Middle Level Preservice Teachers Experience a Natural History Arts-Integrated Interdisciplinary Thematic Unit

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Abstract

Curricular demands and best practices for middle school require interdisciplinary units. Arts integration can provide motivation and a new pathway to learning. This unit focused on inquiry into the natural history of artifacts and rocks recovered from the exposed subsoil of an area near Cedar Falls, Iowa that had been bulldozed as part of subdivision development. The described unit involved preservice teachers in exploration of all subject areas (language arts, mathematics, science, and social studies) with arts-integrated projects (agate watercolor painting, stone tool graphing, acrylic polymer clay agate keyring making, and stone tool drawings). The content area activities for social studies included identification and lifestyle interpretation of stone tools found intermixed with rocks and sand in the subsoil of the site. Science content activities included identification of rocks (igneous and metamorphic rocks; quartz nodules, geodes, and agates; and iron ore specimens) from the site along with interpretation of basalt cobbles that had been ground flat as glacially transported, and interpretation of maps and diagrams of glaciation, iron ore deposits, and agate deposits. Language arts activities involved word study through morpheme analysis of words such as "anthropology" and "artifact" along with matching a set of descriptive adjectives to objects related to agates. Mathematics content activities focused on graphing. Preservice teachers were highly engaged in the activities, remarking that they learned new content and pedagogy. Some expressed lack of confidence regarding artistic ability because of little experience and the desire to complete everything in the correct manner. At the end of the lessons, preservice teachers expressed that teaching the content through themes allowed for a great number of connections between subject areas, increased real-life connections, and deeper understandings of the topics.

Key Words

Thematic curriculum, middle school, arts integration, glaciation, stone artifacts, agates, iron formation.

Introduction

Teachers are asked to teach so many topics and standards that subject integration is necessary because of time constraints, but also to make connections between ideas in a large context. Arts integration has been shown to motivate students and to allow them to explore content through a new media, reaching more learners (Duma, 2014). The true middle school curriculum follows a thematic scheme, integrating ideas from different subjects as they occur in the real world (National Middle School Association/the Association for Middle Level Education [NMSA/AMLE], 2010). This article presents a middle school unit revolving around a set of artifacts and rocks found in the subsoil of a Midwestern city. Students explored these objects, identifying them and interpreting what they implied for glacial history and the lifestyles of early Native Americans. All four major subject areas (language arts, mathematics, science, and social studies) were integrated with art to unite the content under the Upper Midwest natural history theme.

Literature Review

First, the literature related to the benefits of arts integration into the curriculum will be reviewed. Then, best practices for middle level education are examined. Finally, to provide background information for the reader, broad concepts in the natural history of the upper Midwest of the United States are described.

Advantages of Arts Integration

An integrated curriculum provides a holistic approach to learning, rather than an unconnected and fragmented set of lessons, leading to cognitive gains (Mansilla, 2005). A review of the research literature concerning the value of arts integration into the curriculum from 2000 to 2005 (Russell & Zembylas, 2007) found the following positive outcomes from large-scale studies: heightened engagement and enthusiasm in arts-integrated environments (Wilson, Corbett, & Noblit, 2001), both teacher and student-reported enjoyment of school learning (Wilson, Corbett, & Noblit, 2001), and improvement in test scores in basic subjects (Upitis, Smithrim, Patteson, & Meban, 2001; Upitis & Smithrim, 2003). Quantitative studies evaluated by Russell & Zembylas (2007) indicate that students' grades stay the same or improve with arts-integration. Qualitative studies cited by these same researchers indicate that a long-lasting benefit of arts integration is a positive change in attitude toward school. Another more-recent ten-year study (Duma, 2014) showed growth in students' cognitive and social skills along with gains in standardized test scores for lower performing students. Art-integration accomplished well has the following characteristics: meeting both art and content area objectives and standards, creation of an art form to demonstrate understanding of content, engagement in the creative process, inclusion of a "big idea" that cuts across subject boundaries, and metacognition or monitoring of one's thinking (Marshall, 2014).

Arts Mechanisms for Longterm Retention of Learning. There are several mechanisms inherent in the arts that assist students in longterm learning of content: rehearsal, elaboration, generation, enactment, oral production, effort after meaning, emotional arousal, and pictorial representation (Rinne, Gregory, Yarmolinskaya, & Hardiman, 2011). Integration of arts activities that use these mechanisms has been shown to increase longterm content learning (Hardiman, Rinne, & Yarmolinskaya, 2014). Many of these were present in the art activities in the thematic unit described in this paper and will be elucidated here.

Before students made scientific drawings of stone tools during the social studies art activity, they examined the example published drawings, determining their features and looking at the stone tool they had selected to connect shaded or shaped features on the professional drawing with similar features on their tool. This was ***effort after meaning*** – mental energy expended to figure out how features of the professional drawings corresponded to real features of a tool. The ***pictorial representation*** of the published drawings helped students make their own drawing and helped them remember features of the stone tool such as its overall shape and chipped cutting edges. As they drew the stone tools, they noticed details of chipping and shape that they had not noticed before, providing ***elaboration*** of their mental concepts of stone tools. Many of these same mechanisms occurred during the mathematics-art activity of making a stone tool graph.

The science activity of forming an agate keyring ornament of acrylic polymer clay allowed students to practice ***rehearsal*** of the features of an agate, as students needed to incorporate several features such as concentric banding, crosscutting layers, or multiple sites of crystal nucleation into their work. In this art and science activity, as well as the English language arts agate painting activity, students had to ***generate*** a new mental image of an agate and then enact it in polymer clay or paint. These are powerful mechanisms that make the experience and the associated concepts memorable. Especially during the agate-making art activities, students experienced ***emotional arousal*** as they examined the beautiful photographs of colorful and intricately-patterned agates before attempting to produce their own. ***Oral production*** occurred as students discussed the descriptive adjectives they might use to describe their agate paintings. Although not all mechanisms were used with the same frequency and consistency, they all can be seen to play a role in the learning of content through the arts-integration activities.

Middle Level Thematic Units

The Association for Middle Level Education (AMLE), formerly the National Middle School Association (NMSA), in their position paper identified five characteristics for curriculum, instruction, and assessment. The unit taught in this practical paper integrated three of the characteristics. First, “Students and teachers are engaged in active, purposeful learning” (NMSA/AMLE, 2010, p. 16). Second, “Curriculum is challenging, exploratory, integrative, and relevant” (p. 17). Finally, “Educators use multiple learning and teaching approaches” (p. 22).

This thematic unit allows for students and teachers to be engaged in active, purposeful learning in many ways. In the social studies center, students had the opportunity to collaborate and use inquiry to identify stone tools which they had never encountered previously from the Paleoindian culture. Similarly, in science, students were able to move beyond the memorization of the characteristics of rock types, which many had learned in a prior geology course, and focus on applying the characteristics to identify rocks found at the glacial till site. In the language arts content center, the preservice teachers were introduced to a new strategy, morpheme analysis, during which they actively explored the meanings of words and their parts. In the mathematics center, participants created graphs of stone tools by plotting points on an outline of the tool to create a sort of dot-to-dot puzzle. This activity was authentic because archaeologists often plot the chipped areas of stone tools on graphs to compare the morphology of retouched and resharpened areas (e.g. Morales, Soto, Lorenzo, & Verges, 2015). In addition, the integration of art allowed preservice teachers to be engaged in active learning that connected the content areas in new and engaging ways.

These thematic lessons include curriculum that is “exploratory, integrative, and relevant” (NMSA/AMLE, 2010, p. 16). NMSA/AMLE (2010) calls for curriculum to be “organized around a theme” instead of focusing on four distinct subject areas (p. 17). Natural history, specifically the artifacts and rocks recovered from the exposed glacial till subsoil that had been bulldozed as part of subdivision development, connected each of the centers. Students explored lessons and activities to understand how the four content areas can all address one theme.

Finally, this thematic unit highlights how educators can use multiple learning and teaching approaches. One of the main aspects of this AMLE characteristic is that “students should… …engage in learning situations wherein basic skills are mastered in functional contexts” (NMSA/AMLE, 2010, 22). In the social studies and science lessons, preservice teachers used sorting and identifying techniques to reach conclusions about stone tool artifacts and rocks. They learned the skills that archeologists and geologists use in the field. In language arts, students attempted the new technique of morpheme analysis to draw conclusions about important words related to natural history such as archaeology and artifact. In math, students used graphing skills to explore the shapes of stone tool artifacts.

Several examples of integrated units have been written since NMSA/AMLE (2010) published *This We Believe*. Some units integrated science and social studies through the theme of topography, maps, and plate tectonics (Concannon & Aulger, 2011). Others combined science and language arts using writing about raptors and their prey (Senn, McMurtrie, & Coleman, 2013). Some authors even brought together science, language arts, and art (Kuhn & Boyers, 2015) through science haiku artwork. Still others used quilts to study mathematics, language arts, and history (Mitchell, Whitin, & Whitin (2012). Other authors combined ecology, biology, and mathematics through the study of shrimp (Ackerson, Piser, & Walka, 2010). However, the lessons in the current practical article integrate all four major content areas and art into one thematic unit.

Natural History of Upper Midwest

Some components of the natural history of the upper Midwest are discussed in the following three subsections. First, Paleoindian sites and tool-making are discussed. Then, unique geologic features of the area are considered. Finally, because the artifacts and rocks were found in a glacial till deposit, the glacial history of the area is briefly reviewed.

Paleoindians. There are several early archaeological sites of human occupation in the Great Lakes area, generally around the Lower Great Lakes and not near Lake Superior (Eren & Desjardine, 2015). Such sites include Redwing in Ontario and Gainey, Butler, and Leavitt in Michigan. These sites date somewhere around 12,000 to 13,000 years ago and have been classified as “Gainey,” but Eren and Desjardine (2015) argue that they have many similarities with Clovis sites in the American Southwest and may be termed “Clovis” for their prismatic blades and overshot flaking. The Clovis people are the earliest hunter-gatherer culture that has been well-defined and well-studied in North America.

