TRANSFER OF LEARNING IN A K-8 STEM ACADEMY PROJECT BASED LEARNING (PBL) ENVIRONMENT

Mary A. Fuller

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APPROVED:

Jeanne Tunks, Major Professor
Scott Warren, Minor Professor
Ricardo Gonzalez-Carriedo, Committee Member
Lowell Strike, Committee Member
James Laney, Chair of the Department of Teacher Education and Administration
Randy Bomer, Dean of the College of Education
Victor Prybutok, Dean of the Toulouse Graduate School

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The multiple case study investigated levels and types of transfer observed in a K-8 STEM (science, technology, engineering, math) academy in a project-based learning (PBL) environment. The academy was constructed two years prior to the study and conducive to PBL instruction. The students and teachers were in the second year of using PBL in the subject of science at the time of the study. The grade levels observed were second, fourth, and sixth grade and each grade level had three PBL units examined from the beginning to the end of the unit. The nine case studies, from the three different grade levels, were observed to identify Haskell's levels and types of transfer as determined by project requirements, observation of students, completed projects, and student interviews. The findings from this study showed that while projects moved the students beyond knowledge acquisition to application of knowledge in completed projects such as books, films, dances, etc., higher levels of transfer and more types of transfer were not evident. Therefore, based on the results of this study, the evidence of lower levels of transfer suggests that the PBL units, though inventive and potentially valuable to student learning, were not designed for higher levels of transfer.

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CHAPTER 1

THEORETICAL FOUNDATIONS

Introduction

The ability to transfer learning is important in everyday tasks as well as job responsibilities, and/or school coursework. Transfer of learning can be seen as the foundation of thinking, learning, and problem solving (Haskell, 2001), and is important in the instruction of critical thinking. Early in the critical thinking movement in education, it was noted that transfer was essential in teaching critical thinking and problem solving. McKeachie, Pintrich, Lin, and Smith (1986) pointed out that when faculty members spoke about teaching problem solving, critical thinking, or reasoning, the educators were referring to teaching students how to use what they learned in new situations and to problem solve.

In a project-based learning (PBL) environment, curriculum is organized by state or local standards, while learning is typically initiated with an authentic question, and instructions are project or problem inspired (Thomas, 2000). The projects are complex tasks based on challenging questions or problems, where students are involved in design, problem-solving, decision-making and/or investigative activities. Students are given an extended period of time to complete projects which typically culminate in realistic projects or presentations. Thomas (2000) postulated the autonomy of working in a project and the extended periods of time on a project, in turn, helps students as they work through the process to reach a solution related to the project, as well as to help increase their critical thinking abilities. Problem solving and critical thinking are important aspects to transfer learning.

Transferring learning from projects to real world contexts of learning is an important step for learners to accomplish. Skills in project-based learning should be a natural environment where transfer of learning takes place. According to Haskell (2001) students in school often learn the same concept in different courses and these concepts are given different labels by different disciplines, yet students are unaware they are learning the same concepts. Haskell (2001) postulated that near and far transfer were the most commonly discussed forms of transfer in educational fields. Near transfer refers to the direct application of previously learned knowledge in a way that is highly similar to how the knowledge was originally learned (Schunk, 2008). In other words, near transfer involves low degrees of changes in the format and structures of tasks, complexity, or context. Far transfer is applying learning to situations that are quite dissimilar to the original learning. Far transfer is more challenging for students even though the cognitive processes for far transfer are similar to near transfer, it is the difficulty and complexity levels increasing considerably that causes challenges for teachers and students. Researchers in education and practitioners need a point of reference to help determine if transfer is occurring. Haskell (2001) proposed that for educators and researchers to see if transfer occurred a level and type of transfer would need to be clearly identified.

The empirical research on transfer of learning revealed knowledge about transfer as a theory of learning (Carraher, 2002), what was needed for transfer to occur (Engle, 2006; Wittrock & Cook, 1975), different problem solving strategies (Gick & Holyoak, 1983; Hornik & Ruf, 1997; Serpell, Boykin, Madhere, & Nasim. 2006; Vanderstoep & Seifert, 1983), and what transfer ability could do (Dinsmore, Baggetta, Doyle, & Loughlin, 2014), but none of the studies specifically identified transfer in a classroom. Transfer of learning was not studied in most of the project-based learning studies. Project-based learning studies focused on students' perspectives (Grant, 2011), student attitudes and motivation (Bell, Galilea, & Tolouei, 2010), behavioral patterns (Hou, 2010), project assessment (Hansen, 2004), collaboration (Mitchell, Foulger, Wetzel, & Rathkey, 2009), technology use (Hernandez-Ramos & De La Paz, 2009), self-direction, (Lee & Tsai, 2004; Papanikolaou & Boubouka, 2010; Raidal & Volet, 2009), and scaffolding of learners (Hung, Chee, Hedberg, & Seng, 2005; van Rooij, 2009; Wilhelm, Sherrod, & Walters, 2008).

In most of the empirical research reviewed there remains a deficit in the study of the PBL environment and transfer of learning.

Statement of the Problem

There is a paucity of research that specifically addresses levels and types of transfer of learning in K-8 schools, and whether or not transferring knowledge to a new or novel situation in a project-based learning environment occurs.

Purpose of the Study

The purpose of this study was to investigate levels and types of transfer observed in K-8 school students during science and across multiple subjects in a project-based learning (PBL) environment.

Research Questions

1. What levels of transfer of learning were observed in an elementary school project-based learning environment?

2. What types of transfer of learning were observed in an elementary school project-based learning environment?

3. Across which learning environments was transfer observed?

Theoretical Framework

Transfer of Learning Defined. Haskell (2001) defined transfer as “how previous learning influences current and future learning, and how past or current learning is applied or adapted to similar or novel situations” (p. 23). Transfer of learning, according to Haskell, is a way of thinking, perceiving, and processing information. His review of the research findings on transfer of learning concluded that: (a) learning can be enjoyable, but it is hard work; (b) learning has no shortcuts or quick fixes; and (c) the setting or location where a person learns something stays embedded in those settings.

Haskell (2001) theorized that the current educational view of instruction emphasizes specific learning strategies and teaching techniques that do not result in significant transfer. Haskell (2001) noted in his treatise on transfer of learning that virtually all contemporary discussion on instruction and transfer concerns techniques, strategies, skills, and methods of instruction (Bassok & Holyoak, 1989; Brooks & Dansereau, 1987; Clark & Voogel, 1985; Gelzheiser, Shepherd, & Wozniak, 1986; Larkin, 1989; Sweller, 1990). These discussions appear to be inflexible, straightforward approaches to education. According to Haskell (2001) they are not. His discourse showed that whatever transfer of learning may be generated by technique, strategy, and method is typically the lowest level of transfer. He contended that transfer of learning requires more than strategies.

To examine transfer of learning a structure, such as Haskell’s (2001) taxonomy, can guide researchers and practitioners. The taxonomy includes six levels of transfer, fourteen types of transfer, delineation of knowledge of transfer, and principles. The parts of the taxonomy are described in detail.

Levels of Transfer

The first level of transfer is nonspecific transfer; Haskell (2001) believed all learning depended on some connection to past learning, and therefore all learning in this sense is transfer of learning. Nonspecific transfer has connections to past and present learning and is likely a component of everyday learning. This level is a good place to start understanding what transfer is when applied to learning. The second level of transfer is application, and refers to applying what a person has learned to specific situations. For example, when students have learned about a word processing system, they are then able to apply the learning to actually operating a word processor. Learning about a specific word processing system does not necessarily mean the student is able to operate a word processor. This level of transfer is a problem in the learning of many tasks.

The third level of transfer, context transfer, refers to application of what a person has learned in a slightly different situation. Many times, changing the context of a learning task, even though the learned task is exactly the same, may result in lack of transfer. On occasion, what is learned in one place is linked to the place where it is learned because the physical environment provides cues necessary for retrieving the learning. A common example of context transfer is when someone may not recognize another person they know, even though the first person is looking right at the second person. This can happen when there is no experience of a person or expectation for the person being in a particular place.

Lave and Wenger (1991) focused on the relationship between learning and social situations in which the learning takes place; therefore, social engagements provide the proper context for learning to take place. The authors named this type of learning, situated learning, defining the situated learning in certain forms of social co-participation. They noted the learning not in the acquisition of structure, but as an increased access of learner's participatory roles and expert performance. This gives a highly interactive and productive role for the skills that are acquired through learning, giving learners a positive outcome in context transfer.

Near transfer, the fourth level, refers to when previous knowledge is transferred to new situations that are very similar but not identical to previous situations. Using classroom experience to figure the area of rectangles may help in learning to calculate the amount of floor tiles needed for a living room, or using experience in roller skating and transferring that knowledge to ice-skating is an example of near transfer. There are many people who do not make this simple type of transfer.

Far transfer, Level 5, refers to applying learning to situations that are rather dissimilar to the original learning. Examples of this transfer include seeing lightning as a big spark, or similar transfers often involved in invention and product development. Far transfer involves learners using what they learned in a new and authentic way. Level six is displacement or creative transfer, and refers to transferring learning in a way that leads to more than the insight of similarities ("that is like this"). While analyzing a newly discovered similarity between the old and the new, a new concept is created. Levels five and six are considered to both be far transfer reserving Level 4 as near transfer.

Haskell (2001) considered Levels 1 and 2 as simple learning, not transfer suitable, and Level 3 as simply the application of learning. He considered significant transfer as transfer that requires the learning of something new in order to make the transfer. Therefore, Levels 4, 5, and 6 typically require this new learning, and without the requirement of new learning the transfer in Haskell's view is not transfer but simply applying the same learning. He also noted that what is near transfer to an expert may be far transfer to a novice due to the learner's knowledge base.

Types of Transfer

In order to understand something, it is important to know where it belongs in a larger scheme and to become familiar with its parts. Knowing what kind of tools are available for a particular job allows a person to select the best tool for the job, and provides a framework to come up with a plan for how to best accomplish the job. Understanding not just the levels of transfer of learning, but the types of transfer of learning, allows researchers and practitioners to recognize how, when, and where transfer occurs. There are two basic categories transfer can be classified into: a) the type of knowledge the transfer is based on and b) the specific types of transfer. These are described in more detail in the subsequent sections.

Knowledge Types

Haskell (2001) used his understanding of different types of knowledge to elaborate and explain each knowledge type as it related to transferring learning. He described the five knowledge types, procedural, strategic, conditional, theoretical, and declarative by drawing on Singley and Anderson's (1989) research of the cognitive processes of procedural knowledge. Haskell (2001) emphasized that the knowledge base a person possesses was important. He contended that a large knowledge base, with all five knowledge types increases the likelihood of transfer of learning.

Procedural knowledge is how to knowledge; it is important because even if a person can identify a BMW vehicle it does not mean they know how to drive one. Strategic knowledge deals with knowledge of a person's mental processes, such as how they learn and remember. This is the knowledge that helps in the self-monitoring of a person's progress in the act of learning. Conditional knowledge is the knowledge of when to apply knowledge in context-appropriate ways; people do not behave the same way in all situations. Theoretical knowledge is the understanding of deep level relationships, of cause and effect, and other clarifying links about phenomena. Declarative knowledge, knowledge of or about something, provides the prerequisites necessary for the other four kinds of knowledge and it often includes or directs the other four. Declarative knowledge can frequently provide a general framework for assimilating more detailed new knowledge, and often provides useful mental models to help in the understanding of new knowledge. Haskell (2001) stated that declarative knowledge was the most crucial for transfer.

Specific Types

If the specific types of transfer are identified, Haskell (2001) posited that users of the taxonomy could recognize when, how, and where transfer occurs. Content-to-content, procedural-to-procedural, declarative-to-procedural transfer, strategic transfer, general or nonspecific transfer, literal transfer, and relational transfer are ways to specifically recognize how transfer occurs. None of the types of transfer are necessarily mutually exclusive. The fourteen types are shown in Table 1.

Table 1

Haskell's Types of Transfer

Type	Define – Identifiers	Haskell's Examples
Content-to-content	Making use of what we know in one subject area to the learning of another subject area	Knowledge about proteins, fats, and carbohydrates from chemistry being useful in health education
Procedural-to-procedural	Using procedures learned in one skill area in another skill area	Skills used in riding a bicycle transferring to driving a motorcycle or a car; operating similar software programs on a computer
Declarative-to-procedural	Learning about something helps in actually doing something	Knowledge about corporate stocks enables us to more proficiently play the stock market
Procedural-to-declarative	Practical experience in an area helps us to learn more abstract knowledge of the area	Knowledge of programming may help in learning computer theory; practical experience and constructing electronic circuits helps in learning theoretical knowledge of electronics
Strategic	When knowledge about our mental processes, such as how we learn or remember, is expanded by monitoring our mental activities during learning; we are aware of our learning	How we solve one problem may transfer to the solving of another problem.
Conditional	Knowing when to apply the knowledge learned in one context may be appropriate for transferring it to another context.	Area of a rectangle learned in Math class – tiles needed in a kitchen floor
Theoretical	Understanding deep level relationships of cause and effect in one area that can be transferred to another	Recognizing that a spark and lightning are the same; combustion and rusting are the same; inverse square law applies to planets and the tides

(table continues)

Table 1 (*cont.*)

Type	Define – Identifiers	Haskell's Examples
General or nonspecific	When previous knowledge that is not specific to the situation transfers to other situations, even with no apparent similarities between the old and new situations	General – "learning to learn" and "warm-up effects" nonspecific – knowledge about proteins, fats, and carbohydrates from chemistry being useful in health education
Literal	Using knowledge or a procedure directly in a new learning situation	Studying different wars and analyzing each for similar causes; near transfer
Vertical	Prior learning transferred to new learning that is higher in a knowledge hierarchy	To calculate percentages knowledge of division and multiplication must be known
Lateral	When previous learning is transfer to the same level in a hierarchy	Roller skating skills transferred to ice-skating
Reverse	Prior (existing) knowledge is modified and re-viewed in terms of its similarities to the new information	
Proportional	Abstract structure between two items	Recognizing a melody played in a different octave or key
Relational	Illustrated by mathematical analogies; seeing the same/similar structure between two things	Seeing the similarity between the wing of a bird and the fin of a fish; both share similar structure, no underlying causal relationship

Content-to-content transfer was described by Haskell (2001) as declarative knowledge, and this declarative-to-declarative transfer occurs whenever existing knowledge of some content area interferes with simple learning. Declarative or content knowledge helps with taking new concepts and integrating them into a learner's current knowledge, and assists the learner with a general framework for a second content area. In strategic transfer, knowledge of how one problem was solved can transfer to the solving of another problem. A learner familiar with this type of transfer can help themselves monitor their mental activities during learning, and be able to express what steps they used in the new problem. Using procedural-to-procedural transfer, also known as skill-to-skill transfer, viewing procedures learned in one skill area and transferring the procedures to another skill area would demonstrate how and when learners would transfer.

Conditional transfer and procedural-to-declarative knowledge transfer define when transfer occurs by knowing when knowledge learned and applied in one context is appropriate for transferring into another context. If a learner has knowledge of computer programming it may help in learning computer theory. If learners can have deep level relationships of cause and effect in one area to be transferred to another, the ability of theoretical transfer, vertical transfer, lateral transfer, and proportional transfer are all abstract types of transfer and identify where transfer takes place. Learners would need to have a deep level understanding of knowledge content in order to recognize when to place new learning higher in a knowledge hierarchy or at the same level in the hierarchy.

Assumptions

Haskell (2001) theorized that for significant learning and transfer to occur the eleven principles of transfer must be developed in the learner within the instructional models employed in the learning environment. Based on the practices conducted in a PBL learning environment, for the purposes of this study, Haskell's (2001) eleven principles were used as assumed priorities for transfer to occur. It was assumed that if the principles were addressed in the instructional plan, higher levels and types of transfer would have been observed in the PBL learning environment.

Principles:

1. Acquire a large primary knowledge base in the area which transfer is required.
2. Acquire some level of knowledge base in subjects outside the primary area.
3. Understand the history in the area(s) that transfer is wanted.
4. Acquire motivation, or more specifically, a "spirit of transfer".
5. Understand what transfer of learning is and how it works.
6. Develop an orientation to think and encode learning in transfer terms.
7. Create cultures of transfer or support systems.
8. Understand the theory underlying the area (s) in which we want to transfer.
9. Engage in hours of practice and drill.
10. Allow time for learning to incubate.
11. Observe and read the works of people who are exemplars and masters of transfer thinking (pp. 45-46).

At the time of the study, it was unknown which principles were applied in the PBL elementary classrooms where the study occurred.

Limitations

There were limitations to the study. The study was conducted at an elementary school, so results could not be generalizable to other project-based learning environments. The population studied was a population of convenience, and not a random population. The noise level in the study environment was a factor in capturing dialogue from students.

Definition of Terms

Application transfer: Application transfer refers to applying what a person has learned to specific situations.

Conditional knowledge: The knowledge of when to apply our knowledge in context-appropriate ways (our behavior is different in different situations).

Conditional transfer: Conditional transfer occurs by knowing when knowledge learned and applied in one context is appropriate for transferring to another context.

Context transfer: Context transfer refers to the application of what a person has learned in a slightly different situation.

Declarative knowledge: The knowledge of or about something.

Deductive coding: Using other sources such as theory or prior research in the coding of data in a study.

Knowledge base: The quantity of knowledge a person possesses and the way it is organized. This includes knowledge acquired by reading, personal experience, careful listening, perceptive observation, and a person's thinking. When a person thinks, their knowledge base is increased.

Literal transfer: Literal transfer uses knowledge or a procedure directly in a new learning situation.

Near transfer: Near transfer refers to when previous knowledge is transferred to new situations that are very similar but not identical to previous situations.

Nonspecific transfer: Nonspecific transfer has connections to past and present learning and is a component of everyday learning.

Procedural knowledge: The knowledge of how-to do something.

Project-based learning (PBL): An instructional method designed to engage learners in meaningful, real-world, 21st century authentic applications of content and skills where learners collaborate with others to complete a project. General, variously named steps are followed, and a creation of a product or performance is included in project-based learning.

Problem-based learning: An instructional method designed to engage learners in meaningful, real-world, 21st century authentic applications of content and skills where learners collaborate with others to solve an "ill-structured problem". Problem-based learning follows formally observed procedures and more specific, traditionally prescribed steps, than in project-based learning.

Scaffolding: The process in which the instructor provides support to the learner for tasks, then gradually removes the assistance, allowing the learner to work independently.

Self-directed learning: A broad concept including a process in which individuals take the initiative, with or without the help of others, and diagnose their learning needs, formulate learning goals, identify all resources needed for learning, choose and implement appropriate learning strategies and evaluate their learning outcomes.

Self-regulated learning: An active, constructive process whereby learners set goals for their learning and attempt to monitor, regulate and control their cognition, motivation, and behavior, while being guided and limited by their goals and contextual features on the environment.

Strategic knowledge: The knowledge of how we learn and remember; it is the self-monitoring of our progress in the act of learning.

Significance

Project-based learning (PBL) environments have been studied, including focus on student learning, student roles, student behaviors, technology use, and the nature of the problems and products provided in the focus for PBL. If PBL is to move forward and help students' self-direct learning, then attention to transfer of learning needs to be addressed. The research of K-8 students and their ability to transfer what was learned from one context to another may increase the value of teaching in a PBL environment.

CHAPTER 2

RELATED LITERATURE

Origins of Transfer of Learning

A critical assumption motivating instruction is what students learn at one time and place and availability for use at another time and another place (Larsen-Freeman, 2013). In other words, students should be able to transfer what they have learned. This assumption is the basis for all education and learning transfer, also called transfer of learning, transfer of training and transfer of practice, has been the focus of much research for well over a century (E. L. Thorndike & Woodworth, 1901), and continues to inspire even more research in this area (Lobato, 2006). Transfer theory came from an empiricist view where the learner was a passive agent and learning depended on the similarity between past and present situations (Carraher & Schliemann, 2002).

Thorndike and Woodworth (1901) tested the doctrine of “formal discipline” that was prevalent at the turn of the 20th century. According to the doctrine, learning Latin and other difficult subjects had broad-based effects that developed general skills of learning and attention. Rather than developing a type of general skill, Thorndike proposed people seem to learn things that were more specific. Thorndike and Woodworth presented their hypothesis of “identical elements” and viewed identical elements as objective, physical features common to situations. When a student had a similar response between stimuli it indicated learning was conceived. Thorndike (1913), hypothesized that the degree of transfer between initial and later learning depended upon the match between elements across the two events. The crucial elements were presumed to be specific facts and skills; therefore, the skill of writing letters of the alphabet was useful to writing words (vertical transfer). The theory theorized that transfer from one school task and a highly similar task (near transfer), and from school subjects to non-school situations (far transfer), could be assisted by teaching knowledge and skills in school subjects that have elements identical to activities encountered in the transfer situation (Klausmeier, 1985). Thorndike's work exhibited even when learners do well on a test of specific content practiced, learners will not necessarily transfer that learning to a new situation (Bransford & Schwartz, 1999). Most researchers had no contradiction of Thorndike's theories and assumptions and many studies were just a replication of other work (Detterman, 1993).

Other researchers relaxed the requirement of surface similarity, instead focusing on structural or conceptual similarities across tasks. Charles Judd's (1908) research suggested that transfer not only occurs on the basis of identical elements, but also by understanding the abstract general principle underlying a specific phenomenon. A general principle can be transferred to different particular events making this type of transfer more of an abstract rather than a concrete set of elements (Carraher & Schliemann, 2002; Haskell, 2001; Judd, 1908). Judd's experiments with learning to throw darts underwater revealed mimicking a set of fixed procedures was not enough, but learning with understanding was important (Bransford & Schwartz, 1999). Judd proposed transfer was determined by the scope to which the learner was aware of underlying shared deep structure (Lobato, 2006). Another isolated voice of dissent to the identical elements transfer theory was the Gestaltists. They agreed with the dominance of structural similarity (i.e., meaningful understanding) over common surface features (Hanfmann, 1946; Katona, 1940).

In the case of transfer, for most of the 20th century, there were not many challenges to the early 1900s mainstream thought process concerned with how transfer occurred. Lobato (2006) stated the dissatisfaction as “classical transfer perspective gained momentum in the 1980s and the 1990s, when researchers began questioning the conceptualization of transfer by bringing to bear the assumptions about knowing, knowers, learning, and context from the theoretical perspective of situated cognition” (p.434).

Lave (1988) contributed to transfer’s growing body of research by focusing on the individual learner and how they learned. Using an “ethnographic” exercise, Lave examined four well known papers describing thirteen learning transfer experiments. The experiments were conducted by Reed, Ernst, and Banerji (1974) – who carried out research on river crossing problems; Hayes and Simon (1977) - on a version of the Tower of Hanoi; Gick and Holyoak (1980) on Duncker’s “radiation problem” (1945); and Gentner (1983) on models of simple electrical circuits. The experiments were conducted in laboratories with high school and college students as subjects and consisted of sequences of puzzle solving tasks. These experiments used analogical problem solving to identify transfer to a new situation. Underlying analogical transfer, several mechanisms are used in analogical problem-solving (Gick & Holyoak, 1983). Reasoning by analogy implies a comparison of two concepts at the same level of abstraction (i.e., the heart and a water pump). “The essence of analogical thinking is the transfer of knowledge from one situation to another by a process of mapping - finding a set of one-to-one correspondences (often incomplete) between aspects of one body of information and aspects of another” (Gick & Holyoak, 1983, p. 2).

A specific example of analogical problem solving included when Reed et al. (1974) studied the role of analogy and transfer between problems with similar problem conditions. The analysis began with the missionary and cannibal problem – subjects were to show all permissible moves for transporting pairs of people across a river in such a way that cannibals do not outnumber the missionaries on either bank. This problem was paired with another similar problem "the jealous husbands" in which each husband-and-wife pair had a unique identity. Reed et al. compared the solution time, number of moves, and number of erroneous moves for each pair of problem solving attempts looking for a statistically significant improvement. The main conclusions for this experiment included that when the subjects were not told about the relationships between the problems they failed to transfer. In addition, there was only transfer from the more complex to the simpler problem when the subjects were directed to do so.

Researchers from a classical transfer perspective typically gave participants a sequence of tasks that share some structural features (i.e., a common solution approach or shared principle) but have different surface forms (i.e., different word problem contexts), according to the researcher's (or other expert's) knowledge of the topic. Learners are then taught a solution strategy, principle, or procedure with the initial learning task; if the learners perform better on the transfer task than does a control group (who receives the transfer task but no learning tasks), positive transfer is said to have occurred. When performance improves, the researcher infers that students have generalized some aspect of the learning experience to the transfer tasks. Several researchers critiqued the classical transfer approach and were able to note greater levels of transfer by: (a) moving away from one-trial learning situations to ensuring learners had the opportunity to understand a procedure, principle, or theory deeply enough to apply it later in learning (Mayer, 1999); (b) moving from the use of learning transfer tasks that share only structural features to including tasks that also share common surface features (Novick, 1988); and (c) moving away from using independent problem-solving as a test of transfer to using group assessments where learners can utilize resources and gather additional information (Fortus, Krajcik, Dershimer, Marx, & Mamlok-Naaman, 2005).

Lobato (2003) shifted from a traditional (classical) view of transfer to an alternate approach. She conducted a design experiment to help high school algebra students develop an understanding of slope and linear functions. The initial learning tasks scored high involving the slope of objects encountered in the experimental curriculum such as staircases and lines, however, poor transfer occurred to novel tasks such as finding the slope of slides and roofs. Lobato reanalyzed the data from the experiment and stated the definition of transfer was “the personal creation of relations of similarity, or how the single ‘actors’ see situations as similar” (p. 18). She shifted from an observer’s (expert’s) point of view to an actor’s (learner’s) viewpoint by seeking to understand the process by which individuals generate their own similarities between problems. By switching to the actor-oriented transfer model an ethnographic method examined how people appear to understand situations as similar, rather than relying upon statistical measures based on improved performance. For example, Lobato and Siebert (2002) performed two analyses on a case study – one from a classical transfer perspective and one from an actor-oriented perspective. The classical analysis demonstrated failure to transfer the slope formula, but the actor-oriented analysis documented considerable ways in which the student’s reasoning in the transfer situation was influenced by learning experiences from the teaching experiment. Lobato (2006) summed up the two approaches as follows: “transfer from the classical approach is the application from one setting to another of a predetermined set of knowledge from the researcher's or expert's point of view; transfer from the actor-oriented perspective is the influence of learner's prior activities on their activity and novel situations which entails any of the ways in which learning generalizes" (p. 437).

Research on transfer of learning was guided by theorists who emphasized the similarity between the conditions of learning and the conditions of transfer. Bransford, Brown, and Cocking (2000) listed key characteristics of learning and transfer that have important implications for education:

- Initial learning is necessary for transfer, and a considerable amount is known about the kinds of learning experiences that support transfer.
- Knowledge that is overly contextualized can reduce transfer; abstract representations of knowledge can help promote transfer.
- Transfer is best viewed as an active, dynamic process rather than a passive end product of a particular set of learning experiences.
- All new learning involves transfer based on previous learning, and this fact has important implications for the design of instruction that helps students learn. (p.53)

Transfer of Learning Empirical Studies

Transfer of learning has been studied in many environments including business (Baldwin & Ford, 1988; Blume, Ford, Baldwin & Huang, 2010; Hornik & Ruf, 1997), undergraduate college courses (Dinsmore, Baggetta, Doyle, & Loughlin, 2014.; VanderStoep & Seifert, 1993), professional development training of teachers (Sowards, 2000; Moyer, 2014), and K—12 schools (Carraher& Schliemann, 2002; Engle, 2006; Wittrock & Cook, 1975). Transfer of training was analyzed in several meta-analysis by Baldwin and Ford (1988) and Blume et al. (2010) from an organizational context exploring impact of predictive factors (e.g., trainee characteristics, work environment, training interventions) on the transfer of training to different tasks and contexts.

Transfer learning was researched by studying preservice and in-service teachers' ability to transfer learning from college career courses or professional development situations and apply what was learned back to the classroom (Carter, 2008; Mejia , 2011; Moyer, 2014; Sowards, 2000). These dissertation and thesis studies of transfer of learning demonstrated that most teachers successfully transferred content and skills learned in these environments into actual classrooms.

For many years, the study in transfer of learning was frustrating when studies were conducted where participants were given situations totally unrelated to their current problem (Carraher & Schliemann, 2002). Researchers unconsciously put on blinders when looking for evidence of transfer. For instance, when participants were unable to make use of information about infantry attacks to formulate a medical procedure for destroying a tumor, Duncker (1945) concluded they did not exhibit transfer. His results did not actually show that participants' answers were unrelated to their prior knowledge and experience. The results showed that the participants did not elicit the same results from the particular learning situation given to them that Duncker hoped. The failure to transfer was the result of the researchers' tunnel vision.

Transfer has been studied in the K-12 environment for many years. Wittrock and Cook (1975) studied three hundred thirty six Los Angeles public elementary school children from three inner-city schools and were individually, randomly assigned to six treatments and individually taught and tested. The results of the study indicated transfer depended upon the similarity between the students' previous learning in the experiment and successive instruction. Serpell, Boykin, Madhere, and Nasim (2006) studied African-American and White fourth grade students in a communal learning context (social bonds and responsibilities surpass individual privileges) to see if transfer was present. Several aspects of transfer were studied in their experiment including: (a) to see if students in a communal condition would demonstrate more transfer than students in a control condition, (b) if the communal context would yield better transfer outcomes for African-American students than for White students, and (c) would the tools used in the communal context affect transfer outcomes. In other words, if students use a tool that aids greater social engagement (physical apparatus), would more transfer occur than a tool that facilitated less social engagement (computer simulation). The transfer task was an open-ended problem-solving task that allowed students to transfer knowledge and skills gained from participation in the communal workgroup condition to a paper-and-pencil task. The calculations between the initial task and the transfer task on the paper-and-pencil tests were how of the amount of transfer was determined. The study yielded better transfer outcomes for African-Americans than their White counterparts, and work with physical apparatus yielded better transfer outcomes than work with computer simulations. Serpell et al. (2006) hypothesized that research in this area could be important to help student's ability to gather knowledge and skills that are transferable to different subject domains, and possibly, transfer to real-life problems outside of school.

Engle (2006) used the situated approach as a theoretical framework to explain transfer. He believed the analyses of both content and context were needed to determine whether transfer had occurred or not. He and a team of researchers observed, videotaped, collected student work, and wrote field notes about how fifth grade students learned and then transferred a more sophisticated way of explaining special survival and endangerment to others from a fostering communities of learners (FCL) literacy and environmental science unit. The students were from a socioeconomically and racially diverse school in the San Francisco Bay Area, and FCL units were designed to foster transfer of learning. The fifth-grade elementary school classrooms in the study used “research groups” of four or five students who conducted scholarly research to prepare a report about an animal group from their endangered species unit. The groups were facilitated by the teacher, student teachers, or classroom volunteers and students shared their research finding with others studying the same sub-topic in breakout groups. Students/learners went on field trips, consulted outside experts, and were required to display their research findings to a variety of audiences in a variety of formats. These classrooms appeared to have a potential for growth due to the fact the students regularly talked with each other allowing the researchers to trace their learning during the unit. The researchers analyzed how students participated in constructing content they would be presenting to others and concluded that if students are able to see themselves as contributing members of a larger community of people interested in what they are learning about, the students should be able to transfer easily what they initially learned. The context learning structures and learner’s participation in them can be framed as ongoing activities rather than as sequential limited events. If learning contexts are framed as a part of larger ongoing activities in which students are integral participants, (all other things being equal) transfer is more likely to occur. Engle (2006) hypothesized that an environment designed to enhance transfer would give students an understanding that what they were doing was a part of a larger intellectual conversation over time.

Other empirical studies conducted with transfer include problem solving practice and analogical thinking. The problem-solving practice was researched in transfer of learning as individual problem solving performance on a real world deceleration task (Serpell et al., 2006), and analogical problem-solving in learners ages five to seven (Tunteler & Resing, 2007). Analogical thinking is the transfer of knowledge from a learned situation to an unlearned situation through a process of mapping (Gick & Holyoak, 1983). Tunteler and Resing (2007) conducted a study on children's analogical problem solving that focused on effects of one single session of assistance in the use of analogies to solve problems on children's unprompted use of analogy use over a period of weeks. Researchers gave 15 problem analogies made up of 15 base story problems with accompanying pictures and 15 target problems with accompanying target objects to 108 children in three elementary schools from middle-sized towns in the Netherlands. The problems and tasks required of the students for the sessions were age appropriate and carefully similar in structure, that is, the same actions were needed for the solution to the task or problem. Tunteler and Resing (2007) concluded that kindergarten and first grade learners retained the use of analogical problem-solving strategies for several weeks as long as these learners were allowed to practice with a variety of problems of the same type. Hornik and Ruf (1997) concluded transfer was enhanced in learning systems incorporating analogical learning techniques with an explanation, as compared to a system that just provides explanations to novices, and companies providing training in this manner could maintain high quality audits while keeping costs down.

Lee and Tsai (2004) conducted a study in an Internet project-based learning (NetPBL) environment to research and examine the effects of thinking styles on learning transfer. They established an environment incorporating project-based learning and the Internet with elementary school students. The students' thinking styles served as the independent variable.

