; this goes back to the original sort of traditions of college as creating scholars. It had broad training in a lot of different areas and we still hold to that. We of course focus on depth when we're dealing with majors but the core curriculum's role is to help create people that can communicate coherently, and even if they don't use math in their regular job you know at least they're familiar with math and science. For a lot of students, it just fills in a little checkbox they need and I recognize that, but at least in an idealized world that's its role: the bigger picture." -Dr. H, Geog101

> "A lot of [this course] deals with scientific literacy—trying to make the students that take this course have better understanding of some of the concepts that will help them make decisions, whether it be personal or on a more societal basis—starting now and when they get out into life; whether they're personal decisions or if we're talking about things like gene editing, so they have an understanding, because there's so much misinformation out there." -Dr. B, Bio100

If the purpose of the introductory science courses is to provide students with a broad and fundamental scientific understanding, then it stands to reason that students should be able to walk away from each of these courses with the same core skills and knowledge. Even when professors made statements referencing specific course content, their comments still represent this theme despite their various departmental affiliations. This provides evidence that a fundamental scientific understanding is not necessarily tied to any particular source of content.

> "I would like students to walk away with an understanding of what evidence-based research looks like for a range of personal health and wellness topics; to be able to say 'I know that this diet is dangerous because it doesn't have the literature to back it up' or 'I know that this particular personal health x y or z is evidence-based, and here's why evidence-based should be the gold standard, here's why I should be doing that in my own life; here's why I should be promoting that in my career'—that they just have a wiser understanding so that

> they don’t promote or incorporate things that aren’t healthy or don’t have that backing behind it.” -Dr. E, HSC160

> “It serves to give students a basic understanding of the physical aspects of earth; it gives them a foundation largely in meteorology, climatology, some geomorphology, but it also—even before that—gives them an understanding of the framework we use to understand this: latitude, longitude, earth/sun relations, all that.” -Dr. D, Geog101

Professors were also asked about their familiarity with the term ‘science literacy’. Their definitions were in-line with the multitude of definitions available in the literature and reflect the idea of science literacy as being a broad topic which nonetheless demands a certain basic understanding of scientific processes and interpretation of information (DeBoer, 2000).

> “When I think of science literacy, I primarily think about it when we’re talking about the lay-public rather than scientists; if you were working with doctoral students you might define it a little differently. But mainly with the lay-public [it] is to have a functioning, basic understanding of scientific concepts—perhaps facts—that will help informed decision making.” -Dr. B, Bio100

> “What I typically use is just the basic understanding of the scientific method and how that applies to various topics. I think if you understand the idea of the scientific method then you can take that to other physical sciences, social sciences… I think the method is what determines scientific literacy, not just the facts.” -Dr. D, Geog101

After establishing a basis for their understanding of the idea of science literacy, professors were also asked to what extent they believe the core curriculum provides students with the knowledge necessary to be considered scientifically literate. This was further extended in asking what specific aspects of science literacy they believed their courses addressed. This is where professors began bringing back specific content examples to illustrate concepts of science literacy, highlighting how—despite their different content bases—they attempted to instill the same skills in students.

> "I can't speak for the others, but I think mine does. I have built in some additional units since I'm in Ggeography—for some of my students this may be the only geography course they ever take at the collegiate level—at the beginning of the semester talking a little about how we make and create maps. [People] are constantly exposed to maps and those, like statistics—especially the people that aren't as scientifically or mathematically literate—are often viewed as sort of a black box, but also [as] authoritative. So, I sort of peel back a little of the curtain to show how maps can be manipulated, and like statistics, you can't necessarily take them at face value. I think that's a really useful skill. So to me those are the most important goals I have in that unit, because they're going to be the generation making the decisions sooner or later." -Dr. H, Geog101

> "In one respect people get very nervous about different kinds of chemicals, so becoming familiar with multiple different kinds of chemicals; how some are just regular household chemicals we don't have to worry about vs 'these are chemicals that we have to use care when handling'. A greater familiarity with that I think can help in terms of not being afraid every time someone says, 'oh this is a chemical'. Again, I don't tie it in a lot, but I do talk about some reactions in terms of how what we're seeing right now ties into environmental concerns." -Dr. C, Chem111

These similarities across disciplines indicate that there is at least some general consensus on the fundamentals that are required for scientific learning, which could potentially aid in the development of a non-content specific science literacy course. When professors were asked if courses needed to be content specific in order to prepare students to be scientifically literate, in general they were cautiously optimistic. They emphasized this theme of needing to address scientific fundamentals, which could perhaps be enhanced by inquiry-based methods and strengthening communication skills in students.

