

PROMOTING INQUIRY-LEARNING THROUGH THE USE OF INTERACTIVE  
SCIENCE NOTEBOOKS IN SEVENTH GRADE LIFE SCIENCE

by

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A professional paper submitted in partial fulfillment  
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY  
Bozeman, Montana

July 2017

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DEDICATION

To Dominic, the love of my life whose admiration and support has gotten me through this process, thank you so much for all the kind words when they are most needed. And to Oliver, my favorite kid in the whole wide world, if my completing this personal goal gives you the desire to outcompete me in your educational pursuits, as you have stated, then that is reason enough to have done this. I love you both.

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## ABSTRACT

The purpose of this study was to determine if the use of interactive science notebooks in a high school setting would enrich student learning and performance on Next Generation Science Standards, Idaho state Common Core ELA standards, and content objectives in Environmental Science. Four sections of students, totaling 99, were used in the study. Two sections worked for eight weeks on two curricular units using the ISN, while two sections continued using autonomous methods already in place from the previous semester. All students participated in pre- and post-testing of content objectives and constructed response items, and took a Likert survey to measure attitudinal/motivational differences between the groups.

Results suggest use of the interactive science notebook led to gains in student scores on constructed response items, but significant differences in performance on the post-tests do not demonstrate increases in student achievement related to the use of the ISNs. There was also no demonstrable effect on student attitudes toward science.

## INTRODUCTION AND BACKGROUND

As a teacher I have always been interested in inquiry-based learning, however as a student I have not had many educational experiences to pull from in order to implement this style of teaching in my own classroom. Just this academic year I made a move to a teaching position in a district that independently adopted the Next Generation Science Standards in the fall of 2014, whereas the majority of the state (including the district in which I was employed previous to fall 2016) had yet to do so. This move has afforded me the opportunity to work with teachers who are diligently developing and implementing NGSS-aligned curriculum and promoting student-centered learning in their classrooms.

This study was conducted at Lewiston High School (LHS), a public high school serving over 1,000 students in the tenth through twelfth grade levels. Within the district there is also an alternative high school for at risk students in grades nine through twelve, two junior high schools (grades seven through nine), and seven elementary schools (kindergarten through sixth). The demographic makeup of the school largely mirrors that of the community, with 87% of the student body identifying as white/Caucasian. While LHS is not designated as a Title I school, all but two of the schools in the district are Title I eligible. As such, poverty is a struggle for many of my students.

At 32,401 residents, Lewiston is the most populous city in the region and surrounded by many rural communities. It is an urban environment with strong blue collar industrial and agricultural leanings as a result of being Idaho's only seaport and its proximity to timbered forests and dry-land farming. The region is a hot-bed of recreational activity with the confluence of the Snake and Clearwater rivers and

wilderness areas abound; visitors and residents alike are drawn to the hunting and fishing accessibility that is offered here.

Even though the traditional approach to teaching was effective for me as a student, the longer I am in this profession the more that I understand I do not represent the majority of students in the classroom. Rather, there must be other methods of instruction that will help students understand concepts more thoroughly and in such a way that it leads to more meaningful learning and increased abilities to apply the knowledge gained to real life scenarios. Through research and reviewing the NGSS, I have come to understand “inquiry” is not just a buzz word in education, it is an educational approach to learning that will better serve my students and hopefully inspire them to become professionals in the STEM fields that benefit us so greatly in our modern society.

I am the only teacher of Environmental Science at Lewiston High School. I teach four sections of this course, which enables me to make adjustments not only from year to year, but from one class period to the next and even into the following day as a result of the block scheduling at our school. The block scheduling consists of 85 minute periods divided into “A” and “B” days. All students enrolled in the four sections were participants in the study, with two sections serving as the treatment group and the others serving as the comparison group.

I keep my tables arranged into groups, or “islands” as I like to call them, in an effort to encourage collaboration with my students. They are regularly prompted to discuss topics with their “elbow” buddies and table mates as a means to develop

understanding of the content at hand. This classroom setup allows plenty of opportunity for students to write and reflect individually and in small groups.

While I have provided my students some opportunities for inquiry-based learning, I have yet to make the transition to an inquiry-based teacher, yet I recognize the necessity to make changes to my curriculum to better serve all of my students. I want my students to be excited and engaged, and want them to view science as something they can do and that is valuable in their daily lives.

As other teachers in my department require students to keep dedicated notebooks and/or portfolios for their classes, I wondered if by incorporating similar tools in my class would improve student success and engagement. I believe the tool that can help me achieve more inquiry-based learning experiences for my students is through the use of an interactive science notebook. Not only are they useful for inquiry, but they also support the Common Core literacy standards that have been adopted in our state and the Next Generation Science Standards that have been adopted by my district. This belief led me to focus on the following questions for my research project:

- Does the use of interactive science notebooks increase student achievement with regard to state content and literacy standards that are addressed on summative assessments?
- Does the use of interactive science notebooks have a positive effect on students' attitudes about learning science?
- Does the use of interactive science notebooks promote students' abilities to make scientific claims and support them with evidence and reasoning?

## CONCEPTUAL FRAMEWORK

Any science teacher understands the push for STEM education for today's students. The modern world in which we live presents us with an ever-increasing need for the populace to be scientifically literate. In 1996, the National Research Council released the National Science Education Standards in which it is argued everyone needs scientific literacy in order to make everyday choices and participate in public debate about scientific and technological issues, as well as fulfill an innate need to experience and understand the natural world. The NRC argues that science is for all students, and that it is something students do, as opposed to something that is done to them. In other words, science isn't just a collection of facts to be imparted by the teacher to the student, but instead practice in and understandings of the ways in which the natural world is studied and phenomena are explained by scientists. (National Research Council, 1996).

Fifteen years later, prompted by advancements in science and in teaching and learning, as well as the desire to complement the nationwide adoption of the Common Core State standards in math and language arts, the NRC published *A Framework for K-12 Science Education* (2012), which provided the foundation for the development of the Next Generation Science Standards (NGSS, 2013). The *Framework* presented three dimensions through which the NGSS were developed, titled "Practices," "Cross-Cutting Concepts", and "Disciplinary Core Ideas" (NGSS, 2013).

What were formerly referred to as science "skills", the practices outlined by the *Framework* are the types of activities students are doing in inquiry-based learning environments. According to the *Framework* (NRC, 2012), these practices are

encompassed by three spheres of activity that describe the work of scientists and engineers in the real world (Loc. 909). The three spheres are: investigating, evaluating, and developing explanations and solutions. The eight practices defined by the *Framework* (NRC, 2012) are:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information, and computer technology, and computational thinking.
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information (Part 2, Dimension 1).

As a result of the varying interpretations of the term, it is through these practices that the *Framework* (NRC, 2012) seeks to define inquiry:

Similarly, because the term “inquiry”, extensively referred to in previous standards documents, has been interpreted over time in many different ways throughout the science education community, part of our intent in articulating the practices in Dimension 1 is to better specify what is meant by inquiry in science and the range of cognitive, social, and physical practices that it requires. As in all inquiry-based approaches to science teaching, our expectation is that students themselves will engage in the practices and not merely learn about them secondhand. Students cannot comprehend scientific practices, nor fully appreciate the nature of scientific knowledge itself, without directly experiencing the practices themselves (Loc. 690).