Students were divided into the executive group, legislative group, judicial group, and mixed group; the mixed group consisted of the thinking styles of the former three groups. The students were randomly divided in to one of the above-mentioned groups, and they did all their learning in the NetPBL environment. The study found there were: significant differences in near transfer between two of the groups, there was no significant difference in far transfer among groups of different thinking styles, one group had superior near transfer compared to two of the other groups, and far transfer of one group was superior to that of another group. A generalized conclusion from the study by Lee and Tsai (2004), was educators need to understand their students' thinking styles when assembling cooperative learning groups. Diverse thinking styles in these groups allow the students to deliver their best results.

Project-Based Learning Overview

Project-based learning is an instructional method designed to use authentic, "real-world" projects, based on challenging questions, tasks, or problems, involving students in design, problem solving, decision making, or investigative activities (Thomas, 2000). In describing project-based learning as motivational, Blumenfeld et al. (1991) described the framework as learners "pursuing solutions to nontrivial problems by asking and refining questions, debating ideas, making predictions, designing plans and/or experiments, collecting and analyzing data, drawing conclusions, communicating their ideas and findings to others, asking new questions, and creating artifacts" (p. 371). Projects are designed to respond to the interests and needs of learners, explore core concepts of a discipline, build on learners' passions and strengths, and engage students in meaningful learning (Lattimer & Riordan, 2011). Project-based learning is filled with active and engaged learning and inspires students to acquire a deeper knowledge of subjects or topics studied (Edutopia, 2008).

Project-based learning (PBL) means learning through experience where knowledge is acquired naturally, evolving from the learner's participation with daily life situations and helps learners with skills such as data collection, coordination, peer discussion, and information analysis (Hou, 2010). William Kilpatrick (1918), first used the term "project method," and started with the idea of a purposeful activity taking place in a social environment, and then gave it the term "project." Kilpatrick (1921) understood the term project to refer to any unit of purposeful experience where the purpose a) fixes the aim of the action, b) guides its process, and c) furnishes an inner motivation for the learner.

Since the inception of project-based learning, proponents have been challenged to clearly articulate the goals of PBL as the instructional format relates to students/learners. Grant (2011) included elements for project-based learning as: (a) an introduction, anchor, or mission; (b) definition of the learning task; (c) method for investigation; (d) proposed resources; (e) scaffolding tools; (f) collaborations; and (g) reflections and transfer activities. The critical components of a PBL model emphasize a driving question or problem, and the production of one or more artifacts as representations of learning that addresses the driving question (Blumenfeld et al., 1991; Papanikolaou & Boubouka, 2010). Responsibility of the question and activities can be by the students, as well as the creation of the products. In addition, teachers or curriculum developers can create driving questions and activities, but the questions cannot be so constricted as to have the outcomes predetermined. Students' freedom to create artifacts/products is critical, as the creating helps acquire and apply their knowledge

(Blumenfeld et al., 1991). In addition, a project can have a broad scope and may include several problems, while the central focus of the assignment and the completion of the project requires previously acquired knowledge (Bell, Galilea, & Tolouei, 2010; Prince & Felder, 2006).

Problem-Based Learning vs. Project-Based Learning

Problem-based learning is often confused with project-based learning as both use the same acronym – PBL. Hmelo-Silver (2004) described the design of problem-based learning as helping students: “(a) construct an extensive and flexible knowledge base; (b) develop effective problem-solving skills; (c) develop self-directed, lifelong learning skills; (d) become effective collaborators; and (e) become intrinsically motivated to learn” (p. 240). In problem-based learning the focus is on learners as constructors of their own knowledge using ill-structured, authentic problems as the focus for acquiring knowledge and reasoning strategies in a social environment (Hmelo-Silver, 2004; Savery & Duffy, 2001).

In a problem-based learning environment learners are actively engaged in working at tasks and activities which are authentic to the environment in which they would be used (Savery & Duffy, 2001). Constructing an extensive and flexible knowledge base goes beyond having students learn the facts of a domain. It involves integrating information across multiple domains (Hmelo-Silver, 2004). The learning is synthesized and organized in the context of the problem, while in other problem approaches such as project-based learning, the learning objectives and resources are presented, and the learner’s understanding is tested (Savery & Duffy, 2001).

There are a few differences between problem - and project -based learning. For example, Hmelo-Silver (2004) described the collaboration process in problem-based learning as a negotiation of ideas, but by an individual bringing new knowledge to the group for application to the problem. Collaborative groups are important because a learner, working individually, can discuss their understanding and examine others interpretation, allowing for enrichment, interweaving, and expanding of the learner's understanding of particular issues or phenomena (Savery & Duffy, 2001). In project-based learning the collaboration process is the negotiation of ideas with peers and local community members (Hmelo-Silver, 2004). In project-based learning students work together to discuss material with each other, share goals and outcomes beneficial to the entire group, and have individual performance checked regularly to ensure all students are contributing to the group and learning the content, reflecting what Johnson and Johnson (1999) defined as a cooperative learning group.

Other differences between problem- and project-based learning include the type and role of the problem and the problem-solving process (Hmelo-Silver, 2004). In problem-based learning, the learners define the problem to address real issues and are open to explore all dimensions of the problem (Savery & Duffy, 2001). Students should be able to access, study, and integrate information from all the disciplines that might be related to understanding and resolving a specific problem (Savery, 2006). The learners have ownership of the problem as well as the learning or problem solving process and facilitation is focused on metacognitive processes; it is not driven by acquiring existing knowledge and is focused on knowledge construction. In a project-based learning environment the learner may define the problem, but the process to solve the problem may be controlled by the practitioner or curriculum developer (Blumenfeld et al., 1991). If a practitioner gives ownership of the problem to the learner, but dictates the process for working on the problem, that may dictate a particular problem-solving strategy or critical thinking methodology be used, or that particular content domains must be learned (Savery & Duffy, 2001). Unlike project-based learning, problem-based learning never presents a problem with learning objectives and assigned readings related to the problem. If that were done, the learner would be told what to study and what to learn in relation to the problem (Savery & Duffy, 2001). In problem-based learning, the learner should be in control of the problem and their own problem-solving process as part of a group process of social knowledge construction.

Both problem- and project-based learning have differences in how each are implemented and the role of the teacher/practitioner. Problem-based learning requires the acquisition of new knowledge by using complex, ill-structured, open-ended real world problems in a social environment (Savery & Duffy, 2001) and the solution may be less important than the knowledge gained in achieving it (Prince & Felder, 2006). Project-based learning requires a problem, task, or artifact be created by the learner with the learner provided with specifications for a desired end product and the learning process is more oriented to following correct procedures (Savery, 2006). The learner creates a driving question and takes knowledge learned about the question and applies that knowledge to the construction of the problem, task, or artifact.

The practitioner/teacher role in problem-based learning is one in which they act as facilitators who provide materials, support learner cognitions, and only intervene based on the need to make sure students approach the problem correctly. They also act to challenge students' assumptions or mental models, and spur reflections on what has been learned, helping foster group dynamics by conducting a debriefing at the conclusion and evaluating the viability of the group solution (Papinczak, Tunny, & Young, 2009; Savery, 2006). The facilitator's role is complex, because any intervention is based on each unique group and their chosen approach. In project-based instruction, teachers are more likely to be instructors and coaches providing expert guidance, feedback and suggestions to achieve the final product that fits within predetermined parameters. With projects, teaching is provided to the learner when needed by modeling, scaffolding, and questioning within the context of the project. To summarize the difference, Prince and Felder (2006) concluded problem-based learning stresses the process of constructing or obtaining knowledge while project-based learning emphasizes applying or integrating knowledge.

Research in Project-Based Learning

Because the pedagogical approach employed in the setting for this study was determined to be predominantly project-based learning, the studies examined in the remainder of the chapter are from that perspective. For example, Thomas (2000) reviewed the research in project-based learning (PBL) from the 1990s and concluded that most research had taken place in the latter years of the decade, and as the body of PBL research was small, the review was inclusive rather than selective. Research has increased in project-based learning environments and is more extensive and includes student attitudes and motivation, behavioral patterns, project assessment, collaboration, technology use, self-direction, and scaffolding of learners (Bell, Galilea, & Tolouei, 2010; Grant, 2011; Hansen, 2004; Hernandez-Ramos & De La Paz, 2009; Hou, 2010; Hung, Chee, Hedberg, & Seng, 2005; Lee & Tsai, 2004; Papanikolaou & Boubouka, 2010; van Rooij, 2009).

Students in project-based learning environments need to be motivated, engaged, collaborate with peers, and have a positive attitude about creating a project. Engineering students in a three-semester case study tested a model of assessment during five assessment periods (Hansen, 2004). Prior to the study, the instructor asked the questions during the project assessment which was contradictory to the project-organized problem-based learning curriculum, as students were encouraged to learn through a process where they write the questions and find their own answers. During the study, the students were required to ask and answer questions during the project assessment with the instructor/assessor asking questions only if the students were obviously lacking essential understanding of their own project. As a result, the students reported they were more motivated as they learned how to reflect on their own learning process and how to take responsibility for their own learning. A Civil and Environmental Engineering degree program initiated courses using project-based learning to assist in making knowledge gained from the courses closer to a professional reality (Bell, Galilea, & Tolouei, 2010). The old and new curriculum were taught simultaneously, and projects included in the new curriculum were complex and relevant to the engineering professional environment. A student questionnaire was administered after the first two years evaluating the old and new curricula. Students reported higher motivation and perceived better generic skills development.

Studies in the K-8 environment included student collaboration and student perspectives and attitudes. A first-grade veteran teacher collaboratively negotiated a project with students while, at the same time, addressed grade-level standards (Mitchell, Foulger, Wetzel, & Rathkey, 2009). The single-case study observed how the teacher involved students in the planning, implementation, and evaluation of their own learning. The three researchers investigated the teacher's strategies for integrating the district's standards into project topics, investigative activities, and final presentations. The results included a negotiated planning between and among students and the teacher, where students planned, self-monitored and celebrated their learning with the teacher, as well as having the project incorporate the student's interests.

A middle school study contrasting content knowledge tests, group projects, and attitude and opinion surveys determined benefits for students in a technology assisted project-based learning experience and a traditional school environment (Hernandez-Ramos & De La Paz, 2009). There were two schools from the same district involved in the study, one integrated technology-assisted PBL, the other school was not influenced by the PBL method. The school district had an adequate infrastructure to support the use of technology. The students completed a six-week unit on westward expansion. Results from the opinion survey, to gauge the emotional and affective impact of different modes of instruction, indicated most students from the school using PBL had positive views about learning history and social studies and working with others as compared to the students in the comparison group. The PBL students also agreed the project helped their learning, they enjoyed working on it, and they felt they could apply skills learned to future projects.

Grant (2011) studied many aspects of project-based learning including student perspectives by exploring how learners created projects in an eighth grade geography class. The ten-week unit on human rights selected five students for a detailed exploration of the PBL approach by creating computer-mediated learning artifacts. Throughout the unit students used a WebQuest site, an inquiry-oriented lesson format in which most or all the information that learners work with comes from the web, co-created by the teacher and the researcher with specific sites listed for student research. The researcher reported learning outcomes and learning products were more complex than just the artifacts produced. The participants' internal and external influences, their beliefs about projects, and their uses of technology tools directly impacted their learning outcomes and learning products. The results for the student participants was while project-based learning allowed the participants choice, challenge and control of content, resources and types of artifacts, the participants relied on the teacher to guide their learning. The participants were accustomed to primarily didactic teaching and learning experiences, so the quality and expectations for self-direction and self-regulation required in the project were difficult. To aid the students in self-regulation, Grant (2011) suggested a digital scaffold to be developed with the course content. Students noted the project was too long and they were "burnt out" on the topic. The author concluded the eighth grade participants' inexperience with project-based learning may have forced the teacher to be more involved with the content and planned more items in the project, which in turn could have been reflected in the students' artifacts.

The theme of scaffolding, providing structures and frameworks to support the learning process and students' performances beyond what is currently possible, was addressed in several studies (Hung, Chee, Hedberg, & Seng, 2005; van Rooij, 2009; Wilhelm, Sherrod, & Walters, 2008) and mentioned in other articles on project-based learning (English & Kitsantas, 2013; Pritchard & Cartwright, 2004; Thomas, 2000). Van Rooij (2009) defined scaffolding as the process in which the instructor provides support to the learner for tasks, then gradually removes the assistance, allowing the learner to work independently. A scaffold adopted to the level of the learner ensures success at a task difficult for the learner to do on his or her own (Hung et al, 2005).

Hung et al. (2005) described scaffolding as a framework along a simulation, participation, and codetermined interactions continuum, and only through these models of learning could a student be brought through the scaffold process. The concept of scaffolding facilitates the learner, within a community context, from a novice, to an observer, then a participant, and finally to an active contributor in a project. The study involved a group of heads of Information and Communications Technology (ICT) who were scaffold through an experiential workshop to achieve learning outcomes such as ICT-based project work (as product) and other dispositions of learning. The framework was sufficiently broad so that the learners were supported through the continuum of frameworks. The learners agreed there was sufficient support for the creation of an authentic project with the tools and support presented throughout the process. The authors' conclusion was the simulation, participation, and codetermined interactions continuum framework could prepare learners for more challenging interactions in their future professional lives.

Van Rooij (2009) sought to understand which processes and procedures from the discipline of project management could scaffold online project-based learning in a graduate-level instructional technology course. Two sections, comprised of fourteen participants of the same course, were involved in the quasi-experimental design study. One section used project management as scaffolding to facilitate student interaction and promote successful and timely completion of the project with instructor-provided tips and best practices. The other section, the control group, used only the instructor-provided tips and best practices that are normally used for the course project. One outcome from the participants using the project management methodology was the efficiency of the team collaboration postings in the virtual environment. Participants were less frustrated and confused by postings using this method, as the messages were viewed as clear, concise communication between team members. The results of the study concluded the project management methodology versus traditional project scaffolding was not a critical factor in producing high-quality product outcomes or a positive overall project experience. The author stated one reason for the results could have been the relatively small number of learners in the two course sections. Another explanation could have been that both groups were comprised of adult professionals intent on producing a quality product.

Wilhelm, Sherrod, and Walters (2008) conducted a semester-long design study with twenty-four preservice teachers in their mathematics and science methods courses as they participated in project work. Six groups' project work were examined by how preservice teachers applied mathematics needed to accomplish project tasks in an astronomical context. The participants contemplated mathematics and science involved in understanding the moon and its phases. The authors used scaffolding benchmark lessons to bridge many contexts between the phases of the Moon and the concepts in the methods courses. Some benchmarks were pre-planned in the project while others were just-in-time lessons when groups experienced difficulties applying basic mathematics such as scaling, ratios, and sine curves. The authors concluded mathematics understanding can be significantly developed when mathematics is contextualized within the discipline of science and situated within a project-based environment. Instrumental features of the study were the scaffolding benchmark lessons, and the just-in-time benchmarks lessons to facilitate progress in the project.

A prominent feature in project-based learning research has focused on the learner's proficiency in self-regulated learning (SRL) and self-directed learning (SDL) during a project. Many researchers used the definition from Knowles (1975) that stated self-directed learning describes a process "in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implement appropriate learning strategies, and evaluating learning outcomes" (p. 18). Saks and Leijen (2014) conducted a study to explore the similarities and differences between the terms and their usage. Both SRL and SDL incorporate active participation and goal-directed behavior, contain internal and external factors, and are key components of both metacognitive skills and intrinsic motivation. Self-regulated learning originated in cognitive and educational psychology and was studied mostly in school environments. SRL was perceived as the student's independence in learning and the tasks were usually set by the teacher. Self-directed learning originated from adult education and practiced mainly outside a traditional school environment. SDL is treated as a broad concept and involves designing and learning, therefore students plan their own learning and trajectory. SDL may include SRL, but not vice versa. In other words, a self-directed learner is presumed to self-regulate, but a self-regulated learner may not self-direct.

In the articles regarding project-based learning, the authors used either self-directed learning or self-regulated learning. The definitions given by the authors were not consistent, so the discussion to follow will give the name the author placed in their research. Two studies previously mentioned (Grant, 2011; Hansen, 2004) included self-directed learning or self-regulated learning as it related to their studies. During the model of assessment study, Hansen

(2004) noted self-regulation was the unintended influence of an assessment on a student's study behavior where students reflected on their own learning process and took responsibility for their own learning. In Grant's (2011) study the scaffolding of the calendar provided to help to the students monitor progress, might have denied students' negotiations with self-direction.

Raidal and Volet (2009) viewed self-directed learning as a highly desirable goal of professional education because it is directly relevant to a student's future professional career and is a requirement for continuous learning after graduation. The mixed methods approach study of two groups of second year veterinary science students (128) investigated pre-clinical students' predispositions of self-directed and social forms of learning. One group [TRAD] progressed as previous students in the program, through the traditional, science-based course work with more external, teacher regulated, and individual forms of learning. Instruction during the study involved didactic methods, with no clinical exposure. The other group [ALT] progressed through the program using a different course structure – along with a didactic format, clinical placements and the development of clinical competencies were embedded in the course structure from the beginning. During the study students tended to have resentment or frustration with self-directed learning activities due to the heavy workload and prior educational experience. Some students found the self-directed forms of learning unsettling due to the amount and complexity of the information to be mastered. The results of the study concluded that both groups, TRAD and ALT, despite the differences in the programs, had a strong preference for external, teacher regulation and individual forms of learning. The students' preferences were linked to several factors: prior educational experience using didactic methods, volume of information in the degree program, and students' perceptions that their lives are externally controlled in the degree program.

In a K-8 environment Riesenmy, Mitchell, Hudgins, and Ebel (1991) conducted a study with 68 students from 10 fourth and fifth grade classrooms. Thirty-eight students were trained through twelve small-group discussions and four "thinking roles" – task definer, strategist, monitor, and challenger. The experiment was designed to determine whether the trained students retained and transferred their "self-directed critical thinking skills" better than 28 control students from the same school district, who were given no small-group discussions or the thinking roles. The authors concluded the trained students surpassed the control group of students for the use of self-directed critical thinking skills. When the students were instructed in the roles of self-directed critical thinking over the course of the twelve small group discussions, they applied the thinking roles effectively (compared to the untrained students) up to eight weeks after the end of their training.

Student interest can increase when projects are created because they involve students solving authentic problems, working with a team, and building real solutions (products/artifacts). From creating projects there is the potential to enhance deep understanding because students need to acquire and apply information, concepts, and principles. PBL is a natural environment conducive to the skills attained in a positive transfer of learning environment. However, there have not been many studies in transfer learning in a PBL K-8 setting.

Summary

In chapter 2, the history of transfer was examined to outline how transfer was studied in the same manner for approximately a century, and how a new approach of examining transfer was needed. Transfer has been studied in different environments and by different topics, but a comprehensive and universal measure of transfer will be essential in future research. The measure would be Haskell's level of transfer and type of transfer. Project-based learning (PBL) is a viable method of instruction and has been researched using many different topics. In this chapter, project-based learning was defined and discussed noting that many positive outcomes for learners such as critical thinking, problem solving, creativity, peer collaboration and communication skills are prominent in this method of instruction. Transfer of the student's learning should be another positive outcome for PBL, but there was no research in a PBL environment with transfer of learning. By unveiling the gap in the literature of empirical studies using Haskell's theory of transfer of learning showing the level and type of transfer in a PBL environment, this study would add to the literature.

CHAPTER 3

METHODOLOGY

Purpose of Study

The purpose of this study was to investigate levels and types of transfer observed in K-8 school students during science and across multiple subjects in a project-based learning (PBL) environment.

Research Questions

1. What levels of transfer of learning were observed in an elementary school project-based learning environment?
2. What types of transfer of learning were observed in an elementary school project-based learning environment?
3. Across which learning environments was transfer observed?

Design

The design of the study was a multiple case study involving three classrooms. The use of a multiple case study enabled a rich and detailed study of this particular phenomenon of project-based learning in a specific location where the boundaries between the phenomenon and context were not clearly evident (Stewart, 2011) and the phenomenon is within its real-world context (Creswell, 2007). Each classroom project served as a case. The design of this study used a variety of data sources to ensure the issue was not explored through one lens, but a variety of lenses which allowed for multiple facets of the phenomenon, transfer of learning, to be revealed and understood (Baxter & Jack, 2008).

Setting

The setting of the study was a North Texas K- 8 STEM (science, technology, engineering, mathematics) academy in second, fourth, and sixth grade science classrooms. The school was built with an open concept design. The areas of the school were designated as houses or pods (see Figure 1) with all of sixth grade located in one pod/house, and second and fourth grade sharing a pod with another grade level.

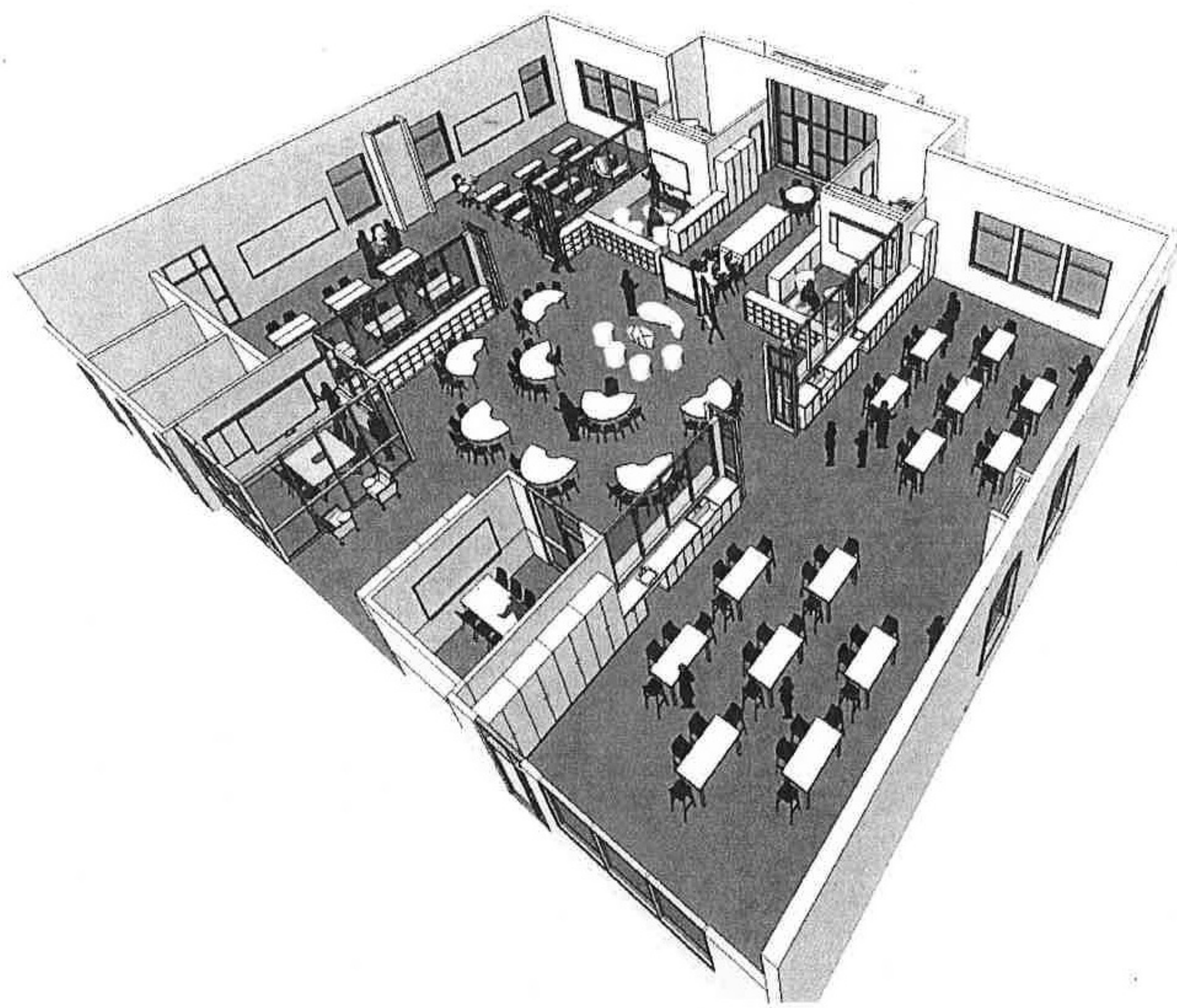


Figure 1. Learning pods/houses at the K-8 school.

Instead of solid, opaque walls there were glass wall dividers within each pod. There were five distinct areas for classrooms to conduct learning with groups around tables and chairs, and some pods/houses contained separate desks pushed together to form groups.

Each pod/house contained a central learning area that was used for class purposes or for groupings from the other four classroom areas. At the front of this area, toward other areas of the campus, were two glassed in rooms, with one room generally used by the teachers as a workroom/student testing room, and the second room contained table and chairs where teachers could conduct small group instruction. These areas were enclosed with a door so the teacher could keep the noise level to a minimum in the smaller room, while being able to monitor the larger area outside the small group instruction area. At the back of this area were two open corner areas with 3 ½ foot walls. These areas contained mounted TV monitors on the walls where the teacher's laptop could connect to the monitor for presentations and lessons. Between the two corner areas was a 10-foot-long, 3 ½ foot tall counter where the science experiments were conducted or grade level animals and reptiles were kept. There was a sink with a water fountain in the back area of the pod along with two restrooms for the students, therefore students did not need to leave the house area and go into the main hall. There was an interactive touch screen collaborative system that could be used by either teacher in the middle section of the pod/house.

On one side of the pod/house there were two closed-in glass carpeted classrooms. Between the two classrooms was a retractable white board wall. The rooms contained round tables with chairs. The entire wall opposite from the glass wall was covered with white board material and it had an interactive short throw data projector pointed to this wall. The teacher's laptop was connected to the device for teaching purposes. The entire wall could be written on with dry erase markers, or the teacher could use large Post-it notes on this wall during daily activities.

On the opposite side of the pod/house the classrooms had tiled flooring with a sink in the room and one glass wall that looked out onto the middle open section of the pod/house. The room had a retractable dividing wall which when not retracted served as a whiteboard for the two classrooms. Opposite the wall where the sink was located there was an interactive short throw data projector pointed to a whiteboard wall, and the projector was connected to the teacher's laptop computer for teaching purposes. These rooms contained rectangular tables with five to six chairs per table.

The school district maintains five elementary schools, one sixth grade center, one middle school, and one high school campus in addition to the K-8 STEM academy. The project-based learning method was implemented in ninth grade at the high school at the same time as the K-8 academy in order for students from the K-8 school to continue with this method of instruction after leaving the academy.

Population

There were 390 students in Grades K-5 and 335 students in Grades 6-8. The ethnic diversity of the school for 2015- 2016 school year was 12% African-American, 18.7% Hispanic, 56.83% White, with American Indian, Asian, -Pacific Islander, and two or more races at 12%. The school had approximately 23% economically disadvantaged students. The percentage of English language learners (ELL) was approximately 9%.

For the 2014-2015 accountability ratings, the K-8 academy performed above performance index target scores set by the state. The campus achieved the accountability rating *met standards on all four performance indexes: student achievement, student progress, closing performance gaps, and postsecondary readiness*. The K-8 academy received the only district distinction earned for the Top 25% Closing Performance Gaps. The Top 25% Closing Performance Gaps emphasizes advanced academic achievement of economically disadvantaged students and the two lowest performing race/ethnicity student groups.

Comparison of Engage!® Model and the K-8 PBL study

The subject curriculum at the K-8 STEM academy was bundled for district standards into units (approximately nine weeks). The teachers followed the district prescribed units' timeline. The academy purchased and used the Engage Learning Inc., Engage2Learn, or Engage!® (https://engage2learn.org) project-based learning model in all content areas on the campus. The Engage2Learn model and the online resources offered are designed to be collaborative, problem-solving, and learning is based on design thinking used throughout the business world. This model uses technology tools to actively engage students in mastering the Texas Essential Knowledge and Skills (TEKS) as the teacher leads, designs, facilitates, and provides direct instruction. The Engage!® PBL model emphasizes the process more than the final product.

Engage!® provides a learning model that includes five steps in PBL planning and implementation: launch/team, plan, research/work, create/critique, and share, with each step defining what the teacher and the students must do. The specific model and steps of Engage Learning Inc. are defined in detail in Appendix A. The following is a synopsis of the steps in the model and as observed in the nine case studies.

Step 1– Launch/Team: Engage!®

In the first phase, launch, PBL teachers give the hook, the challenge brief, and the rubric. The Engage!® model named the first step in launch the hook and it introduces and generates students' interest in the project. Some examples of a hook can include a video segment presenting a problem, presentations from outside community members, or a relevant YouTube video. The second phase of the launch, the challenge brief, includes the problem to solve and all project requirements needed to complete the project. It is a general description of why the project is needed and what specific student created items or steps are required for completion. The third phase in the launch is the rubric. The assessment rubric is a scoring guide listing specific criteria for the student's work on a project. The teacher establishes indicators about the level of detail necessary for the project solution and/or creation. The rubric is not the only evaluation tool used during a project, but the rubric is given to the students at the beginning of the project to guide students through the project and help them to self-evaluate their work during the work completion process.

In the second stage of Step 1 - team, the students create a team name, agree on roles, establish norms, sign a team contract, and check off, with the teacher, the completion of this stage. The students either pick their team members or are assigned members to their team by the teacher. As a group, the team members decide on a name for the team. Many times, the names are relevant to the topic of the project. For example, when working on a weather forecast video, a team name could be Cloudy Cocoa Puffs.

The roles on the team are generally set up to accommodate four members and include a team leader, resource manager, time keeper, and a communication manager. If the group contains more or less members, adjustments to the roles are made. The team leader is a motivator who keeps the group on task, assures work is done by all, and manages the project. The team leader facilitates the team as they establish norms for working, makes sure the group understands and follows the rubric, and keeps members on task (including themselves). The resource manager gets necessary supplies and materials for the team and makes sure the team cleans up its area at the end of the work time on the project. In addition, the resource manager requests workshops, instruction from the teacher about unclear project topics, as needed by the group. The time keeper keeps the team focused on daily tasks and on any assignments due during the project. The time keeper works to keep the team discussing the matter at hand and monitors if anyone is talking outside of the team. The communication manager serves as a liaison with the teacher when she/he has additional information to share with the class, and, as appropriate, shares the team's results with the class. In some activities, a communication manager makes sure that each team member understands what information to record personally. Communication managers may also take responsibility for organizing their team members' contributions as they prepare presentations.

The norms are established by the team once the roles have been decided. Norms are ways students work together to help teams be more thoughtful and more productive. Effective teams define and are committed to norms that guide how the team operates. It is the responsibility of the entire team to make sure the norms are respected. Teams meet and define the norms before any work on the project starts. After all norms are agreed upon, the team signs the contract. The signing of the contract is important as it informs all members of the team of the behavioral and project work expectations. When all the above steps are complete, the communications manager “posts a check mark” indicating the team is ready to proceed to step two. Engage! ® provides an online learning environment, eStudio, where all the actions in Step 1 can be completed.

Step 1– Launch/Team: PBL

The teachers in the nine studies followed the launch/team step very closely. All projects were launched with an item to interest the students, listed project requirements, and students were provided an assessment rubric or a list of how the final project was graded. The teacher created the team name, but the students could change the name if it applied to what was being studied. Establishing roles and norms in second grade took up to two days for some projects. The second grade teachers helped the teams create positive norms, so instead of stating, “No arguing,” the teacher suggested, “Listen to everyone’s ideas.” The fourth and sixth graders accomplished assigning the roles and creating the norms within thirty to forty-five minutes. The contracts for the teams were “signed” in eStudio for the fourth and sixth grade. The second graders used the sheet with the written norms to sign their names.

Step 2 – Plan: Engage!®

In the second step, plan, there are many steps to complete. The teacher may or may not give a pre-assessment at the beginning of this step. The team leader facilitates the team in analyzing the challenge to solve in the challenge brief. The team identifies the project requirements and records a project plan. Then the driving question and audience are identified by the team and recorded on the project plan. Next, the team analyzes the rubric and establishes the team goal for the project. The team goal allows the team to decide what grade the final project will earn. The team comes up with what is known about the information on the challenge brief and what is needed to know to accomplish the project goals. Engage!® named this activity in the model “Know/N2K.” The team adds resources to the need to know list based on the need to know list, and if given, any pre-assessment. The team creates research questions and then a research task list using all the above. A project calendar is set up for progress checks throughout the project. The resource manager requests any workshops needed for the team. Individual team members create a to-do-list based on the team tasks and, if given, outside assignments. When this step is complete, the communications manager posts a check mark in eStudio.

Step 2 Plan: PBL

In general, the plan step was followed by the teachers in the case studies. A paper or electronic project calendar was used for fourth and sixth grade. eStudio has a calendar the sixth grade teacher used, and the fourth grade teacher used a paper calendar, the Google calendar, and eStudio’s calendar. The second graders’ calendar (projects due dates, only a few days out) was listed on a whiteboard. Teachers collaborated with the teams in analyzing the challenge, identifying the project requirements, and analyzing the rubric instead of being accomplished solely by the teams. Teachers allowed teams to establish the team’s goals for the projects, make the teams know/need to know list, and create the team’s research questions.

Many times, after the teams created their research questions, the entire class listed each teams’ questions, and identified from all the questions, a single list of research questions for everyone to research. Other times, teachers provided the list of research questions. The resources for the second and fourth graders were provided by the teacher in order to reduce time spent on searching for websites, or with using ineffective information resources. The sixth grade teacher provided some resources, but allowed students to find other resources independently. The teacher discussed how to tell if a source was accurate, and told the students to look at three different websites to see if the information was the same. If it was not the same, then the students had to find at least three websites containing the same information about a research topic.