> "I don't know that it necessarily has to be content-specific in that there is a lot to be said for having that scientifically inquiring mind. So if you can bring about

> some more curiosity or interest, trying things in a hands-on sort of way to spark that understanding—I don't know how it fits in, because you do have to have some sort of fundamental science education in some respect to address science literacy—I think there is something that could be done there in a very inquiry-based way. You know, 'what are you guys interested in, let's delve into that'." -Dr. C, Chem 111

> "I don't think it needs to be content-specific. I think we could look at issues from a lot of different ways; some of the issues that people will be facing in the future…we don't even know what those are right now. So, giving them too much content on particular things isn't going to do them a whole lot of good. Giving them the basics of things—like how an ecosystem might work, or how a virus might work—are always going to be there and getting too specific isn't so important or at the forefront here." -Dr. B, Bio100

Notably, there were still concerns with the broad nature of the concept of science literacy and suggestions which—despite still contributing to the theme of addressing scientific fundamentals—indicate that content and applicability are still important aspects of science education.

> "I think [a science literacy course] could be very valuable—valuable to the general public and not just students; the general public doesn't know about science. I think we do [need content] because we have to apply it somewhat. So, unless another course—a more generalized, 'here I'm going to teach you how to be scientifically literate'—can be applied… they have to have something to apply it to. It's one thing to hear about the scientific method, it's one thing to get an equation, but it doesn't mean anything until it's applied to something." -Dr. D, Geog101

Recognizing Credible Sources

A subtheme of this fundamental understanding of science emerged in many responses concerning students' ability to find and recognize credible scientific sources. Interestingly, when asked what skills or knowledge they hoped students take away from their introductory science course, none of the professors responded in terms of content-specific understanding. All contributed to the overall theme of understanding scientific fundamentals via the ability to find and recognize credible scientific sources.

> "What I'm hoping the students will take away is that when they might be presented with some sort of story that presents something to do with science, they can initially look through it and look to see if there's any sort of basis behind it; is there any sort of real study behind it, rather than just somebody's opinion. So that's number one, what I would want them to come away with." -Dr. B, Bio100

> "There is a focus on finding and understanding good scientific sources having to do with personal health and wellness." -Dr. G, HSC160

> "I just hope it will get them to understand what appropriate sources of information are to use to develop their knowledge base, so they can be critical of the knowledge they consume. If it's biased, how it's biased, what they can do with that bias if they're encountering it in literature, and if they can identify it. I think where we get our information from affects our lives; it can be integrated into our lives or not, or we choose to believe experts or we don't, or how comfortable we are with science. If we respect experts because we know they've been trained and they have these scientific skill sets that we respect or we appreciate, then [we] can follow the guidance that experts give." -Dr. E, HSC160

Professors were also asked in this section what they believed incoming students are lacking in terms of scientific literacy. This is a critical point because professorial assumptions of student knowledge and skills, particularly in the sciences, has the potential to disadvantage students who lack skills their peers have (Glaze, 2018). The same themes developed in response to this question despite department affiliation. This indicates that professors of all disciplines are attempting to address the same fundamental aspects of science literacy in students that they find lacking: the ability to find and recognize credible scientific sources.

> "The primary thing I think they are lacking is the ability to figure out what is good scientific information and what is poor scientific information. Right now, there is so much bias and other types of—this is not really the word I want but I can't

think of another one—manipulation to present issues in a certain way. [Those] could be political issues, it could be to try and sell them something, but when the science is being reported there's an alternative motive or purpose behind it; it's not just to present the science very clearly and let people make the decisions on their own. I don't think that a lot of the students coming in—and a lot of people in society in general—are able to cut through that and figure out what is actually what." -Dr. B, Bio100

"I would much rather know that students who left me after a few weeks have a resourcefulness to know where to get answers, rather than that they know the answer. I can teach them new terminology—words they've never used before—but I'm not sure that makes them go any further in their field vs knowing where to go. And then there's the 'so what' and the 'at what cost' idea; two and two is always going to be four, but somewhere in there is a why and a how." -Mr. F, NREM101

Perception of Student Differences

Due to the fact that the introductory science courses are all included as potential courses which could satisfy the Ball State core curriculum science credit, the demographics of these courses are predictably varied and consist of different types of student groups. If and how these differences are perceived by educators can potentially influence classroom dynamics and professorial expectations of students. Professors were therefore asked if they noticed any differences in attitude, aptitude, or self-efficacy between student groups. Specific sub-themes emerged throughout the interviews concerning differences between underclassmen and upperclassmen, and between science and non-science majors.