To summarize, “engaging in scientific inquiry requires coordination of both knowledge and skill simultaneously” (NRC, 2012, Loc. 860).

Research suggests that inquiry-based learning creates positive outcomes with regard to student engagement and success. In their study of the effects of an inquiry-

based learning seminar, taken by students in their first year of study at the university level, in which the intent was to provide students with tools for effectively seeking out and using a variety of sources for research, Summerlee and Murray (2010) show that participation in the seminar led to higher average grades throughout the students' four years in college as compared to other students who never enrolled in the course.

A 2014 study in Taiwan (Chen, Wang, Lin, Lawrenz & Hong, 2014) followed 37 low-achieving elementary students as they participated in a weekly after school inquiry-based intervention program. The students who participated in the program were compared to 87 typical fourth-graders who did not attend the intervention; all students completed APLS (affective perceptions of learning science) and positive thinking questionnaires. The improvements in positive thinking were seen very early in the intervention, and by the end of the program the students' scores from the experimental group exceeded the scores of the comparison group for both tests (Chen, Wang, Lin, Lawrenz & Hong, 2014). Any teacher can attest to the impacts of having students in their classrooms that have positive attitudes and outlooks with regard to the content they are teaching.

If we refer back to the practices outlined in the *Framework*, it is easy to see how writing is also an integral part of science. In reference to the Common Core State Standards, which were adopted by the state of Idaho in 2011, Llewellyn (2014) addresses the complementary nature of the CCSS and the NGSS, likening the relationship between the two sets of standards to "spaghetti and meatballs." Indeed, a closer look at just two of the College and Career Readiness Anchor Standards for Writing in grades 6-12 (National

Governors Association Center for Best Practices & Council of Chief State School

Officers, 2010) is quite revealing of this relationship:

1. Write arguments to support claims in an analysis of substantive topics or texts using valid reasoning and relevant and sufficient evidence
5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach (p. 63).

Inquiry-based teachers often rely on portfolios and journal entries in addition to objective-type and multiple choice questions in order to assess their students' learning (Llewellyn, 2014). One method of promoting inquiry—and supporting Common Core ELA standards—in the classroom is through the use of interactive science notebooks (Marcarelli, 2010). Interactive science notebooks allow students to model the practices scientists use in the real world, such as recording data and observations, and through their writing they can clarify their thoughts and deepen their understanding of the curriculum (Young, 2003).

As opposed to the more free-form writing nature of journal entries, the interactive science notebook is more structured (Nesbit, Hargrove, Harrelson & Maxey, 2004) and promotes a constructivist approach to learning in which students organize and maintain notebooks as a laboratory or field scientist would (Chesbro, 2006).

In short, an interactive science notebook (ISN) is a spiral bound or composition notebook in which the right side is reserved space for those items considered input, such as lectures, notes, and labs. The left side is reserved space for items considered to be output, such as brainstorming, flowcharts, pictures, worksheets, Venn diagrams, etc. (Young, 2003). While the degree to which the teacher uses the ISN may vary, Marcarelli

(2010) recommends students use them constantly, writing, reflecting, revising, and using them as reference when interacting with each other and the teacher.

Promoting inquiry through the use of interactive science notebooks could also help under-served students in my classroom, especially with regard to those that are English Language Learners (my foreign exchange students). Through a four-year study in the El Centro Elementary School District of southern California, Amaral, Garrison, and Klentschy (2002) describe the increases in achievement on standardized tests for 615 fourth and 635 sixth grade students in science, reading, writing and mathematics. The inquiry-based science program incorporated the use of science notebooks as part of the curriculum. The results from the tests were disaggregated into groups based on English proficiency and number of years in the program. The researchers found statistically significant gains in all indicated assessments that were proportional to the number of years spent in the program.

For instance, sixth graders who participated in the district science program for all four years had a mean raw score of 26.02 on the SAT-9 science section. Students who had attended the district for the four years but who had never participated had a mean raw score of 16.88. Students with one year experience in the program had a mean raw score of 18.53, two years participation in the district science program scored 21.03, and the group who had three years participation scored 22.81 (Amaral, Garrison, & Klentschy, 2002).

While there were differences between those students classified as Limited English Proficient and those that were classified as English Proficient, all groups made significant

gains that increased with the number of years spent in the science program (Amaral, Garrison, & Klentschy, 2002). What was also interesting were the gains made by students on the district writing assessment. Sixth grade LEP students in their fourth year of the science program had a 92.9% proficiency rate and the English Proficient students had an 88.9% proficiency rate. This compares to the 15.4% and 40% proficiency rate for the LEP and EP, respectively, groups who had zero years in the district science program (Amaral, Garrison, & Klentschy, 2002).

The research clearly indicates a need for science education reform that centers on inquiry-based learning experiences for students. This can be difficult because many teachers themselves are products of teacher-centered educational experiences. Through the use of interactive science notebooks, I believe I can more deliberately infuse inquiry into my curriculum, which will benefit all of my students' attitudes and achievement in science, reading, and writing.

## METHODOLOGY

The focus of the study was to determine if interactive science notebooks promote student engagement in the practices outlined in the NGSS. The questions addressed centered on the effects of the ISN on student achievement with regard to content objectives and NGSS and literacy standards on summative assessments, particularly in making claims and supporting them with evidence, and whether or not they promote a positive attitude about learning science.

The units chosen for this study were "Population Dynamics", which focused heavily on carrying capacity, survivorship, and ecosystem interactions, and "Human

Populations”, which examined factors affecting local and global populations with regard to birth rates, death rates, survivorship, and the demographic transition.

Four sections of environmental science were used in a cross-sectional study. Two sections participated as treatment groups; the other two classes were used as a comparison groups. The determination as to which classes received treatment and which were to be comparison groups was based on random assignment because the student demographics are pretty evenly distributed.

The students in the study were mostly seventeen-years old in their junior year of high school, as well as a few seniors. Within the treatment classes there were three foreign exchange students for whom English is a second language, four students were on IEPs, and four students with 504 plans. The comparison classes combined had two foreign exchange students with English as their second language, five students on IEPs, and six students on 504 plans. Forty-six students in total participated in the treatment group, while 53 participated in the comparison group. The research methodology for this project received an exemption by Montana State University’s Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

In past courses I have taught, students have been required to have three-ring binders or keep science notebooks. This year being my first teaching high school, students were encouraged to have a spiral or composition notebook dedicated to my class. However, in recognizing my students are in their junior or senior years and well on their way to graduating, I allowed great autonomy with regard to how they organized the materials for the course.

At the beginning of the second semester, during which there was significant change-over in my rosters—students can take one or both semesters of the class and in whichever order they would like and the sections to which they are assigned can change significantly—students in the treatment classes were assigned to have science notebooks on each day of attendance. Most of the notebooks were spiral-bound.

At the onset of the research project, students in the treatment classes were provided instruction and examples on how to make their notebooks “interactive.” Whenever new notes were added to the notebook, the students recorded titles and page numbers in their table of contents. Instead of limiting the additions to the notebooks to notes, everything was placed in the notebook—notes, quizzes, handouts and the like were added by using glue or tape.