Step 3 – Research/Work: Engage!®

The third step was research/work and Engage! ® defines many responsibilities for the team members. In the beginning of this step the project leader facilitates a daily opening huddle. This brings the team together, has members check their to-do-list, and report what tasks are completed. The time keeper informs the team of any upcoming progress checks. If needed, the team adjusts the task list and adds any new need to knows, resources, or research questions. The resource manager attends any workshops from the teacher, or sends a member of the team. The team members report any research findings and record a research summary. The resource manager shares information from the workshop with the team. The project leader facilitates a daily closing huddle and adjustments are made to the task list. The closing huddle brings the team together and wraps up the team's progress for the day.

Step 3 – Research/Work: PBL

In the nine case studies, the research section of the project generally took from one week to several weeks. This was partially due to the students' need to learn how to do research. The teachers spent time guiding students on research techniques: finding websites, what to look for on a website, and how to stay focused on the research question. The teams assigned research questions to group members. This was easily accomplished for fourth and sixth grade in eStudio where the team and the teacher viewed who was responsible for research on a specific question. Second graders listed on paper the research questions and completed answers below the question. The teachers checked the team's answers to the research questions, and if needed, after giving suggestions, sent the teams back to research the questions again. During this step, there were many individual and team activities completed and turned in for a grade, and in this step, students received most of their project grades.

When the teacher provided a small group workshop, one individual from each team met with the teacher and learned the information, then returned to their group and shared/taught the information to the members. The teachers kept the to-do-lists up to date, conducted progress checks, and let the class know when assignments were due, instead of leaving it up to the teams, or one member of the team. Each grade level varied regarding teacher input on managing research. Sixth graders had a to-do-list and the teacher checked the list to verify it was up to date with the individual's tasks. It was not observed if the fourth graders had an individual to-do-list. The second grade teachers maintained a list on the whiteboard. Team huddles facilitated by the team leader were not observed in the case studies, but teachers had the class get together daily and update her where each team was in the project, what the teams had researched and activities the team had completed.

Step 4 – Create/Critique: Engage®!

Step 4 was the create/critique step where the plan for the project is created and critiqued for improvements to the project, which occurs in two stages. The first stage in the create/critique step is to look at the team plan and adjust it as needed. The second stage involves feedback from peers, the teacher, and if available, even the audience who will view the final project/presentation. It is more difficult, logistically, for the critique to come from an outside classroom or community audience. As a project progresses and more team-based activities are developed in a project the students want to improve their project. The critique from peers could be from team members or other students outside the team in the classroom. When peers critique the project the teacher needs to be cognizant that students need to acquire the specific skills necessary for effective peer evaluations. The teacher gives critiques and help throughout the project. After a team's project critiques, the team refines the project and completes a presentation proposal. The communication manager schedules a final critique with the team members and the teacher to gain approval for the product/presentation to move to the final step.

Step 4 – Create/Critique: PBL

The case studies followed the create/critique step in most of the projects, but Stage 1, Phases a through g in the Engage!® model (see Appendix A) were not observed in the case studies. After the research was completed on the projects many teams would adjust their projects to meet items discovered during the research step. Teachers visited with each team to assure the teams were meeting the requirements for the project, and checked to determine if students were understanding the Texas Essential Knowledge and Skills (TEKS) being addressed in the projects.

Many times, the team members critiqued their own project, with the teacher modeling how to give positive and negative feedback. This entailed indicating words like stupid or dumb were not allowed as feedback. Students were taught how to provide constructive, negative feedback by stating how the project did not meet the assessment rubric or requirements outlined. Giving positive feedback was easier for the students because they could state what they liked about the project, or how the project met the outlined requirements, or assessment rubric. After the project critique was completed, the teams changed and/or refined their projects, with the teacher giving the final approval for the project to continue to Step 5.

Step 5 – Share: Engage!®

For sharing the project findings, Engage!® recommends sharing the project findings with various audiences, with varying foci. If the audience is composed of students the focus is listening attentively and/or taking notes on the presentation. If the audience is from outside the campus, a rubric is recommended to give community members a tool to evaluate the project. The team leader introduces the team, and different team members share overviews of the project challenges, the success criteria, procedures, and constraints of the project. Team members designate the member responsible for each overview. The team presents the project solution, which could be a presentation, model, diagram, video, etc. and reflects on the project and process. The audience asks clarifying questions, and then reflects on the group's solution.

Step 5 – Share: PBL

The team projects in the case studies were shared by map overlays, brochures, PowerPoint and Google slide presentations, scale models of outdoor learning centers, videos, many types of models, e-books, amusement parks, living museums, flip books, and dioramas. The team leader introduced the team and the team members gave the overview on their section of the project. All team members reflected on the team's project and answered questions posed by the audience. There was one case study that did not complete a PBL unit due to a time constraint, but the projects were started.

Engage! Model Compared to Project- and Problem-Based Learning

The study was conducted at a campus using the Engage!® model and stating the learning environment was project-based learning. The Engage!® model contains components of both project-based learning and problem-based learning containing a blending or mixing of the two learning environments. In the five different protocols the steps can be divided between project- and problem-based learning (see Table 2). When observed, the teachers in the study were using a blended model.

The premise of project-based learning is assigning a project to be evaluated, through specific criteria or assessment rubric, where the learning process is more oriented to following correct procedures. The teacher engages with students, as a facilitator or coach, providing feedback and suggestions to achieve the final product. In problem-based learning the learner confronts an ill-structured problem and is in control of what is studied and obtains the resources to answer the problem. The teacher engages with students, as a tutor, if there is a need to be sure the students are approaching the problem correctly and to challenge the students' assumptions. The Engage!® model has elements of both project- and problem-based learning within the five protocols. This creates a blended model making it more difficult to assess whether transfer is occurring in a project-based learning environment. The data in the study was evaluated through the Engage!® model.

Table 2

Engage!® Learning Model Protocols - Division between Project- and Problem-Based Learning

Engage!® Learning Model	Project-based Learning	Problem-based Learning
Launch/Team Hook, Challenge Brief, Assessment Rubric; create team name; agree on roles; Project leader facilitates team norms; sign contract	Hook Challenge Brief (Project requirements) Assessment Rubric	Presenting a problem (if there is a need to learn)
Plan Project leader facilitates team in analyzing challenge; Team identifies driving question, audience, project requirements; Problem analysis – knows/need to knows; Resources added by team; Team creates research questions; Individuals create to-do-list	Driving question Project requirements	Identifying audience Analysis of problem Some resources from individuals
Research/work Project leader facilitates daily opening huddle; Team checks off and reports completion of tasks; Team adds new resources and research questions; Team member attends workshops given by teacher; Project leader facilitates daily closing huddle; Team members report research findings; Team member shares information from workshop with team	Team checks off and reports completion of tasks Team member attends workshops given by teacher Team member shares information from workshop with team	Team adds new resources and research questions Team members report research findings
Create/critique Critique or feedback from peers, teacher, real audience; Steps to include in critique process	Critique from teacher Steps to include in critique process	Feedback from peers on individual work
Share Audience expectations set by facilitator; Team members share: project challenge, success criteria, procedure and constraints; Team presents and reflects on solution; Audience asks clarifying questions, then reflects on solution	Project challenge Success criteria Procedure and constraints Team presents a project	Team presents and reflects on solution Procedure and constraints

Case Settings and Project Descriptions

Case Study 1, Second Grade, "Holidays Around the World"

Setting

The second grade math/social studies teacher introduced a social studies project entitled “Holidays Around the World.” The environment where the students were working on the social studies project was the open area of the pod/house (see Figure 1). A third grade class was on one side of the open area, and the second grade social studies/math class was on the other side of the open area. Individual desks were pushed together to make long tables so the students could sit in groups/teams of three or four. There was a rolling cart with thirty iPads for second grade student use during the project. The teacher allowed students to meet around the classroom open area and an open area just outside of the pod/house where students were always in view of the teacher. There were two classrooms in this open area, so the noise level was a little loud, but the second grade students appeared to adapt very well.

Project Description

In the three week “Holidays Around the World” project second graders identified the significance of various ethnic and/or cultural celebrations. The project outcome, a living museum exhibit showcased a celebration from another part of the globe, and told why holidays and festivals were an important part of cultures. The second grade teams, created by the teacher, were assigned one country per team for the project. At Stage 1, launch/team, the hook used was a video of different celebrations around the world. The teacher discussed what students viewed in the video to promote interest in the project. The project requirements, written by the teacher for the project included the name of the celebration, clothing, customs, food, a map, and the team members explaining their living museum to the audience. The students maintained project paperwork, research, and documents in a PBL group folder.

At the launch/team stage, teams completed a contract that included the project title, the team name, the team members and roles, and the team norms. Students filled in the team name and team members rather quickly. The social studies teacher reviewed the roles expected in a PBL group, and after much group discussion, the teams decided on the roles. Students were unclear about how a norm was worded, so the teacher gave an example of what a team norm should look like (norms were stated in a positive, rather than a negative way). Launching the project to signing the contract took about a week.

The planning phase began after the contract was signed, and the groups listed in two columns what they knew and did not know about holidays around the world. Students consulted the project requirements and added to the list of what they knew and did not know from re-reading the project requirements. The teacher provided a list of research questions (see Appendix B.1) to each team compiled from the groups' team plans of what the group knew and needed to know about holidays around the world.

During the research/work stage, starting the PBL time each day the teacher brought the whole class together, discussed what the group should do that day, handed out the team folders, and answered large group questions. The major source students received the information during their research was on the internet using the iPads. Students had a difficult time narrowing down which websites to read, and which websites to ignore. The teacher went group to group and helped the teams decide on good websites to use. The research phase of the project was approximately five to seven class days with the create phase taking two to three class days.

The teacher had trouble during the creating of the museum presentations/exhibits. The researcher observed no student or teacher plan during this stage. When the teacher inquired about the groups' plan for their presentations, all the groups' answers dealt with completing items at home. The critique of the final project during this stage, by the teacher or peers, was not observed. No feedback was observed during the stage of creating the students' living museum exhibit. During the share/presentation stage all second graders placed their exhibit on desks which were viewed by the entire third grade. The third graders went from exhibit to exhibit asking questions about the cultural celebrations presented. The researcher went from group to group asking and recording the interview questions.

Case Study 2, Second Grade, "Text Features"

Setting

The second grade language arts teacher introduced a language arts project entitled "Fiction Vs. Nonfiction Reading – Do you know how to read it?" and referred to the project as the "Text Features" PBL. The environment where the students were working on the language arts project was one of the closed-in glass classrooms with carpet in the pod/house (see Figure 1). There were six large circular tables in the room with four to five chairs around each table, and the project teams consisted of three to four members. In one corner of the room was a place on the floor for a large carpet, and the squares in the carpet contained the letters of the alphabet. When the teacher called students to the carpet, they knew to sit in one of the squares "crisscross applesauce." In another corner of the room was a half-moon shaped table where the teacher could have four to five students gather and she would work with them. The classroom had a rolling cart station containing thirty iPads for students' use during language arts time.

Project Description

The purpose of the "Text Features"project was for the second graders to help the school's student population achieve greater success by knowing how to use nonfiction text and using the most effective technique. The students created a guide or a manual for all campus students to help them decide if a book would fit their purpose for reading by creating a visual display (book, poster, PowerPoint, app presentation) or dramatization for campus students to use.

The launch of the project started with the school's principal coming in and discussing what was needed at the school to help students decide which book would fit their purpose for reading. In the team phase of step 1- launch/team, the language arts teacher provided the project requirements and a team contract for the students to complete. The teacher gave the teams an assessment rubric so the team could decide their final project score, and track their progress for the duration of the project. The assigning of team roles and deciding on the team norms took two days. The project requirements were given in a PBL notebook folder to each team so the students could keep all paperwork, research, and documents together in one place.

During the planning stage, the students listed in two columns what they knew and needed to know about text features and included what was needed to know from the project requirements. The research questions came from this list and after viewing the teams' list, the teacher posted a class list of questions on a Post-it note on the front board. The planning of the project took the second graders approximately three days.

Before the teams' research time, the teacher brought the entire class to the carpet daily to review what they should have accomplished in the preceding PBL session and what they would need to accomplish during the current PBL time. The teacher worked individually with each team during class time, and the individual teamwork ranged from the teacher demonstrating what collaboration looked like, showing how groups should sit together and collaborate, to where answers could be located for their research questions. During the seven days of researching the project, the teacher supplied the groups with many pages of examples and definitions of different text features, see examples in Appendix B.2 and B.3. The teacher used EdMoto, a computer application, to post questions to the class and had each team assign a different member to answer the questions posted using the team's iPad. The students completed individual and group assignments to help learn about text features (see Appendix B.4). The teacher prepared a text features game to solidify students' knowledge with the text features they were incorporating into their projects. The students used the class set of iPads to take a quiz about text features.

The teams worked on creating projects for four class periods during the create/critique step. The students discussed with the teacher the options for the final product – book, movie, play, etc. The students were given three days to create their projects, but after four days most were not finished and the teacher decided no more time was available for the completion of the project. No critiquing of the projects, by teacher or peers, was observed. Before moving to the next topic in language arts, the teacher reviewed what was learned during the project with the whole class. This was the only case study that did not produce a final product. This case study worked on the Text Features project for five weeks, but did not have daily PBL time due to testing conflicts, a field trip, and teacher professional development days.

Case Study 3, Second Grade, "Traits and Adaptations"

Setting

All three second grade teachers, math/social studies, language arts, and science, participated in the last project of the school year, “Traits and Adaptations.” The traits and adaptations project started in the science classroom and had a tiled floor with a sink in the room and one glass wall that looks out onto the middle open section of the pod/house (see Figure 1). When working in the science classroom on their projects, one classroom of students sat at rectangular tables with six chairs at each table. The math/social studies teacher used middle area of the pod/house described in case study one, and the language arts teacher used the classroom described in case study two.

Project Description

The purpose of this four-week project was to create a fictitious plant or animal species, explain its habitat, life cycle, dietary needs, and include at least three traits or adaptations to help it meet a basic need in the environment.

For the launch of this project a Texas Wildlife Association (TWA) representative gave a 45 minute presentation to all second grade students in the science classroom. There was a table set up at the front of the room where students could see different animal skins, skulls, and a set of antlers attached to a skull. The TWA representative gave descriptions of the objects and had students complete an activity using the presented information. The team phase of Step 1 – Launch\Team took Day 2 of the Traits and Adaptations unit. To establish teams for the unit, the second grade teachers divided the entire second grade into “coaching” classrooms. The students were mixed with other students outside their normal homeroom classmates, and these “coaching” classrooms worked together for the PBL time during the day, while the rest of the time they were with their set homeroom class of students. From the “coaching” classrooms, the teachers assigned the teams, and students picked the group name, defined the job roles, set up the team norms, and signed the team contract in one day. The teachers discussed the requirements for the project, and reviewed a teacher provided vocabulary list (see Appendix B.5) with all students.

During the plan stage, the student teams reviewed the vocabulary list, the project requirements, and listed what they knew and did not know about traits and adaptations. The entire second grade came together and wrote research questions for the project (see Appendix B.6). The teachers helped drive the time for the planning of the project, and it took one day to complete. During the six days of the research step students watched videos, researched with iPads, and completed activities/research specific tasks produced by the teachers to help answer questions about the traits and adaptations of animals and plants (see Appendix B.7).

The creating and critiquing of the fictitious plant or animal was the longest step in the project that encompassed eleven days. Students wrote paragraphs, made models, drew habitats and planned how to present their plant/animal to the other students in second grade. There was no critiquing of the projects by peers observed, but as teachers went group to group suggestions were given to the groups. After four weeks of work, the animals and plants were presented/shared to the other “coaching” groups as the final presentation. Using a rotation schedule, all groups presented in one day.

Case Study 4, Fourth Grade, “Weather Forecast”

Setting

The fourth grade science teacher introduced a science project entitled “Weather Patterns and Forecasting the Weather” but was referred to as the “Weather Forecast” PBL. The environment where the students worked on the project was the science classroom that had a tiled floor with a sink in the room and one glass wall that looked out onto the middle open section of the pod/house (see Figure 1). For this project the students chose their own grouping of three or four. When working on their projects, students sat at rectangular tables with three or four chairs at each table. Each student in the fourth grade was issued a Chromebook (laptop) at the beginning of the school year, and the computer traveled with them from subject to subject. The laptops were used for entering information into eStudio and researching information in the projects.

Project Description

The purpose of this three-week project was to create a video of a weather forecast to present on the school morning announcements to help students in the school decide what to wear to school the next day. The project was accomplished by completing a weather log with one week’s worth of data and from that data give a forecast of the next week’s weather, describe and illustrate the continuous movement of water above and on the surface of the earth through the water cycle, and explain the role of the sun as a major source of energy in this process.

The launch of the project was a video forecast of the day’s weather from a local meteorologist. The requirements for the project, written by the teacher, were given to each group and a green notebook folder was used by each team to facilitate maintenance of all paperwork, research, and documents. The teacher demonstrated to all students how to use the Google calendar to set up important dates. In the team phase of Step 1- Launch/Team, the teams were set up in eStudio, the online Engage Learning Inc. website, where students entered the team name, team members, team norms, signed the contract after agreeing to the norms.

In the plan step the teams listed, in eStudio, what they did and did not know about weather forecasting. The teacher created research questions (see Appendix B.8) which were placed in the green PBL notebooks and also entered into eStudio by each team. After the list of research questions in the PBL notebooks, there were divided sections with each section containing a research question, the information about that question, and the sources students cited. The teacher provided a list of resources (see Appendix B.9) for students, thereby eliminating a general web search for information needed to answer their research questions. Launching the project, setting up the teams, and planning took three days.

During the research step of the project, the teacher conducted small group workshops for weather vocabulary and large group instruction for weather symbols. Students used online weather forecasts to create the weather log required by the project requirements, and completed activities to aid in answering the research questions. All through the eight days of research and three days creating the weather videos, students watched the local forecast daily. The students created the props and wrote the script/narration for the weather videos. Team members critiqued each other's scripts and offered suggestions if needed. After the team edited the script, the teacher critiqued the narration, and if needed, sent the teams back to change and refine the script. When the teacher approved the written scripts, the teams started recording the weather forecast. iPads were used to record the forecast videos and the files were uploaded to a free web video creation site where students could add music, title slides, and a credit role at the end of the video. The videos were shared with the entire class in one day and the teacher evaluated the final project.

Students used eStudio for the planning and research stages of the project. The teacher used a combination of hard copies in a folder and electronic copies online for the project. eStudio housed resources for the project and gave students access to work on projects as a group. eStudio was introduced to the students one section at a time over the course of two projects. This allowed the teacher and students to move many of the paper documents and check off items to an online environment.

Case Study 5, Fourth Grade, "Food Chains and Food Webs"

Setting

The fourth grade science teacher introduced a science project entitled "Food Chains and Food Webs." The environment where the fourth grade students were working on the two projects was the center area of the pod/house (see Figure 1). This area contained individual desks for students, and the desks were placed into groups of four or five depending on the project. Fourth grade was on one side of the open area with fifth-grade science on the other side. Student laptops were used for entering information into eStudio and researching information in the projects.

Project Description

The purpose of this three-week project was to help the builders of the school's outdoor learning environment include the appropriate plants and other animal friendly products in the plans. The project combined both fourth and fifth grade science students into teams of three to five varied grade level members. The fourth/fifth grade teams were to create a local ecosystem for the school's outdoor learning environment.

The launch for the project was a cartoon video of building a food web in the Savanah. The students discussed with the teacher the project requirements and the assessment rubric. For the team step, the teams filled in team name, team roles, team norms, and signed the contract in eStudio. To start the planning step of the process, the students elicited from the project requirements the driving question, the focus for the entire project, with the help of the teachers. After identifying the driving question, the groups set the team goals. Students reviewed the teacher generated research questions (see Appendix B.10), and in eStudio listed what they knew and needed to know about food webs/ecosystems using the project requirements and the driving question. Each team used eStudio to enter the research questions and specific questions were assigned to group members. Each team member was responsible for researching the assigned questions and reporting the results back to the team.

Research for the project took seven days. The fourth and fifth grade teachers conducted small and large group workshops as needed, and created activities for students to complete individually or with team members. The teachers did knowledge checks with individual team members and asked for definitions of terms, what happened if something was taken out or added to an ecosystem, and descriptions of several of the cycles researched in the project. Many students were sent back to research what was missing from their knowledge check.

Students took five days to create the food web/ecosystem project. All teams went through a critique from teachers and peers four days before the final projects were presented.

The students gave their response to the projects based on what was listed in the project requirements. Teams missing requirements and/or positive feedback were notified with the information immediately after the presentation. The groups fine-tuned their projects after the critique, assuring readiness for presentation. Students presented the ecosystems in one day to the entire class and answered questions.

Case Study 6, Fourth Grade, “Life Cycles”

Setting

The fourth grade science teacher introduced a science project entitled “Life Cycles.” The environment where the fourth grade students were working on the two projects was the center area of the pod/house (see Figure 1). This area contained individual desks for students, and the desks were placed into groups of four or five depending on the project. Fourth grade was on one side of the open area with fifth grade science on the other side. Student laptops were used for entering information into eStudio and researching information in the projects.

Project Description

The purpose of this three-week project was to write an e-book about different life cycles to share with a younger student. The e-book requirement included one animal, one insect, and one plant life cycle with illustrations hand-drawn/computer-generated, or a 3D model constructed and photographed. Students had the option of creating one e-book with all three life cycles or three separate books for each different life cycle. The project was recorded in the online environment, eStudio. An online pre-assessment (see Appendix B.11) was given prior to the start of the project to help students construct what they knew and did not know about the different life cycles referred to in the project requirements.

The launch of the project included a video on life cycles. For the team step, the students entered in eStudio the team name, team roles, team norms, and signed the team contract after agreeing to the norms. The teacher posted an assessment rubric in eStudio so the teams could decide their final project score, and track their progress for the duration of the project. During the planning stage, the teams picked out the driving question, the focus for the entire project, and set the team's goal. Students referred to the project requirements and their pre-assessment test to list what they knew and what they needed to know about life cycles for their project. The research questions, given to the teams as a hard copy, were generated by the teacher. The teams then assigned questions to team members who entered questions into eStudio. The launch, setting up the teams, and planning for the project were accomplished in two days.

The seven days of research included activities (see Appendix B.12, B.13) and experiments in plant life cycles, observations of the life cycle of the mealworm, observations of a live butterfly garden, educational videos about plant, animal, and insect life cycles, and researching the assigned questions by team members. The three days of creating and critiquing the e-books was assisted by the fifth grade science students editing and revising the e-book stories created by the fourth grade students. The fifth grade teacher gave the fourth graders a sheet on editing and revising (see Appendix B.14) and explained what the students needed to complete before the fifth graders read drafts of the stories. The fourth grade team took the editing and revising information from the fifth-graders, updated e-books and decided what illustrations to place in the book. This was the only formal critiquing of the project, but as the teacher met with individual groups, she offered suggestions if needed. The e-books were shared with the class via a projection screen and then "given" to the younger grade levels.

Case Study 7, Sixth Grade, “The Heat Is On”

Setting

The sixth grade science and social studies teachers introduced a science/social studies project entitled “The Heat Is On.” All sixth grade students were issued Chromebooks at the beginning of the school year, which students carried to each class. The laptops were used for entering information into eStudio and researching information for the projects. The environment where the sixth grade students worked on the two projects was the center area of the pod/house (see Figure 1). This area contained nine round tables with four to five students at each table. Between the two corner areas was a 10-foot-long, 3 ½ foot tall counter where science demonstrations and experiments were performed. In front of the counter and in front of the two corner areas, desks were set up and a total of sixteen computers were in this common area.

Project Description

The purpose of this four week project was to create a brochure and a Google slide presentation proposing the teams’ ideas and goals for counteracting global warming. The project encompassed both social studies and science concepts, and the students were given both science and social studies class time to work on the project both individually and collectively as a group. The teacher created teams of four to five members met once daily. Students met as a team during one class period and worked on the project individually during the second class period.

The project was launched with a video about COP21 (Conference of Parties) and the students took notes. The Conference of Parties is an international political response to climate change with many countries attending the conference. The number 21 refers to how many conventions have taken place since 1995. During the team step, team names, assigned by the teacher, came from some of the country participants attending the COP21 conference. A country assigned to a team was the focus of the team's ideas and goals for counteracting global warming. The research of the team name/country assigned was the subject of the brochure and slide show presentation. The teams completed the team roles, team norms, signed the contract, reviewed the project requirements and assessment rubric in one to two days. During the planning stage, the research questions, listed on the project requirement sheet, were assigned by the teachers and the team members divided up the questions. Using a PBL notebook supplied by the teacher, the students kept up with the hard copies of the project requirements, assessment rubric, and reference material handouts. Students used personal science and social studies notebooks for individual assignments and activities. The whiteboard in the center area was used to list due dates as there were many activities and assignments due during the project. The students were also given an individual list which planned tasks to accomplish and completion dates.

As the teams researched for six days the questions assigned, the science teacher conducted various demonstrations dealing with conduction, convection, and radiation, while the social studies teacher dealt with the brochure design and how to use Google slides. The social studies and science teachers used small and large group workshops and educational videos from different sources to help the students during the research time to answer the research questions and questions about the project requirements.

Creating the brochure and Google slide presentations took three days. The social studies teacher critiqued the brochure and sent teams back for refinements and changes. Both teachers critiqued the slide presentations offering suggestions for improvement. There was no peer critiquing observed for either the brochure or the slide presentation. The teams shared the brochure and slide presentation with the combined science and social studies classes taking two days.

In addition to sharing the project, at the end of the second day, the science teacher gave students time to reflect about the project and the team members. General questions or information sought from the teacher included: how the team worked together, who worked hard, those who could have done better; reflection on individual participation including individual contributions to the project and how involved individual students were during the project.

Case Study 8, Sixth Grade, “Ring of Fire”

Setting

The sixth grade science and social studies teachers introduced a science/social studies project entitled "Ring of Fire.” All sixth grade students were issued Chromebooks at the beginning of the school year, which students carried to each class. The laptops were used for entering information into eStudio and researching information for the projects. The environment where the sixth grade students worked on the two projects was the center area of the pod/house (see Figure 1). This area contained nine round tables with four to five students at each table. Between the two corner areas was a 10-foot-long, 3 ½ foot tall counter where science demonstrations and experiments were performed. In front of the counter and in front of the two corner areas, desks were set up and a total of sixteen computers were in this common area.

Project Description

The sixth grade science teacher and the sixth grade social studies teacher introduced a project entitled “Ring of Fire” encompassing both social studies and science concepts. The purpose of this two week project was to understand and explain the importance of plate tectonics as it relates to natural disasters and their effects on populations. As in Case Study 7, students were given two class periods per day to work on the project. The project required students to create a map and an overlay of the “Ring of Fire” location of the tectonic plates on the map, create a model of the structural layers of the earth, and write a paper explaining how major events occur on a regular basis where the plates meet.

The launch of the project was a YouTube video and song about the continental drift theory. During the team phase, the students were divided into nine groups of five to six members and the teams entered the team name, team roles, team norms, and signed the contract in eStudio. For the planning step, the teams recorded in the online environment what they knew and did not know about the “Ring of Fire” by referring to the project requirements. The student generated research questions, entered into eStudio, came from the teams’ project requirement sheet and the list of what they did not know. It took two days from the launch of the project to the completion of the planning step.

Five days of research started with a fossil evidence activity (see Appendix B.15) that emphasized the information in the video that launched the project. The students colored and labeled the continents and then fit them together as one landmass. As another activity, students colored and labeled a map with each continent, researched three recent earthquakes and three recent volcano eruptions in the “Ring of Fire” and labeled each place on the map (see Appendix B.16). Both science and social studies teachers used small and large group workshops and individual/group activities to answer the research questions posed by the teams. Students worked off an individual to-do-list as well as referencing the whiteboard for activities and due dates, as certain items in the project requirements were required of each student and/or team.

After students completed the research and activities required by the teachers, the create step of the final project came from selecting from a tic-tac-toe board one of nine possible final projects. The groups selected one project from the board as the final team project. The final projects selected by the groups included a plate tectonics dance, models of volcanoes, “Ring of Fire” games, dioramas of plate tectonics, and “Ring of Fire” flip books. There was no formal critique of the projects from peers or the teachers. The critique of the final projects came from team members and the teachers during the creating of the project. The students had three days to create their final project, and the teams shared their products with the class for two days.

Case Study 9, Sixth Grade, “The Solar System”

Setting

The sixth grade science teacher introduced a science project entitled “The Solar System.” The environment where the project took place was the science room with a tiled floor and on the right side of the front wall was a large table of the periodic elements (see Figure 1). All sixth grade students were issued Chromebooks at the first of the school year, so each student carried a laptop computer to all classes. The laptops were used to enter information into eStudio and research the project. There were six rectangular tables thirty-four inches in height with adjustable tall chairs and students worked in groups of four to five. Around two walls were countertops with seven sinks and cabinets below for storage; the countertop space was used for completed science projects. There was a science storage room located in this classroom.

Project Description

This three week project included the creation of an amusement park including all elements in the solar system. The project requirements, were entered into the online environment, eStudio, by the teacher for the project. Each group in the project was assigned one section of the amusement park.

The launch of the project was a video by NASA on the solar system, and students took notes in their science notebook. For the team step, students completed the team name, team roles, team norms, and signed the team contract in the online environment. During the plan stage, the teams listed what they knew and what they needed to know about the solar system. The teacher provided the teams with a vocabulary list and a group to-do-list in eStudio. From the teams' list of what was needed to know about the solar system and project requirements, the teacher wrote a classroom research question list on the whiteboard for the class. The entire classroom decided on the research questions from the list, and each team typed the research questions into the online environment and assigned team members specific questions to complete. After the research questions were decided at the end of day two, the teacher assigned the teams "bodies" in the solar system including planets, comets, asteroid belts, and moons.

During the five days of research/work time, students watched videos and read online and book resources provided by the teacher. The teacher circulated and monitored groups during the research time providing feedback and scaffolding steps for the groups as they acquired information needed for their section of the park. The create step started with the team design of their amusement park section on notebook paper. When the design was accepted by the teacher, a list of materials for building the project was compiled and all items were approved by the teacher before construction of the team's section could begin. The teams worked for five days on designing and creating their section of the amusement park. There was no formal critique by teacher or peers for the project. The finished sections were shared with the third and fourth grade students. The students walked around tables with the individual sections displayed, and the sixth grade students explained their section's rides and amenities and where in the solar system their section belonged. At the end of the day of sharing, all sections were placed in the correct solar system order and the amusement park was viewed by the sixth graders in the class.

Procedure

Data Sources

There were multiple data sources included in this study: project requirements, observation of students, completed projects, and student interviews.

Project Requirements

The project requirements included a description of why the projects were conducted, specific types of activities completed during the projects, and a list of what the project should include for the final assessment of the project. For all grade level project requirements, the

Texas Essential Knowledge and Skills (TEKS) were included. Teachers listed the project requirements in a group student project notebook or online using the Engage2Learn software, eStudio, with specific criteria for each project requirement. For each project the teachers gave students a project requirement sheet or entered the project requirements into the online environment. Teachers gave students an assessment rubric with specific criteria for each final project grade.

Observations of Students

Observation and fieldnotes are an important qualitative method as it allows the researcher to record firsthand the activities in which the participants are involved in the context(s) in which the activities happen (Ravitch & Mittenfelner Carl, 2016). Observation of the students was conducted during the entire project process and recorded by hand in a notebook. The fieldnotes included teacher notes written on the whiteboard for students, student behavior as it related to the project, student interaction with other students during the project time, and activities presented by the teachers. During the student interaction time, the researcher wanted to see if the students spoke about prior or current learning, could apply information/skills learned to the projects, and relate the information learned during the project to other subjects or outside of school.

Completed Projects

The completed projects included posters with information, e-books, clay models, slideshow presentations, dioramas, videos, miniature amusement parks, Styrofoam models, and a dance performed by the students for an upper grade level. The projects were either photographed or obtained in electronic format when possible.

Student Interviews

Semi-structured student interviews were conducted only with students who had a signed IRB approved consent form from a parent or guardian. There were 89 students interviewed from a total of 128 students:

- Second grade - 55 interviewed/64 total students
- Fourth grade – 18 interviewed/22 total students
- Sixth grade – 16 interviewed/42 total students

There were set interview questions as well as questions specific to the project. The questions are listed under data collection, student interviews.

Data Collection

Project Requirements

Project requirements were obtained from the teachers at the onset of each observation period. The teachers usually provided a paper copy even if the requirements were listed electronically in eStudio. There was one project where the project requirement list was not collected. A copy of the assessment rubrics were collected when possible.

Observations of Students

During the observation period the researcher acted as a participant observer and walked from group to group, listened to student's comments, answered questions about the project activities, or reviewed instructions given by the teacher. Walking from group to group the students became accustomed, to a certain degree, to the researcher's presence in the room and the researcher observed many different groups while students worked on a project. It was difficult to hear student's comments during the observation of the projects as it was a noisy environment when many groups talked at once, and some groups talked in low levels to each other. On occasion, the researcher sat with groups to ask what the team was working on, or where the team was in the project. Sitting with the groups working on their project often led to the students asking questions not related to the project, so the researcher limited the sitting with groups. Many times, the researcher stayed a little away from a group or two and listened to what the teams said to each other. If it was not noisy, the researcher would write what the members of the teams were doing and saying to each other.

Completed Projects

The completed projects in the nine case studies were photographed where applicable or collected from the electronic environments in the forms of PowerPoint and Google slide presentations, e-books, videos, and a dance. The dance project was not videotaped or photographed, due to consent form limitations.