Differences Between Upper- and Lower-Classmen

Many professors recognized that there are certain groups of students who are taking those courses only to fulfill that core requirement (in addition to the students, who are taking them either out of interest or because they are pre-requisites for many science majors). Many addressed the idea that underclassmen tended to be more anxious and submitted lower quality work, while upperclassmen were more cynical and typically were taking the courses simply to fulfill the university core requirements.

> "In Geography 101 I think the freshmen and sophomores tend to be a little more anxious. The seniors—especially if they're last semester seniors—[are] just doing this to check something off and get out of here, because if they're seniors most of their work is done. They're probably not going to change majors at that point; if they're scientists, great, if they're not then they're not going to be scientists at that point. I just want to make sure that they get out of my class being able to look at clouds a little differently. For example, look a cirrus clouds and say, 'oh I think we've got a warm front coming', things like that." -Dr. D, Geog101

> "The students who are in physics 110—usually upperclassman—are more focused, and more concerned about their grades. With astronomy 100 most of those people are probably non-science majors; I haven't done a survey to sort of see what that's like, but they're not as serious about their grade." -Dr. A, Phyc110/Astr100

> "Yes, there are definitely some differences. Freshman and sophomores tend to be more energetic, less cynical, but their work also tends to stink on average. I mean there are some brilliant ones that are getting 100's but there are others [who are] new; they haven't learned the skills they need to succeed in college. The juniors and seniors tend to be more cynical [and] they are often there because they are meeting that requirement and they've been avoiding it for a while and it's like 'don't take up too much of my time because I just want to get my grade and get out of here'. But they've learned how to study and to somewhat teach themselves so on average their work tends to be a little better, even if they're not as excited to be there. So those classes tend to have less energy but often a better quality of work." -Dr. H, Geog101

While these differences between upper- and lower-classmen seem to be clear to professors, when asked if they had any strategies in place to address differences in student groups none of them specifically addressed the differences discussed above. There was, however, an emphasis on providing group activities and encouraging discussion on an individual level.

> “We’ve worked a lot over the past few years putting together more group classwork activities, and group work in the lab room; trying to get them to talk to the people they’re in class with, and that definitely helps because once they get their study groups together—get people in class that they can talk to about that—[it] helps them build their foundation to move forward. I think it helps them to study also, because often times different groups of people understand different aspects of what’s going on; if they can explain what they understand to someone else, and someone can explain to them, then they can build that up together.” -Dr. C, Chem111

> “One thing I’ve tried to do over the years is connect more with students. Yes, it’s a class of 100, but I make a seating chart, so they sit in the same places every time. I have them fill out index cards and actually go around—it often takes the better part of a semester for me to go around the room—and try to talk with each person on an individual basis at least once before class. In a class of 100 especially some of the very quiet ones will disappear in a sense. So I think that strategy goes a long way honestly in helping them realize—even if they feel this is some general education class and it’s not [their] major and they’re a bit reluctant to care about it—the instructor knows who they are. So that encourages them in a sense to come to class and attempt to participate.” -Dr. H, Geog101

Even though these strategies do not specifically address the differences between upper- and lower-classmen, they could be effective methods of mixing the two groups.

Differences Between Science and Non-Science Majors

While in general, professors stated that they did not have differentiated expectations, there were instances of implied differentiation based on the idea that some of those students would be continuing on within any given department.

> “I [also] try not to differentiate [between students]. Right now, they’re all online; I don’t even know what their majors are. I could look it up, but I don’t memorize 35 students and their majors. Sometimes they’ll tell me, ‘oh I’m meteorology’ and those I probably pay a little more attention to because I’ll see them later on in their college careers, but I don’t really have differentiated expectations for the entire group.” -Dr. D, Geog101

> "Let's say you've got that communications major or that math major or the dance major or whatever; for them, they've checked it off of their list. If they've already declared a major, they're probably not really motivated to go to the next NREM level. The ones I would like to affect the most would be those that I was able to assist in seeing the depth and breadth of natural resources; what pieces of it [they] maybe never thought of." -Mr. F, NREM101

This suggests that even if there are no differentiated expectations put into practice, science majors within these classes could potentially receive additional attention due to their perceived interest in a particular content area. While this is not necessarily a negative implication, further research into this particular course dynamic could provide evidence for the benefits of separating the science and non-science majors in the introductory science courses.

