Using Place-Based Pedagogy to Contextualize and Integrate Science and Mathematics Education

Donna F. Berlin

Global educational reform for the teaching and learning of mathematics and science is characterized by curriculum standards, standardized testing, and accountability. There is ample evidence that student performance in these disciplines is problematic for specific populations, including minorities, women, and Indigenous peoples. The need for a strong science and mathematics curricula and pedagogical approaches that will ensure the development of relevant and meaningful curricula for all students is universal.

This paper is organized into four sections. The first section describes place-based pedagogy that focuses upon community and culture to contextualize teaching and learning. The second section highlights integrated teaching and learning that is part of the infrastructure for place-based pedagogy and is significant to the teaching and learning of science and mathematics. The third section provides an example of a place-based learning experience to integrate and improve science and mathematics education appropriate for students in Wyoming. The final section describes additional place-based examples to integrate science and mathematics education that have universal applicability.

Place-Based Pedagogy

A relatively new pedagogy has been proposed to address the issue of educating students through local phenomena and students’ lived experiences embedded in their community and culture. This pedagogy, identified as a place-based approach to education by The Orion Society, is designed to “…ground school curriculum and instruction in local geography, ecology, culture, economy, and history…” (Sobel, 2005, p. ii) with the goal of maintaining, sustaining, and improving the natural and man-made environment as well as the development of student learning and environmental stewardship. Although the learning experiences arise from the local environment and the unique community and culture, they may help to improve student achievement and attitudes related to science and mathematics aligned with mandated curriculum standards in both local and global settings. “A pedagogy of place brings school and community together on a common pathway … [that] expands outward from local landscape and home, to regional realities, to international issues” (Lewicki, 1998, p. 9).

The following citation captures the spirit and power of place-based pedagogy.

Place-based education is the process of using the local community and environment as a starting point to teach concepts in language arts, mathematics, social studies, science, and other subjects across the curriculum. Emphasizing hands-on, real-world learning experiences, this approach to education increases academic achievement, helps students develop stronger ties to their community, enhances students’ appreciation for the natural world, and creates a heightened commitment to serving as active, contributing citizens. Community vitality and environmental quality are improved through the active engagement of local citizens, community organizations, and environment resources in the life of the school.” (Sobel, 2005, p. 7)

Gruenewald (2008) simply but eloquently states, “As a critical cultural and educational construct, place can be described as the nexus of culture and environment; places are where we constantly experience their interconnection” (p. 145). Place-based pedagogy can adapt to the
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unique characteristics of both the culture and environment with the goal of providing academic opportunities that will enhance student motivation and engagement, initiative and confidence, decision-making and problem-solving skills and dispositions, and develop a sense of ownership and agency associated with participatory citizenship.

Place-based education is a broadly inclusive pedagogy that draws upon a variety of educational approaches to provide a cohesive and coherent infrastructure. These approaches include, but are not limited to, bioregional education, critical pedagogy, community-based education, environmental/ecological education, experiential learning, integration, outdoor education, and situated cognition (see Gruenewald, 2003, and Williams, 1998, for a discussion of different approaches related to place-based education).

Adapted from Smith (2002, p. 593), five common elements can be associated with place-based education:

1. Initial curriculum begins with phenomena in the immediate environment that can be subsequently extended to other locations and the development of abstract knowledge.
2. Learning experiences enable students to become the creators of knowledge rather than the consumers of knowledge created by others.
3. The focus of inquiry and problem solving is student questions and concerns.
4. Teachers serve as guides, co-learners, and sources for school and community resources.
5. The boundary between school and community becomes more permeable with frequent seamless exchanges between students, teachers, and members of the community.

Place-based education is deeply rooted in environmental and outdoor education that primarily deal with the natural environment. However, place-based education also includes man-made environments and relationships that are typical of communities and cultures. Place-based education focuses on the merging of the natural and man-made environments and includes “the history, folk culture, social problems, economics, and aesthetics of the community and its environment ...” (Sobel, 2005, p. 9) along with a commitment to both ecological and cultural diversity.

Place-based education can be viewed as an overarching pedagogical approach that is broadly inclusive and supported by a number of other approaches that are interrelated and share common characteristics and valued outcomes. Of the many pedagogical approaches that contribute to and underpin place-based education, the next section will focus upon integrated curriculum based upon the strong connection to science and mathematics education.