Student Interviews

Interview data was captured using a digital audio recorder. Questions were posed at the end of the project. The interview protocol of questions was asked of all members of the group with answers recorded without the names of the students corresponding to their answers. The semi-structured interview included several types of questions: experience and behavior, opinion and values, and knowledge. These questions allowed the researcher to uncover what the learner had done, will do or is currently doing. It also revealed what the learner thought and knew about the topics, experience, or phenomenon in the projects and what value the learner placed on it (Ravitch & Mittenfelner Carl, 2016). The interview questions queried at the end of every project included:

1. What was the project/task/problem you were solving?
2. How did you arrive at the solution to solve the project?
3. What made you think to create the project in this way?
4. What were the steps you used when creating the project or solving a problem in the project?
5. What were you thinking about as you completed the project?
6. Was there something you had learned before, or known earlier, that helped you finish the project?
7. How do you see this project connecting to other things in your life at school or outside of school?

Other questions about specific project steps or solved project problems were asked as needed. Questions were asked in grade level vocabulary or specific terminology to the student. The student interviews ranged from two to fifteen minutes of the student's time at the end of the project. Interviews for the fourth and sixth graders were conducted individually in one of the glass rooms located in the house/pod. The second grade students' interviews were conducted in groups from two to six students.

Data Analysis

The analysis for all data sources, project requirements, student observations, completed projects, and student interviews, were completed using qualitative analysis. All data sources went through precoding, a process of reading, questioning, and engaging with data before formal coding (assigning meaning to data) began (Ravitch & Mittenfelner Carl, 2016). The researcher read transcripts of student interviews, organized and read the student observations and project requirement field notes, and viewed all completed projects via photo or electronic format before uploading all four data sources independently into Nvivo, a qualitative computer software. A deductive coding process was used to analyze the data using Haskell's (2001) six levels and fourteen types of transfer as initial, etic codes. Each level and type of transfer was used to anchor a node, and therefore coded in Nvivo. This resulted in twenty etic nodes used to code the data. The coding of the data was determined by the definition of the level or type of transfer from Chapter 1. The twenty nodes were created in Nvivo after the precoding was complete.

The data was uploaded into Nvivo in several steps. The project requirements documents and student observation field notes were scanned as PDFs and twenty-two files of various lengths were uploaded into Nvivo, which had the capability to section off a portion of the file and code the specific section of information (see Figure 2).

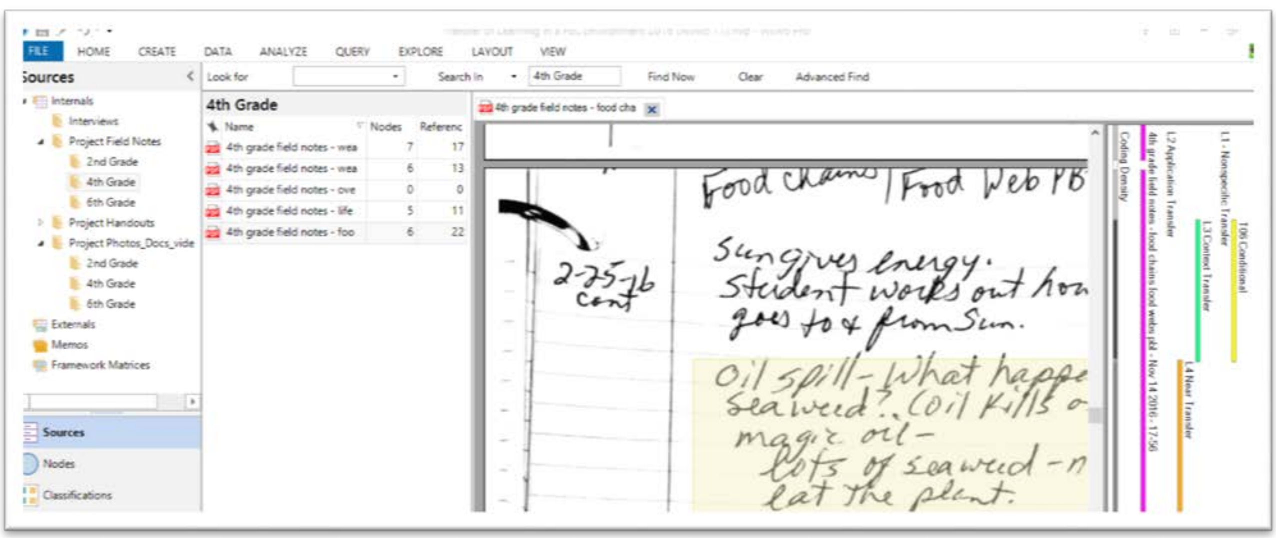


Figure 2. Student observation field notes coded in Nvivo.

The 167 completed projects' files were uploaded or linked (large electronic files/projects) from the computer into Nvivo. The files could be coded by each individual component in the document or photo, as an individual section of a photo or document could be sectioned off and coded (see Figure 3). The student interviews were transcribed and the fifty text files of various lengths were uploaded. Specific lines in the interview could be highlighted and coded in Nvivo (see Figure 4). The Nvivo software program enables the researcher to isolate and code data as specific sentences in transcribed interviews, individual items in a photograph for completed projects, and specific areas of photographed field notes.

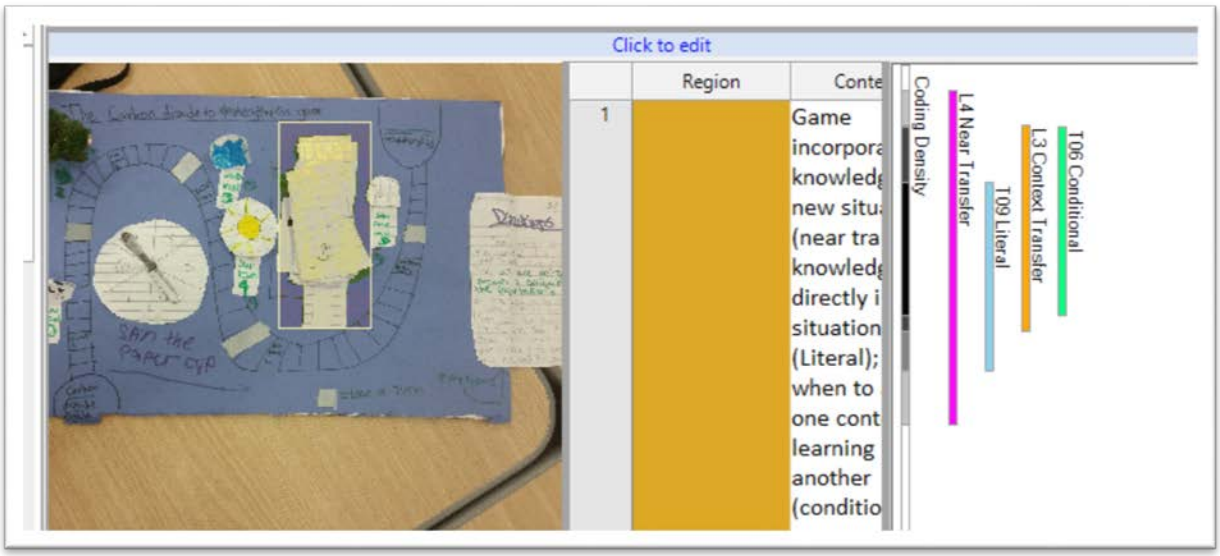


Figure 3. Completed projects coded in Nvivo.

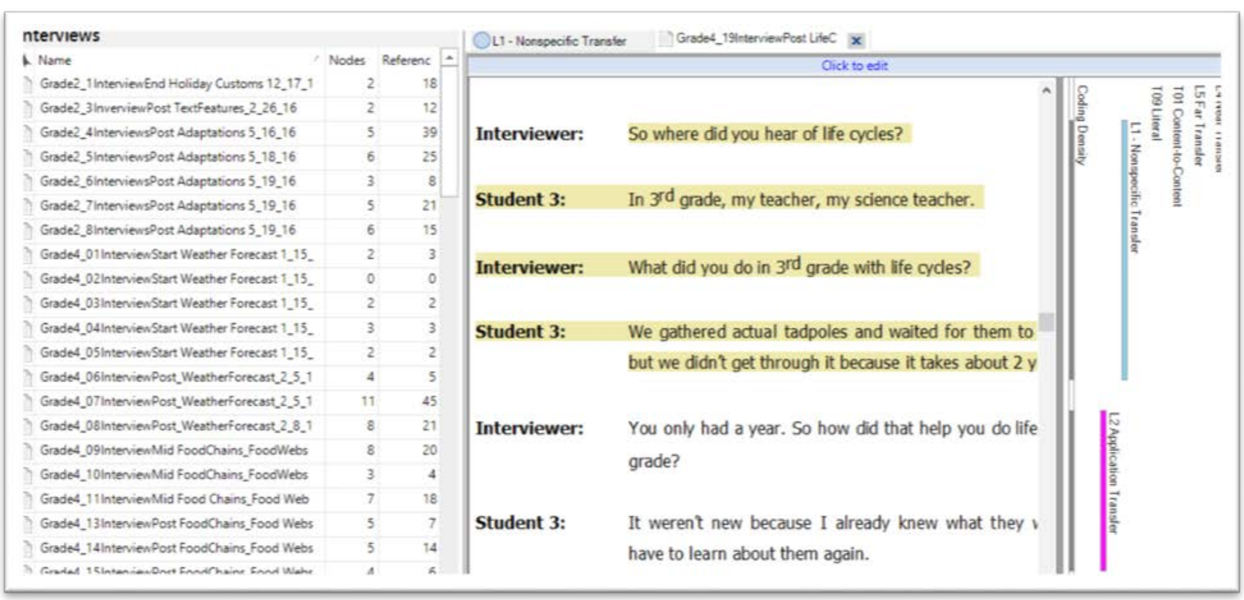


Figure 4. Student interviews coded in Nvivo.

As coding progressed, data were coded at a level and/or type of transfer. When reviewing the data, the nodes with the majority of references coded were further analyzed and revealed four levels of transfer and two types of transfer. The levels of transfer with the highest number of coded references were nonspecific transfer (288), application transfer (281), context transfer (164), and near transfer (138). The four levels are the lowest levels of transfer in Haskell's (2001) hierarchy. The next highest number of coded reference nodes were two types of transfer which included literal transfer (91) and conditional transfer (84). The data indicates when low levels of transfer occur, not many types of transfer references are present. The remainder of the levels and types of transfer had minimal coded references and are not addressed in the findings.

Project Requirements

The project requirements included project descriptions (called the challenge brief), assessment rubrics, research questions, and from one teacher, lesson plans. The project descriptions included project introductions, criteria, and objectives. The objectives, assessment rubrics, and lesson plans listed what students were to identify, explain, discuss, describe, create, evaluate, or analyze. The research questions, created by the teacher or the student teams, varied from project to project in what was to be recalled, identified, explained, or evaluated during the research step in the project. All project requirements were viewed through Haskell's (2001) levels and types of transfer and were coded by what a person does with the knowledge obtained. The level of transfer (as defined in Chapter 1) was coded by whether the learning connected to past learning, the past learning applied to current learning, the learning could be applied to a context, or if the current learning moved to a new or dissimilar situation. The type of transfer coded, if applicable, to project requirements was determined by the definitions of the fourteen types of transfer listed in Table 1.

Observations of Students

The student observations recorded in field notes were identified by student actions when working in groups, during a group or class activity, and working individually on research or the project. The student observations were identified in a PDF uploaded into Nvivo and coded as defined by Haskell's (2001) levels and types of transfer as described earlier in data analysis, project requirements. One example included a project in which second graders watched a video to identify adaptations learned earlier in the project. Students had to name, by calling out, different adaptations as the video played to the teacher. The researcher defined this activity as application transfer as the second graders were applying what they learned earlier about adaptations to a specific situation. Another example of coding the student observations viewed in all three grade levels was when workshops were given by the teachers. One team member from each group would meet the teacher and the information needed would pass from teacher to workshop student, then the workshop student would return to their group and pass the information to the rest of the group members. This activity was viewed as transfer and coded and the appropriate level. The level and type coded for student observations depended on the grade level.

Completed Projects

The photographs, videos, and electronic files of completed projects were coded using project requirements as a guide. If a completed project had multiple requirements, but only one could be observed, the project was coded with one node. If the project had multiple requirements observed in the final product, multiple nodes were coded in the project. Different areas of the completed project photos could be sectioned off in Nvivo, thereby allowing for multiple nodes for one completed project. A single area of the project contained one level of transfer, and if applicable, the number of nodes needed for a type of transfer. By allowing for multiple codes/nodes, the completed project a broader and more in-depth analysis of transfer of learning. The videos, Google Slides and PowerPoint presentations, linked as external sources in Nvivo, contained a memo area where notes were entered about the level and type of transfer observed and a detailed description of the instance. The section of the memo with the name of the level or type was then highlighted, coded, and included in the completed projects analysis.

Student Interviews

Student interviews were coded by the answers to the questions listed in data collection, student interviews, and any project specific questions asked by the researcher. Individual lines of the student interviews were coded in Nvivo as applicable (see Figure 4). Students who discussed the information known prior to the project, information learned from project research, or could apply information from the project were usually coded at lower levels of transfer. Examples included a second and fourth grader stating, “The cheetah’s fast,” and “It will help us because if there’s a cold front coming in we know it will be cold. If there’s a warm front, we know it will be warm.” Students were coded as a higher level and possibly a type of transfer if they could discuss what was learned in the project by relating it to other context, or taking information learned and applying it in a similar, new, or different situation. One example of higher level of transfer was a fourth grade student who described a food chain as “It’s kind of like a video game, there’s different levels. First level would be producers and herbivores, and then carnivores. The herbivores would be first level producer. The carnivores would be the next which is the second level consumers.” When asked what was learned new in the project Ring of Fire, a sixth grade student said, “I thought that earthquakes were earthquakes, like it was just the ground shaking but now I’ve learned that it’s actually moving in weird ways and how the natural disasters could be related like earthquakes can lead to volcano eruptions.” All these student interview responses were coded as different levels of transfer, and the types of transfer were coded in a similar manner. The types of transfer coded used the definitions in Table 1 as a guide.

After Nvivo data coding was complete, the data sources were analyzed. The twenty nodes were placed in order from greatest to least by the number of references to find the hierarchy of the levels and types of transfer (see Figure 5).

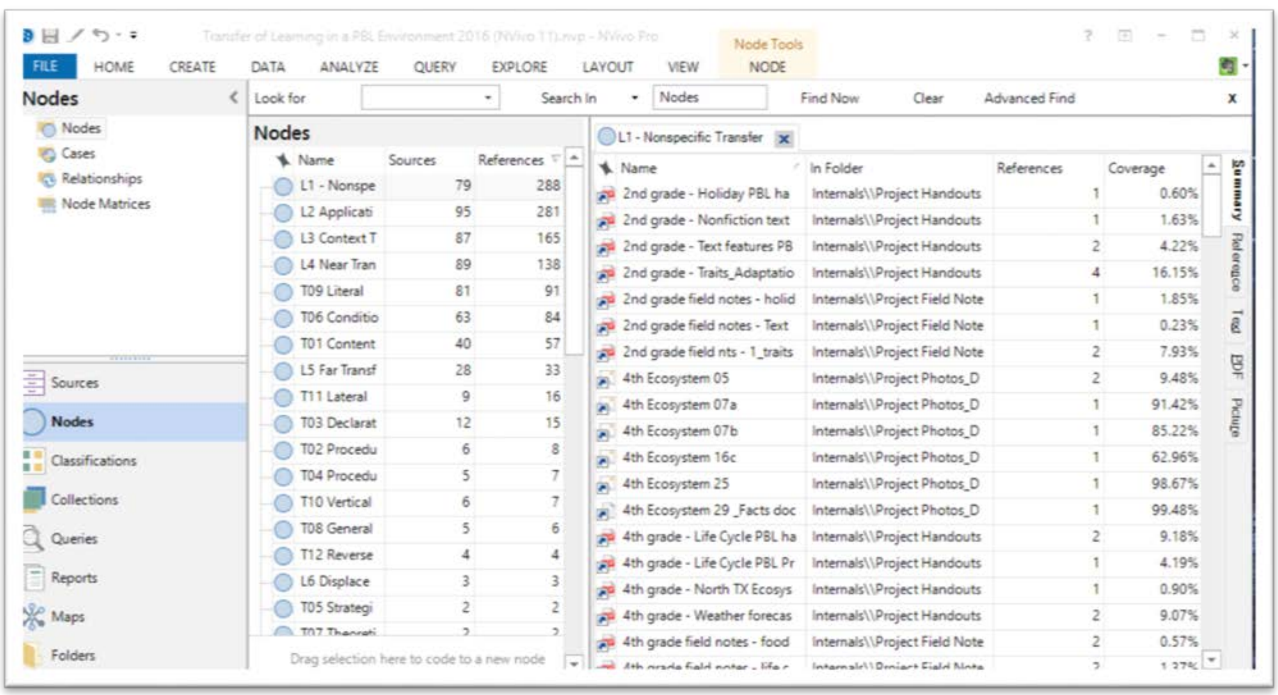


Figure 5. Analysis of nodes in Nvivo.

All twenty nodes and the number of references were exported to Excel to create a bar graph with the hierarchy of the twenty nodes. The highest nodes were opened, and using the information from the summary tab in Nvivo exported to Excel. The levels and types of transfer were analyzed by grade level and data sources tabulations, charts, and graphs (see Figure 6). The specific node tabulations were divided by grade levels with a bar graph created by grade level totals, and pie charts created by grade level data sources.

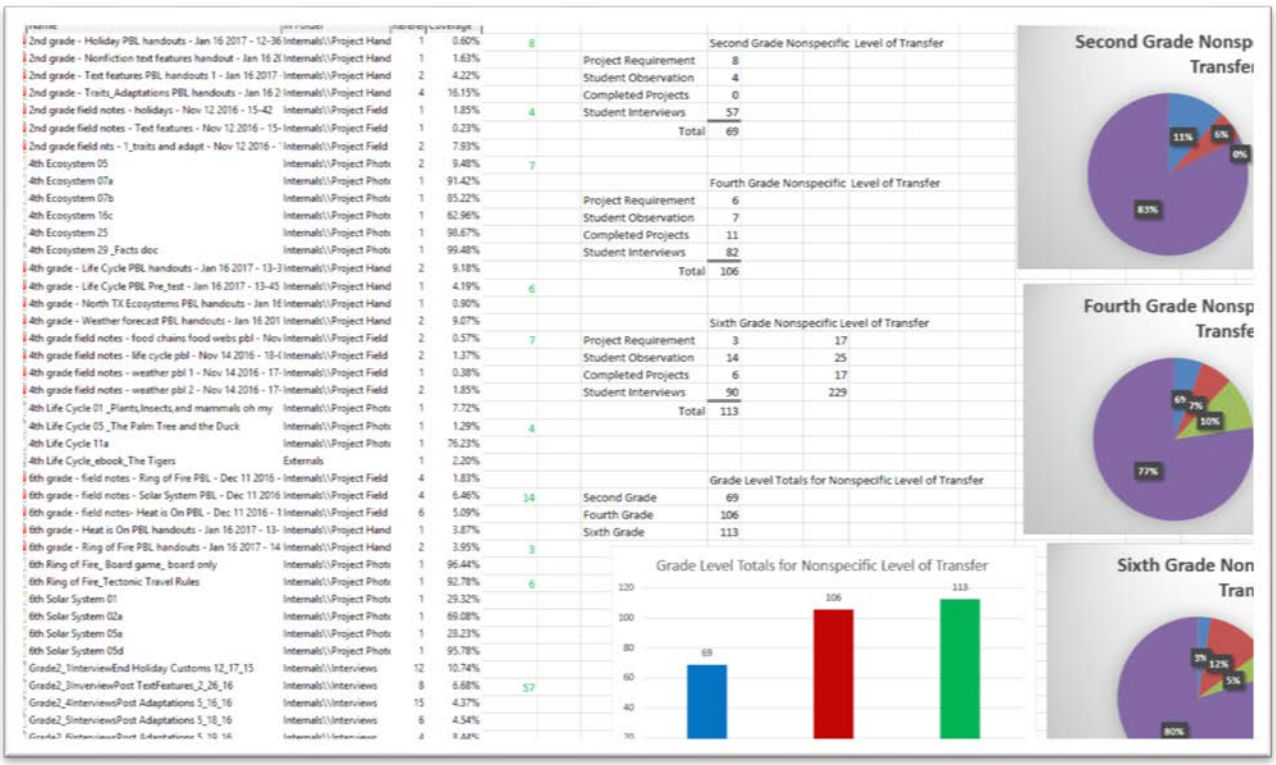


Figure 6. Excel data analysis by node – level and type of transfer.

Summary

In chapter three, a multiple case study was discussed as the research design for the study. Nine case studies were observed to identify Haskell's (2001) levels and types of transfer as determined by project requirements, student observations, completed projects, and student interviews. The teachers in the study incorporated the Engage2Learn model and designed their own project-based learning units. After all data were coded in Nvivo, patterns and trends were derived from the analysis. These trends show the results of whether the students were transferring their learning, at what level, and what type of transfer was apparent across all data sets.

CHAPTER 4

RESULTS

The purpose of this study was to investigate levels and types of transfer observed in K-8 school students across multiple subjects in a project-based learning (PBL) environment. This chapter addresses the three research questions and is organized accordingly:

1. What levels of transfer of learning were observed in an elementary school project-based learning environment?
2. What types of transfer of learning were observed in an elementary school project-based learning environment?
3. Across which learning environments was transfer observed?

In the data analysis in Chapter 3, there were four levels of transfer and two types of transfer that contained the majority of coded references. The levels of transfer with the highest number of coded references were nonspecific transfer, application transfer, context transfer, and near transfer. The four levels are the lowest levels of transfer in Haskell's (2001) hierarchy.

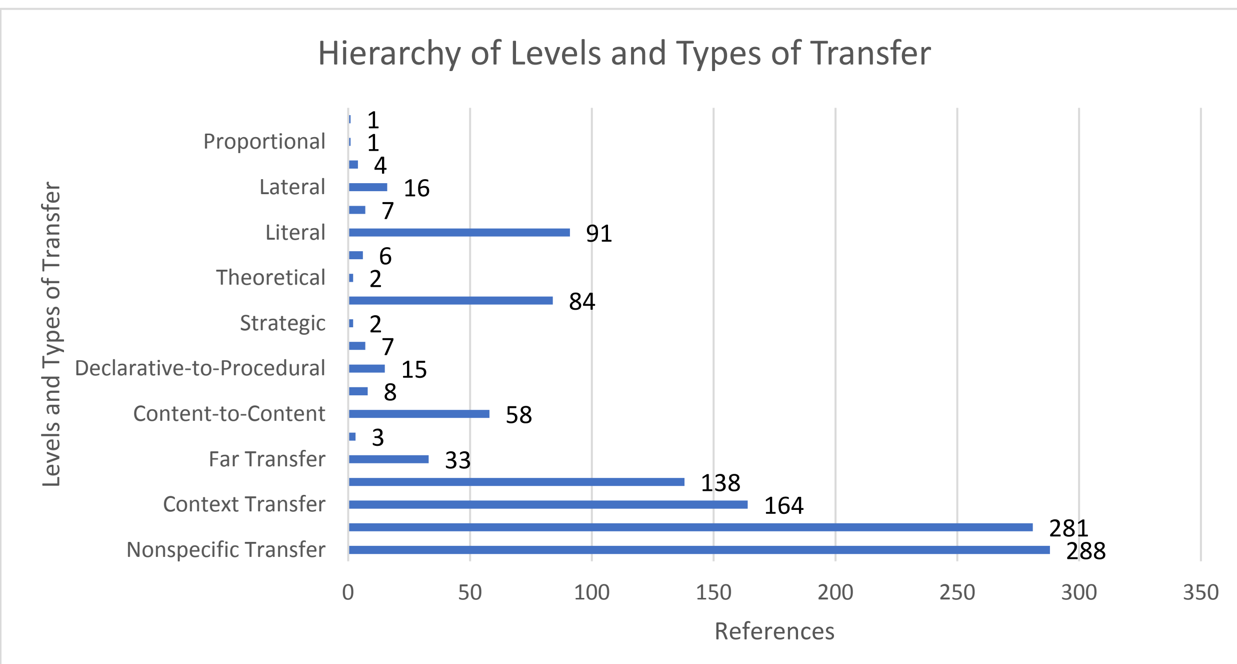


Figure 7. Hierarchy of levels and types of transfer.

The next highest number of coded reference nodes were two types of transfer which included literal transfer and conditional transfer (see Figure 7). The data indicates when low levels of transfer occur, not many types of transfer references are present. The remainder of the levels and types of transfer had minimal coded references and are not addressed in the findings.

Levels of Transfer, Node Findings

What levels of transfer of learning were observed in an elementary school project-based learning environment?

Haskell's (2001) hierarchy contained six levels of transfer and the four lowest levels received the most coded references in the study. A description of the greatest number of codes into that node are discussed in order of largest to smallest number of references. Each level is described further by grade level.

Nonspecific Transfer

Nonspecific transfer has connections to past and present learning and is a component of everyday learning. Haskell (2001) believed significant transfer required learning something new in order to make the transfer, and Level 1, nonspecific transfer, was simple learning, and not considered as learning something new in order to make the transfer of learning. Nonspecific transfer is the lowest of the six transfer levels, and received the highest number of coded references, 229, and was primarily observed among the student interviews (229). All three grade levels' student interviews were coded nonspecific transfer when students defined terminology, listed the steps in a life cycle, food chain, or food web, or repeated information and concepts learned in prior grades or in the process of researching the project. When the information was learned previously or the student gave a definition of a term or concept it was coded as nonspecific transfer.

Second Grade

The three second grade projects with the highest data source coded at the nonspecific level was the student interviews, with 57 coded references in this node. In the second grade interviews the students told what they knew about a term or concept. Each project had examples of nonspecific transfer coded and examples follow.

In the "Holidays Around the World" unit students discussed knowledge known from prior years and facts learned during the unit. The groups' comments focused on customs that were the same and different between their country's holiday customs and the customs in the United States. Students in one group were asked to compare the customs in China and how they were the same or different as our customs. One student replied, "On Chinese New Year, instead of giving like the birthday gift, they give you [an] apple which is different." Another student in the same group stated they had knowledge about Chinese customs before the project started "because we did China last year." Two different groups, one researching Canada and the other France, found there were similarities between the customs in the United States and their countries. The living museum project for Canada contained "stuff about Canada," which the group found easy to add to the group's museum since "we already knew they're just like us." The group researching France discovered the country had a similar holiday to the United States as they "celebrate Christmas and that kind of thing," but were also different since "They have different types of clothing like a beret." The group researching New Zealand found "they celebrate Christmas but they don't celebrate on the same day we do" as Christmas in New Zealand was in the middle of our summer. One group member described differences in the customs as, "They have this big Christmas tree that's almost 100 feet tall at the town hall and then everyone gather around it and sing Christmas carols--and then people will bring ornaments to put on the tree." The group researching Italian customs learned that "some of the food they eat for Christmas is different than the food we eat for Christmas." The group was interested in the fact the Italians ate seafood, chocolate cake, donuts, and honey balls at Christmas time. The topics the students discussed in the interviews from the Holidays Around the World project mainly dealt with facts learned during the unit, with a few references to learning from a prior grade and was coded as nonspecific transfer as defined by Haskell (2001).

The "Text Features" unit had fewer references in nonspecific transfer than the other second grade units. One student learned earlier, when he was five or six, how to identify a map, revealing prior knowledge, a component of nonspecific transfer. When one group of students were asked what they knew about text features, they listed terms in their individual responses - table of contents, index, glossary, types of print, and caption. After the list, one student stated, "So we all kind of knew which one was which." Many students discussed the identified objects, but did not know the items were text features as one student conveyed, "I knew what a glossary was but I don't know it's a text feature." Another student stated the project was important since text features would "help them read non-fiction books." The student defined a non-fiction book as, "They're true and we didn't know about them. Some could really be important." The student responses in the Text Features unit dealt mainly with identifying text feature terms and the student's definition of those terms.

The Traits and Adaptations unit included many references at the nonspecific level. In the unit's student interviews, students discussed facts about the animals, plants, insects and habitats researched comprising phrases such as, "The cheetahs [*sic*] fast," "The peregrine falcon can dive really fast," and "The Amazon rainforest was the biggest forest." Several groups discussed facts related to the Venus fly-trap including: "A Venus fly-trap – we know it eats flies," "One of the adaptations is seed dispersal," and the plant's quest for food and how the plant traps its food by "the flap, trap, and silken trap." During the student interviews groups defined terms including: omnivore, schema, adaptation, diurnal, mimicry, decomposers, and trait. One student said, "Schema is like when you remember stuff in your head." Another student stated, "All I remember about adaptation is that it helps. It's like something that helps me survive." A third student related, "A trait is something that you get from your parents and adaptation is something like warning, coloration, like spikes how the porcupine has. So they can help keep it safe." The students gave the definition and an example of a term, but did not go into depth or state anything other than the definition for the term, demonstrating simple learning. Several students had read a book or watched a television program about terms or concepts in the unit and helped the group members expand their knowledge for the unit. One student had "watched a ton of shows about animal adaptations," and was able to define cold desert from the show "Planet Earth and Life," as the group was deciding what would be included in the habitat of their fictitious animal/plant. As the life cycle was a prominent concept for the project, many groups interviewed went step by step through familiar life cycles. As an example, one group chose the life cycle of the frog and the description follows:

> Student 1: The frog was my favorite. How many converts does it have? It had like 100 stages because tadpole, tadpole with legs –
>
> Student 2: No, it's egg, tadpole with longer tail—
>
> Student 1: No, so it's eggs, tadpole and then the tadpole having little back legs but still having to wiggle. Then it grows some front legs and the tail starts to absorb, then it's from, then it dies.

The life cycle of the group's fictitious animal, plant, or insect was also included in the discussion, but these descriptions usually involved applying what was learned and were coded in another node.

Fourth Grade

The fourth grade projects were case studies four through six and the highest data sources coded, at eighty-two references, was the student interviews. The items coded as nonspecific transfer in the interviews dealt with terminology and facts learned during the projects, weather symbols, the water cycle, steps in a life cycle, food chain, or food web, and knowledge learned from prior grades. The Food Chains and Food Webs and the Life Cycle units contained the largest number of references.

The Weather Forecast project coded some student interview responses as nonspecific transfer when students defined warm and cold fronts and what they learned in third grade. One student stated, "We learned about weather, like what does [*sic*] the symbols mean . . . . we learned the front and how the weather changes and stuff." Students interviewed described the steps in the water cycle and watched television weather forecasts with warm and cold front symbols and described how the fronts moved. One student described the water cycle as, "The sun is heating up the water and that's making water vapor and then the waters came to cool down and then turning into water and then it's going to rain. And so we all know if it's going to rain." The steps described in the water cycle were coded nonspecific transfer since the learner was repeating knowledge known, or demonstrated simple learning from definitions of the cycle.

The Food Chains and Food Webs unit had many references coded as nonspecific transfer including definitions of terms, steps in a food chain and food web, and knowledge gained from prior grades which Haskell (2001) viewed as simple learning. Photosynthesis as a concept clearly made an impression in the learning activity; it was defined and discussed by approximately eight different student interviews. When asked to discuss photosynthesis and list the three things you need for it, a student replied, "Photosynthesis is the process of solar rays coming to a plant and giving it it's energy. You need carbon dioxide, water, and sunlight." Another student discussed what the plants do with all those things by describing the water cycle. "We breathe out the carbon dioxide which gives it to the plants, and the plants breathe out the oxygen and give it to us and they take the carbon dioxide, and they suck in the water to the roots, and sunlight, and they all form together to make glucose." The discussions on photosynthesis were repeating knowledge learned prior to the Food Chains and Food Webs unit and were coded as nonspecific transfer. The carbon dioxide cycle, food chains, and food webs were also defined in several interviews and further, there were many references in the student interviews about the food chains and food webs. The basic description given in the student interviews about the carbon dioxide cycle was similar to the student who stated, "So we breathe in oxygen and we take out carbon dioxide. The plants take in the carbon dioxide changes that into oxygen and it goes around the cycle." Students were asked why they needed to know what a food web and a food chain were for the project and in their replies students could discern the difference. An example of a reply was, "The food chain is just like one part, and the food web is a bunch of food chains that all connect." These replies were coded as defining the difference between the food chain and the food web; there was no application of the learning, so nonspecific transfer was coded in these instances. The steps in a food chain and food web were discussed in five to seven interviews, and one student cited examples in the food chain/food web for the constructed ecosystem from the group project. “First, we put a circle for the sun and then we looked for one producer and look [sic] for something that eat the producer and look for something that eat the herbivore, the producer. So, we did 5 of those and then we did circle for decomposers and all of them led to decomposers.” Students discussed terms used in the unit and how most of the terms were learned in the prior grade. This indicated students were connecting past knowledge to current learning in the project and was coded nonspecific transfer.