Although bifacially-flaked (chipped on both sides) fluted points (arrowheads) are most commonly used to identify a stone-age culture, other stone tools are important for understanding the utilitarian aspects of Paleoindian life (Eren, Jennings, & Smallwood, 2013). Paleoindians who were mobile foragers needed tools that were easily portable, durable, reliable, and could be used for many purposes (Eren et al., 2013). Old tools can reveal information about the people who made them through their design, breakage, recycling, and through the way they were discarded (Seeman, Loebel, Comstock, & Summers, 2013). Seeman et al. (2013) analyzed endscrapers from the Nobles Pond site in Ohio, a site identified as Gainey phase. They found that the tools of these low-population groups who moved frequently over long distances, subsisting on caribou and white-tailed deer, had been resharpened many times. Similarly, Morales et al. (2015), analyzed endscrapers of two groups from the same area, one Late Upper Paleolithic, and one Early Neolithic. They found that earlier peoples did not maintain the shape of the endscrapers after resharpening, while the Early Neolithic people did. These findings may be caused by the greater mobility and raw-materials transport costs of earlier peoples, causing them to reuse tool materials not optimal for maintaining tool shape. As Buchanan, Erien, Boulanger, and O’Brien (2015) state, “When stone and prey are scarce and unevenly distributed across the landscape, foragers typically respond by designing tools to have long use lives, which means they can be maintained and reused multiple times” (p.11). These findings about stone tools of Paleoindians are important to this thematic unit because the only material cultural artifacts found in the deposit were stone tools. There were no pottery fragments, bones, wood, seeds, leather, fabric, or other artifacts mixed with the rocks and found in the sandy clay of this glacial till deposit.

Unique Geologic Features of the Upper Midwest. The Early Precambrian (4.5 to 2.5 billion years ago) Canadian Shield occurs in Minnesota and has metamorphic greenstone belts of volcanic and sedimentary rocks, along with granitic gneisses. Many of the basalt volcanics were extruded from long vents into water, as pillow structures have been found. Some of these volcanoes were felsic and explosive, resulting in layered ash and welded tuff deposits (Ojakangas & Matsch, 2014).

During the Middle Precambrian time (2.5 – 1.6 billion years ago) iron-bearing sediment was deposited in the sea covering this area. These iron-bearing formations are known as banded iron ore and occur in several places across the world. These formations are the source of almost all of the iron ore that is mined worldwide. The banded iron formations consist of layers of quartz or chert alternating with iron oxide minerals such as red hematite, gray, black, or silvery magnetic, and yellow-brown limonite. The northern part of Minnesota contains several iron ranges from this time period, as do parts of the upper peninsula of Michigan. Minnesota is well-known for its iron ore mines and its history of shipping these ores across Lake Superior through the Great Lakes to steel-making factories farther east. Banded iron ores do not occur near the surface in southern Minnesota or Iowa, but magnetic surveys indicate that they may be present at great depth (Ojakangas & Matsch, 2014).

Lake Superior agates are popular collectors’ specimens. Quartz and Thompsonite minerals were deposited in the volcanic gas bubbles of the many lava flows as ground water percolated through the rocks. As the lava flows weathered to form clays, these resistant minerals were released and can be found near Minnesota lava flows and in the gravels of streams that cross them. Lake Superior agates have come to Iowa via glacial transport.

Glaciation of the Upper Midwest. The North American continent has experienced four glacial periods during the Quaternary Period: the Nebraskan glaciation (earliest), the Kansan glaciation (next oldest); the Illinoisan glaciation, and the most recent glacial period, the Wisconsin glaciation. During all of these glaciations, the state of Minnesota was almost completely covered by the ice, meaning that its rocks and surface artifacts could have been transported by ice at any of those times (Ojakangas & Matsch, 2014).

The site at which the artifacts and rocks were found in a glacial till subsoil stratum was located in Cedar Falls, Iowa, in Blackhawk County. The yellow subsoil had been exposed by removal of topsoil and bulldozing to develop the land for a new subdivision. This area is located in the "Iowan Surface" landform region of Iowa. This area is characterized by gently rolling slopes that were primarily prairie before settlement except for wooded areas in floodplains. "The area was once part of the Pre-Illinoisan Southern Iowa Drift Plain" (Iowa Department of Natural Resources, n. d., para. 4). To the west of the Iowan Surface area is the Des Moines Lobe landform region, which is dominated by glacial drift from the farthest-extending lobe of the Wisconsin glacial period. The Des Moines Lobe region has many potholes (shallow wetland basins) and recent end moraines of the Wisconsin glacial period (Iowa Department of Natural Resources, n. d., para. 4). The location of the glacial till site in Blackhawk County indicates that the artifacts and rocks found in this deposit were not moved by ice during the Wisconsin glacial period, but by an earlier glacial period.

Besides landforms such as moraines and drumlins, large boulders moved by the ice, called glacial erratics, provide evidence that the glaciers moved through the area. Another form of evidence is the occurrence of cobbles that have a side ground smooth because the rock had been frozen onto the bottom of a glacier. Several of these flat-sided cobbles of basaltic composition, some with long, parallel scratches, were found mixed in with the artifacts and rocks at the glacial till site.

Methods

This series of lessons was undertaken with a class of preservice teachers to determine the efficacy of the lessons while providing those undergraduate college students with a model of a fully integrated thematic unit. The lessons took place over two days with students rotating through eight centers in the classroom during their 75-minute class sessions.

Standards

The standards for the lessons all came from the Iowa Core Standards, the standards of the state in which the lessons were taught. Language Arts and Mathematics are specifically written for sixth grade students, while the Social Studies and Science standards are general for middle school. The chart in Table 1 lists the subject area, the standard, and the activity and objective which the students completed for that subject area and standard.

Participants

Twenty-five preservice teachers in their junior or senior years of college completed the lessons. All were dual majors; most of them completing degrees in both elementary education and middle level education. Two of these undergraduate students were majoring in mathematics with a secondary education minor and a middle level dual major. Of the twenty-five students, seven will be licensed in all four content areas; seven will be licensed in three content areas (five in Social Studies, Math, and Science; two in Social Studies, Science, and Literacy); and eleven will be licensed in two areas (six in Math and Science, three in Social Studies and Science, and two in Social Studies and Math). The course in which the lessons took place was the final course of a three course sequence for middle level majors. In the following results and discussion, the participants in this practical lesson will be referred to as "participants," "preservice teachers," "students," or "undergraduate students." All participants provided signed consent for use of their photographs, work, and comments in this article.

Table 1. *State or National Standards Addressed by the Lessons*

Subject Area	Standards	Activity and Objective
Social Studies and Archaeology	Iowa Core Standards for Social Studies (Iowa Department of Education, 2010) SS.6–8.H.3 Essential Concept and/or Skill: *Understand the role of culture and cultural diffusion on the development and maintenance of societies.* Understand ways groups, societies, and cultures have met human needs and concerns in the past.	*Sort and identify* stone tools by characteristics and tell how they were used to help the people survive.
Social Studies and Archaeology	Iowa Core Standards for Social Studies (Iowa Department of Education, 2010) SS.6–8.H.8 Essential Concept and/or Skill: *Understand cause and effect relationships and other historical thinking skills in order to interpret events and issues.* Understand processes such as using a variety of sources, providing, validating, and weighing evidence for claims, checking credibility of sources, and searching for causality.	*Make inferences* from observations of photos and objects from the field.
Art Integrated into Social Studies	National Core Arts Standards (National Coalition for Core Arts Standards, 2014). Visual Arts Creating Standard2.1.7a: Demonstrate persistence in developing skills with various materials, methods, and approaches in creating works of art or design.	*Make scientific drawings* of stone tools with shading after examining published scientific drawings.
Science and Geology	Next Generation Science Standards (NGSS Lead States, 2013) MS-ESS2-2 Earth's Systems: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.	*Make inferences* about glaciation and origin of the rocks in the deposit from maps, photos, and rocks Examine natural agates and photographs of agates. *Determine a sequence of events* for the patterns seen.
Art Integrated into Science	National Core Arts Standards (National Coalition for Core Arts Standards, 2014). Visual Arts Creating Standard 1.2.7a: Develop criteria to guide making a work of art or design to meet an identified goal.	*Build a three-dimensional simulated agate* with acrylic polymer clay that shows recognizable features of agates such as concentric banding and cross-cutting.
Literacy and Vocabulary Development	Iowa Core Standards for Literacy (Iowa Department of Education, 2016) L.6.6: Acquire and use accurately grade–appropriate general academic and domain–specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.	*Match* sets of descriptive adjectives to the agate-related objects they describe.
Literacy and Word Study involving Morpheme Analysis	Iowa Core Standards for Literacy (Iowa Department of Education, 2016) L.6.4: Determine or clarify the meaning of unknown and multiple–meaning words and phrases based on grade 6 reading and content, choosing flexibly from a range of strategies. L.6.4b: Use common, grade–appropriate Greek or Latin affixes and roots as clues to the meaning of a word (e.g., audience, auditory, audible).	Conduct a morpheme analysis of prefix, root word, suffixes of words by creating a chart-like layout of word parts and their meanings
Art Integrated into Literacy	National Core Arts Standards (National Coalition for Core Arts Standards, 2014). Visual Arts Creating Standard 1.2.7a Develop criteria to guide making a work of art or design to meet an identified goal.	Use gouache paints to create a painting of an agate *showing several agate characteristics*.
Mathematics and Graphing	Iowa Core Standards for Mathematics (Iowa Department of Education, 2010) Standard for 6th grade geometry # 6.G.A.3: Draw polygons in the coordinate plane given coordinates for the vertices; use coordinates to find the length of a side joining points with the same first coordinate or the same second coordinate. Apply these techniques in the context of solving real-world and mathematical problems.	*Measure stone tools and plot* them on an x-y graph. Color in groups of plotted artifacts to show the shapes of their distributions. Explain these patterns.
Art Integrated into Mathematics	National Core Arts Standards (National Coalition for Core Arts Standards, 2010). Visual Arts Creating Standard 2.3.7a: Apply visual organizational strategies to design and produce a work of art, design, or media that clearly communicates information or ideas.	Make a dot-to-dot puzzle by plotting points on a graph and connecting them to make a picture of a stone tool. Some additional lines or shading may be drawn on the graph as a given.

The Lessons

This set of lessons is centered on the theme of exploring the natural history of the subsoil of a particular site near Cedar Falls, Iowa at which the yellow subsoil was exposed. The subsoil contained many stone tool artifacts and rocks mixed with sand and clay. The subsoil was likely of glacial origin with the artifacts and rocks having been transported from Minnesota to Iowa many thousands of years ago. Inquiry into what can be learned about the Paleoindians who made the stone tools from the artifacts and inquiry into the origin of this deposit through examination of the rocks of the deposit and the occurrences of rocks in Minnesota were undertaken in this thematic unit. Figure 1 shows photographs of the bulldozed ground from the site. The dark brown topsoil was mostly removed while bulldozers sculpted the area for a new subdivision. The artifacts and rocks were collected from the surface of the yellow subsoil as they appeared after rain showers.