The page numbers, too, were important in the organization of the notebooks. Right-hand pages were reserved for input and the left-hand pages were reserved spaces for student output. Examples of input include any lecture notes, vocabulary, and study guides. Some of the notes on the input pages also received makeovers; whenever possible, notes were transformed by using foldable cutouts on which to organize new information.

The left side, output pages, became the place where students used the information from the input pages to organize and construct knowledge about the concepts discussed in class. Creativity through the use of color was explicitly encouraged on the student output pages. Student outputs included drawings, graphic organizers, reflective writing, etc. This was the side where students placed graded quizzes and assignments, too. Figure

1 is a representative example of the student input work and Figure 2 is an example of student output work.

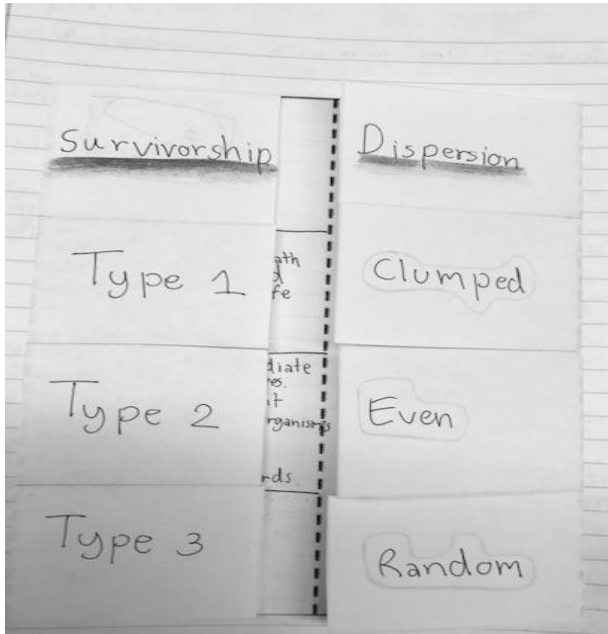


Figure 1. Student input (right-hand side).

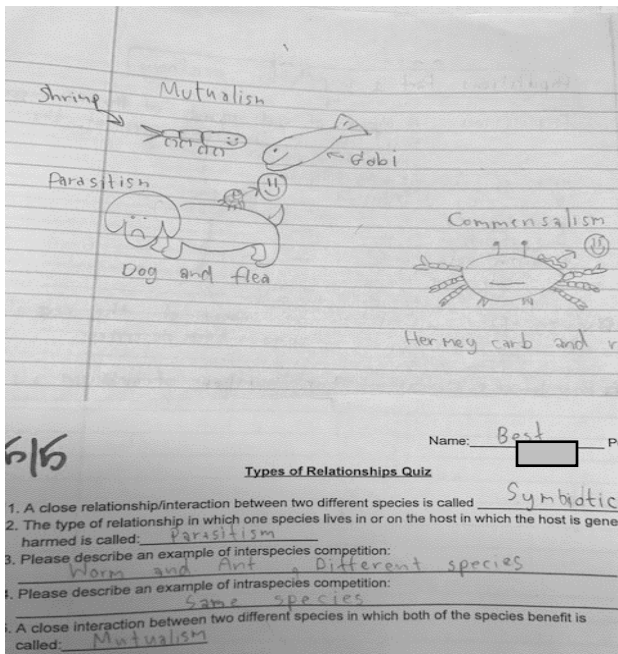


Figure 2. Student output page (left-hand side).

Student use of the left-hand output pages was encouraged through the format of the class. Students were prompted throughout lessons to include brainstorming, scribbles, thoughts and reflections as part of each activity. The last five to ten minutes of each class period were devoted to the development of output pages, and the beginning of the following class periods were used as think-pair-share, or group and whole class discussions, where students were asked to revisit their output from the previous class period. Table 1 summarizes an example of typical lesson plans for the treatment and comparison classes.

Table 1  
*Example Lesson Plan*

<b>Treatment</b>		<b>Comparison</b>	
Activity	Time (min)	Activity	Time (min)
Bell-Ringer, student output then think-pair-share	10	Bell-ringer, think pair share and whole group discussion	10
Lecture and vocabulary notes.	20	Lecture and Vocabulary Notes	20
Foldable Notes, cut/pasted/colored from lecture material	20	Worksheet	25
Worksheet (collected for grading)	25	Trade and Grade	15
Prompt-Output. Draw a picture of...	10	Share out and ticket out the door	10

To assess student learning throughout the units, pre- and post- assessments were given to the treatment and comparison groups (Appendices B and C). These pre- and post- assessments include test items meant to address course content objectives, NGSS, and state literacy standards.

Student attitudes about learning science were assessed through pre- and post-Likert surveys (Appendix D), and student interviews were conducted post treatment

(Appendix E). The SMQII Likert survey was given to all students at the beginning of the research project and again after completion of the second unit summative assessment. The questionnaire contains five components—Intrinsic Motivation, Self-Efficacy, Self-Determination, Grade Motivation, and Career Motivation—and twenty-five statements (items) affirming positive feelings toward science. The students who participated in the interviews were randomly selected from the treatment groups after dividing the classes into three different achievement levels, based on their previous term grades, in order to ensure a variety of perceptions were included.

Constructed responses, where students make claims and support them with evidence in one to two paragraphs, were used as part of formative and summative assessments. Halfway through each unit, students received instruction on how to make a claim that answers a scientific question and support it with reasoning and evidence. Then they completed a constructed response item and it was scored with feedback provided. A constructed response item was included in the summative, unit assessments, too.

Constructed response items were graded using a rubric (Appendix F), and normalized gains were calculated in order to show student growth. I kept a journal of observations of student participation in group and whole-class discussions and other informal formative assessments techniques. Journal reflections included responses to prompts I created prior to implementation of the project (Appendix G).

As an example, at the end of a mini-inquiry lesson on the effects of invasive species on an ecosystem, using Quagga mussels as our case study, students were asked to write a claim-evidence-reasoning response to the question “How do invasive species

affect the carrying capacity of native species in an ecosystem?" I collected and scored their answers, and the scores were used as baseline data for the summative assessment. At the beginning of the next class period, students were asked to revisit their responses by using separate colors to underline where the claim, evidence, and reasoning was in their answers. They were then to tape or glue the index card into their notebooks in their output page and given further instruction and prompting on how to rewrite their answers. The student work in Figure 3 was given a baseline score of 2—a 1 for the claim, 0 for evidence, and 1 for reasoning.