The Life Cycle unit dealt with student knowledge about different life cycles and in the interviews students discussed many different life cycles including the seal, praying mantis, pitcher plant, coconut, frog, fly and butterfly. One group decided to do the life cycle of the coconut tree because on a video they “saw how it spat its seeds, so we chose the coconut tree.” For the seal’s life cycle a student commented, “There’s 5 stages to a seal. First, it’s the baby seal; it’s yellow, and then the next seal is white, and then the next seal is the smaller, but it’s like the brown, and then the next one is brown.” Some students repeated the steps of life cycles learned in prior grades – the frog, fly, and butterfly. Many discussions included facts known by the students and examples included, “That a seal when they’re babies, they’re white and yellow,” and “I knew the coconut tree was also called the palm tree.” Other facts brought up in the student interviews were: baby whales are called juveniles, a list of what orcas eat, a teenage pig was called a shoat, and the concept of revising and editing was defined. “Editing is like spelling mistakes and different things like that, and revising is more like we need to put it -- like add stuff or like add commas or punctuations, and if we have to write a new sentence, that’s revising.”

Nonspecific transfer was coded for these facts as students interviewed defined terms and listed knowledge and facts learned in the research step of the project that was simple learning.

Sixth Grade

Among sixth grade projects the largest data source coded at the nonspecific level was student interviews with ninety coded references. The student interviews coded at this level were observed in all three projects when students discussed terms, terminology and concepts known before sixth grade, new knowledge learned in the project, and discussed where specific items were located on a map.

In The Heat Is On unit many students' interviews defined COP21 (Conference of Parties) "where countries around the world meet and try to discuss how to stop global warming," and is "the 21st conference of over the topic of global warming." Names of terms learned in the current unit – conduction, convection, radiation were discussed in terms of pollution. "Pollution causes convection, and all the radiation and it just causes more of that [global warming] to happen. The more it happens - as convection and conduction and radiation causes glaciers to melt and stuff. And then it causes more water to be there. And polluting causes rain sometimes and it can cause really bad things." The student could include the terminology from the unit, but the concept from the terms was not explained in how it related to pollution, so the simple learning was coded as nonspecific transfer. From prior grades, students "did know that the US and China were the most polluters" in the world, how global warming affects humans and the surroundings, and how alternative resources worked. Student interviews discussed researched facts about Sweden and how they were "trying to become the first fossil fuel free nation in the world." One student "learned that there was more than just the basic energies like geothermal energy, wind energy, solar energy . . . . there was fusion, and a lot of other energies." The student only stated this fact and did not elaborate, so nonspecific transfer was coded to the statement.

The Ring of Fire unit had some references to nonspecific transfer in the student interviews. The terms discussed included "Ring of Fire," continental drift theory, plate tectonics, and seismic waves. When a student was asked if prior knowledge had helped in the creation of this project, a student stated, "I knew about the continental drift that the theory that all the continents were at a point of time all together." Another student stated knowledge known prior to the PBL unit about plate tectonics, "Last school year . . . . We did a lesson on earthquakes and volcanoes . . . . it was like plate tectonics create earthquakes and that's literally the only incident we spoke about." Another student indicated the unit prior to the Ring of Fire discussed tectonic plates and the layers of the earth, and this prior knowledge helped in understanding continental drift theory, plate tectonics and other terms easier in the Ring of Fire unit. "We had just gotten out of the layers of the earth project and I think that helped because we knew more about the tectonic plates. . . I think we got the continental drift theory and plate tectonics and all of the words much easier than we would if we didn't know about the tectonic plates." Several interviews included the term "Ring of Fire", the realization that the "tectonic plates. . .cause tsunamis, earthquakes, and volcanic eruptions," and "how like seismic waves affect earthquakes in the tectonic plates." In all the student interviews, responses for nonspecific transfer included terms referenced and prior knowledge tying past learning to current learning.

The Solar System student interviews contained many references to nonspecific transfer as most of the information dealt with what was known about the solar system in earlier grades and what was learned from the research. Students reviewed knowledge acquired before the unit including facts about Jupiter, where the asteroid belts were located, the composition of Saturn's rings – "ice, dust, pieces of moon, anything, rocks," the composition and rotation patterns of the sun, and the placement of the planets. One student's comments on Jupiter included, "I knew that Jupiter was the biggest planet and it was the 5th planet from the sun. It is the fastest spinning planet. It spins 28,000 miles per hour. And it has faint rings around it. And then about the Galilean Moons, there are 4 of them." Many students discussed new information learned about the researched solar system "bodies" including the length of an earth day, "Some people say it's 24 hours. It's actually 23 hours – and some people will say 23 hours and 56 minutes." Other new information learned by students was coded as nonspecific transfer as it was simple learning - descriptions of planets, moons, comets and asteroids. A comment from a student about comets, "I learned about comets and how they travel through the solar system and they take elongated paths around the solar system. It's like they don't travel in a complete circle. They go like kind of an oval more than they do a circle." Another student described Mercury's gravity in relation to Earth by saying, "I'm not sure but I think Mercury's like 1/6th of Earth's gravity." Other facts relayed to the researcher in the interviews included: "Venus is really hot," "Solar flares are extremely big compared to earth," and human beings "can be light on the sun . . . . You're 1.27 pounds lighter on the sun." The Solar System unit contained many facts and concepts in the student interviews since the project was shared with younger grades. The presenting students were asked many questions by the younger students about the team's section of the amusement park and the part of the solar system the team researched.

Application Transfer

Application transfer refers to applying what a person has learned to specific situations, and is the second lowest in Haskell's (2001) hierarchy of six levels of transfer. Application transfer contained two hundred twenty-one references and was observed primarily among references from student interviews (179) and completed projects (42). Students gained knowledge from investigating the projects' research questions and applied the learning to the completed projects as well as explained the knowledge acquired during research in student interviews. All three grade levels' completed projects were coded application transfer when projects were required how to identify specific items, explain concepts or how to do something, repeat specific information, labeling, or describing items.

Second Grade

The second grade projects were case studies one through three and the highest data source coded at the application level was student interviews with fifty-four references coded. The majority of the interview comments came from the Traits and Adaptations unit. In the Holidays Around the World unit, a student identified the significance a cultural celebration. "We researched it [New Zealand] and they had Christmas in the middle of summer. I think it's because they have really hot weather and it's not that really cold in December. So they have really hot weather so they decided to have Christmas in the middle of summer." It appeared the student knew the seasons were different in New Zealand and explained why the country had the holiday in summer instead of winter.

In the unit on Text Features, a student described how to apply their knowledge of text features into creating each page in a presentation. "Like we put for contents, we put table of contents and there's a picture and then we put a box under it that we wrote about what it means." The student also discussed how the group knew to put the text features book in order, "We didn't know how to do it in order, so we look [sic] at a book in order instead of doing it by not in order." The group of students went through the pages of a non-fiction book and applied what they learned about the order of that book to the text features book they were creating.

At the end of the Traits and Adaptations unit the students described many examples from the application level. This unit was about plants and animals, so students discussed life cycles; predominately the life cycle the group decided to create for their fictitious animal/plant. One student stated, "Well, we wanted to start out with an egg because it's not a normal animal that's always found everywhere. So, we started out with an egg, and then it hatches into a baby one and whenever that one hatches, the old one dies and there's only one on the whole world at a time." This fictitious animal was very complex in their life cycle, with the students applying what was learned about other animal life cycles to their fictitious animal. Students discussed how the team acquired a name for the fictitious animal or plant on their team. When one student was describing how the team's fictitious animal name was being debated he said, "We added some of the letters from other animals that we put in our project. We added letters from those animals and we put in [sic] from tiger. We started at tiger and then we added 2 animals." Another group's created animal was called a Fomzelo made from "5 species of fox, camel and a cactus," with the group liking the creation "because it has all these spikes." The group was applying the names of animals/plants to the team created animal, while applying the physical attributes to how the animal could defend itself. A student described mixing two habitats, "We made up a habitat called Desertica. It's a savannah mixed with Antarctica." The fictitious habitat applied what the group knew about two different habitats and combined it into one habitat for their fictitious plant/animal. What was coded as application transfer in the second grade interviews dealt with repeating what knowledge students had learned and applying it to the project. All the examples demonstrated to the researcher the students were applying what was learned to a specific situation.

Fourth Grade

Among the fourth grade the highest data sources coded for the application level were student interviews (73) and completed projects (33). Student interviews dealt with what was learned and how to apply it in the classroom or outside the classroom. The Weather Forecast project had several examples of application transfer in the student interviews. One student discussed how weather forecasting helped to decide what to wear to school. The student stated, “It helps me if I wanted to go outside and play, I have to know if it’s cold outside, if I need a jacket, or if it’s 82 degrees, if I can wear tank top or something.” Another student interviewed talked about the relationship of warm and cold fronts to the temperature or the weather the next day. “It will help us because if there’s a cold front coming in we know it will be cold. If there’s a warm front, we know it will be warm.” The student thought the front symbols were there to be “cute,” but when they were creating their weather forecast, found out the symbols meant something about the weather in the future and applied the knowledge to their forecast. Another student applied what they learned about fronts to the weather, “I didn’t know what the warm front or cold front is and I now I know that if a cold front hits, it’s going to --- the temperatures are going to drop a little and if a warm front hits, it’s going to come up a little.” The water cycle was discussed in relationship to the weather by one student, “Well, without the water cycle really, actually, we wouldn't have any weather because the water cycle basically is what weather is because when it's raining, that's weather. . . like when it's snowing, that's precipitation so that's basically weather." The student was applying the concepts learned in the water cycle to the Weather Forecast project.

The Food Chains and Food Webs student interviews dealt mostly with the teacher interviewing the students about different food chains and food webs. Once the student could tell what the steps were in the web/chain, the teacher wanted to know why it was important. In one discussion, the teacher wanted to know how the sun's energy traveled through the food web. The student replied, "It's the very bottom of the food web and it involves photosynthesis. It helps photosynthesis grows plants and makes them grow. So and that's the very bottom. Now it's a producer and you always have a producer in a food chain or a food web." The teacher then wanted to know how a carnivore would get the sun's energy and the student replied, "A carnivore will get the sun's energy by eating the herbivore and the herbivore ate the producer." Another scenario the teacher created was a forest ecosystem and all the trees died; what happens to the foxes? "The foxes will eventually die there. . . . Because the rabbits or whatever eats the plants and the trees, I don't know what, the foxes eats those, and then there won't be any of those, like so I'm just going to go with the rabbits somehow." The student elaborated further by saying, "So then all the rabbits die and then the foxes have to depend on their other food, which then the other food gets endangered, and then that just makes everything else dead." The students applied knowledge of the food chain/web steps and discussed why it was important. Students discussed terminology learned or reintroduced during the project. When one student was questioned as to why decomposers were important, the reply was, "Because they clean up stuff and they help to make the soil richer." The student did not stop with the definition, but continued with why richer soil was important to us. "Because then the plants will maybe grow faster and they can breathe." When queried about what plants breathe and what that had to do with us, the student replied, "Because they take in carbon dioxide and give out the oxygen [for us]." The terminology from the project was not only defined, but was discussed as to why it was important, applying the knowledge learned to a specific situation.

In the Life Cycle unit student interviews included discussions on how clay model representations of a life cycle were created and how to apply writing skills needed to write a book for a younger grade. One student described how the team made the praying mantis clay model life cycle representations they photographed for the e-book. "All we did is look up the life cycle, and then we thought about because the praying mantis we know that it looks like a plant, not plant, a leaf. So, we just made it like a leaf and we looked it up because there's the egg it's white and the larva is brown. Then the pupa is yellow with the green leaf under it, and then the adult is the leaf type." The student took the knowledge from the praying mantis life cycle and applied it to what each stage's clay representation should resemble. Another student discussed the differences between books written for fourth graders and the e-book his team wrote for the kindergarteners. He stated, "Because kindergarteners they don't really read chapters. They read picture books or another book where there's a picture and then for us it's a chapter book where there's one picture out of the whole book." The student acknowledged placing a picture per page was not difficult for the group as they "made a 3D model and . . . we took pictures of it and we uploaded it to my drive [Google drive]." The student and his group knew a picture book had more than one picture per book, and applied that information to making the 3D models and photographing different models for each page.

Fourth grade projects at the application level included project photos, videos, e-books, and poster presentations. During the Weather Forecast unit students described and illustrated how water moves through the water cycle and how the water movement applied to weather forecasting. The students also applied weather symbols learned in the unit to the video forecast. The Life Cycle unit e-books contained drawn or photographed models of the life cycle of the plant, animal, and insect (see Figure 8). These images were applied to the life cycle story created by the students. The group described two life cycles in the e-book, a lion and a praying mantis, in a story format on one page. The group applied the two life cycles in their drawings on the page.

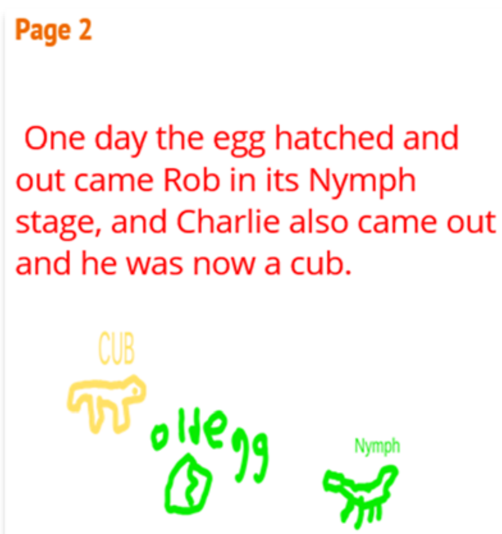


Figure 8. Life Cycle e-book with hand drawn illustrations.

In the Food Chains and Food Webs unit, students created images and wrote paragraphs about the process of photosynthesis, and explained the interaction of living and nonliving elements created in the ecosystem (see Figure 9). In learning the information about photosynthesis, students applied the knowledge and wrote a paragraph in their own words and created an image about the process. When students explained the interaction of the living and nonliving elements, the knowledge of the two items was applied in a written explanation. The completed projects where the project requirements stated to explain a cycle, concept, or repeat specific information, the projects were coded with application transfer as these items dealt with applying what the students had learned to a specific situation.

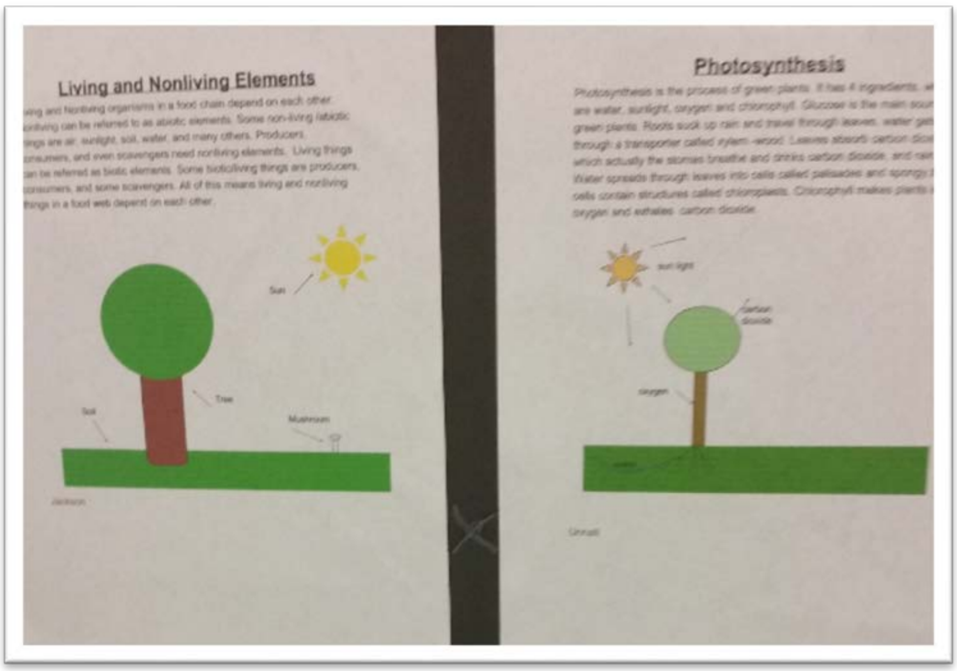


Figure 9. Student written explanations and drawings.

Sixth Grade

The sixth grade projects were case studies seven through nine and the largest data source coded for the application level was student interviews at fifty-two coded references. The students referenced the global warming conference during most of the interviews in The Heat Is On unit and discussed how to stop global warming with their assigned countries. One student applied what the group learned about global warming and their assigned country to all countries. “Everybody has to pitch in because you’re not going to stop global warming overnight. It’s going to take probably years and you’re going to need a bunch of help to make that happen.” Another student applied changing the energy source to produce goods. “They had a lot of factories as well, a lot of industrial things and they will produce a lot of stuff, so we said we could instead, when we use those factories we can use alternative energy to produce this stuff.” The student discussed how the energy used in the production of goods could be applied differently in the factories- by changing factories that produce goods from fossil fuel energy to using alternative energy.

In the Ring of Fire unit students told about what was learned in the prior grade and unit about volcanoes and vocabulary terms they could apply in the current unit. “We had just gotten out of the layers of the earth project and I think that helped because we knew more about the tectonic plates then . . . I think we got the continental drift theory and plate tectonics and all of the words much easier than we would if we didn’t know about the tectonic plates.” One student discussed how knowing about the “Ring of Fire” would help in avoiding tsunamis when he travelled. “How to avoid like a tsunamis. . . my family - we love traveling around the world, so I think it would be helpful to know where there may be an earthquake or an eruption at that time.” When asked if knowing about the “Ring of Fire” would help he and the family plan a trip, the student agreed. The student applied knowing about why and how tsunamis occur, in and around the “Ring of Fire,” to planning the family vacation. One group of students applied a familiar game’s concept, Candyland, to the game the group designed for the unit because they “wanted it [the new game board] to be long so we still made bridges and stuff to make it more like Candy Land but still have the facts.”

The Solar System unit referenced application transfer in the interviews and included: know the earth better so it can be treated better, in sections of the amusement park well known places to eat and drink were changed into solar system names, and games represented bodies in the solar system. One student applied the knowledge learned about earth by saying, "I think it's good to know more about the Earth because then you would know like how to treat it better." The student also thought the more knowledge about the earth that was learned, more help could be applied to becoming an astronaut. Students in one group changed names for the section's food buildings – Starbucks to Sunbucks, and McDonald's became McAsteroids. Students applied the concept of the arcade game skee-ball to represent gravitational pull of asteroids heading towards the planets. One team member described it, "We had 3 cups and one on the top was from comets because it had no gravitational pull pretty much. Then 2 was Venus and then Earth is on the bottom because it has the greatest gravitational pull out of those 3. The reason we put Venus in the middle is because you wouldn't be pulled down to the ground as much. You would probably weigh lighter if you went on Venus. That's why it's on the middle. Comets it has really no gravity that pulls you. What pulls the gravity is the sun so it doesn't really have any gravity. That's why it was on top." The student applied the knowledge from the game skee-ball to what was learned in the unit about gravitational pull, using the cups to represent the amount of gravitational pull. Another team member described the target golf game, "We wrapped the golf ball with construction paper and hid it into holes. The construction paper just messed up where it went, and stuff representing comets, how they move and stuff." The target golf was designed to represent comets travelling through space; and how the comets move erratically. The group applied the comets concepts to a putting golf game. Another student discussed Mercury by saying, “The oxygen on Mercury is mostly made up of helium and we can’t breathe helium. That might make us become light headed. I like to say if you breathe in helium, you’ll become an airhead.” The student applied facts learned about helium and the atmosphere on Mercury, to a saying about not having much intellectual knowledge.

Context Transfer

Context transfer refers to the application of what a person has learned in a slightly different situation and was Level 3 in Haskell’s (2001) six levels of transfer with 125 references. Context transfer was observed largely from student interviews (85) and completed projects (40). Data coded using this node relied on applying what the student understood from their research questions and project requirement list, taking the knowledge and applying it to the creation of the project in a slightly different situation, or creating an item from the project requirements in a different fashion. While second grade had very few codes (14) in this node, context transfer was heavily coded in fourth grade completed projects, with thirty-two references coded. Student interviews dealt with students describing how the information learned in the research stage helped with creating a project for a specific unit. All grade levels were coded context transfer when completed projects required students to explain how to use or identify concepts, create and compare, describe and explain processes or stages, identify and analyze, and explore, illustrate and compare.

Second Grade

For the second grade the highest coded data source at the context level was the student interviews with fourteen references. The interviews came from one project, Traits and Adaptations, and dealt mainly with the researched animals/plants’ information and the creation of a fictitious animal/plant. Students selected information researched about traits, adaptations, and life cycles and applied the knowledge to creating a fictitious animal/plant. A student described creating the fictitious animal/plant lifecycle as, "Since we're making plants and animal mixed together, we thought why don't we mix a plant and animal life cycle together and that's how we decided that." One group of students discussed knowledge of the sea star's regenerating capabilities as, "If it loses one of it, it grows another one of that," and transferred those capabilities to the fictitious animal's adaptations, "If stuff tries to eat it, it will generate [regenerate]." The group took the knowledge from the sea star and applied it in a slightly different situation, the adaptations of the fictitious animal/plant. Another group's knowledge of adaptations, including color, and cycles of hibernation helped to create the fictitious animal called a Creger. "It's orange and black in spring/summer and fall and it's white in the winter. Because it hibernates in the winter, and it goes out, it's a bunch of white like other animals sometimes it goes out and eats food and it goes back to hibernation." The knowledge of adaptations and cycles of hibernation from animals researched was used in a slightly different situation when the Creger was created. Using the data sources coded, there were very few references made in context transfer for second grade.

Fourth Grade

Among the fourth grade the highest data sources coded for context transfer were student interviews (39) and completed projects (32). The student interviews did not just deal with basic facts during the project, but how the basic facts would impact the students and the world around them. One team in the Weather Forecast unit discussed how to forecast predictions of rain. The team decided it would be determined by a water cycle's stage, precipitation or evaporation, since “if the water cycle’s in the evaporation stage, then following that there’s not going to be much precipitation where you are; it’s not going to be because it’s evaporating but if it’s in the precipitation stage, you’re probably going to get some rain.” Context transfer was observed as the students took the information about the water cycle and weather forecasting and applied the information in a slightly different situation; forecasting the weather by using the water cycle. As students prepared the weather forecast video, the preparation was compared to a news forecast on television by “doing it like NBC like having those other things like the squares and it says inside the news.” The student wanted to apply the format the local news daily forecast used to the group’s weather forecast in the video, and it was done slightly different than the local news.

In the Food Chains and Food Webs unit one student discussed why it was important for humans that plants make glucose and applied the explanation to why we need plants for the environment. “If the plant does not make glucose, the plant will die and if all the plants die, trees, lots of plants die, then we couldn’t have oxygen, lots of oxygen to clean out the air.” This concept was applied to the photosynthesis cycle and relating it to what could harm plants. “Engines, lots of stuff, that can pollute the world and we cannot breathe that much. Like if we use lots of cars, big bus, all that gas or the motor can puff out the black stuff that comes out from the cars behind and it puffs out black smoke. And that kind of like stinks and it kind of makes us not breathe that much. So, we need plants.” The situation was slightly different for the importance of photosynthesis, and the student applied the important function of keeping the air clean to the context of why plants needed to make glucose. In another slightly different situation as to why photosynthesis was important a student stated, “If we never learned about it [photosynthesis] when we grow up, then it helps with gardening and stuff." Gardening is what the student needed to learn; the plants would need nutrients, sunlight, and water, "Because if we grow up and like no people are left except me, and I didn't know how to plant stuff, and there's a big fire, everything burned, and I was the only one alive. I did not know how to plant stuff." The student needed to know about photosynthesis so he/she could plant and have food – just in the case there was an apocalyptic event.

In the Life Cycle unit one team of students discussed the life cycles of the animal, plant and insect chosen for the team's e-books for younger grade students. One team member discussed the e-book story of a poppy seed life cycle starting with a seed. "She started to grow because she got all those nutrients from the rain, sun, soil, and then she sprouted and then when she grew into an adult, she was getting old, and she had to let go of her children, because all those children are on her head. And then the big wind that took her away, took the kids away too. She was a little sad, but she was happy for her children." The student used the information of the life cycle of a poppy seed and applied the life cycle in a slightly different situation, an e-book story for kindergarteners. Another student applied the concept of editing and revising used for the e-books, and changed the context of when the skills might be important. "If you're writing a story for a job or for a paper somewhere like if you're applying for a job somewhere like a camp and you need to type up a paper and make sure it's good and everything." The student decided to know how to edit and revise could be important when searching for a job.

Completed projects had the second largest number of references (32) in context transfer for fourth grade. In the Weather Forecast unit, the videos created by students contained images, concepts, terminology, and ideas learned in the unit. One group showed warm and cold fronts on a paper drawn map by making moveable fronts out of colored paper and placing a “handle” on the front. The warm and cold fronts were originally viewed on a local forecast and the group applied the computer animation from the local news station to a paper copy of the same content. Another team created a computer slide show presentation, displayed the slides on the front wall with a data projector, and discussed each of the slides for the weather video (see Figure 10). The five day forecast represents students using what the local news station displayed for a weather forecast and applying the context in a similar situation - in a slide presentation.

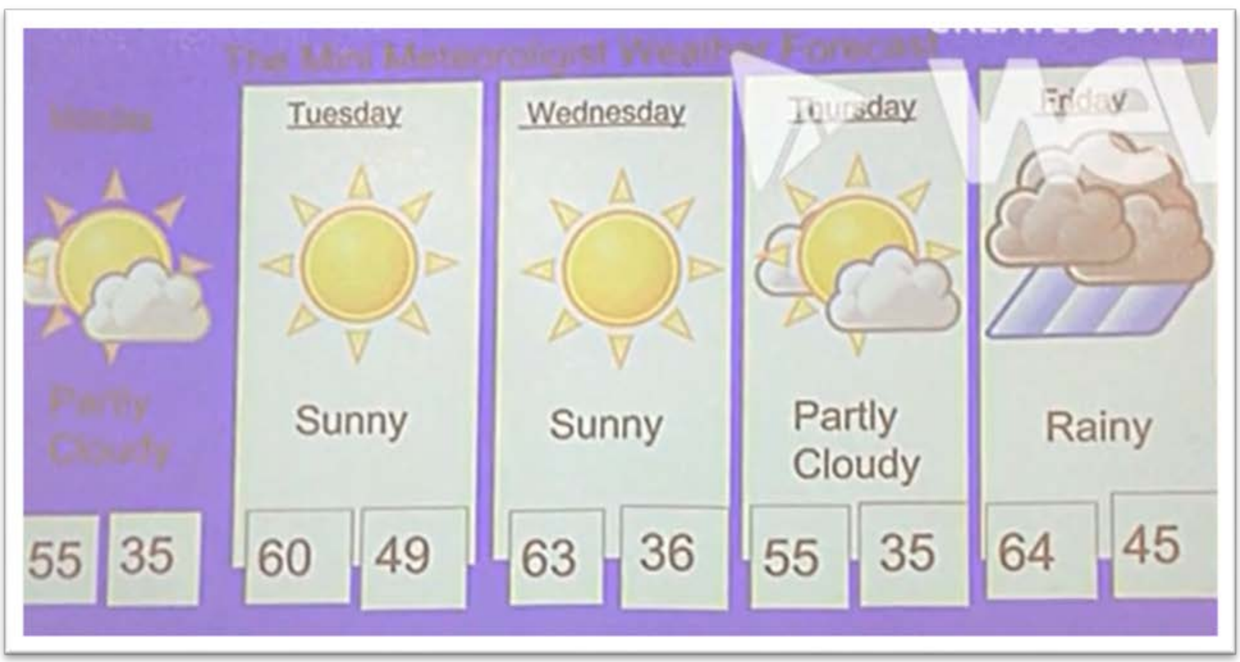


Figure 10. Weather video slide displaying a five day forecast.

The Food Chains and Food Webs unit had many completed projects in context transfer. Projects included many North Texas food webs drawn and labeled, specifically designed 3D food chains/food webs for the school's outdoor learning center, and 3D models of how an ecosystem looked before and after humans. The North Texas food webs applied the knowledge from other food chains/webs in a slightly different situation (see Figure 11).

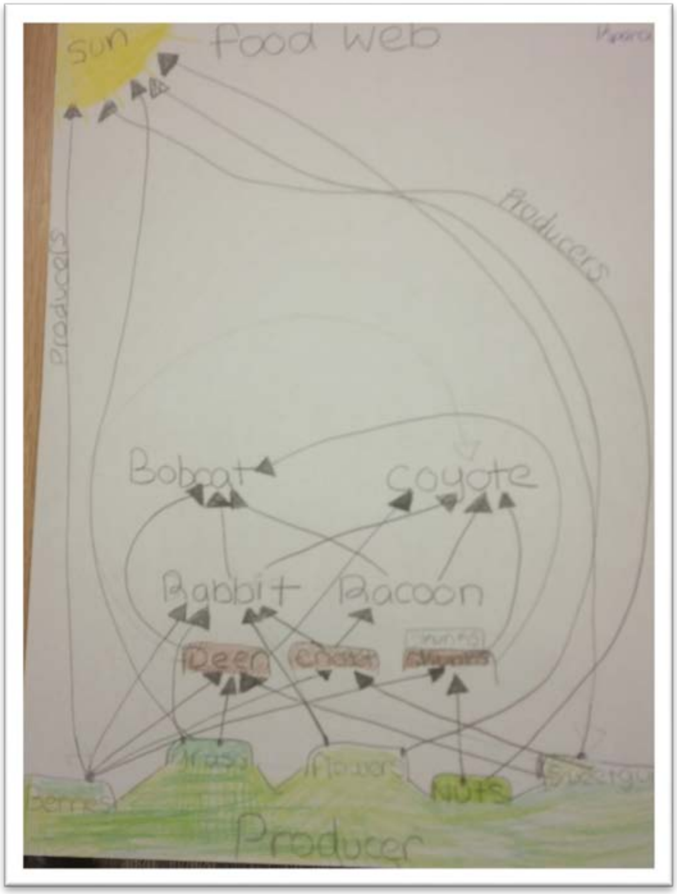


Figure 11. Food Chains and Food Webs - North Texas food web.

After students learned about different food chains/webs, the project for the Food Chains and Food Webs unit was to create a model the architects of the school's outdoor learning center could refer to for ideas (see Figure 12). Students applied knowledge of the North Texas food chain to a different situation, the school's outdoor learning center.

Figure 12. Food Chains and Food Webs -model of outdoor learning center.

The Life Cycle's e-books contained animal, plant, and insect life cycles told in a way younger grades, kindergarten and first grade, would learn about the specific life cycle. One group took the three life cycle e-books and had the story continue from one book to the next, but changed the life cycles from animal to plant to insect. This way the younger students could learn about different life cycles and the characters were familiar. The fourth grade students created projects for all three units and described, presented weather terminology and concepts, a North Texas food web, and different life cycles by creating, comparing, and explaining what was learned in the units in a slightly different situation and were coded as context transfer.

Sixth Grade

In the sixth grade, student interviews (32) had the highest number of references at the context transfer level. Fourteen coded references in student interviews came from the Solar System project where teams discussed why they chose the rides for their section of the park, how the rides were constructed to represent research about the solar system "body" assigned to them, and how they came up with names for food in their section. A waterslide in the amusement park section for the Sun and Mercury had “water fountains of yellow in it and it would shoot out yellow water. And it would shoot out like solar flares and go across, filter through, and then get shot again throughout different parts of the water slide.” The group took the concept of how a slide in a water park stays wet and applied the concept to their area of the amusement park, altering the slide’s water color to represent solar flares; a term learned during the project. One ride in the Kuiper Belt was described as, “Our ride was called the Belt Loop. We made our car like in Jurassic World, the gyrosphere. So that outside would go down the roller coaster and since there’s many dwarf planets, the padding that would stop you would be the dwarf planet.” Since the Kuiper Belt contains comets, the students thought the gyrosphere would be the car for their ride with the stopping mechanism a “dwarf planet.” This ride took concepts from a roller coaster and applied them in a different situation for their amusement park ride. The food in the park sections tended to be familiar food to the students with slight differences to the original food. Mercury chose “hot foods like Flaming Sweet Popcorn. . . . comet dogs and comet burgers which were kind of like holes to fit the look of the comet.” The food was familiar, but the context the food was applied in was slightly different.

In The Heat Is On project, context transfer was noted when one team discussed alternative energies in the UK. “We came up with geothermal because it’s on, it’s everywhere basically because we’re on the earth, and that’s it because all the other stuff that we tried still had to had come from somewhere and it still was a fossil fuel.” The group applied their knowledge of energy sources in a slightly different situation, and eliminated fossil fuels to discover the geothermal alternative for the UK. The Heat Is On unit had no photos of completed projects so only in student interviews were the projects discussed. In one team's project, their brochure contained a plan for stopping global warming by using the concept of electric cars. "We were thinking how we could stop it and we thought electric cars . . . . We thought if we make electric cars, then we wouldn't be using as much gasoline. We will have cleaner air because we won't be burning bad gasoline. We won't be creating the CO2 going up to our atmosphere and contaminating the air." By using a brochure to get the message out to the population of their country, the students applied the concept of stopping global warming by using electric cars.

In the Ring of Fire project, a student discussed the map assignment the class completed and how the knowledge could be applied to help the eighth graders with the science terms and the "Ring of Fire." "We already did a map project so we were thinking about it would be cool to make it bigger so people can see it more like in 8th grade and they can get some definitions, so they can actually physically see where the plate tectonics are and the Ring of Fire is." Students designed cards for their game board projects and knowledge from the unit was applied in a different situation. One student described the cards as, "Some are just like move up 2 and it's pretty much like what would happen if the tectonic plates start acting up in general."

Near transfer. Near transfer refers to when previous knowledge is transferred to new situations that are very similar but not identical to previous situations. According to Haskell (2001), the knowledge base of a learner determines whether transfer is occurring at near or far transfer. What is near transfer to an expert, may be far transfer to a novice. Near transfer is the fourth level in Haskell's (2001) six levels of transfer and received one hundred seven references in the data and was observed mainly in student interviews (61) and completed projects (46).