The lessons were organized by content area topic and contained arts integration activities that reinforced the content. Eight centers were organized for the lessons with each focusing either on the content or on a content-integrated art activity. Table 2 presents the materials needed for each of the lessons. This thematic unit was based upon an authentic find of artifacts and rocks in a glacial deposit. Teachers who do not have access to such a deposit might simulate the set of artifacts and rocks by purchasing them, borrowing them, or assembling artifacts and rocks from different areas. The following sections describe the content area lessons and their corresponding art activities.

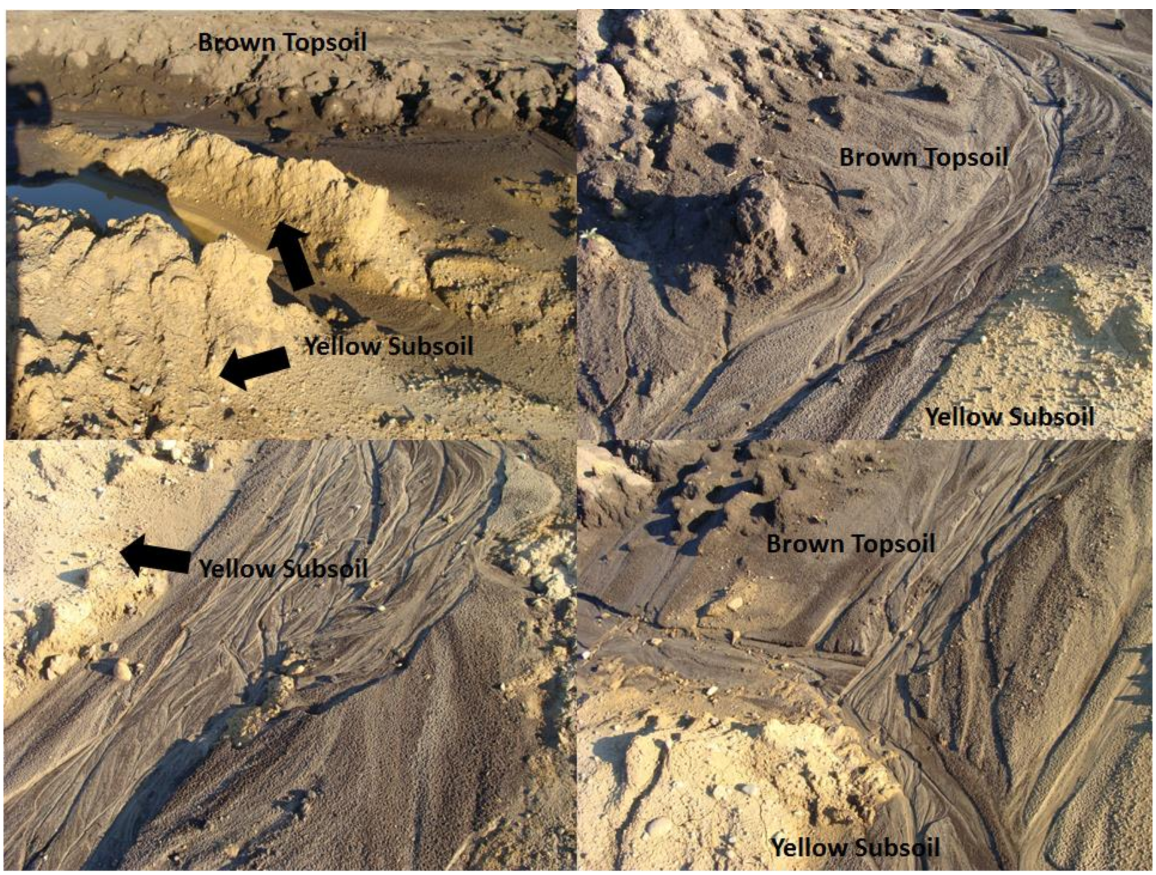

Figure 1. Photographs of the ground at the site where the artifacts and rocks were found. Each of the four images is about 2 meters wide.

Table 2. *Materials Needed for Implementing the Lessons*

Subject Area	Content Lesson Materials	Integrated Art Lesson Materials
Social Studies	Stone tool artifacts Stone tool identification cards Towel or pad to protect tools and table top Container for stone tools Worksheet for recording responses to questions that guided the work	Published examples of stone tool drawings Pencil or pen Paper
Science	Rocks from the site Rock identification cards Towel or pad to protect rocks and table top Container for rocks Maps of glaciated areas, banded iron formation, and agate deposits Worksheet for recording responses to questions that guided the work	Example finished polymer clay ornament on a keyring Acrylic polymer clay in several colors Baggies with four marble-sized pieces of 4 different colors of clay for quick distribution A container in which students can place or take left-over clay Plastic clay-shaping tools or plastic knives Conventional oven for baking the clay Aluminum foil-covered cookie sheet for baking
English Language Arts	Descriptive adjective cards Corresponding agate-like objects Morpheme analysis card set with objects representing meanings Worksheet for recording responses to questions that guided the work	Photographs of beautiful agates Gouache paints Trays for mixing paints Paint brushes Watercolor paper Water in a container for washing brushes and painting Black ink pen for outlining features Pen to record descriptive adjectives
Mathematics	Graphing puzzles printed on paper Pencil or pen Worksheet for recording responses to questions that guided the work	Stone tools Graph paper Pencil or pen

Social Studies

The social studies lessons focused on archaeological understandings of the stone tools found at the site. Six main types of stone tools were found: burins, pestles, knives, hoes, scrapers of many types, and hammer stones. Stone tool identification cards in Appendix 1 show example photographs of tools from the site and essential characteristics for tool identification, along with descriptions of the use of the stone tools. Students were provided with a couple of sets of stone tools from the site and the six identification cards to use in sorting the tools. Each artifact had an accession number marked on it and students wrote these numbers onto a record sheet. They also read the descriptions of how the tools were used and discussed the lifestyles of these people as revealed by the stone tools they used. An abundance of stone scrapers may have indicated that these early inhabitants of North America hunted animals and scraped their skins to make clothing. The burins were probably used to poke holes in the skins to insert thongs for holding them together. Pestles were used to grind seeds or to make iron oxide paints. Digging tools may have been used to obtain nutritious roots for food, supporting a hunter-gathering lifestyle. These stone tools had been moved by glacial processes and were somewhat dissolved-looking in surface appearance with the chip-marks being somewhat rounded. Some of these very early and primitive tools possibly may have been misidentified, especially some that had less chipping and shaping; however, many of the tools show bifacial chipping for a sharp edge.

Quite a few of the stone tools were made from agate material –microcrystalline quartz with colored bands, blotches, or swirls. Figure 2 shows many of these recovered from the site. Agate rock materials were fairly common north of Iowa in Minnesota, especially near Lake Superior, but not generally a part of the exposed bedrock of Iowa.

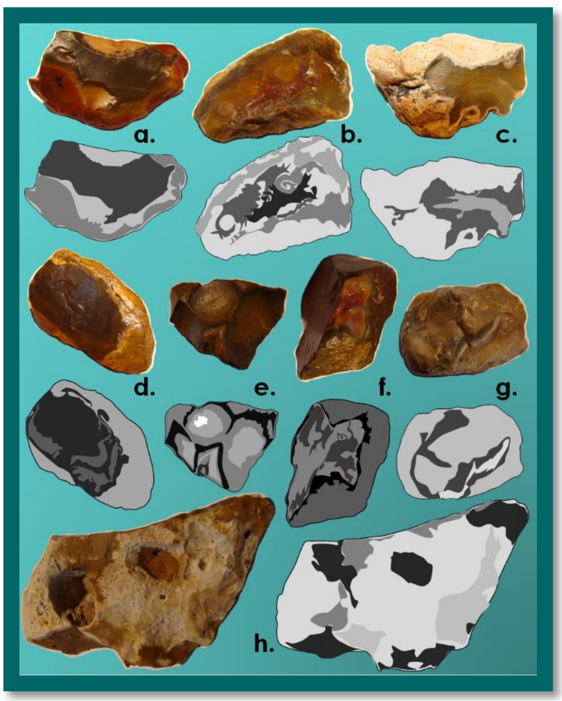

Figure 2. Stone tools that show agate characteristics such as concentric banding. Each photograph has a gray drawing below it or to the right showing the layered or mottled structure for clarity. The tools are: a) pestle, b) scraper, c) scraper, d) pestle, e) scraper, f) scraper, g) scraper, and h) digging tool.

Science

The science activities focused on identification of rocks found at the site, identification of their possible origin in Minnesota, and inferences about what their features, such as ground-flat sides, can reveal about their mode of transport. The rock identification cards used in the lessons are shown in Appendix 2. Figure 3 shows example igneous and metamorphic rocks that were mixed in with the stone tools in the deposit. These indicate an origin in an area showing past volcanism and metamorphic processes. The basaltic cobbles in Figure 4 not only show additional evidence for an origin in a place with past volcanism, but they each have a side that has been ground flat possibly through glacial transport when frozen onto the foot of a glacier. The banded iron formation iron ore specimens (also found intermixed with the artifacts and rocks) indicate an origin in a place that has such banded iron formations. Minnesota has several Precambrian banded iron formation sites mined currently and historically. See Figure 5 for example rocks of the banded iron formation from the site. Finally, Figure 6 shows examples of the many quartz nodules, geodes, and crystalline masses recovered from the site. All of this rock evidence points to an origin in Minnesota where many similar rocks are exposed.

After sorting, identifying, and making inferences from the rocks, preservice teachers were provided some diagrams and maps showing the locations of banded iron formations (Fitz, 2012, 2017), locations of agate sources (Gator Girl Rocks, 2017), and the locations of different phases of glaciation in the upper Midwest (Fitzpatrick, 2007). The arts-integrated activity involved preservice teachers in using acrylic polymer clay to model a colorful agate keyring ornament with characteristics of agates such as concentric banding, cross-cutting layers, and multiple sites of crystal nucleation. Figure 7 shows the example keyring fob that was provided.