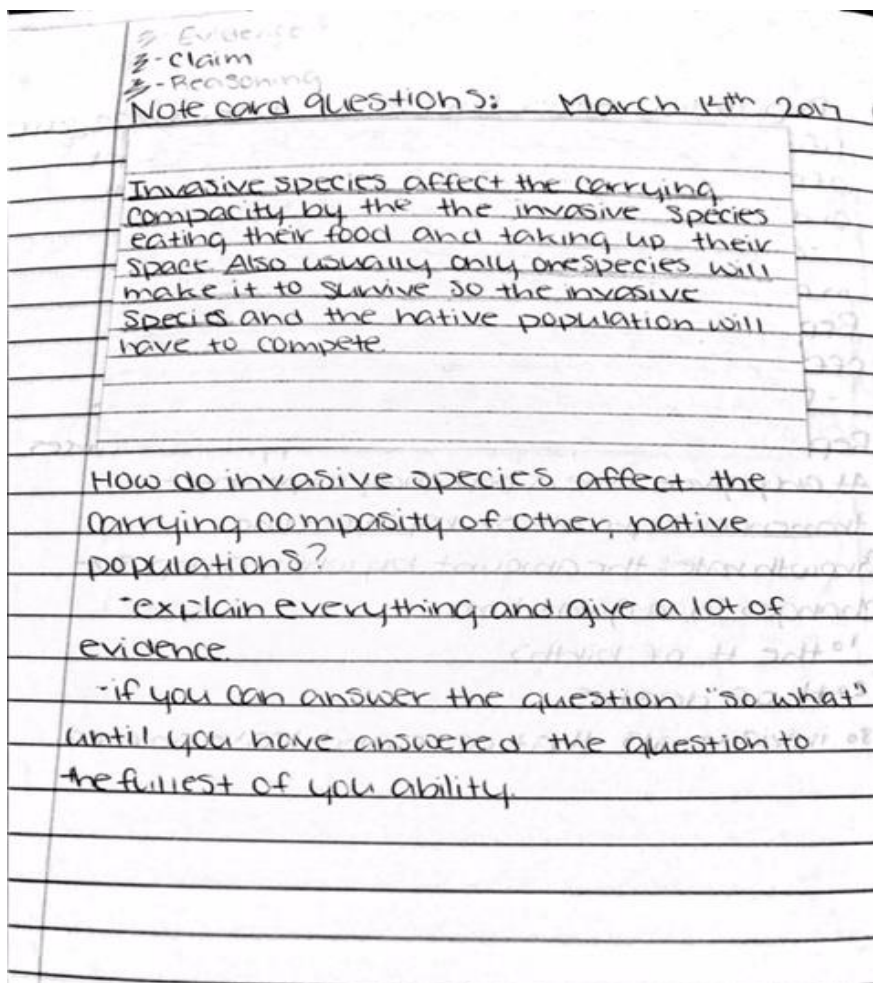


Figure 3. Example student work for constructed response item, midway through first instructional unit.

Students in the comparison groups did most of the same activities and assignments as the other groups did with a couple of notable exceptions. Whereas much reflection in the treatment groups was done by hand in their notebooks via drawings and writings, in the comparison groups most of the reflection was done by reviewing previous notes and through verbal interaction in small and whole group discussions. Revision of student work in the comparison groups was also more informal, where students were asked to trade and give feedback of each other’s work.

Table 2 shows the triangulation matrix of the data tools used to answer the research questions.

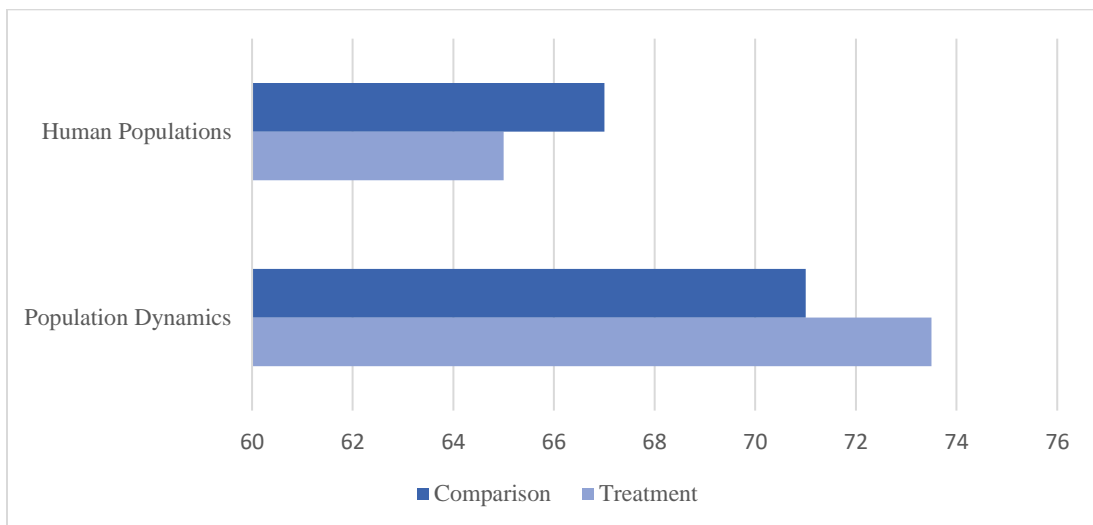
Table 2  
*Data Triangulation Matrix*

Questions	Data Source 1	Data Source 2	Data Source 3
Does the use of interactive science notebooks increase student achievement on NGSS and content objectives that are addressed on summative assessments?	Pre- assessments measuring prior knowledge and growth during the curricular units.	Teacher journaling of both comparison and treatment groups throughout curricular units	Post- assessments measuring student growth in knowledge after treatment
Does the use of interactive science notebooks have a positive effect on students’ attitudes about learning science?	Pre-treatment Likert survey assessing student attitudes	Student interviews post-treatment	Post-treatment Likert survey assessing student attitudes
Does the use of interactive science notebooks promote students’ abilities to make scientific claims and support them with evidence?	Pre- assessment evidence-claim constructed response items to demonstrate prior abilities and student growth	Teacher journaling of informal and formal formative assessments throughout curricular unit.	Post- assessment evidence-claim constructed response items to demonstrate student growth

## DATA AND ANALYSIS

This research project was conducted from the end of February 2017 through the end of April 2017, during which time there was spring break and other interruptions of the normal school week, such as school-wide standardized testing and senior project presentation schedules. Two curricular units were administered, each one consisting of limited lecture, notes, laboratory investigations, and guest speakers.

Pre- and post-summative assessment data show average normalized gains for the treatment and comparison groups. Both treatment and comparison groups show high normalized gains for the first unit on population dynamics. The treatment group showed higher normalized gains than the comparison group for this unit, while the reverse is true of the human population unit test. The average normalized gains for population dynamics was considered high (>70%) for both groups, while a medium average normalized gain was shown for the second unit (30%-70%) (Figure4).



*Figure 4.* Average normalized gains on summative assessments, treatment ( $N=46$ ), comparison ( $N=53$ ).

Formative assessment scores were compared to summative assessment scores in order to assess growth on constructed response items. A majority of students in both groups showed some level of improvement, however gains were more noticeable for the classes where the interactive science notebook (ISN) was used as part of the instruction. Indeed, fourteen percent more students showed growth in the first unit compared to the growth shown in the comparison group (Figure 5).