An additional aspect of this sub-theme was the assertion that non-science majors were more intimidated by science, and science majors potentially finding the courses easier and being more disdainful of what they consider to be simple topics.

> "I would say that the [non-science majors], their attitude for the most part when they come in is 'just have to hold on tight, I just have to survive, I will be so glad to be done with this'. And then in terms of students who are science majors, they usually split out in chemistry 111 into people who get in and then change their major, like 'this is not for me, I'm not going to do more of this' and they switch out. There's definitely a handful coming in thinking they're going to do some sort of science and then it's just more rough than they expect. If you talk to people who actually make it through their major—talking to them in their junior or senior year—a lot of times they're like 'that class was SO easy'. So, the people that make it all the way through are typically not the ones that struggled in any way that first level; they didn't hit road blocks until later. Occasionally we get some students that have had a lot of support in the beginning and then can turn over that confidence in themselves; that faith in their ability to make it to the end… But I guess a lot of people get intimidated and back off; they don't know what to do."-Dr. C, Chem111

> "Sometimes I think science majors perhaps think they already know this type of thing, or they're above it, or they have the ability to do it already when in reality

> they may, but they also may not. I think the non-science majors are really interested in this, and when it's presented to them [as] 'this is the type of thing we're doing in this course, and it's the primary goal rather than learning all the different chemical reactions in a cell or learning a lot of memorization'…they're very open to that. I do think sometimes the science majors are more, 'well I already know that'." -Dr. B, Bio100

This is a facet of this issue, which could potentially provide further evidence of the need for separation of science and non-science majors within the core curriculum science courses; because their needs from a basic science course are different. Science major students not only require the foundational understanding of the scientific processes, but they require specific content knowledge that they can build upon in subsequent courses; this does not apply to non-science majors.

Relevancy to Student Lives

This theme—the idea of relevancy to student lives—was discussed both directly and indirectly by professors when responding to a variety of questions. When asked what role their courses played within the core curriculum, and what aspects of science literacy those courses addressed, there was an understanding of the importance of this relevancy.

> "I think…that the content is really important, and [it's] about personal health and wellness. I like this course because it's not theoretical in nature; you're learning material that you can directly apply to your life. You can directly apply it to what you have for dinner that night, or how much sleep you get, or the exercise that you do, or your mental health and wellness, your stress levels. All of those topics that we talk about are very applicable to an individual's life. So, I think it's really relevant, and I think science plays into it because on all of those topics I can provide information that is evidence-based. So rather than them going to the fringes of the Internet to find out about health or diets, we can provide evidence-based information; we can provide an opportunity for them to critically evaluate different sources of information that will ultimately affect their health." -Dr. E, HSC160

> "I try to get across to them that they are going to be faced with issues, and we don't even know what those issues are; that the future is now up to this particular group of students. I like to tell them, 'I hope you folks do a better job than my generation as a whole did'. So, I put a little responsibility on them. I always try not to get too partisan, but I do say 'you can believe what you want when you get out of here, but I at least want you to understand the issues and concepts of science behind it, and what you do with that is completely up to you'." -Dr. B, Bio100

One aspect of the classroom dynamic which was explored involved a discussion about which subjects or topics the students within these courses tended to find particularly interesting or engaging. Many responses were predictably content-specific, however the purpose of this question was to see what—if any—commonalities there were in the nature of the subjects students tended to prefer. Despite the predominantly content-specific responses, the topics professors perceived as being the most interesting to students were those which could be interpreted as the most—directly or indirectly—relevant to student lives.

> "Sexual health and well-being is always an interesting one; it's always relevant for students. I think it's all interesting to students when you can apply it to your own life. The introduction chapter to the whole book isn't interesting because it's not relevant to their life, but once you start talking about sexual health or weight loss or violence prevention or mental health…all of those content-oriented chapters that are directly relevant to their own lives, I think all of them are interesting because we can see ourselves in that material. But when it starts to get too far removed from their personal lives, then I think that you lose interest." -Dr. E, HSC160

> "Everybody loves severe weather. When we're doing thunderstorms and tornadoes and hurricanes, [students] seem to like that. It's actually not my area… But they like it. They do like the geomorphology part as well; they like learning about landforms and earthquakes. They have some sort of 'disaster foundation' that makes it pretty fascinating although when you think about that it makes a lot of sense, because disasters get press. Think about tornadoes, we read about hurricanes striking seaside communities, we read about earthquakes destroying centuries old towns; we don't read about the gorgeous weather under a dome of high pressure." -Dr. D, Geog101