Integration of Science and Mathematics Education

It seems that mathematics students regularly ask, “When are we ever going to use this?” and lament the abstract nature of mathematics while science students often struggle with the mathematics needed to solve scientific problems. During the past century, one distinctive effort to improve science and mathematics education is an approach that recognizes the natural and logical relationships between science and mathematics and seeks to appropriately and effectively integrate these two disciplines in teaching and learning through real-world, problem-solving situations.

A review of over a century of literature focused on science and mathematics integration uncovers 16 different terms: alliance, connection, cooperation, coordinated, correlated, cross-disciplinary, fused, infused, interaction, interdependent, interdisciplinary, interrelated, linked, multidisciplinary, transdisciplinary, and unified (Berlin, 2007). This litany of terms for “integra-
“Integration” leads to the need to clearly and comprehensively describe what one means by “integration,” regardless of the choice of terms. A succinct definition that has been embraced by both science and mathematics curriculum supervisors in the United States is as follows: Integration of science and mathematics education blends the conceptual, procedural, and attitudinal aspects of science and mathematics without compromising the integrity of either discipline.

**Models of Science and Mathematics Integration**

A series of three conferences over the last 30 years have attempted to craft a definition of integration through the development of theoretical models. The first model, an outcome of the 1969 Cambridge Conference on the Correlation of Science and Mathematics in the Schools, defined five categories of interaction between science and mathematics: math for math, math for science, math and science, science for math, and science for science (“Goals for the Correlation of Elementary Science and Mathematics,” 1969). Throughout the literature, one finds numerous authors using this same linear continuum with minor wordsmithing for each of the categories (e.g., Huntley, 1998; Lonning & DeFranco, 1997). A simple representation of this continuum, with a capital letter denoting the primary emphasis and a lower case letter representing the secondary focus, is illustrated in Figure 1.

<table>
<thead>
<tr>
<th>M</th>
<th>Ms</th>
<th>MS</th>
<th>Sm</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math</td>
<td>Math</td>
<td>Science</td>
<td>Science-</td>
<td>Science</td>
</tr>
<tr>
<td>Science</td>
<td>and</td>
<td>Apply</td>
<td>Math</td>
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<tr>
<td>Context</td>
<td>Science</td>
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*Figure 1. Math and science linear integration continuum.*

Either end of the continuum represents the pure mathematics (M) or the pure science (S) whereby each discipline is preserved as a separate entity. The beauty and abstractness of mathematics is explored without an obligatory application or use and the science phenomena are investigated without need for quantification. The next category, labeled Ms, focuses upon mathematics that utilizes the science context as a way to enhance student use and understanding of mathematics. Similarly, the category labeled Sm focuses upon science that applies the tools of mathematics to quantify scientific patterns and relationships. MS or the balance between mathematics and science warrants further clarification.

Only one theoretical model, the Berlin-White Integrated Science and Mathematics (BWISM) Model (Berlin & White, 1994, 1995, 1998), uniquely describes the center of the continuum, mathematics and science (MS). Evolving over a period of 15 years, BWISM reflects a comprehensive review of literature spanning 100 years, the perspectives of the science and mathematics K-16 communities, curriculum research and development projects, and current standards-based reform documents. Thus, the BWISM blends the conceptual, procedural, and attitudinal aspects of science and mathematics without compromising the integrity of either discipline.

The BWISM Model is a multidimensional model that includes six aspects: (a) ways of learning, (b) ways of knowing, (c) content knowledge, (d) process and thinking skills, (e) attitudes and perceptions, and (f) teaching strategies. Using the analogy of a kaleidoscope, the integration of science and mathematics teaching and learning can be described as an every-
changing combination and interplay of aspects appearing in the visual foreground or background. The Berlin-White Integrated Science and Mathematics Model is designed to provide a conceptual base and a common language that advances the research agenda, serves as a template for characterizing current resources, and guides in the development of new materials related to integrated science and mathematics teaching and learning.

Rather than using a linear integration continuum, this author proposes a more complex approach to the process of designing integrated mathematics and science learning environments. Figure 2 depicts a multi-directional sequence model in contrast to the often cited linear integration continuum model. The starting point must be the curricula standards for both mathematics and science to identify the mandated content and processes to be taught to achieve the desired student conceptual, procedural, and attitudinal outcomes. It is important that both the mathematics and science teacher work together to decide upon the appropriate sequence in the integrated learning environment so that the perspectives of both disciplines are fairly represented in a coherent and cohesive manner.