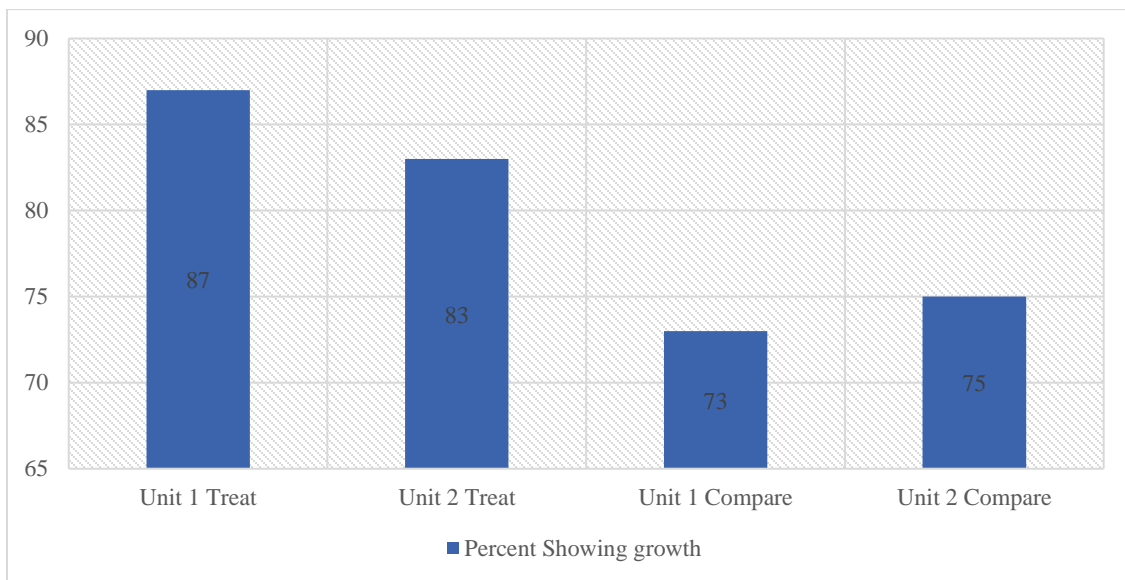


Figure 5. Constructed response growth, treatment ( $N=46$ ), comparison ( $N=53$ ).

As much of the instruction for constructed response was cumulative, student scores from the first formative assessments were compared to scores of their constructed responses from the last assessment of this research project. Students in the treatment groups showed more improvement than those students who did not keep interactive science notebooks (Figure 6). The percentage of students scoring proficient in the treatment group grew from 22% to 60%, while the comparison group grew from 19%

proficiency to 49%. Means and standard deviations for each data set are also shown in the figure below

<b>Constructed Response Raw Scores # of Students</b>				
<b>Score</b>	First Written Response – T	Last Written Response – T	First Written Response – C	Last Written Response – C
<b>Unsatisfactory 0-3</b>	13	8	17	9
<b>Basic 3.5-4</b>	23	10	26	18
<b>Proficient 4.5-6</b>	10	28	10	26
Mean	3.57	4.49	3.43	4.11
Standard Dev	1.19	1.17	1.25	1.02

Figure 6. Constructed response scores, treatment (N=46), comparison (N=53).

The means of the treatment and comparison groups were 3.57 and 3.43, respectively, on the first formative assessment for constructed responses. The standard deviation for the treatment scores was 1.19, and 1.25 for the comparison. With a P Value of 0.57, there appears to be no statistical difference between the two classes.

P Values for first and last CR scores for both groups were calculated. The treatment group scores had a P Value of 0.0003, and the comparison group had a P Value of 0.027. Therefore, statistically significant gains were made for both classes.

An unpaired *t* test was also performed on the last summative assessment constructed response scores for the treatment and comparison groups (M = 4.49, SD 1.17; M = 4.11, SD 1.02). A P value of 0.0874 shows the gains made by the two groups were not statistically different from each other.

Twenty-five questions measuring student motivations in science were assessed through the SMQ II Likert survey and grouped into the five components. Average

component scores for pre- and post-surveys show gains in three of the five components for the treatment group, while the comparison group made gains in two of the five (Figure 7). The higher the average component score, the greater agreement with positive statements of science motivation and perception. The results are small and inconclusive, as scores across all classes were quite similar within the five components.

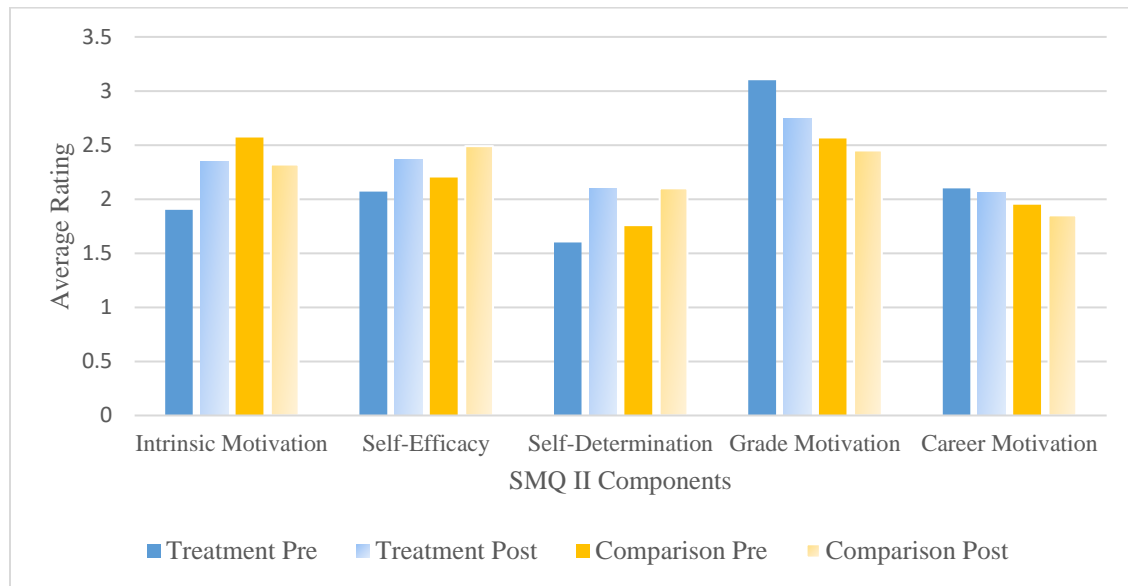


Figure 7. SMQ II Likert survey results by average component scores, treatment ( $N=46$ ), comparison ( $N=53$ ).

Student perceptions of the usefulness of the ISN were assessed through interviews with eight randomly selected students at the conclusion of the second unit under consideration for the project. Answers to three questions from the survey were ranked as being overall positive, negative, or indifferent (Figure 8). While a majority of the students indicated the ISN was helpful in learning content material, common explanations had less to do with the “interactive” part of the notebook and more the usefulness of keeping all class materials in the in them—i.e. organization. One student who consistently had negative feelings referred mainly to the tedious nature of assemblage; the cutting, pasting,

and drawing all felt like “extra work” that did not enhance his learning experience. Of note, when asked what else he would like to tell me he said, “I appreciated not having to leave them in the classroom. My math teacher who did this made us leave them and then I did not have it to study for my tests.” Another student who would like to discontinue use of the ISN reported frustration with having to use the left-right, input-output method of adding items to the notebook, as well as having to remember to use the table of contents.