This focus on relevancy reinforces the idea of science literacy as a broad and not necessarily content-specific idea and is supported by the literature in discussions on what a science literacy-based education would consist of (DeBoer, 2000). With that in mind, professors were also asked to discuss which topics or subjects they believed students should be taught in a non-content specific course designed to address science literacy directly, as an alternative to the traditional introductory science courses. They each provided predictable examples, which were consistent with their respective fields of expertise, yet nonetheless their responses revealed an overall concern with relevancy (either directly to the students themselves or to contemporary issues that students see in the media).

> "It would also be important to get into what is reputable science vs junk science. That's out there; pseudoscience. From a biologist's point of view, it's interesting. In chemistry you think about molecules and bonds, and in the chem100 class they look at some of the issues in climate change from a chemical view which is interesting, [so] a basic understanding of the environment would be very important. Certainly, the process of how natural selection works I think would be a very important one for everybody. That's another thing students don't understand coming in; that there's a difference between natural selection and evolution. Most of the students in my class are traditional—in the 18-21 range—[and] many of them are going to want to have kids someday, so there needs to be a basic understanding of how things are inherited and a little bit about genes. That's a wide and burgeoning field right now." -Dr. B, Bio100

> "I'm still pretty focused on that idea of becoming a citizen who is informed and able to contribute, and to be a wise consumer. It goes right down to being able to take care of your own checkbook, establishing the value of things. The whole idea of where we get values and how we place them." -Mr. F, NREM101

> "What evidence-based interventions are and where to find them. Sexuality education [is] a great example of this with abstinence only education; it just does not have the evidence base to support it being federally funded or even state mandated in some areas of our country. It just isn't effective, it doesn't work, and

> in some cases, it can be more harmful than it can benefit students. We shouldn't be promoting something that doesn't have evidence behind it. Something else to include in the course I think, is to bring politics into it. Make sure you bring current events into it, because I think that's a way to make students feel that it's real and relevant. If you leave politics out of it or you don't include current events, you might run the risk of [students] thinking 'this doesn't matter, this doesn't apply'. But if you can use real current events—and there's so many of them, we're rife with good examples right now—then it makes it really salient for students; it makes it seem like it really does have long-term impacts if we take away the respect for science." -Dr. E, HSC160

Developing a New Science Literacy Course

Professors were asked a series of questions concerning the potential development of a new, non-content specific, core curriculum science course. This section is dedicated to discussing the potential difficulties in teaching or implementing such a course, because unique sub-themes emerged in response to this section of questions including concerns about academic resources, and the suggestion of integration rather than fresh development. This was a particularly important sub-section of the interviews, because there is so little precedent for such a course in the existing literature.

Academic Resources

Several concerns were echoed across departments and will be important to address in future research concerning the development of a course such as the one suggested here. These concerns included the availability and development of course materials to be used (i.e. textbooks and lab materials), as well as the multitude of additional responsibilities held by professors (such as institutional research requirements).

> "A course like that would need structured flexibility, so a guinea pig semester would maybe be a good way to test that out. Something else to consider is what readings or textbook would be used; there is a lot out there, and not all of them are particularly good or useful." -Dr. G, HSC160

> "I think the first big thing would be to figure out what you want to use as course materials; what are you going to draw from? There's a lot of not-great general science course material out there. Probably part of that is that scientists write all of that stuff, and I think it's hard to write something you understand for people who don't… We're [also] starting to work on TA preparation and training in chemistry, and we did a workshop at the beginning of the fall semester. One of the things I see there is that a lot of times for graduate students it's their first time being in charge of people. So, we have to work on what ways [they] can effectively communicate and still be in charge, but not feel like a bad guy. I think that sort of role-play or workshopping can come into play too in terms of being scientists and trying to communicate with non-science people. There are a lot of people out there that just really like their research. Another problem [with that] is how institutions are set up; for tenure at Ball State even it's set up to preference the researcher—publications, grants, money—which does not preference teaching well… Most of the work gets done by us teaching faculty in terms of making adjustments and changes and trying to make classes better. A lot of the [other] faculty are focused on their research, and you know they try to do their best to teach, but they don't spend enough brain power thinking about how to make things different and better or asking why we are doing things this way." -Dr. C, Chem111

These difficulties are also echoed in the extant literature, based on the challenge of assessing science literacy in students rather than assessing specific content knowledge (DeBoer, 2000). Even with the successful guided-inquiry approach suggested by Gormally et al (2009), there would be issues involving the time and effort involved in assigning and grading writing or discussion-based work by students.