**Figure 2.** Science and mathematics integration sequence.

### Place-Based Pedagogy and Science and Mathematics Integration

Mathematics and science are a part of the student’s personal life, community, and cultural heritage. Contextualizing the integration of mathematics and science education embeds the teaching and learning of mathematics and science within specific locales, communities, or cultures. The prefix “ethno-” comes from the Greek word “ethnos” which refers to an identifiable cultural group of people characterized by habits, attitudes, beliefs, and knowledge that govern their general behavior and way of life. Ethnoscience and ethnomathematics are terms that can denote culturally responsive pedagogy applied to the teaching and learning of science and mathemat-
ics. “Ethno-Integration,” a term created by Berlin (2007), focuses upon the relationship between community and culture and integration. Thus, ethno-integrated science and mathematics education seeks to identify culturally relevant mathematics and science used to understand, explain, and manage the environment of a particular community or culture.

With this deep understanding of integration along with principles of place-based pedagogy, one can contextualize and integrate science and mathematics teaching and learning by connecting integrated instructional activities to the community and the culture of students. Figure 3 illustrates this contextualization and integration or ethno-integration.

![Figure 3](image)

**Figure 3.** Ethno-Integration: Contextualizing science and mathematics integration.

Evoking a somewhat similar perspective, Davison and Miller (1998) connect ethnosciences, ethnomathematics, and the integrated curriculum. Based upon ethnosciences as including both ethnomathematics and ethnosciences, they state, “The use of an ethnosciences approach in developing curriculum makes the curriculum relevant to the students’ interests and provides a structure for the curriculum that systematically builds on the students’ culturally embedded background knowledge” (p. 260). They developed a course entitled “Learning Mathematics and Science in Cross-Cultural Settings” for teachers and prospective teachers of American Indian students. The authors describe a learning experience focused upon native loom beadwork that was created to explore mathematical topics such as symmetrical geometrical patterns and fractions. Davison and Miller recommend the use of a thematically integrated curriculum format to reflect a holistic learning approach for Native American Indians.

The contextualization of integrated mathematics and science teaching and learning (ethno-integration) through community and culture is an innovative approach to provide students with unique opportunities to:

1. investigate the important relationships between culture and mathematics and science;
2. develop an awareness of the relationships between the real needs and interests of human beings and the development of mathematics and science;
3. develop an understanding of the history and development of knowledge in mathematics (e.g., numbers, space, and patterns); the sciences (e.g., astronomy, biology, botany, chemistry, physics, earth sciences); and their applications (e.g., agriculture, anthropology, architecture, engineering, textiles);
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4. develop an understanding of the history and development of knowledge in mathematics and the sciences as related to the arts, history, literature, music, and religion;
5. develop an awareness, understanding, and appreciation of the scientific and mathematical advancements and technologies developed by one’s ancestors;
6. identify and connect the science and mathematics curriculum to one’s culture to enrich the curriculum through unique, compelling, relevant activities;
7. develop an awareness, sensitivity, appreciation, respect, and pride in one’s culture; and
8. maintain and sustain the uniqueness and integrity of one’s culture.

(Modified from Berlin, 2007, pp. 15-16)

As communities and cultures differ and are distinctive, appropriate place-based learning experiences should reflect the particular locale. In general, the best examples of place-based learning experiences are those developed through the collaboration of teachers, students, elders/community leaders, and community experts so as to be justly responsive to each unique environment, community, and culture. To craft place-based activities, teachers and students in collaboration with tribal elders/community leaders and community experts can employ the following cyclical approach: (a) choose a local need, interest, context, or issue related to the natural or man-made environment; (b) compare the ways of generating, confirming, and communicating knowledge by the community or culture to that of conventional science and mathematics; (c) compare and connect Indigenous worldviews and knowledge to conventional scientific and mathematical knowledge and worldviews; (d) identify and make explicit the relationship between the place-based learning experiences and the mandated curriculum and standardized assessments; (e) teach concepts in the mathematics and science curriculum that provide the requisite knowledge, skills, and dispositions; and (f) develop a solution or action plan to address the need, interest, context, or issue related to the natural or man-made environment.

**Wyoming Example to Contextualize and Integrate Science and Mathematics**

Place-based learning experiences provide opportunities to develop student mathematics and science knowledge, skills, and dispositions through the community and culture rather than about the community and culture. Contextualized integrated mathematics and science experiences use students’ real-world experiences, community, cultural heritage, and background experiences and vocabulary to develop authentic, relevant, and meaningful learning in mathematics and science education. Moreover, contextualized integrated experiences can help to build and deepen teacher and students’ understandings of and respect for local community and cultural practices and values. The following example of a place-based learning experience is intended to be responsive to the environment, community, and culture in Wyoming and is designed to improve the teaching and learning of mathematics and science. This example is merely illustrative to encourage local educators in collaboration with elders/community leaders and community experts to design more meaningful and relevant learning experiences.