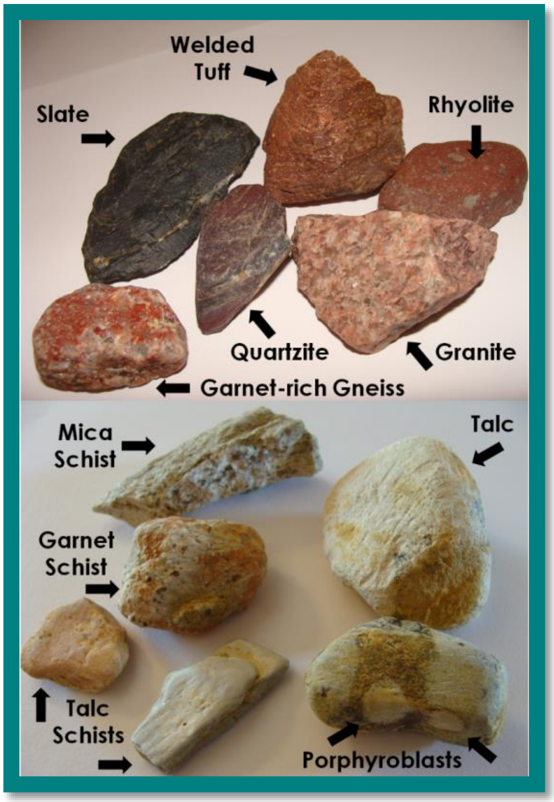

Figure 3. Igneous and metamorphic rocks mixed in with the artifacts in the subsoil.

Figure 4. Basaltic rocks with flat sides that were likely frozen onto the base of a glacier and scraped flat as the glacier moved.

Figure 5. Banded iron ore specimens that likely originated in Minnesota and were found intermixed with other rocks and artifacts in the subsoil in Iowa.

Figure 6. Quartz nodules and geodes from the site

Figure 7. Example keyring fob with agate features such as banding and crosscutting relationships.

English Language Arts

The English language arts activities focused on word study through morpheme analysis (the relationship of the meanings of word parts and the meanings of the entire words) and descriptive adjectives. Appendix 3 shows the components of the morpheme analysis activity. On the far left is an object (box with cardstock cutouts) that represents the meaning of the word. Next is the word with its definition below it. On the far right, the word is divided into parts with the meanings of those parts below them. At the beginning of the activity, all of the pieces were mixed. Then, students worked to make a large chart-like layout to show the morpheme analysis.

The descriptive adjective activity had twelve agate-related objects and corresponding cards with four different descriptive adjectives on each card. The four adjectives on a card together described just one of the objects. The goal was to match each set of descriptive adjectives to the correct object. The reverse of each card revealed the correct object. Some of the objects were not agates, but showed characteristics of agates such as layering, banding, swirled bands or mottling. See Figure 8.

Figure 8. Fronts (first and third columns) and Backs (second and fourth columns) of descriptive adjective cards

The integrated art activity for language arts was to examine photographs of agates, paint a gouache painting of one, and then provide four unique descriptive adjectives for the agate painting. An example painting and the corresponding adjectives are shown in Figure 9.

Mathematics

Two dot-to-dot graphing puzzles were presented to students to solve by graphing the points and connecting them in order at the mathematics content center. One example puzzle is shown in Figure 10. The art activity involved sketching a stone tool with shading and then determining the coordinates of the points on its outline to make a similar graphing puzzle.

Figure 9 (at left). Example agate painting showing concentric banding, multiple points of crystal nucleation, and crosscutting relationships. The descriptive adjectives connected to this painting were concentric, oval, multicolored, and cross-sectioned.

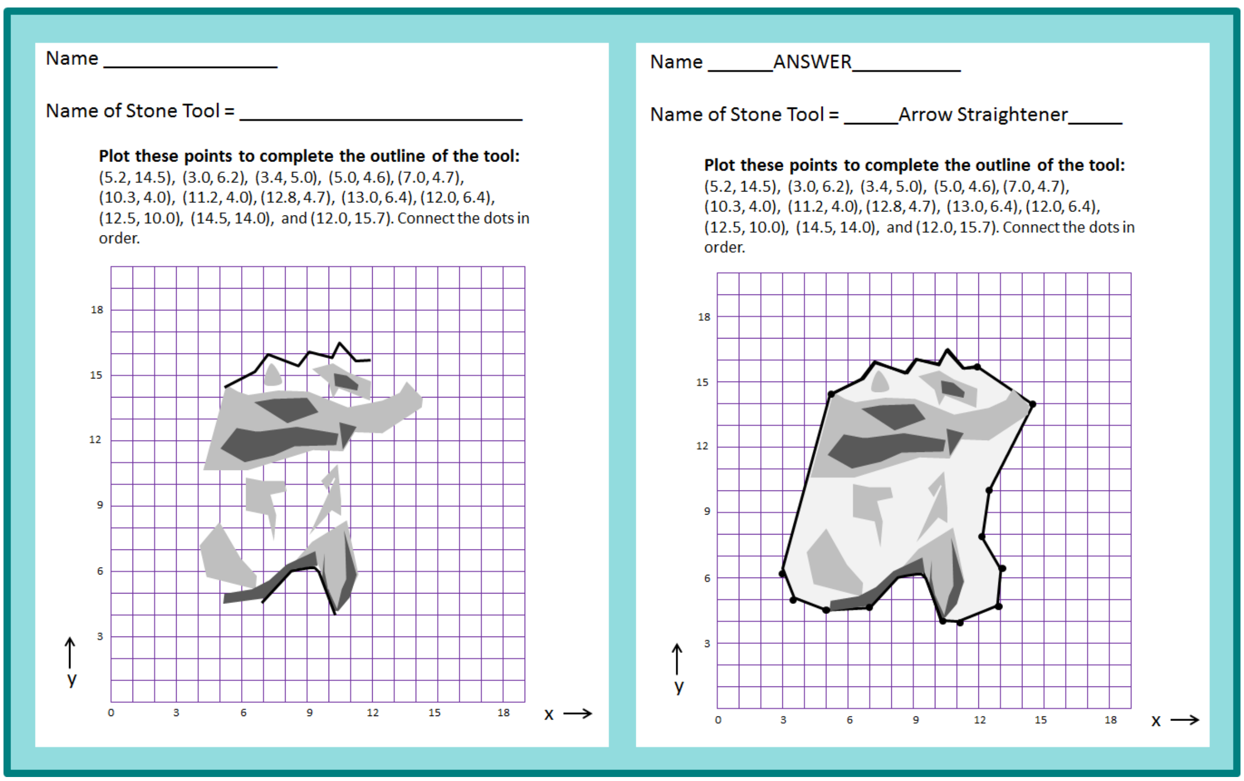

Figure 10. The graphing puzzle (left) and its solution (right).

Lesson Results

Teacher observations of student reactions to the content area lessons are addressed first in this section. Then, student work on the integrated art projects is presented. Finally, summaries of student written reflections are provided.

Teacher Observations of the Content Area Lessons

Overall, the lessons seemed to be a success. Students were engaged throughout, learning new content and participating in an example thematic lesson.

All Activities. A few days after the completion of the lessons, students remarked that the time went by quickly because of their high level of engagement. In fact, many said that these two class periods seemed to be the shortest they had ever attended. Preservice teachers also believed they learned content in addition to pedagogy.

Social Studies. Preservice teachers expressed that they had learned content about stone tool artifacts through the sorting and identification activities. Many were very excited to handle actual stone artifacts. They enjoyed learning how their shapes were related to their use supporting the Paleoindian lifestyle. Preservice teachers mentioned that they had started talking to other people about these items and activities. One student said she spoke to her mother about the different types of stone tools because it was such an interesting activity. Figure 11 shows preservice teachers sorting and identifying the stone tools with the help of pictorial identification cards.

Figure 11. Preservice teachers identifying the stone tools using illustrated definition cards.

Science Rock Identification and Sorting. Several students remarked how the rock identification activity reminded them of the content they had learned in their former geology classes. They began to remember some of the terms and identification characteristics. Students enjoyed handling the rocks and were surprised to feel the heaviness and density of the iron ore specimens that had been found in the subsoil. Students asked if this really was what iron ore was like (Yes!). An effective strategy was to first sort the rocks on similarity of color and texture, then try to match them with the rock identification cards. Students were able to infer that the set of basalt pebbles with flat sides indicated being ground flat by being frozen onto the bottom of a moving glacier. They were able to use the glaciation maps and diagrams showing the locations of iron formation in Minnesota to determine that glaciers had moved the rocks into Iowa. Figure 12 shows students involved in the science content activities.

Figure 12. Preservice teachers identifying and discussing the meaning of rocks found in the subsoil mixed in with the stone tools.

Language Arts Word Study: Morpheme Analysis. Morpheme analysis was a new concept to most of the preservice teachers. The idea of examining the meanings of word parts to better understand the denotations of words was something not emphasized in their prior schooling. Many of the words were new to the preservice teachers and so they had difficulty matching to the objects that represented the words. Many of the preservice teachers had not previously arranged word cards to make a chart-like layout, so that was a new experience. Dividing the set of ten words into two sets of five words with their corresponding definitions and word parts would have made the work easier. Figure 13 shows these lesson participants working on the morpheme analysis layouts.

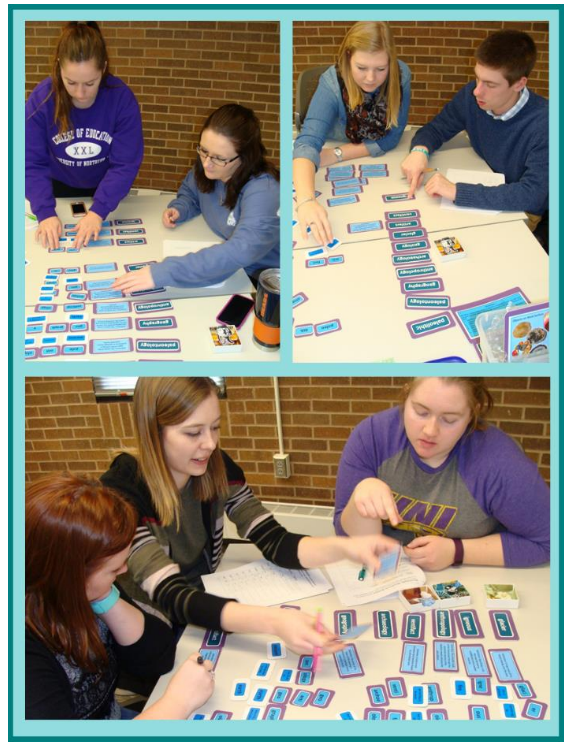

Figure 13. Groups of preservice teachers working on the morpheme analysis layout.