When I asked the students to show me pages of which they were the most proud, four of them directed me to pages where they got to be the most “artistic” with their work. Two of them showed me the tests they glued into their notebooks, having done well on them, and the other two turned to pages with foldable notes from lectures.

Question	Responses		
	Negative	Indifference	Positive
How does your notebook help you learn?	1	3	4
How does your notebook motivate you to work?	1	4	3
Is the interactive science notebook a tool you would like to continue using in class? Why or why not?	2	4	2

*Figure 8.* Student interview responses, ( $N=8$ ).

My journaling throughout the project revealed several themes, some that in many ways mirrored my students’ views of the ISN. The time devoted to planning the activities to go in the notebooks was a huge factor, especially when it came to choosing the more “interactive” pieces of the ISN, such as foldable notes that accompanied lectures. The

issue of time arose repeatedly throughout the process; photocopies of papers to glue into the notebooks usually were single-sided while the copies for the comparison groups tended to be double-sided to save paper, thus extra minutes in the copy room. Also, the class time it took for students to complete activities meant that at least two times during the project my “A” days ran behind my “B” days. It is not abnormal for this to happen because each class is responsive in its own way, but the threat of “getting behind” was much more imminent with my treatment groups.

Reflection data also revealed somewhat higher engagement for my students, though this was uneven between the two class periods in which the ISN was implemented. Both classes combined served as my treatment group, but on three occasions I wrote about students “groaning” as I passed out foldable notes. This had me questioning whether I’d unnecessarily chosen pieces to be interactive when they need not be. However, the time set aside for extra writing showed my treatment classes following through more on evaluating and revising their own writing. This was starkly different in the comparison classes where students were more likely to waste time and lose work. For instance, one day I asked students in my comparison classes to retrieve the index card on which they’d written and revised constructed responses to the mid-unit formative assessment item on invasive species (which they’d worked on one week prior)—a full third of the students could not or would not produce them.

## INTERPRETATIONS AND CONCLUSION

In this research project, students benefited most with regard to outcomes on written extended response items on their unit tests. In using interactive science

notebooks, my students were able to be more reflective of their understandings of important content in Environmental Science, and I was able to more deliberately focus instruction toward desired outcomes. In conclusion, I will address the three focus questions from this study.

1. Does the use of interactive science notebooks increase student achievement with regard to NGSS and content objectives that are addressed on summative assessments?

Studies have shown improvements in student performance on assessments (Amaral, Garrison, & Klentschy, 2002). Pre- and post-test data of performance on content objectives for this research project did not demonstrate student use of interactive science notebooks improves student achievement. However, pre- and post- assessment of written answers to constructed response items, which ask students to make claims and support them with evidence or examples from previous class work, such as case studies, and connect evidence to claims using reasoning statements, did show higher achievement for students using the notebooks as a learning tool. Teacher field notes also supported this finding because students in classes not using the ISNs were less likely to focus on self-evaluation and revision of written work.

2. Does the use of interactive science notebooks have a positive effect on students' attitudes about learning science?

In their study of low-achieving students, Chen, Wang, Lin, Lawrenz & Hong, (2014) students showed statistically significant increases in positive perceptions about science. In my project, the Science Motivation Questionnaire II was administered at the

beginning and end of the research process. Findings suggest only slight, if any, improvements in student motivation in learning science. My journal entries and student interview data indicate while students appeared to be more engaged when using their ISNs, there were also times when student apathy was exacerbated by the time-consuming processes of cutting and pasting items into the notebooks. Moreover, interview data suggest more indifference with the use of interactive science notebooks, as opposed to positive feelings about ISNs as learning tools.

3. Does the use of interactive science notebooks promote students' abilities to make scientific claims and support them with evidence, as required by NGSS and ELA writing and literacy standards?

Written answers to constructed response items, which ask students to make claims and support them with evidence from previous class work, such as case studies, and connect evidence to claims using reasoning statements, did show higher achievement for students using the notebooks as learning tools. Teacher field notes also supported this finding because students in classes not using the ISNs were less likely to focus on self-evaluation and revision of written work. This supports previous researchers' findings that achievement improves with the use of the interactive science notebook (Summerlee & Murray, 2010).

The *Framework* defined practices—constructing explanations, engaging in argument from evidence, and obtaining, evaluating, and communicating information--clearly demonstrate the interconnectedness of the Next Generation Science Standards with literacy standards (NRC 2012). Because inquiry-learning requires students to engage

in these practices, the use of the ISN supports inquiry learning (Marcarelli 2010). While achievement gains were not made in every assessment, I believe interactive science notebooks are a step in the right direction of me implementing more inquiry into my curriculum.

#### VALUE

While the ISN allowed me to infuse more inquiry into my lesson planning, the scope with which they were used was more limited, in retrospect, than the other practices outlined by the *Framework*. In the future, I will make concerted efforts to address those other practices. For instance, developing and using models, and planning and carrying out investigations, are both practices that would be conducive to the design of the interactive science notebook.

When I first planned this research project, I was working as a seventh-grade life science teacher, where the use of foldable notes seemed more relevant than it was, perhaps, with the older students I currently teach. Combined with the evidence that these high school students did not always care for them, in the future I would scale back their use in the interactive science notebook. But, seeing that students did make gains, and that the other, highly effective, teachers in my department use some form of portfolio or notebook, I think continued use of the ISN has a place in my classroom.

Other improvements I intend to make is to adjust my grading practices to reduce grading of the individual pieces that were placed in the science notebook. There were several times where I collected student work, graded it, and returned it to be glued or pasted into the notebook. This created a feedback delay at times that I could probably reduce by

having students check their own work against available keys. I would incorporate regular notebook checks for formative assessment and use a grading rubric for a summative assessment at the end of the grading term.

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APPENDICES

APPENDIX A  
IRB APPROVAL



**INSTITUTIONAL REVIEW BOARD**  
**For the Protection of Human Subjects**  
**FWA 00000165**

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**MEMORANDUM**

**TO:** Jamie Morton and Eric Brunzell  
**FROM:** Mark Quinn, Chair *Mark Quinn CJ*  
**DATE:** January 13, 2016  
**RE:** "Promoting Inquiry-Learning Through the Use of Interactive Science Notebooks" [JM011316-EX]

The above research, described in your submission of December 21, 2015, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

PRE- POST- TEST POPULATION DYNAMICS

Name: \_\_\_\_\_ Period: \_\_\_\_\_

**Population Dynamics Test****Please Fill in the Blank with the correct vocabulary word.**

1. \_\_\_\_\_ A group of individuals of the same species living in the same general area.
2. \_\_\_\_\_ The spatial distribution of individuals within the population.
3. \_\_\_\_\_ A graph that shows the likelihood of survival at different times in the life of an organism.
4. \_\_\_\_\_ A relationship between two different species that is particularly close in proximity and behavior.
5. \_\_\_\_\_ A symbiotic relationship in which one species benefits and the other is unaffected
6. \_\_\_\_\_ This occurs when members of the population are reproducing at an increasing rate.
7. \_\_\_\_\_ The number of individuals the environment can support over a long period of time.
8. \_\_\_\_\_ A model of population growth in which growth slows or stops following a period of exponential growth.
9. \_\_\_\_\_ The interaction between two different organisms in which one captures and feeds upon the other.