Data coded at near transfer dealt with creating: a fictitious animal or plant species, an exhibit, a system to classify materials, a visual display, images or paragraphs, or an e-book. Students also illustrated, evaluated, demonstrated information learned, and explained the significance of a cycle. Near transfer was mainly observed in fourth and sixth grade with eighty-eight coded references from interviews and completed projects. Second grade references coded at near transfer were from one unit's completed projects. Data coded using this node relied on student's transferring knowledge from the research questions and project requirement list and applying the knowledge to a new situation that was similar but not identical to the learning that occurred during research and project construction/completion.

Second Grade

The second grade projects highest coded data source for near transfer was the completed projects at thirteen, and all references for this node were from the Traits and Adaptations unit. The projects were coded with near transfer since the knowledge researched about plants and animals was used in a new learning situation. The completed projects combined two different animals or plants studied in the research and students created many different combinations including the fomcelo, venus tiger, mimic cobra, and picky pointy venomous snake (see Figure 13). The fictitious animal/plant included dietary needs, life cycle, adaptations, and habitat. Students combined one plant life cycle with the dietary needs of another plant, or the habitat of one animal with the life cycle of another animal. Sometimes students would alter the facts from the research to have a unique animal or plant. All fictitious animals/plants took information from the research and transferred the knowledge to a new situation. The animal/plants were similar to the animals and plants the groups researched.

Figure 13. Traits and Adaptations completed projects – fictitious animal/plant.

The second grade responses in the near transfer level were limited in the number of references, and did not support the classification of second grade making it to near transfer, but there was anecdotal evidence from among the few who did respond the way it is described here.

Fourth Grade

The fourth grade data sources with the most coded references in near transfer were the student interviews (28) and completed projects (15). The student interviews, noted in all three projects, had the largest number of references in near transfer. From the student interviews, the Weather Forecast unit had many explanations of the water cycle and how it related to the weather forecast. Students discussed condensation in the clouds and the evaporation stage of the water cycle and how it related to the groups' weather forecast. "The water cycle--- it can help us know about weather, so like condensation is less stuff that's in the clouds, and we can know that for our forecast like where the clouds are - so it's going to be really cloudy and tell us how much precipitation there's going to be, and if it's [in the] evaporation stage we're probably not going to get any precipitation." The student did not discuss only the water cycle and how weather is affected, but how to apply both topics to a new situation - the weather forecast.

In the interviews from the Food Chains and Food Webs unit for near transfer, a student decided to make a scratch off game for a quiz about the ecosystem created in the project. A student described how a team member made the game. "She got the paint and tape. The answer was on the board before when she put on the tape. So, when she put down the tape, she painted it with blue paint. You know like those scratch off like to get money. It's like that, she did that and it works." The student took the concept of a scratch off for money and applied it to a new situation that was similar, a scratch off on a board to reveal an answer to a question. Another student was asked why learning about chlorophyll, photosynthesis, and food chains/webs was important. The student stated, "If I get a house which I sure hope I do, I'm going to put plants in the yard and I'm going to have to find a good spot for it otherwise, like it's going to die and then I don't want that because I have to buy new ones and that cost money." The student applied knowledge learned in the research of the terms and discussed a new situation, keeping plants alive to save money, where the knowledge was applied. When a student was asked why it was important to know what a food web was, the response was, "Because if you know what the food web is, like if you --- especially for us, we have a little dog and there’s a bobcat in the neighborhood so if we didn’t know bobcats eat dogs, our dog could’ve been gone.” The student took the knowledge from the research on food chains/webs and the North Texas food web, and applied it to a new situation, what would happen to his dog.

Interviews during the Life Cycle unit included students discussing topics for an e-book, and how editing and revising could be applied outside the school environment. When one group decided on the story for their e-book, the idea was based on a saying from a movie. “Well we were thinking like the saying, like the song like ‘tigers, lions and bears oh my.’ So, we were just thinking for like ‘plants, insects, and mammals oh my,’ because we did a project on a plant, a mammal, and an insect.” The group applied the familiar saying to the e-book, using a new idea in a new situation. Another student was asked to discuss how editing and revising an e-book in the Life Cycle project would help outside of school. The student answered, “I can write my brother children’s books because he’s 2, about sharks because he loves sharks.” The student used editing and revising knowledge in writing the e-book for kindergartners, then applied the knowledge to a new, but similar situation, writing a book for a sibling.

Fifteen references provided evidence of near transfer observed in completed projects. The fourth grade completed projects included the Life Cycle unit e-books and a few posters and models of North Texas ecosystems. The e-books in the Life Cycle unit were on Google slides and written for the younger grades. In all the e-books students used knowledge gained during research of an animal, plant and insect and applied the life cycle knowledge into an e-book for a younger student. The authors of the books adjusted and applied their writing skills for communicating the knowledge of the different life cycles into language younger students could understand. A few teams created 3D models, photographed and inserted the illustrations into the team's e-book (see Figure 14).

Figure 14. 3D model in a Life Cycle e-book.

The e-book *Fly Dude* was the story of a fly's life cycle. The team created pages for each stage in the fly life cycle and created an easy to follow story for a younger student. One page has a computer drawing and the following text, "At that time Dude sheds his skin several times and then chooses a dark place to pupate (which is like a cocoon) and turns into a grown up Dude." This e-book took the stages of the fly and placed the information in a new, but similar situation. All completed e-books were coded as near transfer as students took the knowledge about the life cycle of a plant, animal, and insect and applied the information to a new situation that was very similar, but not identical.

Four Food Chain /Food Web completed projects were coded near transfer. One team's food web took the basic knowledge of consumers, predators, and decomposers, and added the prey and producer levels. The added levels were not in the project requirements, so the completed project was coded near transfer since the added information produced a project in a new, but slightly similar setting. Another team created a presentation of their food web and placed thought provoking “what-if” questions on slides for the participants to answer. This feature allowed the transfer of learning to a new and slightly different situation, since the fourth grade projects/presentation typically did not include the audience answering thought provoking questions. A third team created a game to incorporate knowledge gained from research of the carbon dioxide cycle and photosynthesis (see Figure 15).

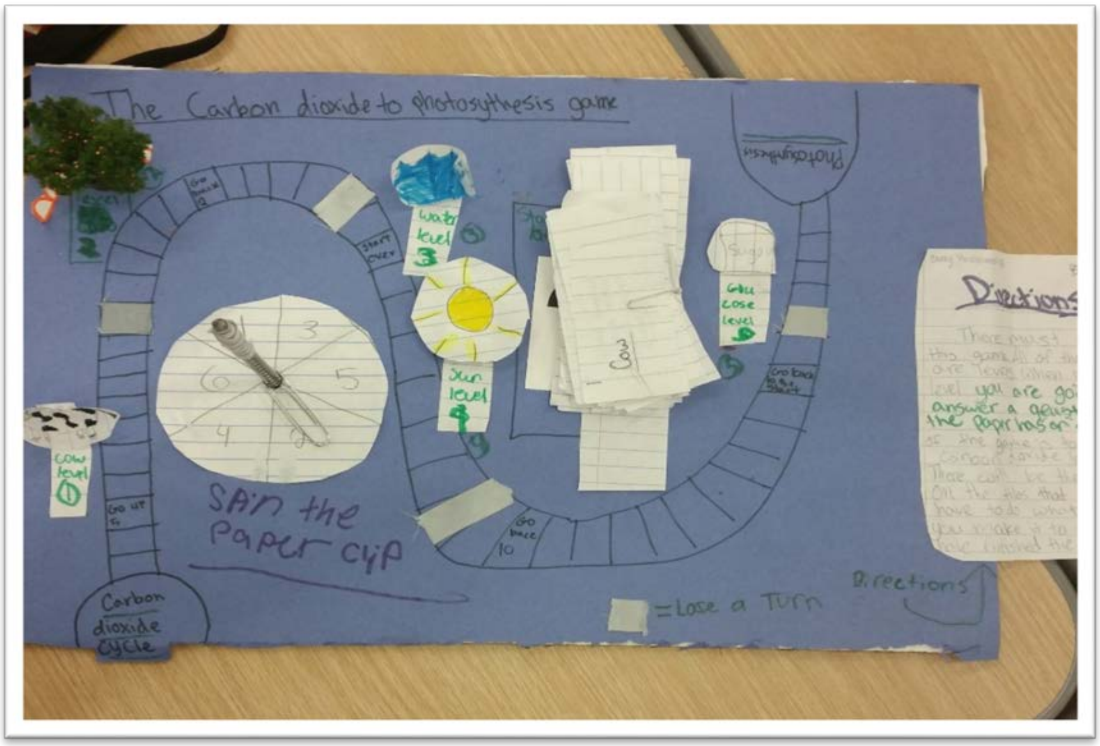


Figure 15. Carbon dioxide cycle/photosynthesis game.

The game board contained different levels as a player travelled from the carbon dioxide cycle circle to the photosynthesis circle. The game cards, used when a player reached a specific level, contained questions the player had to correctly answer to move forward in the game. The questions came from the research on the carbon dioxide cycle and the photosynthesis process. The player who moved from the carbon dioxide cycle circle to the photosynthesis circle won the game. The game cards applied the learning of the carbon dioxide cycle and photosynthesis process to a new situation that was similar, but not identical to learning the facts associated with the researched information.

Sixth Grade

The sixth grade projects with the largest data sources coded as near transfer were student interviews (27) and completed projects (18). Student interviews for the sixth grade encompassed all three units at the near transfer level. In The Heat Is On unit a student discussed how their team's country could "donate some of that money to the countries that can't afford alternative resources like windmills and solar panels, so that they could have electricity and to create charities so that we could raise money for them." The student's team took the alternative resource idea and created a new situation, donation of money and creating charities, for getting alternative resources to countries without them. Several teams discussed how humans treat the earth today would affect everyone in the future. One student reflected, "Everyday my dad says turn off the lights when you're not using them because that could really help with global warming and he always tells me don't take a shower too long . . . plant more trees and go out there and pick up trash because it could really make a difference no matter how little you do." The student realized from The Heat Is On project there was an impact he could make, so his dad telling him ways to help with global warming was a new situation that was similar, but not identical to the research he learned. One team presented the idea to use algae to power cars so people can drive without polluting the air.

Student interviews for the Ring of Fire unit discussed several projects. One team created a circular board game for the Ring of Fire unit and described it as, "Our team got a board game for the Ring of Fire, and we did a board game kind of like the Sorry sliders game except with a little more rules and have something more to do with the tectonic plates and stuff." The student then went into detail about the game rules and how it progressed, the number of players, and the starting pieces each player used – tectonic plates and volcanoes (see Figure 16).

Figure 16. Ring of Fire completed project - circular board game.

The team created a game other students would understand, but applied information from the research they did in the unit. Another student presented to the class an additional project, the magnitude of earthquakes, in the Ring of Fire unit. When asked if the presentation helped the class to understand earthquakes and volcanoes better the student replied, "They told me that they learned all about magnitudes and they didn't really know what a magnitude was before I showed them it and they learned how magnitudes give an earthquake different abilities." The presentation on magnitudes applied learning during the project to a new situation, why magnitudes were important, and this concept was especially important to understand if you lived around the "Ring of Fire."

The Solar System unit had a few student interviews coded at near transfer. One student described the team's section of the park for Jupiter, "We made 4 restaurants and they all had --- they were named after the 4 Galilean Moons and the restaurants were like --- the type of food that they have were the way the moons were like. For one of them, it was for Ios, it was spicy food because it's hot there." The student applied researched information about one of Jupiter's moons to the type of food served in the amusement park section. The spicy food reflected the temperature of the moon and created a new situation with known or researched information from the project. For the Mars section of the park the team had to calculate the weight of a person so the ride would work correctly. A team member described the process, "We tried to figure out how much would it weigh for a person on Mars, if they were on Earth to Mars, and then we took the gravitational pull if you were on Mars. So, if you were on Mars plus being in the machinery we took all of that and we found out how much you would weigh." The was a calculation needed for the bungee type ride to work in the team's section of the park. The team's research revealed the gravitational pull for Mars, so the team applied the information to calculate the weight of a person. Both the gravitational pull and the weight of a person was important for making the team's ride work. This was a new situation for using gravitational pull in a different setting - to calculate how the ride would work. The team assigned to the Sun and Mercury section of the park created a water slide based on the water cycle on Earth. The water for the slide was filtered, freeze dried, then cooled down when the slide needed it. The student explained how the water from the ride was collected and how the water cycle was important in the collection process. “Whenever you evaporate water, it goes through the precipitation cycle like how it does on earth and then so it goes through the cycle and then it starts to precipitate in a certain area that we contain water. And then it precipitates, gets freeze dried and then it will be unfreezed, cool-down, so it’s not like steaming hot and then it goes back through the cycle.” The student applied knowledge from the water cycle, as he/she understood it, and brought the knowledge to a new situation, collecting water for the ride in the team’s section of the park.

Two of the three units had the completed projects referenced in near transfer. The Ring of Fire completed projects coded at this level included clay models demonstrating, not just defining, the movement of plate tectonics in a new situation. Two games, Tectonic Travel (see Figure 17), and the circular board game (see Figure 16) described in the student interview section, was created to learn about earthquakes, volcanoes, and tectonic plates. The Tectonic Travel game was like Candy Land, but students created the game with terms and concepts researched from the Ring of Fire unit. Students had to apply both social studies and science concepts to move through the game. The game was dissimilar to the original learning in the unit – activities including drawing maps and learning terminology by research.

Virtually all Solar System completed projects were coded at this level as represented by creating an amusement park that incorporated solar system “bodies.” The sixth grade students used research data on the assigned solar system body and placed the information in a new situation, a section of an amusement park (see Figure 18).

Figure 17. Ring of Fire completed project - tectonic travel game.

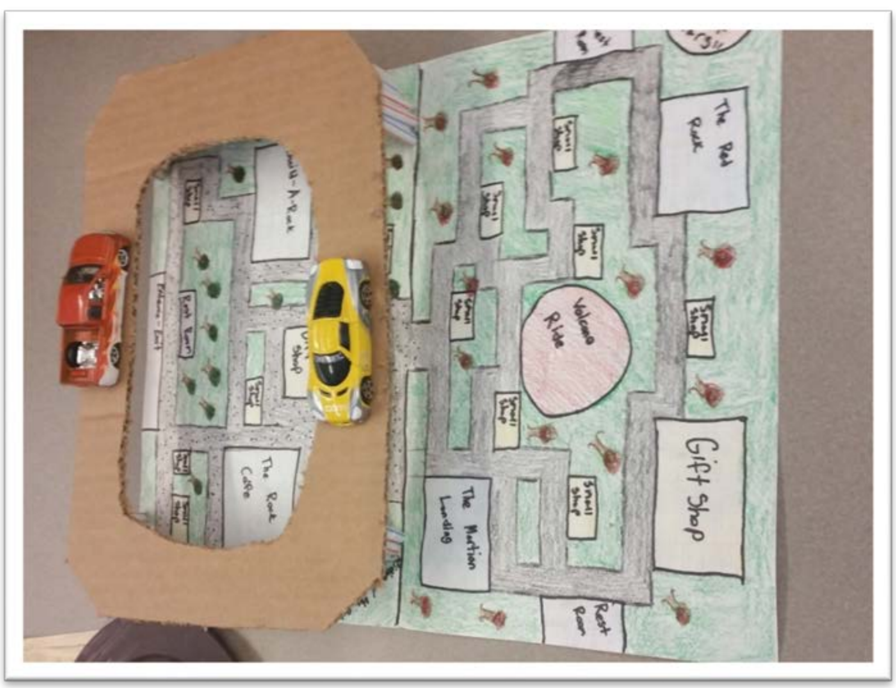


Figure 18. Solar System completed project – Mars section.

Near transfer was identified in sections of the park where teams correctly used facts from research to build the rides in the teams' section of the park, included different modes of transportation to move around the section, and detailed menus of food items relating to concepts about the teams' section. In the Mars section of the park, a restaurant had brownies and jawbreakers made from basalt as the planet was made of basalt. Students did not simply discuss what they learned in the units but pursued avenues in their projects that created new situations.

Summary of Levels of Transfer

The levels of transfer coded by grade levels indicated application and nonspecific transfer had the most references (see Figure 19). The results indicated students were using current and past knowledge and could apply the knowledge in similar situations. The levels of transfer of learning were recorded mainly in the student interviews (see Figure 20).

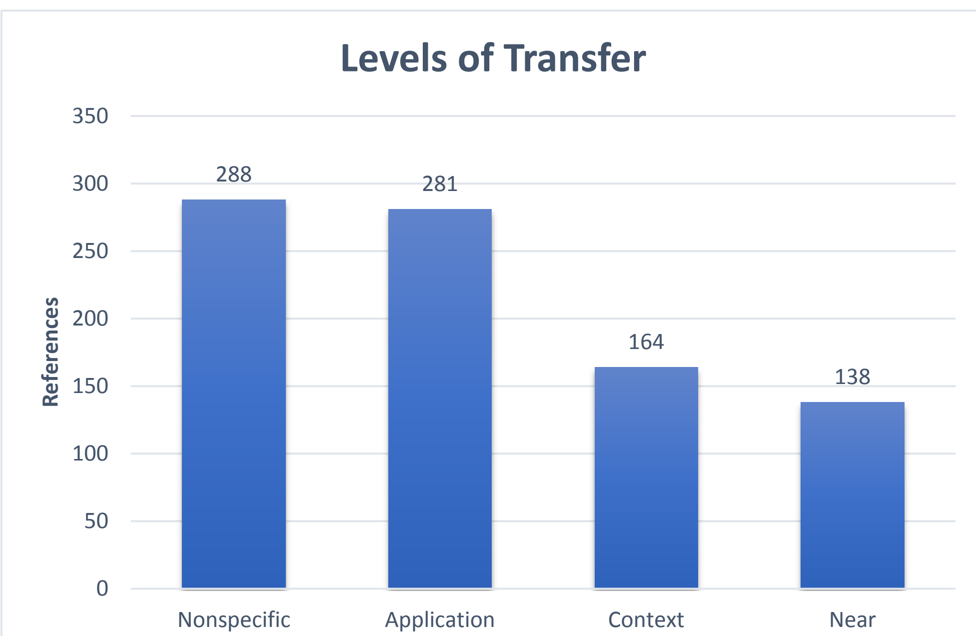


Figure 19. Levels of transfer.

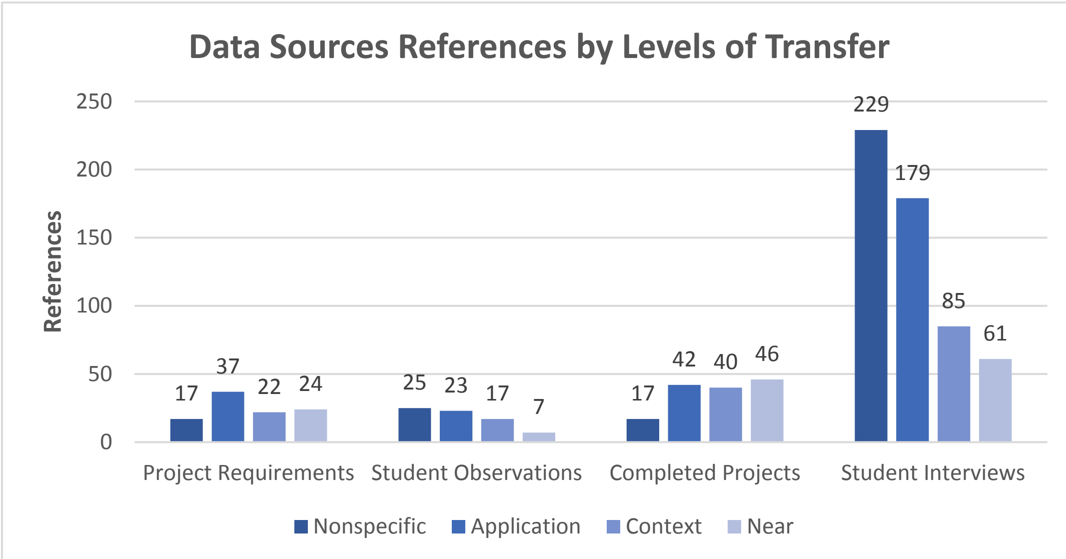


Figure 20. Data source references by levels of transfer.

Students could express verbally levels of transfer of learning as apparent in the student interview data source, but the other three data sources were exceptionally low by comparison. The project requirements, student observations, and completed projects data source coded had low indications of the levels of transfer of learning. During student observation, while students were going through the steps of PBL, indications of transfer of learning were not evident.

Types of Transfer, Node Findings

What types of transfer of learning were observed in an elementary school project-based learning environment?

An analysis of the coded data resulted in two types of transfer that emerged as having the highest number of coded references (175) - literal (91) and conditional (84) (see Figure 7). Literal transfer describes how transfer occurs and conditional transfer explains when transfer occurs. A description of the nodes are discussed in order of largest to smallest number of references. Each type is described by grade level.

Literal Transfer

Literal transfer refers to using knowledge or a procedure directly in a new learning situation and describes how transfer occurs. Literal transfer is one of Haskell's (2001) fourteen types of transfer, received 78 references in the data, and was observed mainly in completed projects (48) and student interviews (30). Data coded using this node relied on using knowledge gained from research, the project requirement list, and project activities in a new manner. When students explained, created, explored, illustrated, compared, analyzed, evaluated, or investigated terminology or a concept literal transfer was included in the coding of the data references. Fourth grade at 44 coded references, and sixth grade at 34, had the highest occurrences of literal transfer, while second grade had a lower amount at 13.

Second Grade

The second grade projects highest coded data source for literal transfer was the completed projects at eleven, and all references for this node were from the Traits and Adaptations unit. The projects were coded with literal transfer since the knowledge researched about plants and animals was used directly in a new learning situation. The completed projects combined two different animals or plants studied in the research and students created many different combinations including the Venus fly trap, fomcelo, and creger. The fictitious animal/plant included dietary needs, life cycle, adaptations, and habitat. Students combined one plant life cycle with the dietary needs of another plant, or the habitat of one animal with the life cycle of another animal. Sometimes students would alter the facts from the research to have a unique animal or plant. The students demonstrated in the fictitious animals/plants the knowledge learned from researching different animals and plants was directly applied to a new learning situation.

The second grade responses in the literal transfer type were limited in the number of references, and did not support the classification of second grade making it to literal transfer, but there was anecdotal evidence from among the few who did respond the way it is described here.

Fourth Grade

The fourth grade projects with the largest data sources coded as literal transfer were student interviews (23) and completed projects (17). The Weather Forecast interviews contained six students discussing how to put the weather forecast together. One student described how their team put together the weather forecast. "First, we had the introduction, . . . we said, 'Good morning Prestwick Academy, this weather forecast is by,' and then we would all say our names. And then the next slide was all the weather, and then since we had to do the water cycle - the very last slide, we went onto Google Drawings and we do arrows and stuff and we put the definitions on there. And then we took that and we put it on to the Google Slides." The student described the procedure in sequential steps how the team took the information learned and applied it to a new situation. Two students discussed how their team came up with one of the project video's details. One student stated, "We got our idea from how the people like on the news how they do it, how they--- the slide that they do, like the weather forecast how it comes in. We decided to do that and we found a way that we could do that." The team watched the news, at school and at home, saw how the forecast "comes in" on the screen, and described how the team's forecast could do the same thing with Google slides.

The team took the procedure of making the slides "come in" for the daily temperature and applied it as one of the video details to their project. Three students discussed the steps to create their teams' forecast video using Google slides, including the details some of the slides would contain. As one team member described a slide in the video presentation, "We made a table and it had all the different things. We had humidity, wind speed, precipitation, what the sky is going to look like, cloudy or sunny, and then we have the high and low temperatures." The student described the procedure of how the team created one of their slides by placing the information in a new situation, a table on the Google slide.

The student interviews in the Food Chains and Food Webs unit dealt mainly with how to decide what animals and plants would be included in the North Texas food web and how these animals and plants could be used in the outdoor classroom at the school. In one interview a student discussed how the team "wanted to show a before and after, because like we wanted to do like before nobody disturbed the ecosystem, and then after we came along and disturbed the ecosystem." The team created a project that contained a new situation based on what was in the North Texas ecosystem, prior to humans and after humans were an influence on the ecosystem. As project guidelines were to include a complete North Texas ecosystem, the new knowledge gained from the "before and after," was presented in the team's model describing the ecosystem. Another student described a 3D food web and how people would interact with animals, what animals would be in the food web, and what happens when one animal leaves the ecosystem. "The model was a 3D food web, and it shows like the North Texas animals and how people interact with animals, and just like about the animals that would be over here [school's outdoor learning center] and what they will do to each other, what happens when one leaves and stuff like that." The student was applying new knowledge about the food web and how the information could impact the learning center.

Student interviews in the Life Cycle unit discussed information from the animal, plant, and insect life cycle researched and how to present the information to a younger grade student. One interview was about the life cycle depiction of a 3D clay model of the praying mantis, and the student was asked how the clay figures were created. As the student pointed to the clay figures in the project, he/she described how each life cycle stage was made and the correct order of the stage. "So, we just made it like a leaf and we looked it up because there's the egg it's white and the larva is brown. Then the pupa is yellow with the green leaf under it, and then the adult is the leaf type kind of." The student also described how the e-books were constructed into one book, "We needed it to be like in good order. Not just on there mixed up. And we thought about doing the e-book and doing it into one book, because since the pitcher plant and the praying mantis live, plants and insects - so those are just together, and then the seal, I really don't know how we got that idea." Originally, the group wanted to have three separate books and they transferred the three books into one. The knowledge and procedure of putting all life cycles in one book was a new situation for the group. Another student discussed the how the life cycle of the mealworm was hard to put in a story for the younger grades, since there was so much research and information about each stage and the story needed to be cut down so it was not overwhelming for younger students. "Whenever we were trying to make it kid bearable and the life cycle, it was kind of tough because we got so much research, we don't know how to put it in each stage." The team took all the knowledge gained during research of the mealworm life cycle and applied the new knowledge into an e-book the younger students could understand.

Seventeen references provided evidence of literal transfer observed in completed projects. Five weather videos combined knowledge researched about weather terminology, symbols, and skills to decide what information to include in the video, how to incorporate the water cycle into the video, and the team members' roles in the production of the video. The teams' videos transferred prior knowledge and knowledge learned in the project to new situations directly to the final weather forecast production. Two videos transferred knowledge of computer programs directly to the use of online slides to deliver a weather forecast. Four videos placed the water cycle information by itself at the end of the forecast, while one video incorporated the different stages of the water cycle into an explanation during the weather forecast. The video that incorporated the different stages into the forecast transferred the knowledge from the water cycle directly to a new situation. The Food Chains and Food Webs unit had a game board coded at the literal level and discussed in the near transfer section (see Figure 15). The carbon dioxide cycle/photosynthesis game took knowledge learned and incorporated the new information from research directly to a new situation, the game.

For all the e-books created in the Life Cycle unit (10) and coded for literal transfer, the prior knowledge, researched information, and procedures of writing a story/book were used directly in a new situation. Students took information about three life cycles, presented to the younger grades and decided how much information to include about each life cycle. The e-books needed text and picture to match for a story and a life cycle, and the creators of the books decided where and how to place each of the items in the book. The e-book, The Two Caterpillars, was created in a story format with dialog between characters and how the stages of the life cycle of a butterfly progressed between the two caterpillars. The stages of the butterfly's life cycle were not too technical for a younger student and the dialog in the story, along with pictures on each page, was well balanced. Another e-book, *Fly Dude*, presented the life cycle of a fly by the main character, Fly Dude. The e-book was written in story format and age appropriate for the intended younger audience. In this book, a fly's life cycle was presented and at the end of the story, the reader understood that Fly Dude has a "son" Dude Jr., "starting his cool life." In the next book the team wrote Sunzilla (a Sundew plant), who sprouted up right in front of Dude Jr. The story continued with the two discussing the stages in Sunzilla's life and how he will name his youngest seed Bob (see Figure 21). The team wanted to continue the story with Bob, but ran out of time to create the complete e-book. Literal transfer was coded for all e-books as the prior knowledge, researched information, and procedures of writing a story/book were used directly in a new situation.

Figure 21. Example of an e-book's page in a story.

Sixth Grade

The sixth grade projects with the largest data sources coded as literal transfer was completed projects (20). Fourteen Solar System projects were coded in this node as these projects used knowledge from research directly in making different areas of the amusement park. The areas contained rides, food, and transportation matching the environment of the solar system body assigned to the team. Another unit, The Ring of Fire included Styrofoam cube with pipe cleaners defining plate tectonics vocabulary terms (see Figure 22), as well as science terminology represented by clay models (see Figure 23). Ring of Fire projects also included clay depictions of plate tectonics movement, flip books made from the knowledge of volcanoes and plate tectonics, and a plate tectonics dance. The visual project representations of knowledge gained in the unit demonstrated how concepts directly transferred. The plate tectonics dance, a completed project for one team, depicted student demonstrated science terms and definitions and was performed for the eighth-grade science classes.

Figure 22. Ring of Fire completed project – styrofoam cube with vocabulary terms.

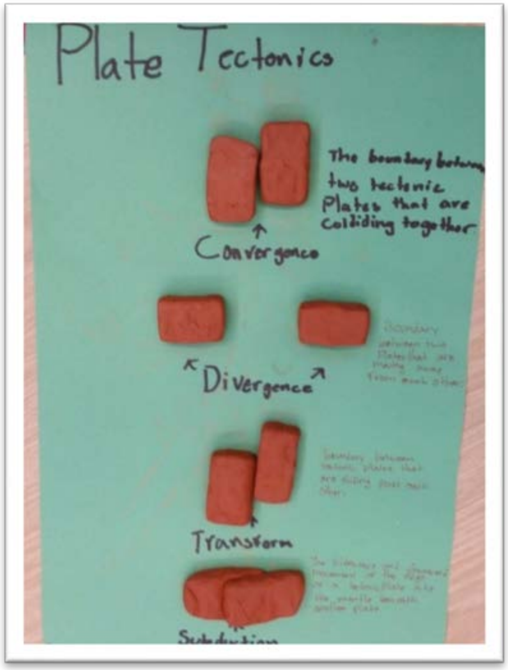


Figure 23. Ring of Fire completed project – clay models with vocabulary terms.

Conditional Transfer

Conditional transfer occurs by knowing when knowledge learned and applied in one context is appropriate for transferring to another context. Conditional transfer is the type of transfer that explains when transfer occurs, received 65 references in the data, and was observed mainly in completed projects (36) and student interviews (29). Data coded using this node encompassed student knowledge gained from research questions and the project requirement list as applied to another context. Fourth grade and sixth grade had the highest occurrences of conditional transfer, while second grade had very few.

Second Grade

There were very few second grade projects coded in conditional transfer, only seven references, and did not add to the trend in the analysis.

Fourth Grade

The fourth grade projects with the largest data sources coded as conditional transfer were completed projects (23) and student interviews (21). All three units had completed projects referenced in this node, with a majority noted in the Weather Forecast and Life Cycle units. In the Weather Forecast project, student teams decided when to draw pictures to place on their large map, and when to take what was viewed on the daily local weather forecasts and apply it to their project. Comparisons were made to live weather forecasts, and teams decided when to have their recorded weather forecast include some of the same components/concepts. The team who used Google Slides to have the weather "come in" for each day used the knowledge from watching local forecast's format and decided when to apply the concept to their video. Students needed to know when to apply knowledge of weather logs, weather symbols, weather prediction, and the water cycle to the weather forecast videos. The weather concepts learned in the unit could be used in the video; the teams needed to know when to apply the knowledge to their forecast.

In the Food Chains and Food Webs project, the model of the ecosystem that illustrated "before and after" humans encountered an area demonstrated the students knew when to include different aspects in the model. Students learned about the North Texas ecosystem during the unit and could determine when the knowledge learned should be applied to either the "before" or "after" side of the model. A Carbon Dioxide Cycle/Photosynthesis game (see Figure 15) allowed students to decide what to include on the game cards and when to introduce concepts related to the topics.

The Life Cycle completed projects included student knowledge of when to apply knowledge of the different life cycles, and in what order, to the e-books written for the younger grades. The fourth grade students took the knowledge of the different life cycles and decided when to apply life cycle facts and when to apply story elements to the e-book. The older students needed to know when the e-book stories were age appropriate and understood by a younger student, which entailed many written revisions of the stories. When working on the e-books, students had to decide when to put text on the book pages and when to have a picture.

In the student interviews, twenty-one references for conditional transfer were coded in the Weather Forecast and Food Chains and Food Webs units. The Weather Forecast unit interviews included one group using what was viewed in a local forecast about fronts and adapted it for their video. “They [meteorologists] had all these computer screen things that was showing them [warm/cold fronts], but we didn’t have that so we said we can use props and Pate can move them, because they had a computer moving them and we didn’t have the computer moving it so he can be our computer.” The team viewed the computer images from the local forecast and decided when to use the concept of moving fronts, and how the adaptation should occur. Another student discussed when to seek shelter in certain types of weather. “You never know what it’s going to be like if there’s a tornado or earthquake. So, you should probably look at the news, or you can predict it yourself, to see what the weather is and if you predict there’s going to be fire drill then you should probably go somewhere safe to keep you alive.” The student took several concepts, weather, tornado or earthquake, and shelters during storms, and applied the knowledge to when a person should seek shelter in certain types of weather. Several students thought knowing a weather forecast would “help you pick what to wear in the mornings.” Student interviews dealt mainly with students knowing when to apply knowledge learned either in the research stage or in a prior grade.