> "The difficulty in teaching courses like that at a 100 level is [that] you need to have students at a high enough level that they can communicate and think and write at that level. The more you start to get in those debates the more you move away from the model where it's a bunch of facts and test to a model where it's more discussion and writing, and that's a bit more difficult to assess in terms of time. As faculty we teach and enjoy teaching—that's why we're here at Ball State—but we also have research agendas and other responsibilities and it's considerably less time consuming to just give a multiple choice test with a whole lot of facts, and although you can make them rigorous and challenging from a grading standpoint that's a lot easier than reading 100 essays. And of course, having class discussions… in the honors class I had 20 people, and really 20 would have been better because even at 25 you get to the limit of what you can really do with a discussion. So, to try and pull it off in a 100-person

> class…that's difficult. I have found—oddly enough through some of this COVID-19 shutdown—that in Canvas I had students do [a discussion] for tornado safety and they actually had a great, vigorous online discussion. So perhaps some of it is a matter of changing around some of our content delivery. But still, that's with 40 people, I can't imagine how you could scale it up to anymore that than even in an online forum without a lot of people just sort of disappearing." -Dr. H, Geog101

Integration

Finally, professors were asked if a non-content specific course in science literacy should be explored as an option to satisfy the Ball State core curriculum science credit. Again, most of the responses were cautiously optimistic and echoed the previously mentioned themes. Most professors also suggested a possible integration of science-literacy based methods into existing courses rather than creating a new one to promote the ideas of scientific understanding and improved communication skills.

> "There should be a focus on STEM; so maybe instead of a brand-new course, it could be linked to university goals and integrated into existing classes rather than as a brand new concept" -Dr. G, HSC160

> "I think there would be a place for it, but I also think there are courses right now that could adopt some of that without needing a brand-new course. In other words, if we're talking about scientific literacy, making scientific literacy the first order of the course in say biology 101, geography 101, or geology 101." -Dr. D, Geog101

While integration into several courses would be an option that could satisfy the need to increase science literacy levels in students—and the general populace—there is still the issue of having to train educators in those methods, which can be difficult and time consuming (Gormally et al, 2009). This concern is echoed in some of the interview responses, indicating that re-training entire departments may not be the most feasible option.

> "I think the difficulty with that is scaling. We have thousands of students to serve here at the university and it's somewhat of a labor challenge. With that said, we could certainly start to develop a course like that; maybe the new EGNR department is the closest to that. Then perhaps rather than trying to create a whole new course, you could take concepts or smaller chunks of a course like that and start to integrate them into some of our other courses so to speak. I think there may be some benefits of developing courses like that to connect with other people in other disciplines very far afield, over toward humanities that do have more experience with this. We're talking about more literature, social sciences, psychology departments; we've done some of that within our geography program because human geography courses tend to be more discussion and writing based. [There has been] a push to develop more of a project and paper model and move away from the 'just learn the facts' model. So, in that respect, some of this has been done in other units already, or other courses within my own department. But it hasn't necessarily been trained among the sciences because we haven't been trained to think that way." -Dr. H, Geog101

Instead it may still be more practical—at least for the short term, until scientists and science educators can be trained in more effective communication and education strategies—to allow science majors to continue using the traditional introductory classes as stepping stones to more in-depth training, and give non-science majors an option to take a course which is designed specifically to meet their needs.

CONCLUSION/IMPLICATIONS

This study provided a first step toward exploring college level educators' opinions on and relationship to science literacy within the classroom. The main findings indicate that regardless of their specific discipline, university science educators are most concerned with addressing scientific fundamentals in their courses. This includes the idea that students should have an ability to find and recognize credible scientific sources, such that they are able to participate in informed decision-making processes. Professors also overwhelmingly indicated that—with or without specific content examples—a key aspect of engaging students involves a focus on topics, which have a sense of relevancy to student lives. This combination of imparting a fundamental scientific understanding within the context of relevancy is a cornerstone of science literacy-based education found in the literature (Harring and Jagers, 2018; Gormally et al, 2009; DeBoer, 2000). There was also an understanding that within each course there are differences in particular student groups: specifically, between science and non-science majors, and between upper- and lower-classmen. Despite being aware of these differences, professors did not have specific strategies in place to address them; however the strategies professors stated they used to engage students did include aspects of the guided-inquiry approach discussed by Gormally et al (2009).