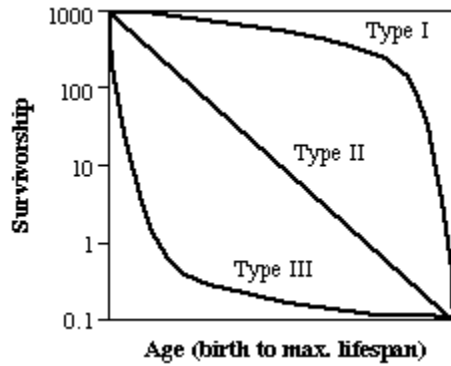
B. population density                      D. Geographic Distribution

16. \_\_\_\_\_ Which of the following would most likely occur if a population exceeded the carry capacity of the environment?
- A. The birth rate would likely increase.
  - B. The population would experience exponential growth.
  - C. Birth rate would be equal to the death rate.
  - D. Immigration would increase.
  - E. The death rate would increase.
17. \_\_\_\_\_ According to the exponential model of growth:
- A. population growth continues indefinitely.
  - B. population growth stops at the carrying capacity.
  - C. the population growth fluctuates with the availability of resources.
  - D. the death rate greatly exceeds the birth rate.
18. \_\_\_\_\_ Which of the following would cause a decrease in population size?
- A. Birth rate higher than death rate    C. birth rates and death rates the same
  - B. Birth rate is lower than death rate    D. Immigration into population
19. \_\_\_\_\_ Which of the following would reduce competition between individuals?
- A. a disturbance such as a drought                      C. A higher than normal birth rate
  - B. fewer individuals in the population                      D. fewer available resources.
20. \_\_\_\_\_ Which of the following would least likely be affected by a density-dependent factor?

- A. A small and randomly dispersed population.
- B. A population with a high birth rate.
- C. A large, clumped population.
- D. A population with many immigrants.

**Short Answer:**

21. Choose any one of the three survivorship curves, type 1, type 2, or type 3.



Describe the probabilities of that type of organism surviving different stages of life (beginning, middle, late).

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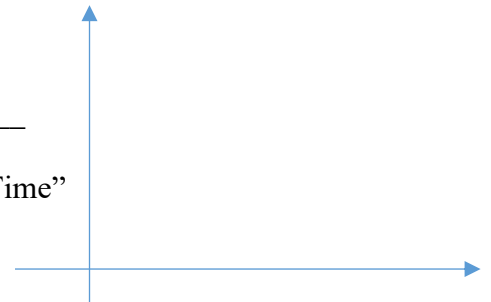
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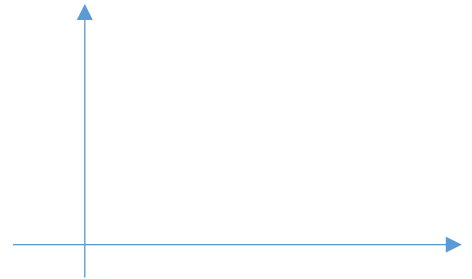
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22. Of the three survivorship curves, which one represents a species that is more likely to have a lot of offspring all at once? \_\_\_\_\_

23. Draw an exponential growth curve. Label the x-axis "Time" and y-axis "Population Size"



24. Draw a logistic growth curve. Label the x-axis "Time" and y-axis "Population Size"



25. The quagga mussel is an invasive species that can move into an area and outcompete native species in the ecosystem for food, meaning they have seemingly endless supplies of resources. If quagga mussels are introduced to an Idaho reservoir, which type of population growth can we expect them to have?

\_\_\_\_\_

26. Two populations, Alpha and Beta, are the same size with approximately 200 members of the population. Population Alpha occupies a range of 12 km<sup>2</sup> while population Beta occupies a range of 7 km<sup>2</sup>. Which of these two populations has the lowest population density? \_\_\_\_\_

27. Of the three types of dispersion discussed in class, which one is the least likely to have resulted because of the social behavior of a species (even, clumped, or random)? \_\_\_\_\_

28. For each of the following, write whether the carrying capacity of a population of deer will increase or decrease:

- a. A wet spring with lots of plant growth \_\_\_\_\_
- b. A forest fire. \_\_\_\_\_
- c. A drought year. \_\_\_\_\_
- d. A new housing subdivision that occupies previously undeveloped natural grounds. \_\_\_\_\_

29. Choose one of the scenarios above and explain why you answered the way you did.

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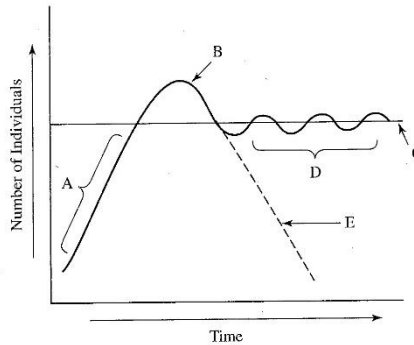


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**Use the graph below to answer 32-36**



30. \_\_\_\_\_ Which letter represents the carrying capacity of the environment?

31. \_\_\_\_\_ Which letter is an overshoot of the carrying capacity of the population?

32. \_\_\_\_\_ Which letter represents a population that has an abundant food supply and relatively few predators?
33. \_\_\_\_\_ Which letter represents a well-established population living in favorable conditions?
34. \_\_\_\_\_ Which letter represents a population crash?
- 35. Extended Response: Use your best writing to make a claim and support it with evidence and reasoning from our assignments or investigations in class as specific examples. You must use the appropriate vocabulary for full credit**

How can one species affect the carrying capacity of other species?

APPENDIX C

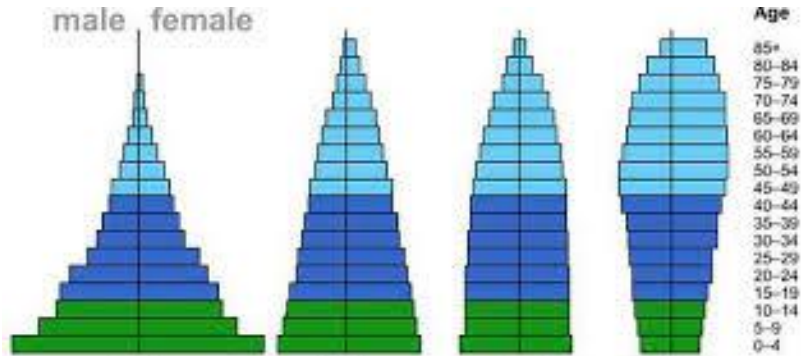
PRE- POST-TEST HUMAN POPULATIONS

Name: \_\_\_\_\_ Period: \_\_\_\_\_

**Test - Human Population Dynamics****Multiple Choice: Write a CAPITAL letter in the blank corresponding to your answer**