The student interviews in the Food Chains and Food Webs unit included the teacher asking students specific questions about the food chains and food webs the teams were researching. The same type of questions would be asked to the students at the end of the unit interviews by the researcher, but as the teacher was posing the same questions, the dialog between the teacher and student was recorded and transcribed. The teacher named an ecosystem, added or deleted a member, and the student described the food chain /food web and told why the addition or deletion affected the ecosystem. For example, the teacher said, “You have a forest ecosystem and you take out the eagles. What would happen to the grasshoppers in that ecosystem?” The student replied, “The grasshoppers would – there’d be so many of them that it would go crazy.” When asked why, the student stated, “There’s like since the eagles won’t be there, they won’t be able to eat the grasshoppers and then there’d be so many like take over the forest.” The student took information learned about multiple ecosystems and knew when to transfer the needed information to the teacher’s named ecosystem.

Sixth Grade

The sixth grade projects with the largest data source coded as conditional transfer was completed projects (13). In the Ring of Fire and Solar System units, students applied knowledge they learned in research and transferred it to the completed projects, when appropriate. One project in the Ring of Fire unit were the flip books (see Figure 24). The students took the knowledge learned about plate tectonics, volcanic eruptions, or Pangea and the dividing continents and decided when information learned applied to creating the flip book. Other projects coded with conditional transfer in the Ring of Fire unit included a circle game with pieces representing items in the "Ring of Fire," (see Figure 16) and a Styrofoam and pipe cleaner cube displaying vocabulary terms (see Figure 22). When the students built these projects they needed to know when the information learned could be applied to the game or the Styrofoam cube.

Figure 24. Ring of Fire completed project– flip books.

The Solar System projects included the diagram the team presented of their park section, models of the rides in the teams' section of the amusement park, and when younger grades came to view the amusement park sections, demonstrations were provided to the students. The teams constructed the amusement park sections took all the knowledge learned about the assigned "body," and knew when to apply the knowledge to their area of the park (see Figure 25). When younger students viewed the amusement park sections, the sixth graders answered questions posed. The sixth grade students had to know when to disclose information to the younger student, and how much information the younger students could understand.

Figure 25. Solar System completed project – amusement park section.

Summary of Types of Transfer

The types of transfer analyzed by grade levels indicated literal and conditional transfer had the most references (see Figure 26).

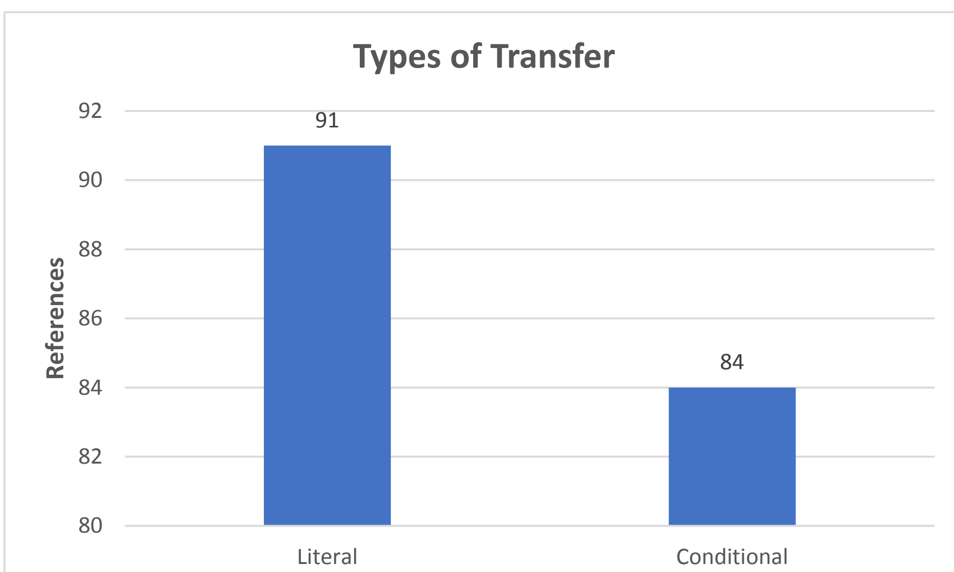


Figure 26. Types of transfer.

This indicated students knew how and when to transfer the knowledge. The types of transfer of learning was recorded mainly in the completed projects and student interviews (see Figure 27).

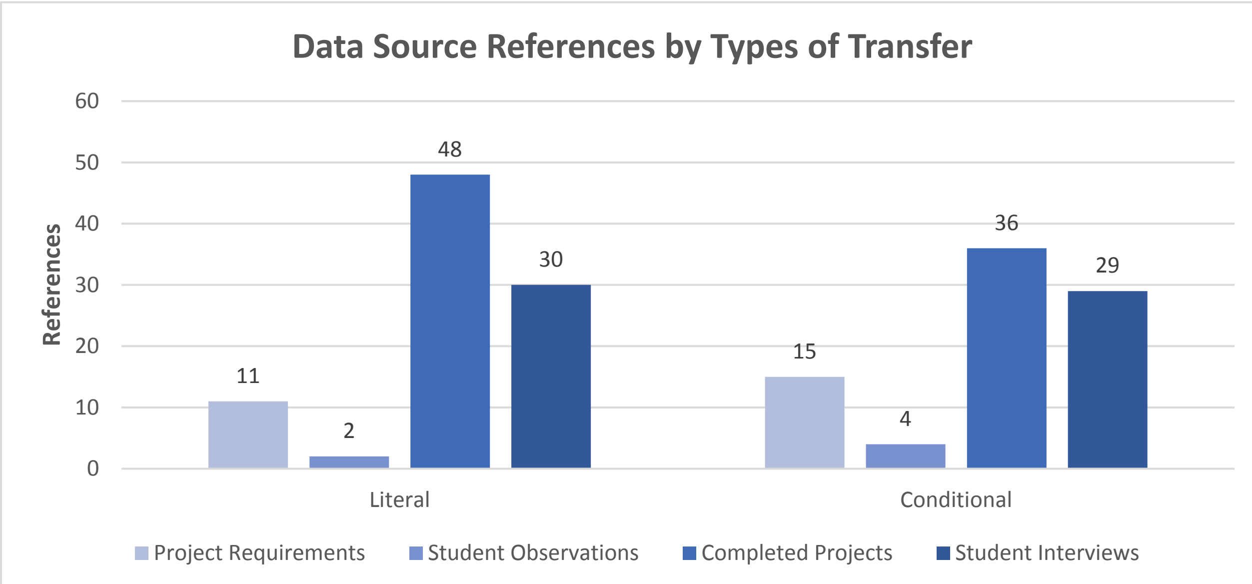


Figure 27. Data source references by types of transfer.

When students completed a project, they could express the types of transfer of learning, as apparent in the completed projects and student interviews data source, but the other two data sources were low by comparison. During student observation, while students were going through the steps of PBL, indications of transfer of learning were not evident.

Across which Learning Environments was Transfer Observed?

Transfer of learning was coded across the following sources: student interviews, completed projects, student observation, and project requirements with a total of 1046 coded references (see Figure 28). Student interviews (613) and completed projects (229) acquired the most coded references while project requirements (126) and student observations (78) were nominally noted in the coded references.

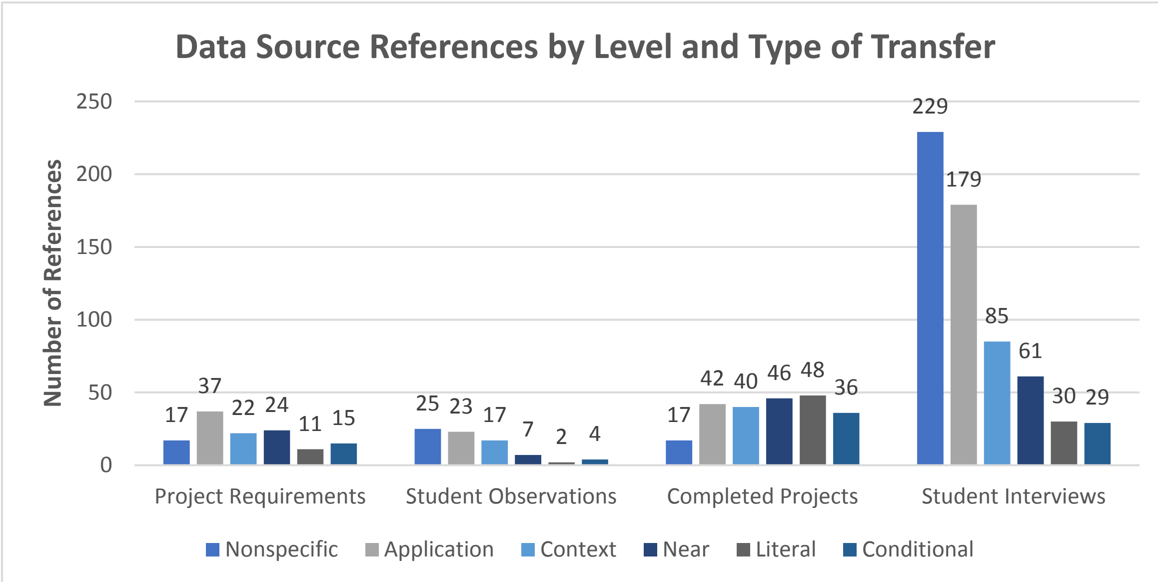


Figure 28. Levels and types of transfer by data source – all grade levels.

In the largest data source, student interviews, specific questions about each project were posed to the students. The questions asked dealt with how they transferred by asking what they did and thought during the project and could they use any information from the project in another class or outside of the school. The students' answers contained the different ways they transferred information and skills from prior knowledge to current knowledge, how they applied what they learned during the project, or how they used information in one context in another context. The students' responses dealt largely with the lower levels of transfer, and was noted in the three lowest levels in the study. The questions in the interviews dealt specifically with transfer, and student responses were coded with a level and/or a type of transfer where applicable. In turn, the specific questions posed could be the reason why student interviews contained a large amount of coded references.

Completed projects had the next highest number of coded references indicating students could apply knowledge learned from the research as well as create new learning in the final project(s) in the units. Students could take the knowledge gleaned during the team's project construction and apply or create new learning. Each grade level had completed projects coded at the near transfer level indicating new learning emerged from the research conducted during the units. This could be due to the completed projects being constructed by a team, and new learning happened because many students worked on the same project.

Project requirements and student observations had the fewest coded references and were not noted as any grade levels' highest source of references. Project requirements contained few references (126) and indicated the projects were not designed with transfer of learning as a part of the project. This could be due to teachers not being instructed how to include transfer of learning in the project requirements. Student observations were the lowest coded data source (78) and indicated transfer was not observed during the project construction. The classroom environment was not conducive to hearing what students said to each other, therefore there were not many recorded student observations with transfer of learning.

Summary

There was a total of 1209 coded references in the study for all levels and types of transfer. Of these, 569 (47%) of those were coded at the nonspecific and application levels of transfer indicating students, across second, fourth, and sixth grades, transferred at the lowest levels in Haskell's (2001) hierarchy of learning transfer. This indicated students could connect prior knowledge and present learning, and apply what was learned to specific situations. Among the 14 types of transfer the results showed the students used very few types of transfer with a total of three hundred two coded references in the study. Literal (91) and conditional (84) transfer were the two types with any significance among all 14 types. The types of transfer students displayed indicated they knew occasionally how and when to transfer, but were unable to transfer at higher levels or types. These findings demonstrate that while the projects moved the students beyond knowledge acquisition to application of knowledge in completed projects such as books, films, dances, etc., higher levels of transfer and more types were not evident. It cannot be assumed that higher levels of transfer will occur because students are asked to apply knowledge in alternate ways. As Haskell (2001) notes, if transfer is not intentionally being taught, it will not occur. Therefore, based on the results of this study, the evidence of lower levels of transfer suggests that the PBL units, though inventive and potentially valuable to student learning, were not designed for higher levels of transfer.

CHAPTER 5

IMPLICATIONS

Purpose

The purpose of this study was to investigate levels and types of transfer observed in K-8 school students during science and across multiple subjects in a project-based learning environment.

Research Questions

1. What levels of transfer of learning were observed in an elementary school project-based learning environment?
2. What types of transfer of learning were observed in an elementary school project-based learning environment?
3. Across which learning environments was transfer observed?

The research questions addressed the idea of transfer as a process, how to recognize characteristics of transfer, and that transfer needed to be included in the planning of lessons across many environments, otherwise transfer of learning may not occur.

Discussion

According to Haskell (2001), transfer of learning has greater potential to occur when the eleven principles are applied. In this study, it was assumed the eleven principals for transfer were present in the project-based learning (PBL) environment, and therefore transfer of learning would occur. What follows is the evaluation of the eleven principles within the PBL environment to determine if the projects’ design, creation, and completion within each grade levels’ units had potential for transfer.

1. Acquire a Large Primary Knowledge Base in the Area in which Transfer is Required

The assumption for Principle 1 is the acquisition of a large primary knowledge base of science concepts would lead to transfer. Second grade topics for units included social studies (holiday customs), language arts (text features), and science (life cycles). The students did not have a large social studies, language arts, or science base of knowledge as they are young, and had one or two school years to acquire the knowledge, hence the knowledge base is limited. The students' knowledge about customs around the world, text features, and life cycles prior to the unit's presentation was limited, and the students did not discuss in the interviews information from prior years, but largely discussed facts found in research and how the team worked on a project. The completed projects for the Holidays Around the World and Traits and Adaptations' units contained mainly information gleaned from research as this material was new to the second graders.

The fourth and sixth grade students had prior knowledge in science concepts, although it was limited as well due to their ages. Fourth grade interviews reviewed student learning in weather, food chains, and life cycles from prior grades. The weather forecasts contained information students had learned in prior years about weather symbols and the water cycle. Also, discussed from prior grades, were the steps in a life cycle, and how a food chain works. Sixth grade students could relay more prior knowledge than the lower grades. Student interviews contained references to learning in prior grades and units earlier in the school year. A unit prior to the Ring of Fire examined the layers of the earth and tectonic plates, and a student acknowledged the concepts helped in learning concepts in the Ring of Fire unit. The Ring of Fire and Solar System units contained completed projects where a large primary knowledge base of the Earth and the Solar System was needed. Knowing how to describe and define an earthquake, a volcano and the layers of the earth prior to the Ring of Fire unit was helpful for the students to gain concepts presented in the unit. Prior knowledge containing information about planets, comets, asteroids, and the Sun was useful for the Solar System unit's construction of an amusement park. Students in all grade levels were asked specifically if they could use the information from a project in another project, class, or outside of school, and they usually could not see where the content learned would be used outside the current project.

The two main data sources reported in the findings of the study, student interviews and completed projects, were coded at the lowest levels of transfer. Student observations, with 78 coded references was not a viable data source, but could have been an area where transfer of learning was observed. Project requirements, another data source not discussed in the findings, received 126 coded references, and could have been addressed in the design/requirements of the projects. The assumption that a primary knowledge base is necessary for transfer to occur was supported, however, there was no high level of transfer evident.

2. Acquire Some Level of Knowledge Base in Subjects Outside the Primary Areas

According to Haskell (2001), peripheral knowledge often provides important links to a primary area of knowledge that makes it possible to engage in transfer. The second principle was noted in two sixth grade projects. The Heat Is On and Ring of Fire units were planned by a science and social studies teacher to incorporate both subject concepts. The Heat Is On unit incorporated five science objectives with three social studies objectives. The unit's science objectives dealt with the layers of the Earth, major tectonic plates, and how plate tectonics caused geological events. The social studies objectives dealt with the effects of the interaction of physical processes and the environment on humans, the effects of the physical environmental process such as erosion, ocean currents, and earthquakes on the Earth's surface, and the ways people have adapted to the physical environment in various places and regions. One student comment indicated he was glad the two subjects were together in one project, or he would not have made the connection between the "Ring of Fire," how it affected people, and how they adapted to the physical environment in different places and regions.

A subject all grade levels used was computer education. All grade levels used computer skills to research information for the topics presented. Students needed knowledge of software programs for the computer presented projects including presentations with slides, e-books, and videos. Although it is noted that knowledge was gained from another subject and from computer skills, this principle did not have enough support in all grade levels to ensure transfer of the concepts between subjects.

3. Understand the History in the Area(s) that Transfer is Wanted

It is critical to have a grasp of history in the content area(s) where transfer is wanted because without it transfer may be incorrect or inadequate. Learning from a content's history is important as transfer uses past learning to create new learning. This principle speaks to knowing history in the science content area will increase transfer between past and present concepts in science. Even though the students could express past concepts learned in science, the history of science was not present. If the teachers wanted to address the history of science it needed to be addressed in the project requirements. The study of the history of science was not addressed, therefore, the assumption of knowing the history of science content was not evident.

4. Acquire Motivation, or More Specifically, a “Spirit of Transfer”

According to Haskell (2001), the transfer spirit is not just another term for motivation, but is a psychological, emotional, and motivational outlook toward deep learning. The spirit of transfer is not merely a mental model; it is a motivated, affective personality matrix, and a key to significant and general transfer. Students expressed in interviews and in observations they enjoyed the PBL units and their motivation to create the projects was high. Scaffolding by the teachers during projects could have been used to direct the transfer spirit and lead the learners toward a deep learning of the concepts being addressed. Student observations and project requirements noted mid-levels of scaffolding by the activities students completed during the project research and completion of the team’s project. The project requirements did not address the transfer spirit, nor was it observed in the student observations. Deep levels of learning were not observed during the building of the projects, or discussed in the student interviews. Creating projects in a PBL environment has the potential to enhance deep understanding because students need to acquire and apply information, concepts, and principles. Psychological, emotional, and motivational outlooks toward deep learning was minimized, as low levels of transfer were noted throughout the study. This assumption was slightly evident, but only at a low level of transfer.

5. Understand What Transfer of Learning is and How it Works

Haskell (2001) further defines this principle as transfer of learning involves carrying over previous learning to new situations, and the learner knows the transfer theory and skills. Knowing what transfer is and how it works is important because transfer effects all learning, memory, problem solving, and cognitive processes. Transfer is present at all levels of learning, from the low-level skills to high-level theoretical thinking. The understanding and knowledge of transfer of learning are not the main goals of project-based learning which has learners interpret the physical and social world around them to build their knowledge. The classroom teachers in the study were not instructed in transfer of learning and therefore, had no knowledge of how to include transfer in the design of the projects. The students would have no knowledge of transfer of learning and how it works if the teachers were not including transfer in the design of the projects. The project requirements data source confirms the design of the projects included minimal instances of transfer of learning. The concepts and project parameters listed terms as identify, explain how to identify, measure and record, sequence and label, and describe when explaining what to include in a project. As students completed these parameters for the team project, low levels of transfer were noted as this was applying what was learned, but new learning was not taking place. In a sixth grade project students identified the major tectonic plates, and as this was not new learning, low levels of transfer were noted. The tools for acquiring transfer, the types, was only evident in two of the fourteen types of transfer with few references. The assumption of this principle is not supported and was noted at the lowest levels of transfer.

6. Develop an Orientation to Think and Encode Learning in Transfer Terms

How learners encode new information determines how they retrieve and apply it. Haskell (2001) noted, learners need to think and encode their learning in transfer terms because transfer never happens automatically. Retrieval of information is influenced by how a person encodes and stores information. Observed during the research step of the projects, students wrote the information found in personal science notebooks, in a specific notebook for PBL units, or in the online environment under team notes. The fourth and sixth grade teachers gave the students notes, deemed necessary by the teachers, by placing the information on the interactive board, or on a white board for students to copy. The fourth grade teacher also had scaffolding activities. In the Life Cycle unit, one activity had students label the parts of a bean, get it checked by the teacher, and students cut out and glued the diagram into the science notebook. The project requirements listed what the students needed to know and include in the projects. The teachers made sure the information was given to the students in the form of the notes they supplied to the students, hence the only information students coded themselves was the information recorded from the research of the topic. As a result, much of the information the students collected was not infused with meaning of their choice, and the information was transferred into knowledge at the lowest levels of transfer. This principle was not met, except at the lowest levels of transfer.

7. Create Cultures of Transfer or Support Systems

According to Haskell (2001), learning and transfer needs to be understood as a cultural, social, group, and team process. Transfer is a collective process. Student observations did not record any transfer systems or an environment to support transfer of learning. Teachers did not set up the project requirements for transfer opportunities and therefore the culture of transfer was not evident. The levels of transfer were low for student interviews, project requirements, and student observations and only two types of transfer were indicated; the assumption for this principle was not met since the levels of transfer were low and the types, or tools for transfer, were not numerous.

8. Understand the Theory Underlying the Area(s) in which We Want to Transfer

The students had limited science theory due to their ages, however, prior learning discussed in student interviews revealed each grade level could discuss science concepts learned in earlier grades. The teachers had science theory exposure due to the preparation classes for teacher certification. The knowledge of science theory for the teachers would be greater than the students, as indicated in project requirements by the listed objectives and design of a project. It was not apparent for students or teachers in student interviews, completed projects, project requirements, or student observations any theory of transfer was evident. Even though science theory was evident for the students it was at very low levels of transfer and the application of this principle was not supported.

9. Engage in Hours of Practice and Drill

Fundamentals of a concept need to be learned thoroughly before significant and creative transfer can occur (Haskell, 2001). All grade level projects included activities to aid in practicing knowledge gained from researching topics for the completion of a project. The Fossil Evidence activity in the Ring of Fire unit helped to scaffold the learning during the research. During the fourth grade Life Cycle unit, students took information learned during research and practiced skills or knowledge in more than one activity by labeling sections of a seed, stages of an insect, and the life cycle of a plant. A second grade teacher used a game to practice the terminology in the Text Features unit. Fourth grade students practiced the weather forecasting script many times before recording it. Sixth grade students practiced presentations several times before presenting amusement park section to an audience. Project requirements, student observations, and student interviews had low levels and two types of transfer referenced in the study, therefore the amount of practice time was not evident, or if noted was minimal. The amount of time practicing during the units was not the length the assumption dictated, therefore, the assumption that hours of drill and practice will transfer is not evident.

10. Allow Time for the Learning to Incubate

Haskell (2001) notes that learning needs to incubate as transfer does not occur instantaneously. The PBL model used in the study set a time for incubation in the create/critique step. As noted in chapter 3 this step was either not completed, not completed with peer critique, or if the step was done, only one critique was given. Through the process of many critique sessions, the step allowed the learning presented to be thought about for a period of time and changes could occur to the project and/or presentation. Student observations did not note any instances of student reflection during the projects. Project requirements did not include an incubation time and students did not discuss in the interviews a time during a project where they were "thinking" about the research or the project. Low levels of transfer among student observations and project requirements allows this assumption to be evident, but at very low levels.

11. Observe and Read the Works of People who are Exemplars and Masters of Transfer Thinking

This assumption states it is vital that learners read and observe people who are masters of transfer thinking (Haskell, 2001). The teachers in the PBL study could have found books/information on people who are excellent in the content field and transfer learning, or in transfer thinking. There was no evidence in student observations, student interviews, project requirements, and completed projects the teachers or students were reading children's books about exemplars in transfer thinking, therefore this assumption was not evident.

Students in the study were essentially transferring at the lowest levels, or not transferring. According to Haskell (2001), nonspecific and application levels of transfer are simple learning. A learner needed to gain more than simple learning, new learning was required, and it was the new learning that counted as transfer of learning. Context transfer is applying what is learned in a slightly different situation and the students accomplished that level infrequently. Near transfer, the first level indicating new learning as a result of transfer, was rarely evident. Out of the nine projects in the study, only three were coded at near transfer, consequently students were attaining new learning in those projects. It seems prudent that PBL projects provide opportunities to acquire new learning in all projects. According to PBL literature (Grant, 2011; Lattimer & Riordan, 2011), PBL projects promotes higher order thinking skills such as critical thinking/problem solving and therefore have the potential for transfer of learning.

Conclusions

According to Haskell (2001) transfer of learning is a way of thinking, perceiving, and processing information. Transfer of learning influences current and future learning and how past or current information is applied to new or novel situations. Transfer of learning is present at all levels of learning – from low-level skills to high-level theoretical thinking. A project-based learning (PBL) environment processes learning through experience where knowledge is acquired naturally, evolving from the learner's participation with daily life situations (Hou, 2010). Projects are based on challenging questions, tasks, or problems, involving students in problem solving, design, decision making or investigative activities (Thomas, 2000). Haskell (2001) noted that transfer of learning could be the foundation of thinking, learning, and problem solving, and is important in the instruction of critical thinking. The PBL environment where students are motivated, engaged, and have a positive attitude about creating a project would appear to be a good environment for transfer of learning to occur.

The study investigated Haskell's (2001) levels and types of transfer of learning, and what environments contained transfer in a project-based learning environment. It was assumed the study setting was orientated to a PBL setting, but was discovered the teachers were using a model that blended problem- and project-based learning. The data were evaluated against the blended model making it harder to evaluate if transfer of learning occurred. The levels of transfer observed in the study were at the lowest four levels of Haskell's (2001) hierarchy – nonspecific, application, content, and near transfer. When transferring at the lowest levels only prior or current knowledge, application of the knowledge to a specific situation, or application of the knowledge to new situations that are similar but not identical to the previous situation can occur. There were only two out of fourteen types of transfer observed as having significance in the study – literal and conditional transfer. These two types of transfer were the tools that helped students know how and when to transfer their learning.

The data sources project requirements, student observations, completed projects, and student interviews, were analyzed by the total number of references in the levels and types of transfer. In two of these environments, project requirements and student observations, there were low levels and few types of transfer observed indicating there was little evidence the teachers in the study were teaching for transfer as defined by Haskell (2001). If transfer was considered as a purpose in the learning process then the levels and types of transfer would have been evident in the data sources. The student observations and project requirements contained low levels and types of transfer, indicating transfer was not observed while students researched and created their projects, and transfer was not planned into the projects. The completed projects contained more instances of transfer than the project requirements and student observations indicating transfer was observed more in the final artifact or presentation created by students. The student interviews contained the most references to transfer in the study comprising 47% of the total number of references. The student interview questions were designed to uncover through specific questions what levels and types of transfer the students in the study encountered during the projects. The interviews revealed students were transferring at the lower levels where prior or current knowledge and application of what they learned to a specific situation was identified in the research phase and completion of a project. The design of the PBL projects had the potential to serve as transfer opportunities, but were opportunities unrealized. Transfer of learning could not occur at any higher level that what was observed since teachers in this PBL setting were not aware of how to teach for transfer according to Haskell's (2001) taxonomy.

There were limitations to the study. The study was conducted at an elementary school, so results could not be generalizable to other project-based learning environments. The population studied was a population of convenience, and not a random population. In the open areas where the study was located, the noise level was very high, so it was difficult to hear what the students were saying to each other. Sometimes the students would stop talking when the researcher approached the group making it difficult to capture what was said in the group. To the best of my ability as the researcher, I tried to capture as much information as possible.

Recommendations

Further research in transfer of learning includes evaluating instructional planning and classroom instruction, evaluating what practitioners are including in the daily instruction to the learner, and auditing curriculum for evidence of transfer opportunities. This study employed a multiple case study which included the following data sources: project requirements, student observations, completed projects, and student interviews. Other methods of research that would be useful for studying transfer of learning noted in instructional planning and classroom instruction, practices of instructors teaching for transfer, and educational curriculum are content analysis and illustrative case studies.

Instructional planning is important for teachers to be able to create cultures of transfer in the classroom. A beginning step to creating this culture is to observe and read the works of people who are exemplars and masters of transfer thinking. Practitioners who have the knowledge of transfer thinking start to develop an orientation to think and encode learning in transfer terms. Once a practitioner is thinking in terms of transfer it will be easier to plan the instruction for their subject/classroom. In a standards-based system of educating students, practitioners need to determine the goals of a lesson or course, the assessment of the standards, and then determine how and what to teach students so they achieve the learning expectations described in the standards. Incorporating transfer of learning into instructional planning in a standards-based system will be easier for a practitioner who is thinking in terms of transfer and have a culture of transfer in the classroom.

Evaluating classroom instruction could include assigning levels and types to classroom activities. Using two to four different practitioners with a minimum of two activities per practitioner, include the written form of the activities and the observation of the activities as presented to the students. Compare what was occurring during the activity in the classroom to the written form of the activity, and analyze the difference in levels and types between the written and observed activities. Reviewing lesson plans and coding a level and type in the plans is another way to evaluate classroom instruction. In a K-12 environment, assess the classroom to see if there are opportunities for transfer to occur by viewing posters of student work containing transfer, a bulletin board with opportunities for transfer, or how the seating is arranged. Transfer occurs in a social or group setting, so if the seating is individualized, transfer would be harder to accomplish. Instruction could be evaluated by observation. A tally of when a practitioner points learning a specific direction, scaffolds learning, or allows opportunities for students to transfer could be tabulated and analyzed for a teacher's classroom instruction inclinations. Reviewing activities and units of study for opportunities for transfer would help practitioners know where to encourage transfer in the students.

Evaluating what practitioners are including in the daily instruction for the learner is important for transfer to transpire. The illustrative case study gives the researcher the ability to be descriptive in the observation of classroom instruction and the daily practices the practitioners are exhibiting in the classroom. The illustrative case study allows the researcher to use more than one instance of observation of classroom instruction and daily practices the practitioners are using in the classroom. Daily observation of a practitioner includes detail of the activities completed by the learners and what is said to the learners daily. Observe the practitioner's processes built into the daily instruction by both activities and statements made to the learners. Assign a level and type to these activities and statements and compare the transfer opportunities noted for each item. Observing a practitioner during class time for several weeks gives an indication of the daily instruction pattern in the classroom. For evaluating PBL on a daily basis, there needs to be a tradeoff between how much teacher intervention is needed during a project. Practitioners focus on course objectives to help motivate learners, reduce task complexity, provide structure, and reduce learner frustration, so practitioners must know how much structure to apply in a PBL environment. A log itemizing the structure a practitioner uses daily would determine how much structure occurs during a unit in PBL, and this structure could be evaluated for transfer of learning levels and types. Scaffolding information or skills for the learner is a good way for the practitioner to help the students form their own direction, path, motivation for the project, and knowledge to be absorbed. Activities used to scaffold information could be evaluated noting levels and types of transfer.

The auditing of educational curriculum, including K-12 and higher education, for evidence of transfer opportunities could include a content analysis of a curriculum. This would allow the researcher to decide and define the elements in the curriculum to analyze, the context relative to the analyzed data, and set up the boundaries of the analysis. A quantitative content analysis of the curriculum permits word frequencies and keyword frequencies to be measured. A qualitative measure used in content analysis would be employed by categorizing and classifying text content. Assigning Haskell's (2001) levels and types of transfer to the curriculum's objectives would allow a researcher to conclude if the curriculum was written at high, mid, or low levels of transfer and the types of transfer present.

In this multiple case study, an absence of teaching for transfer was confirmed. Haskell (2001) points out that for transfer to occur it must be intentional and supported. Practitioners, unaware of Haskell's principles, levels, and types could not have applied these to the organization and coordination of the project-based learning projects. Therefore, practitioners need constructed curriculum built for transfer opportunities, in the form of projects, and the structure, issues and implementation for transfer of learning in a PBL environment. When practitioners can implement transfer of learning into a PBL project, learners can acquire new learning. When transfer of learning is present in the curriculum and the planning and practices of instruction, project-based learning can help learners make learning relevant to their personal interests, become motivated, self-directed, and achieve new learning.

APPENDIX A

ENGAGE!® LEARNING MODEL

Engage! Learning Model | 5 protocols

launch/ team	**Launch:** 1. Hook 2. Challenge brief 3. Rubric **Team:** 1. Create team name 2. Agree on roles 3. Project Leader facilitates team as they establish norms for working 4. Team members sign team contract 5. Communication manager posts check mark
plan	1. Project Leader facilitates team in analyzing challenge 2. Team identifies driving question, audience, and records on project plan 3. Team identifies project requirements and records on project plan 4. Team analyzes rubric and establishes team goal for project 5. Team completes know/need to know list based on problem analysis and needs assessment 6. Team adds resources to need to know list based on need to know (N2K) list and pre-assessment 7. Team creates research questions and then research task list utilizing all of the above and the project calendar to note desk critique dates and progress checks 8. Workshop Manager requests workshops 9. Individuals create to-do list based on team tasks and pre-assessment 10. Communication manager posts check mark
research/ work	1. Project leader facilitates daily opening huddle. 2. Team members check to-do lists and report tasks complete. 3. Time Manager informs team of any upcoming progress checks. 4. Team adjusts task list and adds any new need to knows/resources/research questions. 5. Workshop manager makes any workshop requests or signs up for any applicable workshops. 6. Individuals create and work on to-do list for the day. 7. Workshop Manager attends workshops or sends a team member. 8. Project Leader facilitates daily closing huddle and adjustments to task list. 9. Team members report any research findings and record on research summary. 10. Workshop Manager shares information from workshop with team

Engage! Learning Model | 5 protocols

create/ critique	1. Brief plan protocol again. Adjust plan as needed. 2. Request critique or feedback from peers, teacher, and even your real audience early and often during the create phase following steps a-g below for the critique process. a) Team A shares ideas using a mind-map or other draft visual. b) Team B asks clarifying questions. c) Team A clarifies and asks for feedback (use rubric). d) Team B provides warm feedback based on rubric and team A's question. e) Team B provides cool feedback based on rubric and team A's question. f) Team A asks any clarifying questions. g) Team A & B reflect on process. 3. Following critique and resulting changes and refinements, the team completes a presentation proposal. 4. Communication manager schedules a critique with the team and teacher to approve the product/presentation for Share.
share	1. Facilitator sets audience expectations for listening/evaluating (use rubric if applicable). 2. Project Leader introduces team. 3. A different team member shares overview of each of the following: project challenge, success criteria, procedure and constraints. 4. Team presents solution. 5. Team reflects on solution. 6. Audience asks clarifying questions. 7. Audience reflects on solution.