The International Union for Conservation of Nature (IUCN) provides conventional descriptors and categories to identify the conservation status of species along with a red list of threatened species. There are two categories associated with Extinct: Extinct and Extinct in the Wild. The Threatened descriptor includes the categories of Critically Endangered, Endangered, and Vulnerable. Those species deemed a Lower Risk include species that are Conservation Dependent, Near Threatened, or Least Concern.
There are approximately 56 species (21%) of amphibians in the United States that have been classified as threatened. The various causes for the decline in the amphibian population include climate change (e.g., less rain and prolonged drought, increased ultraviolet radiation due to decreased stratospheric ozone); acid rain; agro-chemicals such as pesticides, herbicides, fertilizers, and toxic oil from farms and ranches; introduced species (including other amphibians); traffic mortality; over-exploitation and human collection for food, medicines, bait, pets, and teaching biology; and pathogens (i.e., Chytrid fungus) that are attacking and destroying amphibians. Habitat degradation and destruction from tree harvesting, agricultural development, and urban development has resulted in the critical loss of 50% of the world’s wetlands and 54% loss of the US wetlands—seriously impacting amphibian habitation.

One might ask, Why study amphibians, including toads? Toads are common and widespread, and for most students, toads are interesting and fun to learn about. Moreover, amphibian conservation is an important environmental issue that can help us learn more about maintaining species in their natural environments. For example, amphibians are an indicator of the overall health of the ecosystem and parts of the ecosystem as their permeable skin is sensitive to environmental pollutants such as heavy metals and acid rain. They are a significant link in the food chain—they consume both living and dead material and eat insects and other invertebrates and they, in turn, are preyed upon by fish, reptiles, mammals, and birds. As they recycle nutrients from aquatic systems to terrestrial systems, they play a significant role in the cycling of nutrients. Historically, they have played a role in various cultures and religions. For example in early Asiatic and pre-Columbian cultures, amphibians were considered a divinity and either the source or end of life. In addition, amphibians have been associated with witches, brews, and plagues.

The Wyoming example focuses upon amphibians, specifically the Wyoming Toad or Baxter’s Toad and the Western Toad or Boreal Toad. The Wyoming Toad is approximately 5.6 cm or 2.2 inches long and their skin is brown, gray, or greenish with small dark markings and an indiscernible dorsal stripe. They eat small insects—relying on the movement of their prey rather than their poor eye sight. Prior to the mid 1970s, they could be found in the wetlands of the Laramie Basin but today they exist only in captivity in the Mortenson Lake National Wildlife Refuge. They are classified as Extinct in the Wild. Western Toads are relatively large—approximately 13 cm or 5.12 inches long and they are found in Western Wyoming near ponds, lakes, rivers, creeks, and streams. They eat any type of insect and can jump a considerable distance—an unusual characteristic for a toad. They are greenish or dusky gray in color with a white or cream dorsal stripe. They are deemed a Lower Risk species and are classified as Near Threatened.

For the integrated mathematics and science experience, a commonly taught science lesson on natural selection is contextualized or “placed” in the Wyoming environment and extended to include more mathematics concepts and skills. Students model natural selection using the Wyoming and Western Toads.

The materials needed for this activity include three environments represented by three sheets of 8 ½ x 11 inch green paper, one with two brown squares, one with a brown circle, and one with a brown irregular shape on it; a supply of brown-colored and green-colored hole punches; an 8 ½ x 11 inch box with a lid; graph paper; and a transparent centimeter grid. The three environments, group worksheet, and group data record can be found in Appendices A, B, and C, respectively. This activity engages students in a place-based experience in which conceptual, procedural, and attitudinal aspects of science and mathematics are developed and integrated. Specifically,
1. Students model natural selection using “green” environments with different “brown” shapes and colored dots to represent brown Wyoming Toads and green Western Toads.