Language Arts Agate-Related Descriptive Adjectives. Determining descriptive adjectives was easier and they were more successful at it than the morpheme analysis for students. Students enjoyed handling the beautiful agates and agate jewelry as they matched theses objects to sets of descriptive adjectives. These undergraduate students enriched their vocabularies with new descriptive words as they worked. Figure 14 presents photographs of the preservice teachers matching objects with descriptive adjectives.

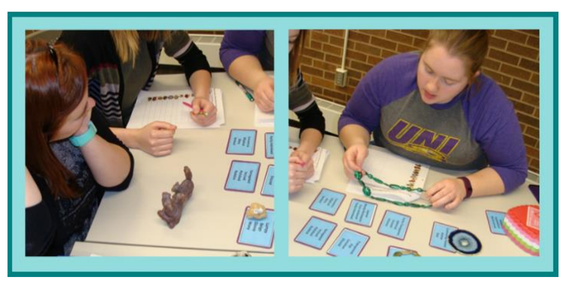

Figure 14. Preservice teachers matching objects with corresponding sets of descriptive adjectives.

Mathematics. Preservice teachers were able to quickly graph the x and y coordinates of points to solve the two dot-to-dot stone tool puzzles provided at this center. This activity may have been too easy for these undergraduate students. They used the extra time to complete activities from other centers or answer reflection questions. Figure 15 shows preservice teachers working on the graphing activities.

Figure 15. Preservice teachers determining coordinates for stone tool graphs.

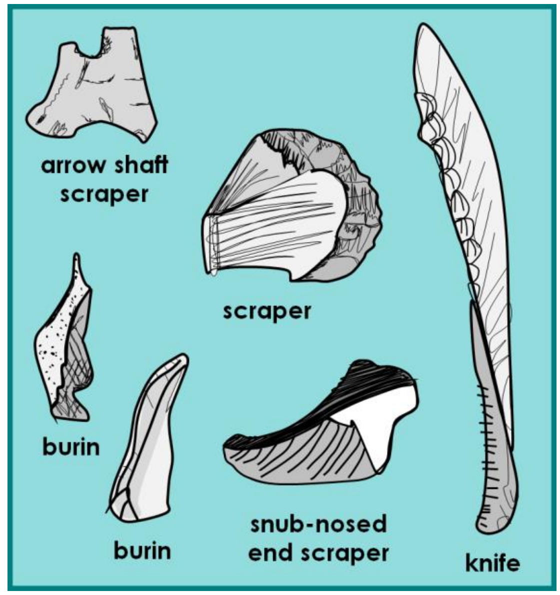

Figure 16. Example stone tool drawings made by preservice teachers.

Student Art Products

Overall, the preservice teachers seemed to enjoy the arts activities connected to each content area; however, several were self-conscious about their art abilities.

Social Studies-Related Stone Tool Drawings. Preservice teachers spent more time examining and classifying the stone tools than sketching a scientific drawing. The example cards of scientific stone tool drawings from published papers assisted them in determining how chipped areas were depicted and shaded. The drawings students produced accurately showed the tool outlines, shading, and chipped areas. Figure 16 shows students sketches of several types of stone tools. Figure 17 shows the preservice teachers working on their stone tool drawings.

Figure 17. Preservice teachers working on stone tool drawings.

Science-Related Agate Keyring Ornaments of Acrylic Polymer Clay. Students were completely engrossed in their tasks of rolling, pinching, mixing, and shaping the acrylic polymer clay into thick, flattened works to be baked and adjoined to metal keyrings. Many keyring fobs displayed concentric banding, in common with students' agate paintings. A further personalization on many keyrings was the addition of one or more initials. See Figure 18. Others showed more complex designs such as mottled coloring and crosscutting relationships, as in Figure 19. Figure 20 features four students making their agate keyring fobs.

Figure 18. Student-made acrylic polymer clay keyring fobs with concentric banding and added initials.

Figure 19. Student-made keyring ornaments with mottled or crosscut designs

Figure 20. Preservice teachers shaping the polymer clay keyring fobs

Language Arts-Related Agate Paintings. Preservice teachers seemed to enjoy making the agate paintings, relaxing and taking their time in mixing colors and brushing on the paint. Several expressed that they had not really heard anything about agates before this experience and they found them very beautiful and inspiring. Preservice teachers were able to show authentic features of natural agates in their paintings. Figure 21 shows agate paintings that emphasized the frequent concentric banding of agates, while Figure 22 presents paintings that depicted multiple sites of crystal nucleation, another common feature. Part of the assignment was to generate descriptive adjectives for one's agate painting. The following descriptive adjectives were among those that were generated by preservice teachers: bean-shaped, blue, bold, bright, cerulean, circular, colorful, cool-colored, contrasting, curvy, flat, flowing, glossy, irregular, layered, lumpy, multi-layered, multicolored, oval, rough, round, rounded, smooth, and vibrant. Figure 23 shows preservice teachers engaged in producing the agate paintings.

Figure 21. Participant paintings that depict concentric banding of agates.

Figure 22. Preservice teacher agate painting that show multiple points of crystal nucleation.

Figure 23. Preservice teachers making paintings of agates with gouache paints.

Mathematics-Related Dot-to-Dot Stone Tool Puzzles. Students found this to be an easy activity, quickly sketching the stone tool and writing graph coordinates. The most difficult aspect was identifying the stone tool and adding shading; many students completed only an outline of the tool without shading and moved on to other activities. Figure 24 shows two student graphing products.

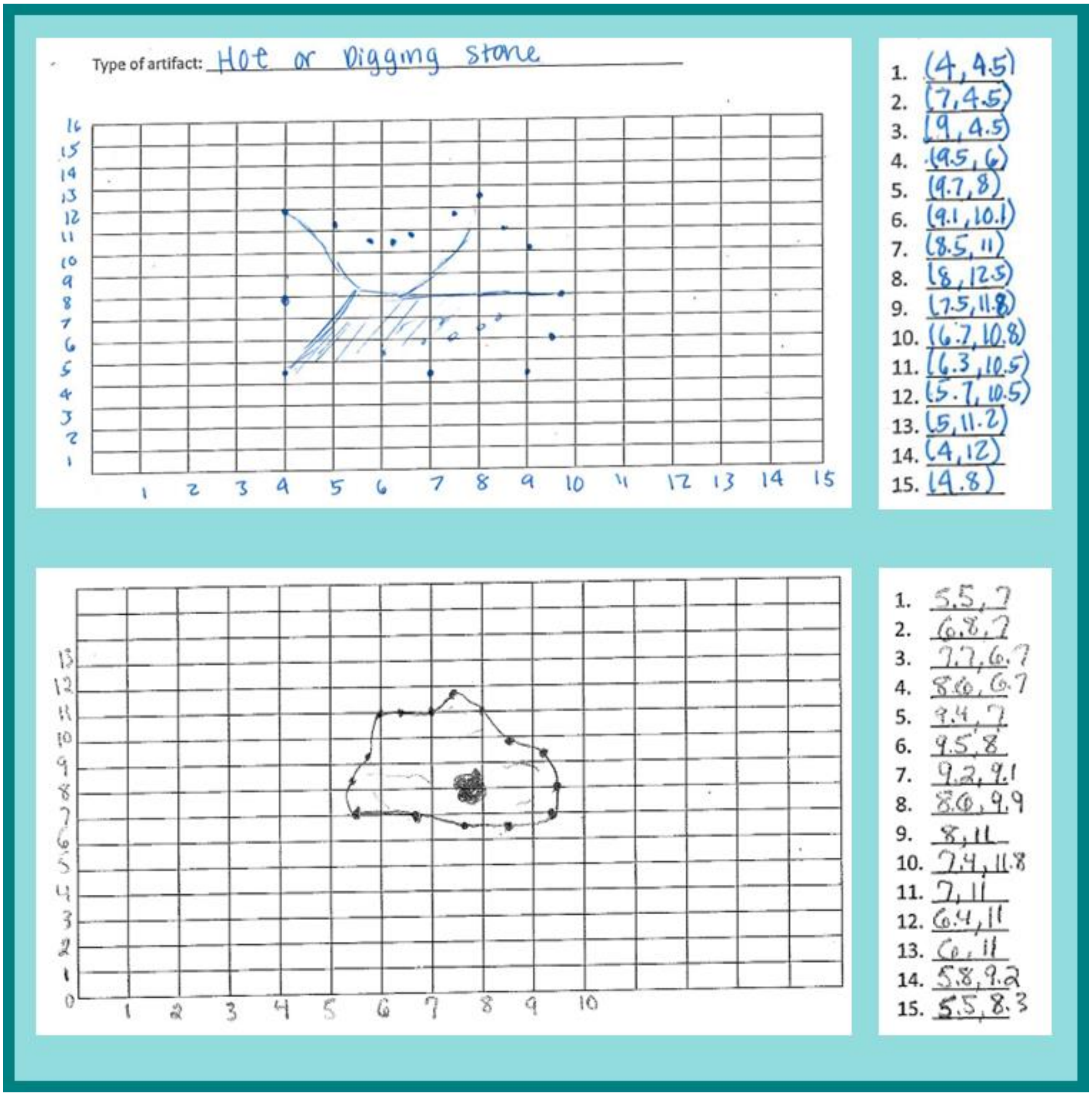

Figure 24. Mathematics graph puzzles completed by preservice teachers.

Discussion

Student Reflections

During and after the two class periods in which preservice teachers engaged in the interdisciplinary arts integration lessons, they were asked to complete a series of reflection questions. The questions concerned why middle school teachers should teach units that are theme-oriented across the content areas and why art should be integrated into social studies, science, language arts, and mathematics.

Thematic Units. Two common themes emerged as to why middle school teachers should teach units that are theme-oriented across the content areas. First, thematic units allow students to make connections across subjects and to create a bridge from classroom learning to real-life. This finding connects with the middle school *This We Believe* philosophy (2010) in having relevant curricula. Second, the preservice teachers believed integrating content areas through themes leads to middle level students developing a deeper understanding of the topic. The This We Believe ideas of educators using multiple teaching and learning approaches supports this deeper understanding.