In addition to the discussion involving existing course dynamics, professors were asked for their professional opinions concerning the potential development of a new science literacy-based course. There is no extant literature available which explores this aspect of the development of science literacy education, and as such this study provides a new perspective on this issue. In general, professors were cautiously optimistic about this concept, although all had concerns involving the utilization of new course materials and resources available. Many also suggested the idea of integrating scientific literacy-based education methods to existing courses, however it was acknowledged that those methods also pose difficulties. Namely, the time it takes to assess discussion and writing-based assignments and the interference of non-teaching responsibilities held by faculty.

Research Complications

Achieving the goals of this particular project was made more difficult by the unexpected influence of the COVID-19 pandemic, which severely restricted the ability to contact potential interviewees and conduct interviews. Due to the additional responsibilities and difficulties faculty faced ensuring that course materials and goals were available to students, many declined participating in this project. The added difficulties and absence of on-campus instruction also prevented many students from participating, meaning that they either could not or would not be available for in-depth interviews. This is an aspect of this project that should be re-visited in the future, when students are more able and willing to engage in this type of research. Nonetheless, this case-study provided evidence that there is potential for the development of a new non-content specific course in science literacy as part of the Ball State core curriculum.

Recommendations

Science literacy is still a topic which has endless potential and need for future research to obtain a more complete understanding of its role within science education, and how best to implement strategies to enhance student understanding of science. More research is needed both in this particular study area and in the extant literature on the topic in general to determine several factors including what course materials would be used, how to develop the curriculum for such a course, and which departments are best suited to host a course of this nature. Another important aspect of science literacy research which will need to be addressed in the future will be from the student perspective, not only because their willingness to participate in such a course would—in the end—be the deciding factor in its continuance, but because there is a decided gap in the literature concerning student attitudes and perceptions of science literacy. Ball State should—at the very least—re-evaluate the goals of the core science courses offered such that all students, regardless of major, can benefit from them to the fullest extent. To that end, the development of a new non-content specific course should be explored at Ball State as an option to provide non-science major students the scientific understanding necessary to be productive and responsible citizens. This is an assertion which is not only supported by the extant literature (Gormally et al, 2009; Eslinger and Kent, 2018; DeBoer, 2000; Glaze, 2018), but is now also supported by this exploratory study of Ball State science educators.

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APPENDICES

APPENDIX A

PROFESSOR INTERVIEW QUESTIONS

1. What is your name, department, and position at Ball State University?

2. Which of the following core curriculum science courses have you taught at Ball State: Anthropology 105, Astronomy 100/120, Biology 100/111/112, Chemistry 100/101/111, Geography 101, Geology 101, Health Sciences 160, Natural Resources 101, or Physics 100/101/110/120.

3. Approximately how long have you been teaching these courses?

4. What role do you believe these courses serve within the Ball State core curriculum?

5. Are you familiar with the term "science literacy", and how might you define it? (The operational definition I have been using is from the 2013 National Science Education Standards document which defines it as: "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity")

6. The BSU website states that the core curriculum is meant to enable students to "undertake the broad responsibilities of citizenship in a free society", and because science literacy is a key aspect of this citizenry (as stated by the National Research Council in 2013), the core science classes offered then should address this issue and provide students with the knowledge necessary to be considered scientifically literate. Do you agree with this position, and to what extent do you believe that the core science courses offered fulfill this expectation?

7. What do you believe incoming students are lacking in terms of scientific literacy?

8. What skills/knowledge do you hope students take away from the traditional introductory science courses within your department, and how might those expectations differ for science major and non-science major students?

9. Have you noticed any differences in attitude, aptitude, or self-efficacy between different types of students such as freshmen vs seniors or science vs non-science major students?

10. Do you have any strategies for addressing these differences in student motivations within the classroom?

11. Are there any particular subjects or topics within the course that students tend to find particularly interesting or engaging? Have you noticed if these are consistently different between different student groups (major, class standing, etc)?

12. What aspects of science literacy do you believe your course addresses?

13. For many students (non-science majors), the introductory science course they choose will be the last science-based course they will take in their adult lives. If there were a non-content specific course (rather than specifically chemistry, biology, etc) designed to address science literacy directly, offered by Ball State which could satisfy the university core science course requirement, do you believe it could satisfy the university's goal of preparing students to be successful?