2. Students determine the area of the environment and calculate the area of the various shapes in the environment.

3. Students model the survival rate of the brown and green frogs over 5 generations.

4. Students use ratios and proportions and predict which organisms will be most likely to “survive.”

5. Students graph their results and find a line of best fit to support their predictions.

This place-based, integrated activity can provide opportunities to develop science concepts and processes that include collecting and organizing data, diversity and adaptation, genetic variation, graphing, hypothesizing, interpreting data, measuring, modeling, observing, organisms and their environment, and prediction. Supportive of this activity, The National Science Education Standards (National Research Council [NRC], 1996) state that, “Biological evolution accounts for the diversity of species developed through gradual processes over many generations” and “Extinction of species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow for its survival” (p. 158). The recommended science content standards from the National Science Education Standards (NRC) include the following:

As a result of their activities in grades K-4, all students should develop understanding of

- organisms and environments (p. 127)

As a result of their activities in grades 5-8, all students should develop understanding of

- populations and ecosystems
- diversity and adaptations of organisms (p. 155)

The mathematics concepts and skills involved in this place-based, integrated activity include algebraic equations, area measurement (standard and non-standard units), error (measurement and experimenter), graphing, non-standard and standard units of measurement, percentage, probability, randomization, ratio and proportion, and sampling. The relevant content standards are elaborated in the Principles and Standards for School Mathematics (National Council of Teachers of Mathematics [NCTM], 2000). The Number and Operations Standard states, “In grades 6-8, all students should—understand and use ratios and proportions to represent quantitative relationships” (NCTM, p. 214). The Algebra Standard (NCTM, p. 222) includes,

In grades 6-8, all students should—

- represent, analyze, and generalize a variety of patterns with tables, graphs, words, and, when possible, symbolic rules;
- relate and compare different forms of representation for a relationship;
- identify functions as linear or nonlinear and contrast their properties from tables, graphs, or equations;
- model and solve contextualized problems using various representations, such as graphs, tables, and equations;
- use graphs to analyze the nature of changes in quantities in linear relationships.

The Geometry Standard states, “In grades 6-8, all students should—recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life” (NCTM, p. 232). The Measurement Standard (NCTM, p. 240) includes,
In grades 6-8, all students should—

- understand, select, and use units of appropriate size and type to measure angles, perimeter, area, surface area, and volume;
- develop and use formulas to determine the circumference of circles and the area of triangles, parallelograms, trapezoids, and circles and develop strategies to find the area of more-complex shapes. The Data Analysis and Probability Standard states, “In grades 6-8, all students should—

use proportionality and a basic understanding of probability to make and test conjectures about the results of experiments and simulations.” (NCTM, p. 248).

This place-based natural selection activity can clearly provide a natural and logical connection between the teaching and learning of science and mathematics. Important science and mathematics concepts, processes, and skills can be developed through this place-based, integrated learning experience that is relevant and meaningful to students in Wyoming.

**Other Place-Based, Integrated Instructional Examples**

As a culminating assignment in my course entitled “Using Community and Culture to Integrate Science, Technology, Engineering, and Mathematics (STEM) Education,” groups of four students developed place-based, integrated instructional units to teach the STEM disciplines in grades 7-12. These place-based instructional units are situated in common places so that the activities can be easily modified for implementation in other locations. Four examples are described along with the relevant mathematics and/or science content standards in parentheses.

In the place-based, integrated instructional unit focused on the local dam, the four lessons with the content standards are as follows: (a) Types of Dams (Science and Technology); (b) Construct Model Dams (Measurement); (c) Draining a Dam (Patterns, Functions, and Algebra: Exponential Functions); and (d) Dams and Societal Impact (Science, Technology, and Society).

The Landfill instructional unit included the following lessons: (a) Construct an Edible Landfill (Science and Technology); (b) Carbon Cycle (Earth and Physical Science); (c) Area, Perimeter, and Volume of Landfills (Measurement); and (d) Wasted Paper in the School and Tree Impact (Data, Analysis, and Statistics). A farm setting was used for the third example. The lessons in this place-based, integrated instructional unit include: (a) Constructing a Corn Maze and Attendance at the Corn Maze (Number and Number Sense: Percents); (b) Genetically Modified Organisms/Foods (Science and Technology); (c) Effects of Fertilizers in the Environment (Life Science); and (d) Theorems of Circle Geometry to Find Locations in the Corn Maze (Geometry and Spatial Sense). The context for the final unit example is the local hospital. The four lessons include: (a) Burn Unit and Surface Area (Geometry and Measurement); (b) Diabetes and Biomedical Engineering (Science and Technology); (c) Radiation and the Cell Cycle (Physical Science, Life Science, Science and Technology); and (d) Diagnostic Imaging (Physical Science, Science and Technology).