Many participants remarked that combining subject areas by theme provided the opportunity to see how the content areas connected to each other and to real-life. One preservice teacher remarked that the thematic connections "show how similar the subjects really are." A second wrote, "It's important to have a theme across content areas because then students can create connections between classes and their community." A third remarked, a thematic unit "engages students and makes lessons connectable to daily student life." Each of these participants believed that teaching through a thematic unit allowed middle school students and teachers to make important connections between content areas and to students' lives outside of school.

A second common idea was that thematic units encourage middle level students to understand content better. One preservice teacher said, "By using a unit theme, this helps students more deeply retain the information and apply it to different courses." Another wrote, "Using the same theme across content areas allows students to learn about all aspects of the theme leading to a greater understanding." Finally, another believed that thematic units are "a way to build student knowledge." The undergraduate students believed that middle level students learn more when instructed through themes instead of when taught through disconnected content areas.

Social Studies and Art. When asked why it is important to integrate social studies and art, students focused on culture and engagement. Several students commented that art is an essential component of both historic and contemporary cultures. One preservice teacher wrote, "The arts are an important part of history as people have expressed themselves through songs, pictures, and writing. I think that if you want to see what history was like you need to look at the art of people." Another agreed, stating, "It is important to integrate art and social studies because students can learn a lot about a culture/region by looking at their artwork." Other students commented on how they felt social studies could be boring, but that art integration would improve student engagement. This deepening of student engagement is a consequence of arts-integration (Russell & Zembylas, 2007; Wilson et al., 2001). One student said, "In my opinion, social studies is boring and complicated. Social studies has a lot of content and is a lot of lecture so integrating art gives it life and a chance to view the content in a different way." Similarly, another student wrote, "Art can increase the appeal of social studies class." Participants thought art added to the content and engagement of social studies.

Science and Art. When asked why it is important to integrate science and art, participants commented on visualization and creativity. One student said, "Science is hard to learn without visualizing or creating models." Another wrote, "Sometimes it is hard to describe what you see in science so it may be easier to draw pictures of it." Visualization through art would make science clearer for middle school students. This finding is supported by the arts mechanism for longterm learning called "pictorial representation," which is based on the idea of picture superiority (Rinne et al., 2011). Preservice teachers also believed using art in science allowed middle level students to be more creative. One said that integration "gives students a chance for creativity and [to] see science through different perspectives." Another remarked, "Art allows for students to use their creativity, helping them retain information." The preservice teachers thought arts increased understanding of science through visual aids and by allowing students opportunities to be creative. The inclusion of the creative process when art-integration is implemented, according to the criteria outlined by Marshall (2014), brought this creativity to the thematic unit.

Language Arts and Art. Preservice teachers responded to the question about why it is important to integrate language arts and art by focusing on visuals leading to understanding and engagement. One participant wrote, "By integrating art into language arts, students' comprehension and understanding of texts will increase as they will be able to create and use visuals to make connections." Another wrote that arts integration allows us "to visualize the words we use in action." Others believed that integrating art into language arts improves engagement. One said, "Art makes literature come to life, therefore, students are much more engaged in the book or short story." A second student remarked, "Arts can add interest or enhance meaning/learning of words, stories/plays/etc. in language arts." Participants believed visualization and engagement were important reasons to include art in language arts. These student comments again connect to the longterm learning mechanisms of the arts (Rinne et al., 2011) and the increased engagement of arts-integrated lessons (Wilson et al., 2001).

Mathematics and Art. Preservice teachers thought mathematics and art should be integrated because art expands mathematics so that middle level students are not dependent on learning merely through computation and because art can reveal the more practical aspects of mathematics. This idea of transcending subject area boundaries and demonstrating knowledge through a new medium aligns with Marshall's (2014) criteria for art-integration. One student said, "It is a more detailed way of learning that shows more than just computation." A second student agreed stating that integrating art and mathematics, "helps students think about math in a different way than just sitting down and doing problems." Preservice teachers also believed that arts could help with the complex nature of mathematics. One said art and mathematics could "build bridges between concrete and abstract math ideas." Another student said integration "provides a visual marker for the math concepts so students can see the math." Preservice teachers thought arts would make math less complicated and more visual for middle level students to understand.

Preservice teachers wrote that theme integration was a beneficial method to teach middle level concepts. They also explained that arts integration would improve understanding and engagement in every content area.

Difficulties Encountered with Suggestions for Solving the Problems

While overall the lessons were successful, a few difficulties arose during the two days they were implemented. This section addresses the problems faced that affected all of the lessons, and then focuses on each individual content area. Art stations are discussed as part of the subjects when necessary. After identifying and explaining each difficulty, possible solutions are proposed.

General Difficulties Overall

Preservice teachers often needed a clearer, more in-depth explanation of what to do before starting work in a center. They wanted to get started right away and, because of their impatience, did not take the time to wait for instructions. Students need to take more responsibility in figuring out what they are supposed to do. One possible way to improve the directions in the centers is to have a homework assignment prior to the in-class lessons that involves them in thinking about the correct center procedures. In the preceding homework assignment, students are given a description of work for each center. A photo of someone completing the center assignment incorrectly is provided. Students must identify what is wrong in the photo and how the center assignment needs to be completed correctly. Another idea is to do one or two centers at a time and explain how each center works to everyone; small groups of students rotate through the one or two centers during the morning.

A second problem follows. Students expressed they were uncomfortable with doing the art because of lack of skills and experience in this area. More step-by-step directions regarding skills and comments about creative ways to vary the work might help. Too many step-by-step directions may cause the work to become very similar and "cookie-cutter" in appearance. This situation may be resolved by emphasizing individual and creative aspects of the art integration projects.

Social Studies

Students were very unfamiliar with stone tools and had a lot of difficulty identifying them. An example of each stone tool attached to the identification card would help with the identification because the photographs did not always look like the tools. Some of the photos were effective, but an actual three-dimensional example tool would have been better. Because they spent too much time sorting and identifying the stone tools, they often delayed doing the stone tools drawings until the last minute of time for that group. The stone tool drawings showed many important features like intricate outline, major different tilted areas, shading, etc., but could have been improved if students had been allotted more time.

Science

In the rock sorting center, some groups took rocks one at a time to identify, slowly proceeding to the next rock. One person did most of the work and the others recorded the results. This process was inefficient without group collaboration or active involvement of everyone. To improve efficiency and collaboration, ask students to identify similar characteristics in rocks to initially sort them into groups. This process would allow students to identify the group as a whole.

Giving students a few minutes to sort the rocks before giving them the cards could improve the center because students depended too much on the card descriptions rather than on their own differentiation abilities.

At the station in which acrylic polymer agate keychain fobs were made, one group disassembled the baggies of clay and took clay from multiple bags without thinking about the purpose of having clay divided into baggies. If there were clearer directions in the center (or, in a prior homework assignment) with an explanation, the participants may not have disassembled these baggies.

English Language Arts

Students had difficulty completing the morpheme analysis. As stated previously, this activity was a new concept for many of them. Probably, instead of ten words, two sets of five words would have been better to narrow the possibilities for each set.

Mathematics

In the mathematics activity, students encountered difficulty naming the artifact (a part of the puzzle activity) when they had not yet completed the social studies activity on artifact identification. Similarly, on the dot-to-dot graphing activity, students generally drew the tool outline without internal shading. The graphs with tools showing internal shading were from people who had already completed the social studies center with scientific drawings of stone tools. To solve both problems, have stone tool identification and scientific drawings at the center for those students who had not seen these items previously or consider the order of the stations, so students complete social studies before mathematics.

Conclusion

The lessons reported in this article revolved around the theme of natural history, particularly addressing stone tools and their use in Paleoindian life along with the inferences that can be made from the types of rocks in a deposit and its origin (north of the site in Minnesota) and mode of transport (glacial). Twenty-five undergraduate preservice middle level teachers participated in the lessons delivered at eight centers over two days. Students appreciated participating in the arts integrated thematic unit because they recognized how the integration of subjects around a theme improved their abilities to make connections from the classroom to the real world. They also recognized how the arts integration allowed them to concretely experience many concepts. Students remarked that both the thematic approach and integration of art projects made the lessons more engaging. The thematic unit presented here was unique in that the lessons integrated all four major content areas and art. The authors observed intense engagement from preservice teachers during the implementation of this unit; perhaps this will inspire the reader to apply arts integration to a thematic unit.

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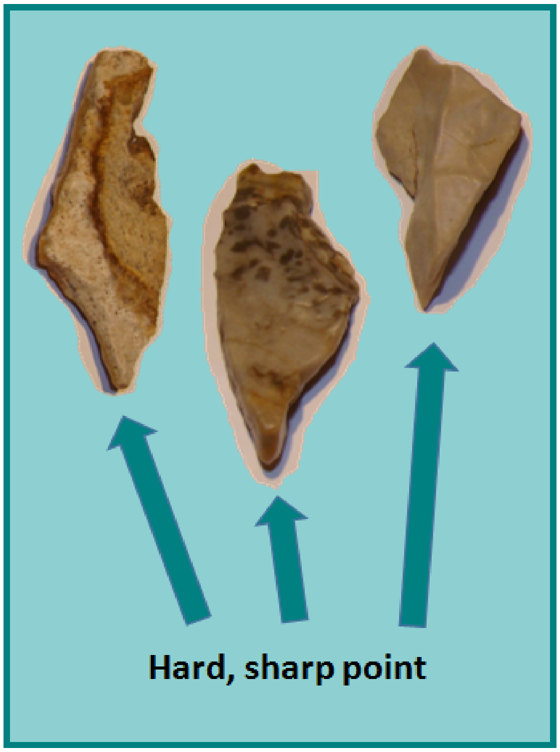
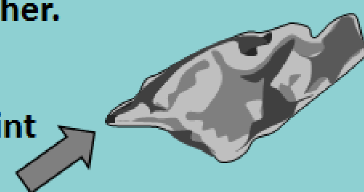
Appendices Begin on the Next Page