1. \_\_\_\_ Which survivorship curve would represent a country that has undergone demographic transition as a result of economic improvements?
  - a. Type I
  - b. Type II
  - c. Type III
  - d. Type IV
2. \_\_\_\_ During the middle phases of a demographic transition, what (specifically) leads to such dramatic increases in population growth?
  - a. Birth rates fall before death rates
  - b. Death rates fall before birth rates
  - c. birth and death rates are roughly equal
  - d. Increase in the use of birth control
3. \_\_\_\_ A population pyramid is used to represent the \_\_\_\_ of a population
  - a. Fertility rates
  - b. Death rates
  - c. age structure
  - d. Migration
4. \_\_\_\_ Most of the significant increases in population growth in the last century have occurred in:
  - a. The Americas
  - b. Asia
  - c. Africa
  - d. Europe
5. \_\_\_\_ By 2100, Asia is expected to have added how many more people to world population?
  - a. 1 billion
  - b. 2 billion
  - c. 3 billion
  - d. None of the above
6. \_\_\_\_ By 2100, Africa is expected to have added how many more people to world population?
  - a. 1 billion
  - b. 2 billion
  - c. 3 billion
  - d. None of the above
7. \_\_\_\_ By 2100, Europe is expected to have added how many more people to world population?
  - a. 1 billion
  - b. 2 billion
  - c. 3 billion
  - d. None of the above
8. \_\_\_\_ By 2100, North and South America are expected to have added how many more people to the world population?
  - a. 1 billion
  - b. 2 billion
  - c. 3 billion
  - d. None of the above

Use the following graphic to answer questions 9-10.



9. Label each of the population pyramids above according to the type of growth the population is experiencing--rapid, decreasing, stable, or slow. **ALSO provide a reason for your interpretation!**

- a. \_\_\_\_\_  
\_\_\_\_\_
- b. \_\_\_\_\_  
\_\_\_\_\_
- c. \_\_\_\_\_  
\_\_\_\_\_
- d. \_\_\_\_\_  
\_\_\_\_\_

**Short Answer - Fill in the Blank**

10. Which of the population pyramids represents a population that may struggle to support their older citizens, **why?**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

11. In “Overpopulated - Don’t Panic...” Hans Rosling projects human population growth will grow to be \_\_\_\_\_ billion by the year 2100.

12. What makes populations “dynamic” is that they \_\_\_\_\_ in size and composition over time.

13. A shift in the demographics of a population, such as age structure, often related to the economic progress of a country, is called a \_\_\_\_\_  
\_\_\_\_\_.

14. Check all of the statistics you might want to follow if you are assessing whether or not a society/country is undergoing a demographic transition?  
a. \_\_\_\_\_ birth rates c. \_\_\_ survivorship e. \_\_\_ food preferences  
b. \_\_\_\_\_ death rates d. \_\_\_ genetic makeup f. \_\_\_\_\_ population growth rate

15. What are the CURRENT approximate populations in the following areas:  
a. Asia \_\_\_\_\_ c. Americas \_\_\_\_\_  
b. Africa \_\_\_\_\_ d. Europe \_\_\_\_\_

16. What is peak child, and when did it occur?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Use the Demographic Transition Diagram on the next page to answer 17**

17. In the graphic below, write the following words phrases, in parentheses, into their corresponding boxes:

- a. Birth rate - (Low) (High) (Falling) (High) (Very Low)
- b. Death rate - (Low) (High) (Low) (Falls Rapidly)  
(Falls more slowly)
- c. Natural Increase - (stable or slow increase) (stable or slow)  
(very rapid)
- d. Reasons for Changes in Birth Rate -  
(family planning, improved status for women, later marriage)  
(many children needed for farming, religious/social encouragement, no family planning)
- e. Reasons for Changes in Death Rate -  
(good health care, reliable food supply)  
(Improvements in medical care and sanitation, fewer children dying)



APPENDIX D  
STUDENT ATTITUDE LIKERT SURVEY

## SCIENCE MOTIVATION QUESTIONNAIRE II (SMQ-II)

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In order to better understand what you think and how you feel about your science courses, please respond to each of the following statements from the perspective of "When I am in a science course..."

Statements	Never 0	Rarely 1	Sometimes 2	Often 3	Always 4
01. The science I learn is relevant to my life.					
02. I like to do better than other students on science tests.					
03. Learning science is interesting.					
04. Getting a good science grade is important to me.					
05. I put enough effort into learning science.					
06. I use strategies to learn science well.					
07. Learning science will help me get a good job.					
08. It is important that I get an "A" in science.					
09. I am confident I will do well on science tests.					
10. Knowing science will give me a career advantage.					
11. I spend a lot of time learning science.					
12. Learning science makes my life more meaningful.					
13. Understanding science will benefit me in my career.					
14. I am confident I will do well on science labs and projects.					
15. I believe I can master science knowledge and skills.					
16. I prepare well for science tests and labs.					
17. I am curious about discoveries in science.					
18. I believe I can earn a grade of "A" in science.					
19. I enjoy learning science.					
20. I think about the grade I will get in science.					
21. I am sure I can understand science.					
22. I study hard to learn science.					
23. My career will involve science.					
24. Scoring high on science tests and labs matters to me.					
25. I will use science problem-solving skills in my career.					

Note. The SMQ-II is copyrighted and registered. Go to <http://www.coe.uga.edu/smq/> for permission and directions to use it and its discipline-specific versions such as the Biology Motivation Questionnaire II (BMQII), Chemistry Motivation Questionnaire II (CMQ-II), and Physics Motivation Questionnaire II (PMQ-II) in which the words *biology*, *chemistry*, and *physics* are respectively substituted for the word *science*. Versions in other languages are also available.

APPENDIX E  
STUDENT INTERVIEW QUESTIONS

1. How does your notebook help you learn?
2. How does your notebook motivate you to work?
3. Can you show me a notebook page of which you are especially proud and share why? One that you are not pleased with and why?
4. What are the disadvantages of using an interactive science notebook?
5. Is the interactive science notebook a tool you would like to continue using in class? Why or why not?
6. Is there anything else you want me to know?

APPENDIX F  
WRITING RUBRIC

Component	Level		
	0	1	2
<b>Claim -</b> Statement or conclusion that answers the original question/problem	Does not make a claim, or makes an inaccurate claim	Makes an accurate but incomplete claim	Makes an accurate and complete claim
<b>Evidence –</b> Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim	Does not provide evidence, or only provides inappropriate evidence (evidence that does not support the claim)	Provides appropriate, but insufficient evidence to support the claim. May include some inappropriate evidence	Provides appropriate and sufficient evidence to support the claim
<b>Reasoning –</b> Justification that links the claim and evidence and includes appropriate and sufficient principals to defend the claim and evidence. Justification explains why evidence supports the claim	Does not provide reasoning, or only provides recording that does not link evidence to claim and does not explain why evidence supports the claim	Repeats evidence and links it to some scientific principles, but not sufficient explanation of why evidence provided supports the claim	Provides accurate and complete reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles and clearly explains why evidence provided supports the claim

APPENDIX G  
TEACHER RELECTION PROMPTS

1. Describe some examples of students' use of the science notebooks that highlights the strengths of the ISN.
2. What are some struggles you are noticing with the use of the ISN?
3. Are there noticeable differences between the treatment and comparison groups with regard to student organization and use of materials? If so, describe specific examples.
4. Are there noticeable differences in engagement between the treatment and comparison groups? If so, describe specific examples.
5. Describe any other relevant observations regarding your personal feelings about the value of the interactive science notebooks.