One can clearly see that typical science and mathematics instructional activities can be modified or developed to integrate and contextualize student learning in the local place. These activities can stimulate student interest and motivation while developing essential mathematics and science concepts, processes, and skills. Science and mathematics teachers in Wyoming and around the world can provide place-based, integrated learning experiences that make science and mathematics relevant and meaningful while aligned with national science and mathematics content standards.
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References


Appendix A
Wyoming Place-Based, Integrated Example: Environments

Figure 1. Environment: Square shapes

Figure 2. Environment: Circular shape

Figure 3. Environment: Irregular shape
Appendix B
Wyoming Place-Based, Integrated Example: Group Worksheet

Group Worksheet

Circle the letter of your group and write the student names.

Group A  B

Student Names __________________________ __________________________

You should have 3 sheets of green paper with brown shapes on them. One sheet has two brown squares, one sheet has a brown circle, and the third sheet has an irregular brown shape on it. You should also have some brown and green hole punches and a transparency with a centimeter grid on it. Each brown sheet represents a different environment, and the hole punches represent cheetahs and spotted hyenas.

Step 1: Count out 20 toads (hole punches) of each color. This is the first generation of toads for this activity.

Step 2: Tape the environment with the two large squares in a box and randomly distribute the toads over the environment by putting the lid on the box and shaking the box. Be careful that none of the toads escape or get lost.

Step 3: Predators such as reptiles, mammals, and birds often catch and eat toads that stand out from the environment. Open the box and capture all of the toads that stand out due to color.

Step 4: Count the toads that are not captured for this first generation and record the number of each color on the Group Data Record.

Step 5: Determine the area of the brown and the green regions of the environment. Describe how you determined the area and record your value in the space provided on the Group Data Record.

Description: ______________________________________________________

____________________________________________________________________

____________________________________________________________________

Predictions: Predict the number of brown toads and the number of green toads you would expect to survive from the first generation for:

(1) the environment with the brown circle
   Number of brown toads = ___________________
   Number of green toads = ___________________

(2) the environment with the irregular brown shape.
   Number of brown toads = ___________________
   Number of green toads = ___________________
Group Worksheet (continued)

Circle the letter of your group and write the student names.
Group A  B
Student Names __________________________________________________________________________

A Groups: Determine the actual number of each color toad from the first generation that
survives in the environment with the brown circle. Enter here and on the Group Data
Record sheet.

Number of brown toads = _________________
Number of green toads = _________________

B Groups: Determine the actual number of each color toad from the first generation that
survives in the environment with the irregular brown shape. Enter here and on the Group
Data Record sheet.

Number of brown toads = _________________
Number of green toads = _________________

Step 6: Using the first generation survivors in the environment of your choice (squares,
circle, or irregular shape), add one brown toad for two brown toad survivors
and one green toad for two green toad survivors. Collect all of the toads and
randomly distribute this new population over the environment. Repeat steps
3 and 4 from the Group Worksheet (page 1) and record the number of brown
toads and the number of green toads remaining in the environment on the
Group Data Record.

Step 7: Repeat step 6 three more times using the most recent generation each time.
Record the number of toads of each color left in the environment after the
predators have captured the toads that stand out.

Question: What happens to the number of brown toads, the number of green toads, the
number of toads overall?
____________________________________________________________________________________

Step 8: Make a graph of the number of brown toads and green toads on one set of axes
to help describe the trends of natural selection.

Predictions: Predict the number of brown toads and the number of green toads you would
expect to survive from the first generation for:

(1) the environment with the brown circle
   Number of brown toads = _________________
   Number of green toads = _________________

(2) the environment with the irregular brown shape
   Number of brown toads = _________________
   Number of green toads = _________________

Step 9: Using your data and a graphing calculator, find the “line of best fit” and write
the equation that best represents your data.
## Appendix C

**Wyoming Place-Based, Integrated Example: Group Data Record**

<table>
<thead>
<tr>
<th>Group Data Record</th>
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</thead>
<tbody>
<tr>
<td>Circle the letter of your group and write the student names.</td>
</tr>
<tr>
<td>Group A  B</td>
</tr>
<tr>
<td>Student Names ____________________________________________</td>
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### Environment: Square Shapes

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<thead>
<tr>
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<tr>
<td></td>
<td>Brown</td>
</tr>
<tr>
<td>1</td>
<td></td>
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</tr>
<tr>
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<td>5</td>
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<tr>
<td>Area:</td>
<td></td>
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<tr>
<td></td>
<td>Brown</td>
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### Environment: Circular Shape

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<td>Area:</td>
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<td>Brown</td>
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### Environment: Irregular Shape

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