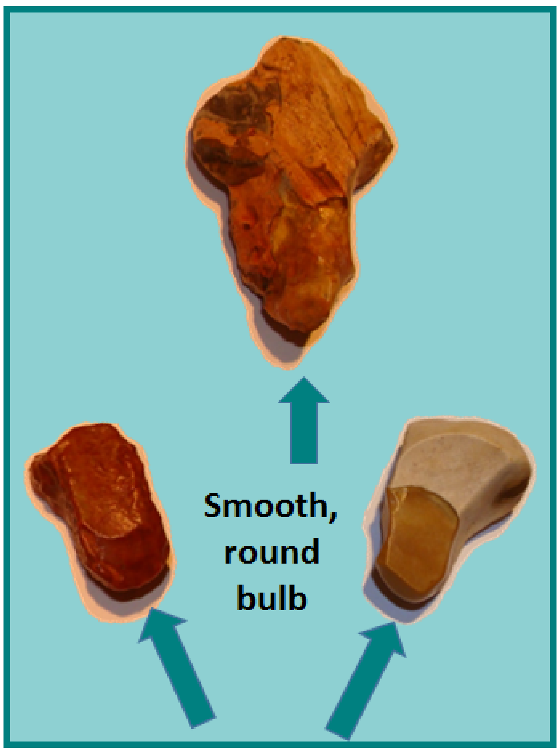
Appendix 1 Stone Tool Identification Cards



Burin or Graver

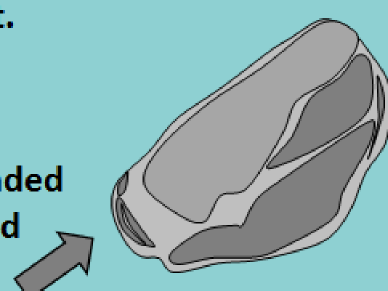
A small stone tool made of chert or flint that has been chipped to form a sharp point. The hard point was used to inscribe, scratch, or engrave grooves in softer materials such as wood, bone, and antler or to punch holes in leather.



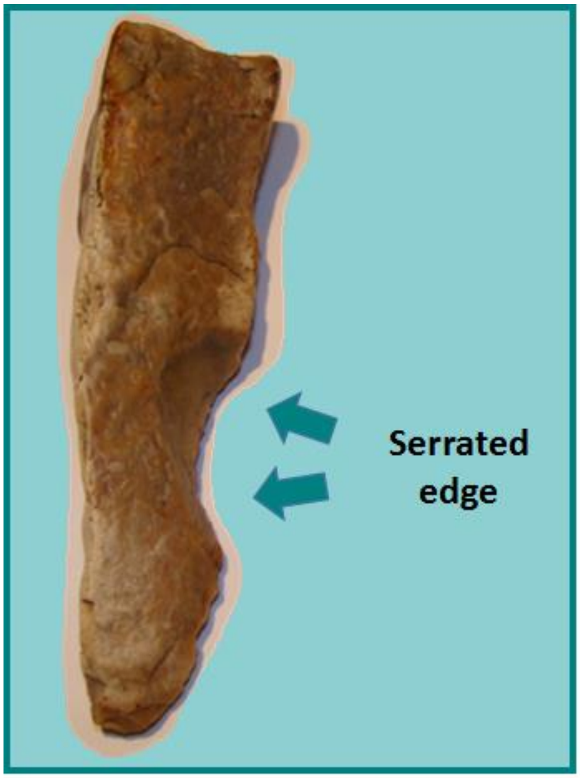


Pestle or Crusher

A stone tool that has been chipped or ground to form a round, smooth bulb or ball-shaped end. This end is used to crush seeds and herbs for food or iron oxide minerals for paint.



Fronts (right column) and backs (left column) of the stone tool identification cards for burins and pestles.



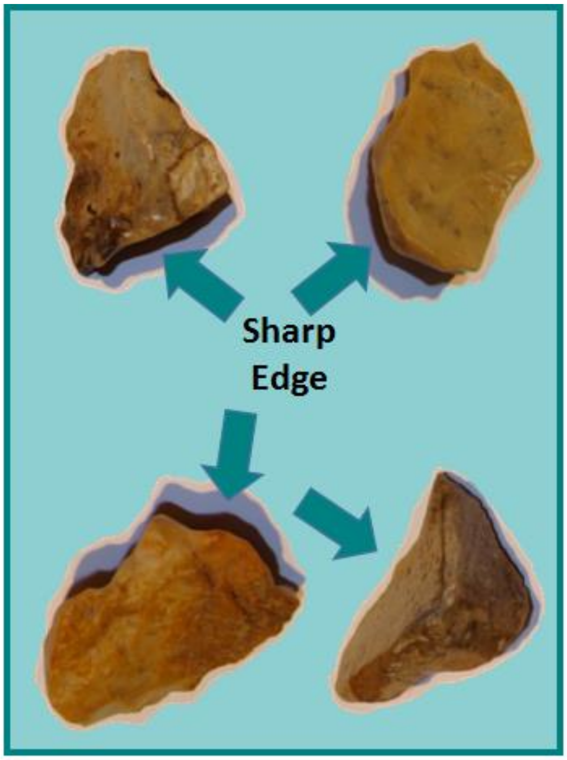
Knife

An elongate stone tool with one or more sharp, serrated (saw-toothed) edges used for cutting.

Hoe or Digging Tool

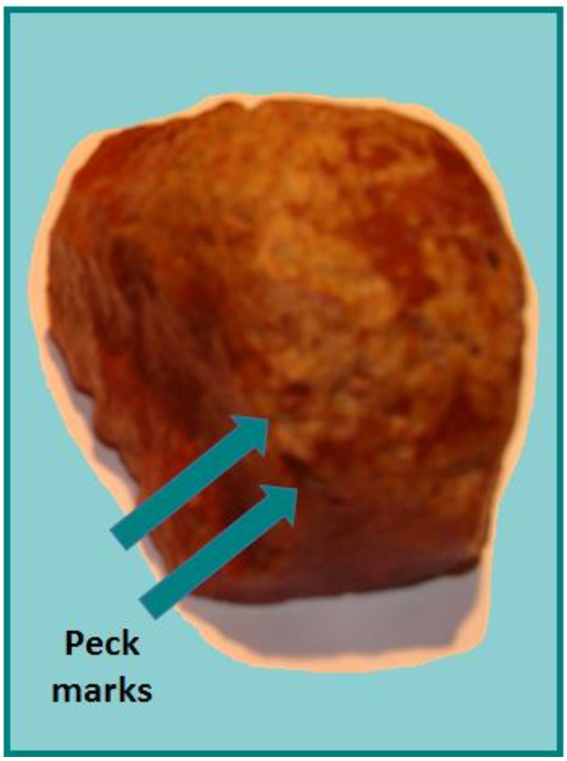
A fairly large, strong, thick stone tool that ends in a broad, rounded point. This tool is held in the hand and used for digging roots from the ground or for planting.

Fronts (right column) and backs (left column) of the stone tool identification cards for knife and digging tool.



Flake Scraper

A flake of chert or flint that is about the size and shape of a small, thick potato chip that has a sharp, almost razor-thin edge used for scraping animal hides or bark.



Hammer Stone

A palm-sized, strong river cobble used as a hammer to assist in making stone tools or used to crush and grind foods or to break the shells of nuts. The stone sometimes shows peck-mark damage from hitting objects.

Fronts (right column) and backs (left column) of the stone tool identification cards for flake scraper and hammer stone.

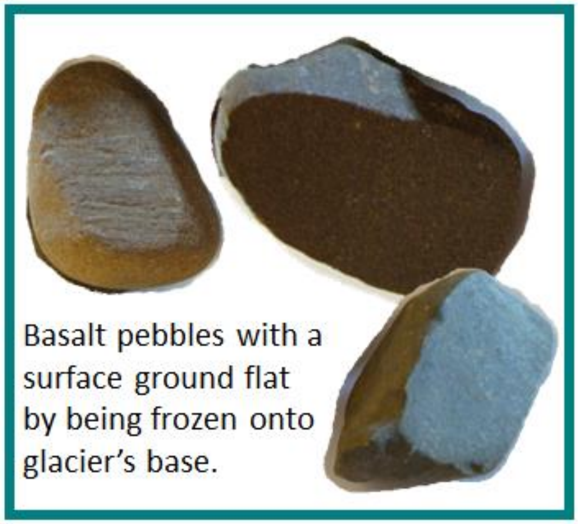
Appendix 2. Rock Identification Cards

Quartz

Quartz is a glassy mineral that, when pure, is colorless, but is often tinted yellowish or other colors by impurities. Quartz crystals are 6- sided prisms with 6-sided points on top. Quartz is hard (hardness of 7 on the Mohs Scale) and often fills cracks and volcanic bubbles, forming nodules, agates, and geodes. Quarts nodules often signal metamorphism and hot fluids, spherical geodes form in volcanic air bubbles. Quarts weathers to form sand.

Basalt Rock

Basalt is a fine-grained igneous rock formed by solidified lava from a volcano or vent on the earth's surface. Basalts are extrusive igneous rocks. Their presence indicates volcanism or the presence of volcanoes. Basalt is gray to greenish to black in color and weathers to form clay. Many basaltic pebbles from the glacial till were frozen onto the bottom of the glacier and therefore have a very flat side that was ground smooth as the glacier moved across the earth's surface.



Iron Ore Rocks

Magnetite is a black to blue-gray iron oxide that is magnetic. Hematite is a reddish iron oxide. A related iron oxide mineral is limonite, which is usually yellowish brown. Great layered iron ore deposits were created during Precambrian times in many parts of the world. Particles of iron were precipitated by algae on the seafloor of ancient oceans to form banded iron ore deposits. Such deposits can be found in northern Minnesota. The bands are alternating layers of magnetite or hematite and quartz. Nodules of hematite and limonite are also present.

Part 1 of rock identification cards

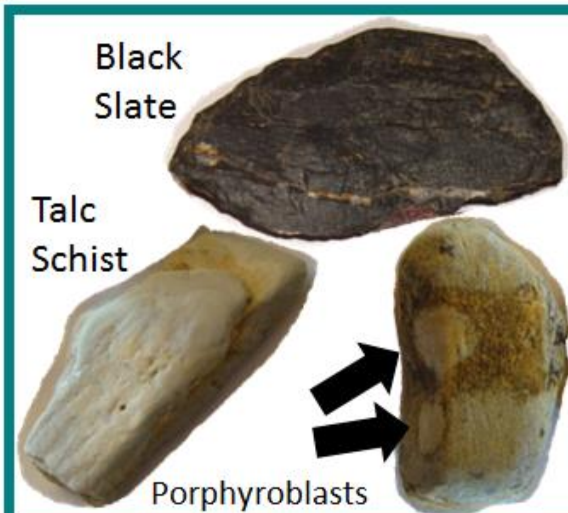
Granite Rock

Granite is a coarse-grained igneous rock that solidifies slowly below the earth's surface, forming visible crystals. Granite is a plutonic or intrusive igneous rock. Granite is usually light-colored (pink or gray) because it contains a lot of quartz grains. Granite at the surface indicates that the roots of mountains have been exposed or that rocks from a mountainous area have been transported. The feldspars in granite weather to clay; the quartz later forms sand.