APPENDIX B

TEACHER PROJECT HANDOUTS

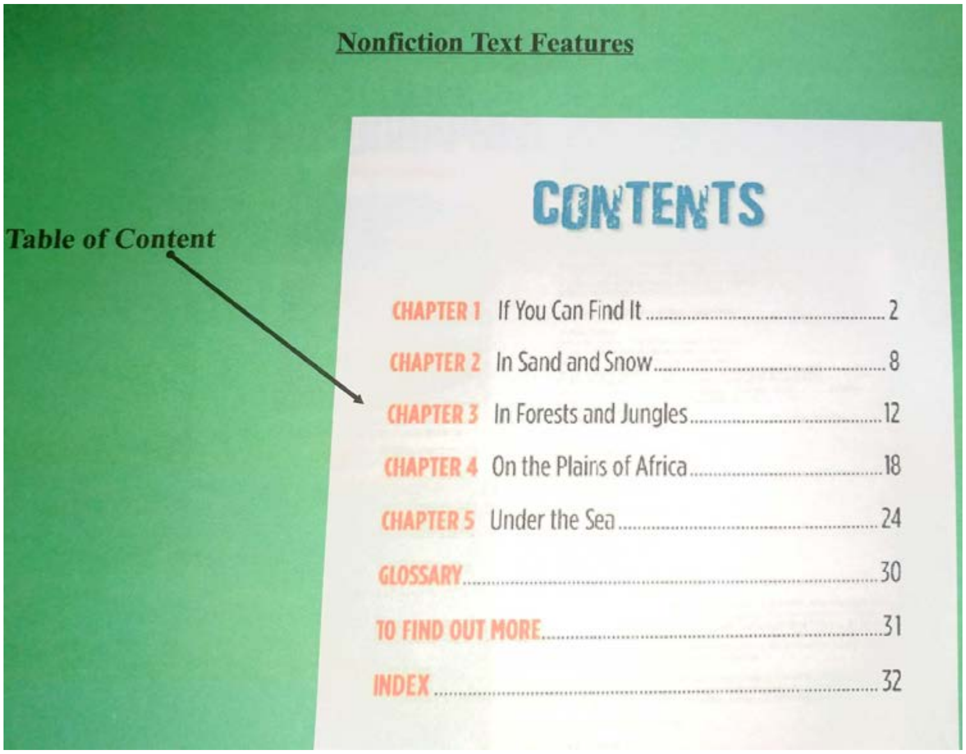
B.1 Research questions for Grade 2, Holidays Around the World project

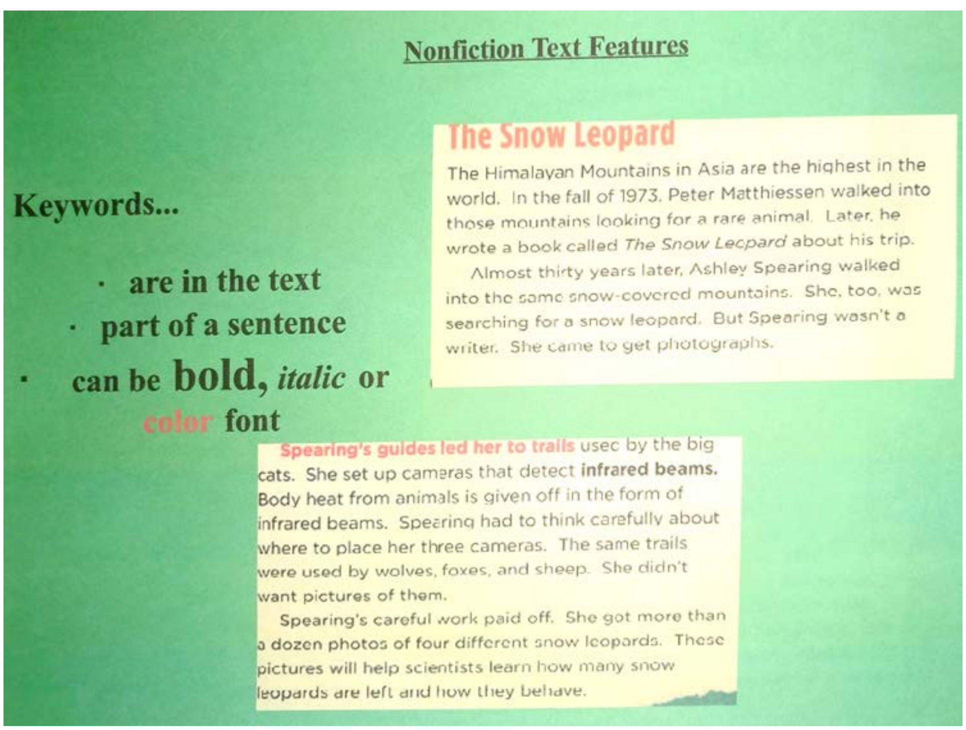
Research Questions for Holidays Around the World

Group: ______________________________

1. What celebrations does my country celebrate?
2. What kind of clothing do the people of my country wear?
3. What are some customs in my country?
4. What types of food do they eat in my country?
5. Where is my country located on a map?
6. What is a living museum?
7. What is an exhibit?
8. How do their celebrations compare to mine?

B.2 Case Study 2, Text Features. Examples of Text Features





B.3 Case Study 2, Text Features. Purpose/Definitions of Text Features

Nonfiction Text Features Chart

Text Feature	**Purpose**	**Example**
Title	Identifies the topic of the text/tells what the text will be about	**Bones and More Bones** The Skeletal System The skeletal system is made up of all the bones in your body. It is also made of the things that connect your bones together: tendons, ligaments, and cartilage. The skeletal system also includes one set of hard objects that aren't bones: your teeth!
Title Page	Tells a book's title, author, illustrator, and publisher	The Amazing **Human Body**  Author: Drew Science Illustrations: Julie Penn
Table of Contents	Tells the names of chapters and what page the chapters can be found	Bones .... Page 3 Muscles .... Page 17 Skin .... Page 28 Brain and Nerves .... Page 42 Major Organs .... Page 57 Veins and Arteries .... Page 71
Index	Tells what pages the reader can find certain topics	**A** Abdomen, 24 Ankles, 14 Armpits, 15 Arms, 15-16 Arteries, 75-76 **B** Back, 16 Belly Button, 28 Blood, 77-80 Body Parts, 57-65 Bones, 3-16 Brain, 42-50 Brain Stem, 43 Breathing, 54-60 Bronchi, 61-62 Byproduct, 87
Glossary	Tells the definitions of some of the words found in a text	Shin – the front of the leg bone that runs from the knee to the ankle. Skin – the outer layer of tissue that covers the entire body. Skull – the large structure of bones in the head. Thigh – the part of the leg that runs from the knee to the hip. Tooth – a hard bony object in the jaw; used for chewing.
Heading	Divides the text into sections and explains what the sections will be about	**Central Nervous System** Brain Your brain controls all functions in the body. This includes things like breathing, having a heartbeat, moving your arms and legs, etc. The brain controls these functions by sending and receiving messages through the nerves. Spinal Cord The spinal cord is the main pathway that connects the brain with the peripheral nervous system. It is protected by your spinal column, which is a long series of bones called vertebrae.

B.4 Case Study 2, Text features. Activity examples.

Adding Your Own Text Features

Read the passage below. Then, add text features to help support the passage.

1. Add a title and headings.
2. In the empty box next to the first section, add an illustration and a caption to support the text.
3. In the empty box next to the second section, add a side bar or a fact box.
4. In the third section, add appropriate text next to the bullet points.

Title: ____________________________________

<u>What is Bullying?</u>

Bullying is a common problem for kids and teens all over the world. There are a lot of different ways that bullies can hurt other people. For example, some bullies hurt by kicking, pushing, making threats, or other things that hurt people's physical bodies. Other bullies insult or tease people verbally in order to hurt their feelings. You can also bully people indirectly by ignoring them or spreading rumors about them. Anything that is done on purpose to hurt somebody is considered bullying.

Heading: ____________________________

If somebody is bullying you, do not bully them back! There are other things you can do to help stop the bullying. First, you can try to ignore them or make a joke. The bully is trying to make you angry or upset, so they are less likely to continue to bully you if you do not react. Also, you could try to walk away from the bully and avoid going places that they go. Finally, if the bullying continues, you can talk to an adult or teacher that you trust and explain the situation to them.

If you see somebody else being bullied, do not just stand around and watch! There are several ways you can help them.

- Ask the bully to stop.
-
-

If more people would stand up for others, then maybe we could stop the bullying!

B.4 Case Study 2, Text features, Activity examples.

Adding Your Own Text Features

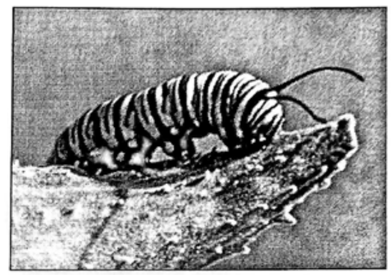
Read the passage below. Then, add text features to help support the passage.

1. Add headings to each section.
2. Add a caption to the photograph of a caterpillar.
3. Fill in the chart using information from the passage.
4. Underline two words in the text that you believe should be in a glossary.

Monarch Butterfly Life Cycle

Heading: ______________________

A monarch butterfly begins its life as an egg. Usually these eggs are laid on milkweed plants, one egg per plant. This egg stage lasts approximately 4 days.



Caption:

Heading: ______________________

After the egg hatches, a monarch caterpillar emerges. The caterpillar's main purpose is to eat and grow as much as possible. The caterpillar often begins by eating its eggshell and then the milkweed plant that it was laid on. As the caterpillar eats, it grows too large for its skin and must molt, or shed, its skin. This happens several times before the next stage of the life cycle. The caterpillar stage lasts approximately 10-14 days.

Heading: ______________________

After the caterpillar molts for the last time, it attaches itself to a leaf or a stem to begin the next stage of the life cycle – the pupa stage. During this stage, a chrysalis forms around the pupa. Inside the chrysalis, the pupa is undergoing metamorphosis, changing from caterpillar to butterfly. This stage also lasts between 10-14 days.

Heading: ______________________

The final stage of the monarch butterfly's life cycle is the adult butterfly stage. The butterfly emerges from the chrysalis. It is unable to fly for a few hours after emerging, because its wings are wet and crinkled. After the wings harden, it can begin its life as a butterfly! Adult monarch butterflies can live anywhere from 2 weeks to 8 months.

Stage in a Butterfly's Life Cycle	How Long the Stage Lasts
Egg	
	10-14 days
Pupa	
Adult	

B.5 Case Study 3, Traits and Adaptations. Vocabulary list

Traits and Adaptations Vocabulary List

Mimicry

Adaptation

Camouflage

Hibernate

Migration

Seed dispersal

Inherited traits

Learned behavior

Behavioral adaptation

Threatened

Endangered

Extinct

Physical adaptation

Body covering

Warning coloration

Blubber

Carnivorous plant

Organism

Environment

Survival

Diurnal

Nocturnal

RESEARCH QUESTIONS

1. What is seed dispersal?
2. What does threaten mean?
3. What are carnivorous plants?
4. What is a physical adaptation?
5. What are inherited traits?
6. What are learned traits?
7. What is an organism?
8. What is blubber?
9. What does diurnal mean?
10. What is a body covering?
11. What is mimicry?
12. What is a learned behavior?
13. What is a behavioral adaptation?
14. What does fictitious mean?
15. What is an inherited behavor?

B.7 Case Study 3. Traits and Adaptations, activity sample.

Animal	Animal Classification	Where it Lives	What It Eats	Body Part Adaptations	Behavior Adaptations	How Adaptations Help the Animal Survive
 GIRAFFE	Mammal	Grasslands of Africa	Leaves from shrubs and trees	Long legs, long neck, long tongue, good eyesight	Live in herds	Height and long tongue help it reach food; living in herds provides protection
 SEA OTTER						
 KANGAROO						
 GECKO						
 FALMINGO						

B.8 Case Study 4, Weather Forecast research questions.

Weather Research Questions

- What factors influence the weather?
- How does the water cycle influence the weather?
- What tools do we use to measure weather?
- How can you predict the weather?
- How do you create a weather map?
- How do you read the symbols on a weather map?
- How do you explain what the water cycle is?

B.9 Case Study 4, Weather Forecast, research resources.

Weather Resources

Weather Websites:

1. http://www.wunderground.com/
2. http://www.fbd.ie/CreativeContentHub/how-to-read-a-weather-map/desktop/
3. http://schools.bcsd.com/fremont/5th_sci_weather_prediction_and_maps.htm
4. http://www.weatherwizkids.com/weather-forecasting.htm
5. https://www.brainpop.com/science/weather/weather/
6. http://studyjams.scholastic.com/studyjams/jams/science/weather-and-climate/weather-instruments.htm
7. http://studyjams.scholastic.com/studyjams/jams/science/weather-and-climate/weather-and-climate.htm
8. http://studyjams.scholastic.com/studyjams/jams/science/weather-and-climate/air-masses-and-fronts.htm

Weather Books on Destiny Quest

1. Weather Q and A by Janice Parker
2. DK Guide to Weather by Michael Allaby
3. Weather and Climate through Infographics by Rebecca Rowell
4. Weather by Kay Robertson
5. Forecasting Weather by Terri Seivert

Other Books on Weather

1. How is Weather Predicted? Page 373 in Science Fusion
2. Weather and Climate-Page 15- Delta Science Readers
3. Library Books

Water Cycle Resources

Water Cycle Websites:

1. https://www.brainpop.com/science/earthsystem/watercycle/
2. http://studyjams.scholastic.com/studyjams/jams/science/ecosystems/water-cycle.htm
3. http://water.usgs.gov/edu/watercycle.html
4. http://www.kidzone.ws/water/

Water Cycle Books on Destiny Quest

1. Earth's Water Cycle by Robin Nelson
2. Water Pollution by Melanie Ostopowich

Other Water Cycle Books

1. What is the Water Cycle? Page 345 in Science Fusion
2. Weather and Climate-page 8- Delta Science Reader
3. Library Books

B.10 Case Study 5, Ecosystem research questions.

Ecosystem PBL
Research Questions

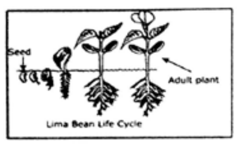
1. Explain what role each of these terms play in a food web: decomposer, omnivore, carnivore, producer, predator, prey (4.9A)
2. What do plants need to make their own food? What is this process called? (4.9A)
3. What would happen if one species in your food web decreased? What is that same species increased?(4.9B and 5.9A/B)
4. How does the sun's energy flow through a food web? (4.9B)
5. Explain what a food web and a food chain are. What is the difference between a food chain and food web? (4.9B)
6. How do organisms interact with living and nonliving elements in the ecosystem? (5.9A)
7. Explain overpopulation in an ecosystem. (5.9C)
8. What is the carbon dioxide-oxygen cycle? What is the significance in the carbon dioxide - oxygen cycle to the survival of plants and animals? (5.9D)
9. What are some plants and animals that live in a North Texas ecosystem? How do they interact with each other?

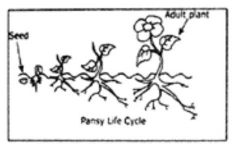
B.11 Case Study 6. Life Cycles pre-assessment sample.

Name: ______________________________ Date: ________ Group: ____

Life Cycle PreAssessment

1. The diagrams show the life cycles of two plants.
   How are the life cycles of these two plants similar? In their life cycles, both plants –





   A develop the same kind of flowers
   B have exactly four stages in their life cycle
   C have the same number of leaves as adults
   D begin life as seeds and then grow larger

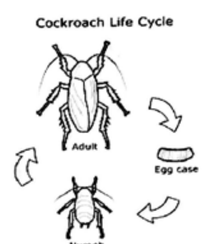
2. One way in which a plant life cycle is like an animal life cycle is that both plants and animals –

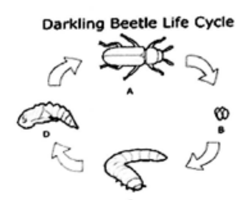
   A use seeds to reproduce
   B live for hundreds of years
   C lay eggs that hatch
   D grow larger over time

3. Which of the following organisms go through metamorphosis, including the stages of egg, larva, pupa and adult, the way a beetle does?

   A Human beings
   B Trees
   C Butterflies
   D Lima beans

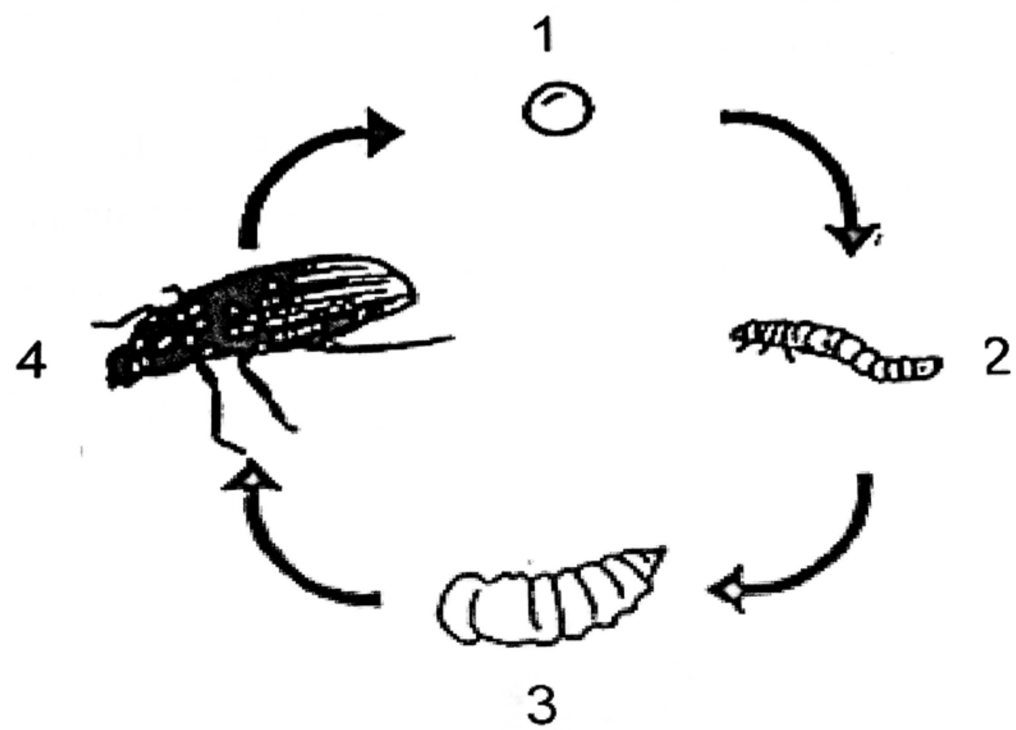
4. The images here show the life cycles of a cockroach and a darkling beetle.
   In the cockroach life cycle, the nymph is the stage that emerges from the egg. In this way, it is similar to which stage of the darkling beetle life cycle?





   A A
   B B
   C C
   D D

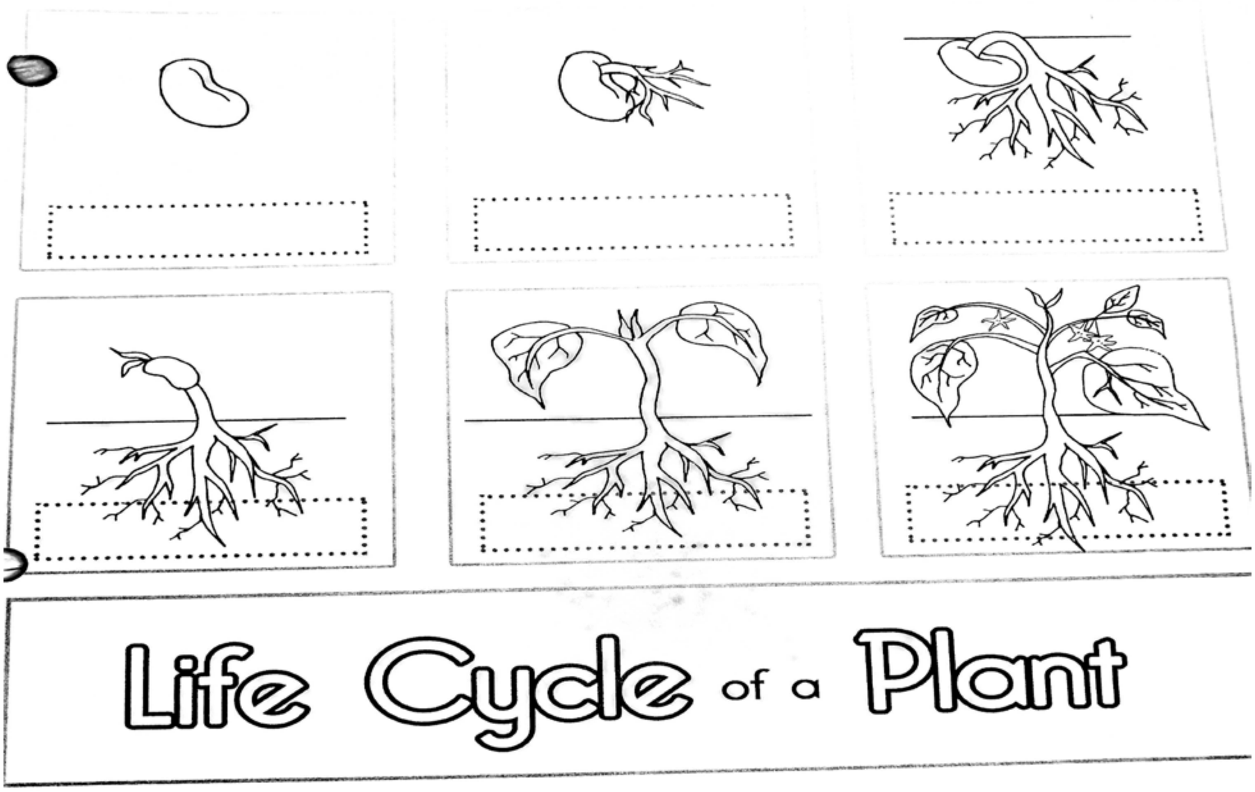
B.12 Case Study 6, Life Cycle activities.

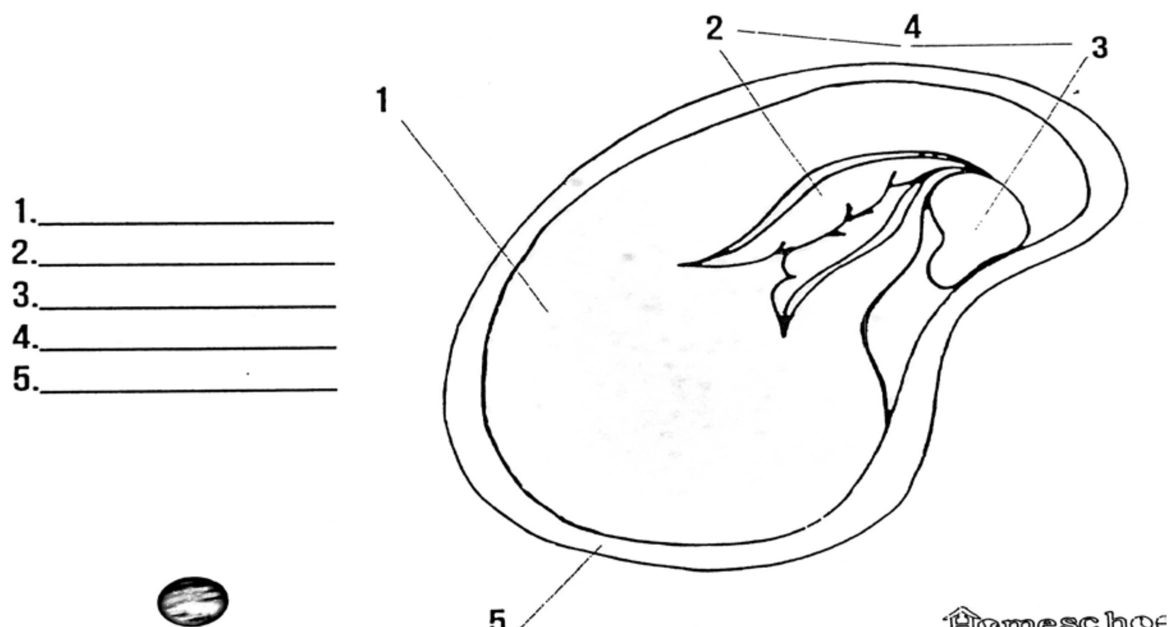


Please list and describe each stage shown above.

1.
2.
3.
4.

B.13 Case Study 6. Life Cycle activities





Section of a Seed

B.14 Case Study 6, Life Cycles. Editing and revising sheet.

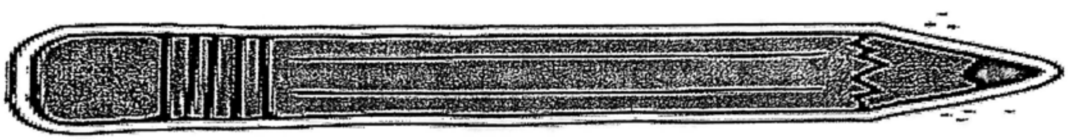
Editing and Revising Checklist- Expository

Editing

Author Name: ______________
Editor Name: ______________

Author | Peer

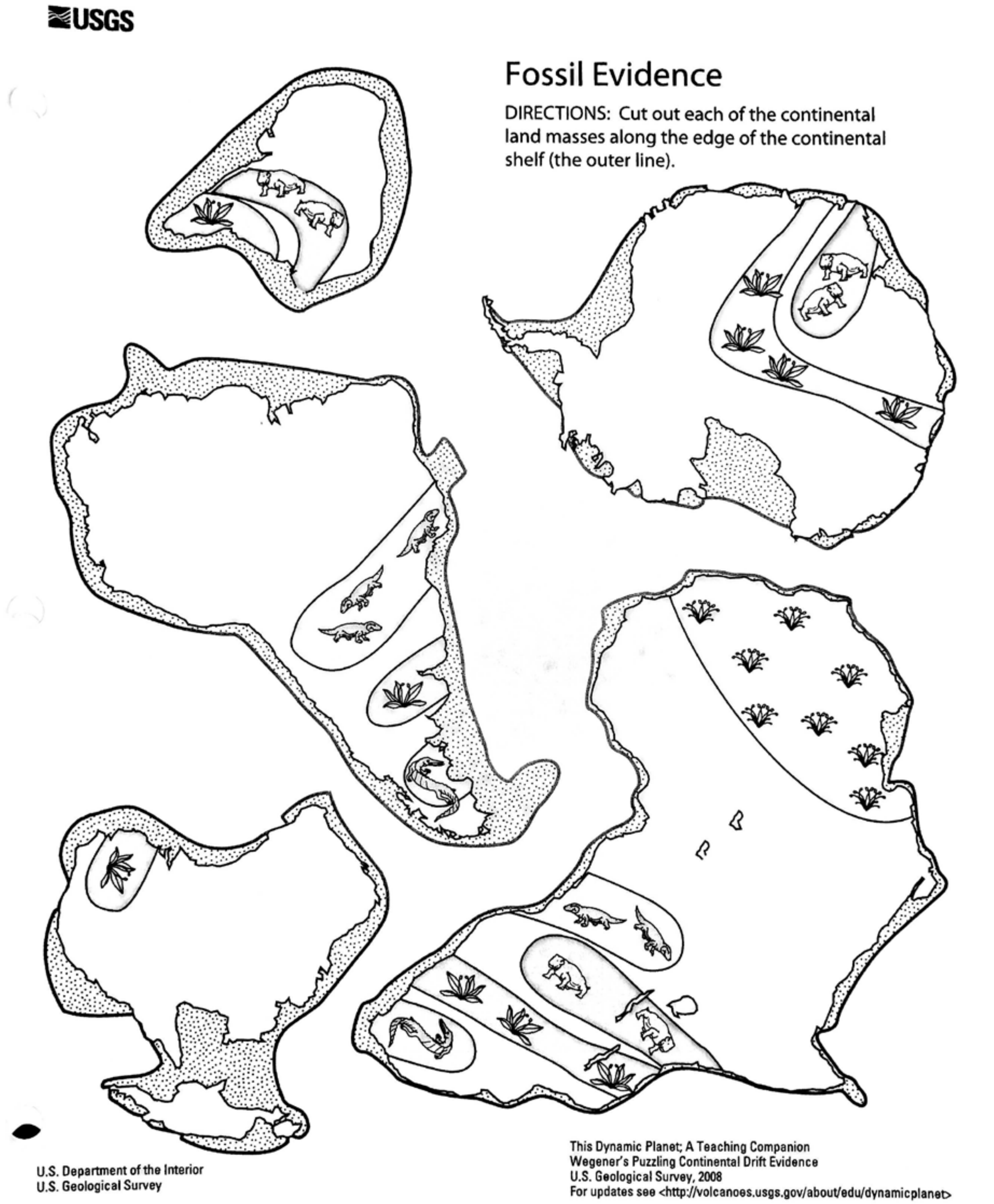
- ____ 1. I remembered to indent all of my paragraphs.
- ____ 2. All of my sentences start with a capital letter.
- ____ 3. I used capital letters on proper nouns.
- ____ 4. I have punctuation at the end of each sentence. (. ! ?)
- ____ 5. I checked my words for correct spelling.



Revising

- ____ 1. Who will read my work? Will they find it interesting?
- ____ 2. Did I start my story with an interesting introduction that will make the reader want to read more?
- ____ 3. Did I use transition words on my body paragraphs and my conclusion paragraph?
- ____ 4. Will my sentences "paint a picture" in the reader's mind so that they can visualize what I have written about?
- ____ 5. Did my sentences stay focused on the topic?
- ____ 6. Do all of my sentences make sense?
- ____ 7. Have I used interesting words that the reader will enjoy?
- ____ 8. Have I overused any words or phrases?
- ____ 9. Is my conclusion effective? Does it end the story?

B.15 Case Study 8, Ring of Fire fossil evidence activity



B.16 Case Study 8, Ring of Fire map overlay activity

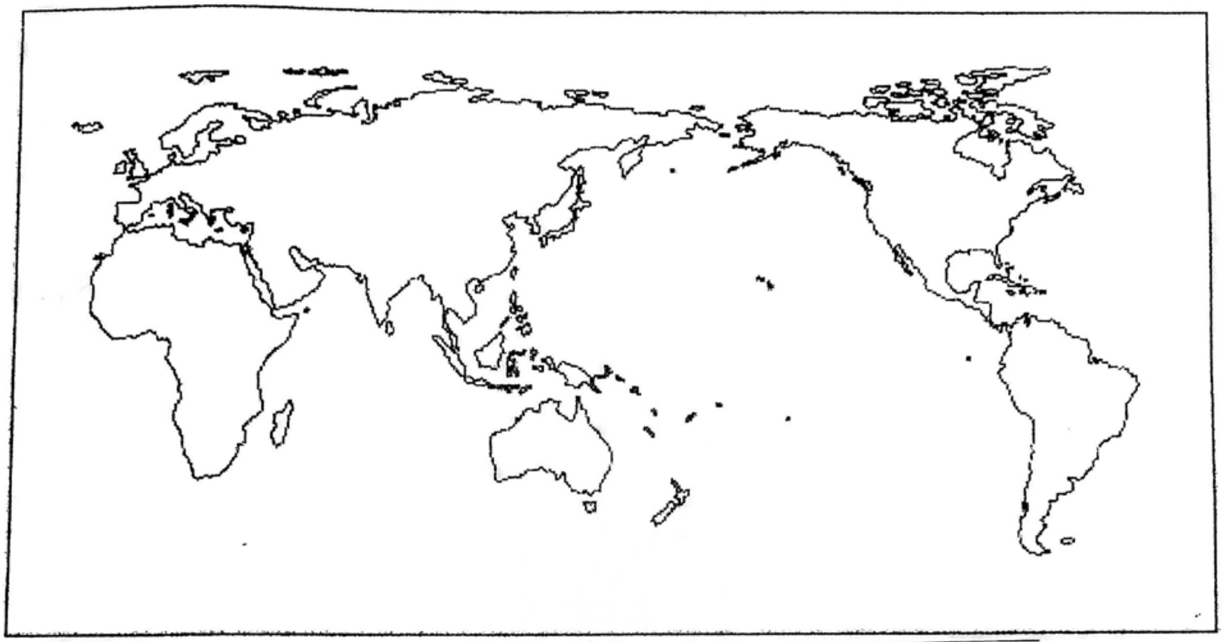


Plate Tectonics Map Rubric- Science and Social Studies

Neatness/Colored Nicely	______________/5
Spelling/Proper Nouns Capitalized	______________/5
Map key with symbols	______________/10
Compass rose	______________/10
Appropriate map title	______________/10
7 continents correctly labeled	______________/12
5 oceans correctly labeled	______________/12
Ring of fire properly placed	______________/13
Tectonic plates properly placed	______________/13
3 Volcanoes and 3 earthquakes located on the Ring of Fire on the map	______________/10

TOTAL______________/100

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