14. What issues or topics do you believe students would need to be taught in a course designed to address scientific literacy in order to reach the same level of understanding which is assumed to be acquired upon passing one of the currently offered core science courses?

15. Do you believe professors (including yourself) would be willing to take on and teach such a course? What difficulties would you anticipate with teaching such a course?

16. Do you believe there should be a required or optional undergraduate course concerning science literacy as an alternative to the traditional introductory courses (in particular for non-science major students)?

APPENDIX B

PROFESSOR EMAIL CONTACT:

Good afternoon Dr. ________,

My name is Ashley Pavey and I am a graduate student within the Natural Resources and Environmental Management program here at Ball State. I am conducting a master thesis on the subject of science literacy, and my research involves collecting interview data from Ball State undergraduate students and professors within the various science departments which offer the core curriculum science courses (IRB #1546871-1).

According to the Ball State course catalog, you are either currently teaching or have previously taught the introductory course _________. I would like to ask if you would be willing to participate in an online WebEx interview with me to discuss science literacy and the role it plays in the classroom, your expectations of students in the classroom, and your professional opinion on the state of science literacy within the student body population and its role within the university core curriculum. The interview is expected to take approximately 30-45 minutes, can be scheduled for a time most convenient for you, and your identifying information will not be used in the final project unless you grant your express permission as per the attached informed consent document.

Also attached to this email is the abstract of my proposed research which will describe my research goals in more detail. I would be happy to provide you with any further information at your request!

Thank you for your time, and I look forward to hearing from you!

--Ashley Pavey

APPENDIX C

INFORMED CONSENT FORM

Science Literacy: An Undergraduate Alternative to Traditional Introductory Science Courses

IRBNet #: 1546871-1

Study Purpose and Rationale

Research objectives include assessing the science literacy and self-efficacy levels of Ball State Undergraduate students, as well as the attitudes and expectations of both students and professors. Science literacy has not been widely studied. This study is expected to provide a more nuanced exploration of the science literacy levels and expectations of Ball State undergraduate students which will be compared to professorial expectations within the science departments. This could help the Ball State core curriculum better meet the needs of its students.

Inclusion/Exclusion Criteria

You must be a Ball State professor who is currently teaching or has previously taught at least one of the following core curriculum science courses: Anthropology 105, Astronomy 100/120, Biology 100/111/112, Chemistry 100/101/111, Geography 101, Geology 101, Health Sciences 160, Natural Resources 101, or Physics 100/101/110/120. You will be excluded if you are not currently a faculty member of Ball State University.

Participation Procedures and Duration

Voluntary participants will complete an online interview which will take approximately 30-45 minutes to complete and will be audio-recorded and transcribed. You may choose not to answer any of the interview questions asked. Interview questions may include teaching experience and background, expectations of students within the science classroom, and your professional opinion on the state of science literacy within the student population and its role within the university core curriculum.

Audio or Video Tapes *(only include if applicable)*

Audio recordings of interviews will be saved and kept on a password protected computer. They will be kept until July 2020, after which they will be deleted. They will be transcribed, and quotes will be used in the final project. No identifying information will be included in the final paper or presentations unless permission has been expressly granted by you, the participant. Audio recordings will not be included in the final project.

Data Confidentiality or Anonymity

Interview data will be maintained as confidential, and no identifying information such as names will appear in any publication or presentation of the data unless permission has been expressly granted by you, the participant.

Storage of Data and Data Retention Period

Raw data will be kept in on a password protected computer in a locked office until the completion and acceptance of the thesis project (July 2020) after which it will be deleted.

Risks or Discomforts

There are no perceived risks for participating in this study.

Benefits

There are no perceived benefits for participating in this study.

Voluntary Participation

Your participation in this study is completely voluntary and you are free to withdraw your permission at anytime for any reason without penalty or prejudice from the investigator. Please feel free to ask any questions of the investigator before signing this form and at any time during the study.

IRB Contact Information

For questions about your rights as a research subject, please contact the Office of Research Integrity, Ball State University, Muncie, IN 47306, (765) 285-5052 or at orihelp@bsu.edu.

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Researcher Contact Information

Principal Investigator:

Ashley M. Pavey, Graduate Student

Natural Resources and Environmental Management Management

Ball State University

Muncie, IN 47306

Email: ampavey@bsu.edu

Faculty Supervisor:

Dr. Joshua B. Gruver

Natural Resources and Environmental

Ball State University

Muncie, IN 47306

Telephone: (765) 285-5789

Email: jbgruver@bsu.edu