Pink granite: The pink grains are orthoclase feldspar; the clear grains are quartz.

Metamorphic Rocks

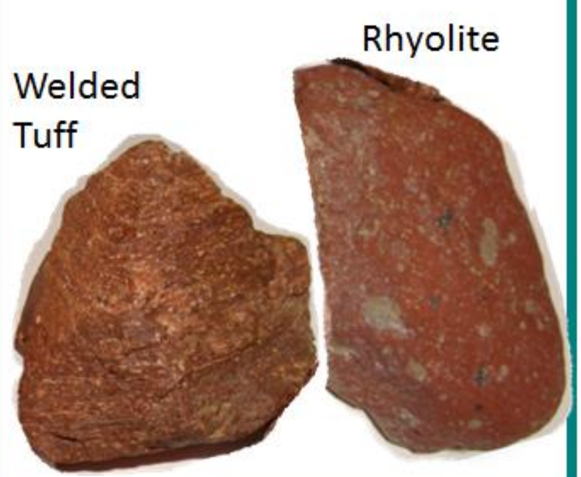
During metamorphism, rocks are buried deeply below the surface. The pressure of overlying rock and the heat of being deep in the earth cause changes to the rocks. Many rocks become layered like slate and schists, which form from metamorphosed clay or mica-rich rocks. Some rocks show circular areas called porphyroblasts made by growing minerals. Hot mineral-rich water often circulates at this time, depositing quartz geodes, nodules, and agates in cracks and volcanic air bubbles.



Other Volcanic Rocks

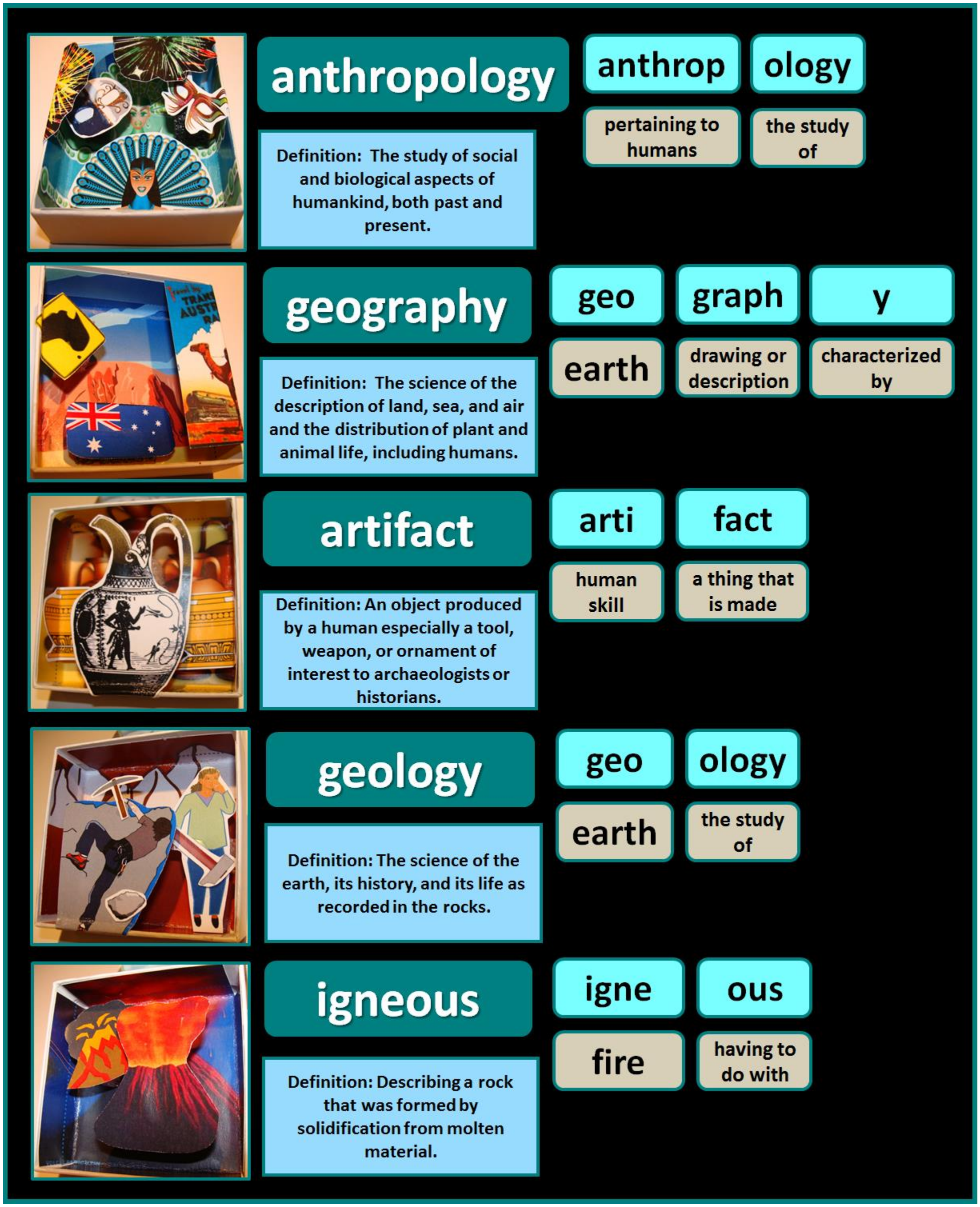
There are several other types of volcanic rocks besides basalt. Rhyolite is an extrusive, fine-grained lava rock that is usually reddish or purple in color. Sometimes fine-grained extrusive rocks have large crystals in the fine groundmass. These large crystals are called phenocrysts.

Volcanic ash that is blown out of a volcano can fall to the ground while still hot. The ash particles then become welded together to form a welded tuff. Welded tuffs often show layers and some larger ash particles.

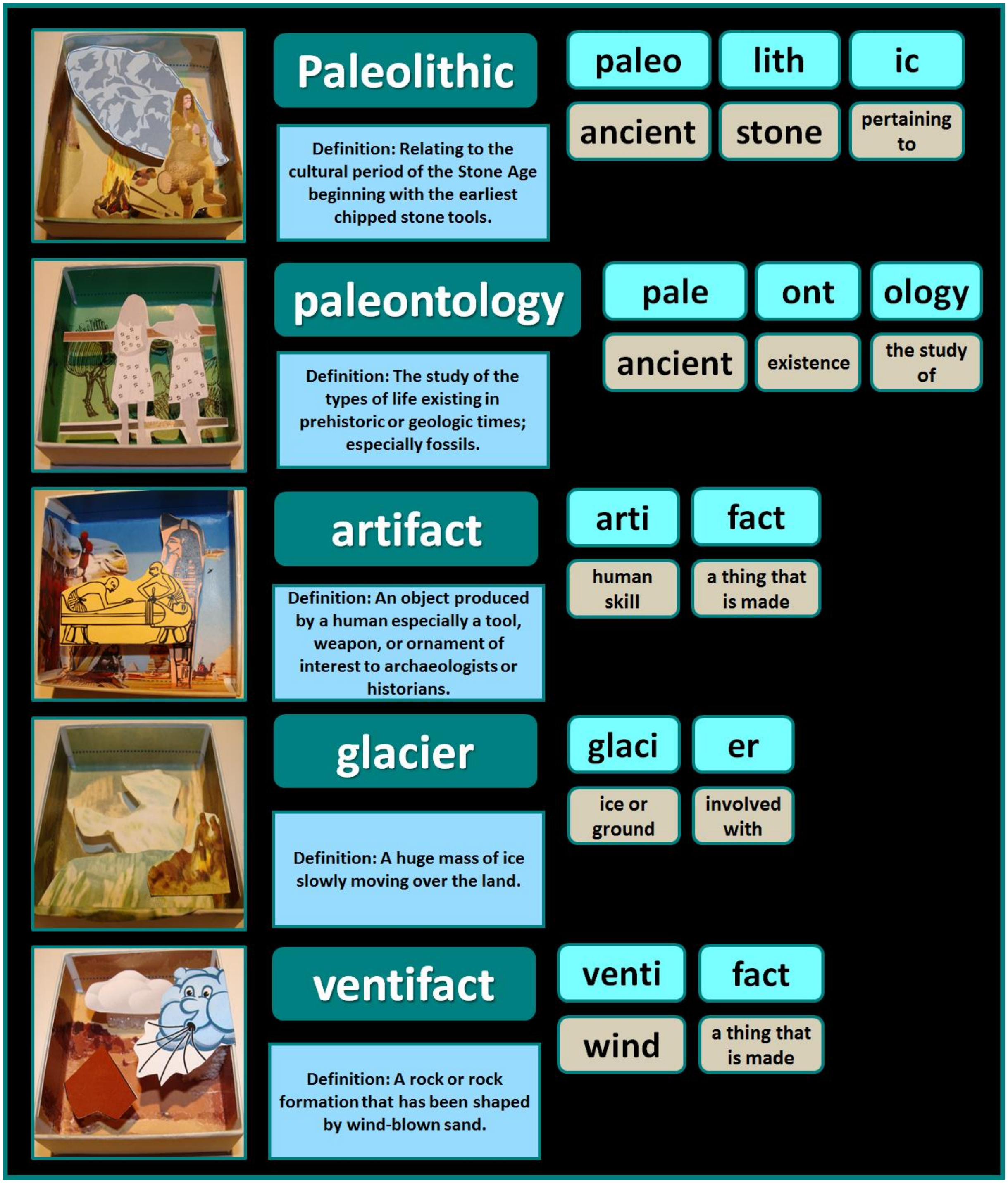


Part 2 of rock identification cards

Appendix 3. Layout of Morpheme Analysis Cards and Objects



Part 1 of the morpheme analysis layout.



Part 2 of the morpheme analysis layout.