To learn meaningfully, individuals must choose to relate new knowledge to relevant concepts and propositions they already know. In rote learning, on the other hand, new knowledge may be acquired simply by verbatim memorization and arbitrarily incorporated into a person's knowledge structure without interacting with what is already there. (Novak & Gowin, 1984, p. 7)

Chapter 1

Introduction

Rationale

Within the prevailing educational climate in the United States, accountability for student success is of paramount concern to a broad range of interest groups (Shepard, 2002; Stahl, 2003; Turner, 2003). Public school teachers, administrators, teacher educators, researchers, parents, students, business leaders, and taxpayers all have a vested interest in the effectiveness of schools as indicated by the success of students (Milloy, Winans, Jehlen, Loschert, & O'Neil, 2003). Arguably triggered by the 1983 publication of *A Nation at Risk* (National Commission of Excellence in Education, 1983), this wide-ranging demand for demonstrated proof of student success has, in recent years, resulted in multiple initiatives at the state and national levels (McLaughlin, 1994). The State of Virginia's mandatory Standards of Learning testing program is one example (Virginia Department of Education, n.d.). President Bush's No Child Left Behind Act is another (No Child Left Behind, n.d.; Sclafani, 2002). Both initiatives are broad in scope, extensive in requirements, and specific in their demand for demonstrated proof of student success, most often determined by standardized test results.

These initiatives carry serious and potentially damaging consequences if schools are unable to prove their effectiveness through these narrowly prescribed guidelines. Standardized test results, listed by school division, school building, grade level, or individual teacher, have been published in newspapers, displayed on the internet, and interpreted as ‘report cards’ for schools. Although it has been argued that no test score ever ‘improves’ a school (Allington, 2002; Shannon, 2001; Smith, 1991b), assumptions have been made by politicians and the public at large that these scores accurately portray the overall degree to which schools and teachers are effectively teaching and to which students are effectively learning. Although accurate assessment of a comprehensive instructional program is much more complex than can be reported by a compilation of student standardized test scores, numerous vitally important decisions are made based on these scores (Gordon & Reese, 1997). For schools who fail to improve their effectiveness, consequences are serious and thus far, have included loss of substantial state or federal funding, loss of mandatory local student enrollment, and loss of administrative and/or teaching positions (Stahl, 2003).

At the risk of their reputation and, in some cases, their job security, teachers are feeling intense pressure to produce students who will achieve high standardized test scores. The effects of these high-stakes on teachers have been negative and well documented (Gordon & Reese, 1997; Johnson, Afflerbach, & Weiss, 1993; Johnston, Guice, Baker, Malone, & Michelson, 1995; Smith, Edelsky, Draper, Rottenberg, & Cherland, 1991). For example, Smith (1992a) found that teachers experienced anger and frustration at having their worth judged by a single test score. Feelings of alienation and dissonance grew because teachers believed that such scores were actually ‘worthless’ as measures of their teaching. Likewise, teachers felt the tests were measuring only a small portion of student knowledge rather than assessing a broad range of knowledge. In another study, Barksdale-Ladd and Thomas (2000) reported heightened levels of anxiety and stress among teachers when preparing students for high-stakes testing. Teachers also reported feeling intense pressure to cover the tested material in the time allotted even though they believed it was an impossible task (Guth, 2000).

In light of the possible consequences to schools and the heavy responsibility placed on the shoulders of teachers, rapid and sweeping changes have been implemented in schools to align curriculum and instructional practices with these standardized tests (Koczor, 1984; Shepard, 2002). School administrators and teachers have become increasingly anxious to find ways to raise student test scores to meet the required benchmarks (Barksdale-Ladd & Thomas, 2000; Smith, 1991a). Instructional strategies, classroom activities, and learning outcomes have been influenced by increased pressure for students to perform on these state and nationally mandated standardized tests. In many instances, this pressure manifests itself in the practice of ‘teaching to the test’ by gearing instructional techniques toward rote memorization while moving away from a broader, more integrated instructional focus on strategies that promote students’ complex knowledge systems (Herman & Golan, 1990; Hoffman, Assaf, & Paris, 2001; Johnston, 1998; Smith, 1991a).

As instructional priorities and goal outcomes shift toward producing high test scores, many stakeholders are concerned about the kind of learning that is taking place in classrooms (Allington, 2002; Shannon, 2001; Shepard, 2002; Shepard & Dougherty, 1991). Some research has suggested that some teachers stopped giving essay tests to make time for more classroom quizzes in the format of standardized tests (Darling-Hammond & Wise, 1985). Others gave up reading books, writing, and long-term projects to focus on objective drill and skill activities (Smith, 1991a). Recent research indicated that teachers adjusted their instructional practices when they knew that standardized, high-stakes tests were imminent (McMillan, Myran, & Workman, 1999). McNeil (2000) found that some teachers differentiated between teaching what students needed to know to pass the tests mostly through rote memorization and ‘real knowledge’ aimed at conceptual understanding. Based on their survey of 100 teachers in Texas, Gordon and Reese (1997) reported that the entire curriculum was redesigned to drill students on a daily basis in the format of the standardized test. Barksdale-Ladd and Thomas (2000) found that teachers reported discontinuing activities that were pleasant, promoted in-depth understanding, involved collaboration, independence, and higher order thinking skills, and had goals that were not measured by tests. Hoffman, Assaf, and Paris (2001) concluded that the state-mandated achievement testing program in Texas affected instruction in negative ways, literally “undermining teaching and learning” (p. 490). David Berliner argued, “High-stakes tests result in narrowing the curriculum. People are doing anything they can to achieve the scores they need. They’re not teaching students to transfer knowledge, but just to answer questions like those on the test” (Jehlen, 2003, pp. 9-10).

This move toward rote memorization counters 50 years of theory and research. Since the rise of cognitive psychology in the late 1950s, the focus of educational research has moved away from rote memorization to an emphasis on meaningful learning. This new emphasis did not deny that knowledge of the facts was important for thinking and problem solving, but did assert that remembering a list of disconnected facts does not constitute ‘useable knowledge’ (Bransford, Brown, & Cocking, 2000). Degroot (1965) conducted one of the earliest studies on expertise and found that the difference between ‘expert’ and ‘novice’ knowledge was not the *amount* of factual information one has, but the *organization* of that factual information into complex, meaningful patterns. Subsequent research (Chi, Feltovich, & Glaser, 1981; Wineberg, 1991) in multiple domains of expertise, including teaching, (Sabers, Cushing, & Berliner, 1991) indicated that ‘knowing more’ does not necessarily mean having more factual information available. Instead, research showed that although the same factual information was available to both novices and experts, the experts’ knowledge was grouped into conceptual chunks with connections to other related chunks of information. These related chunks were organized in interrelated patterns that allowed for efficient retrieval and application of appropriate informational units when needed in problem-solving contexts (Chi et al., 1981).

Miller (1956) explained that although there are limits to the amount of information people can hold in short-term memory, the capacity is greatly enhanced when learners are able to organize information into familiar and meaningful patterns. Forty years later, Markham (1992) found that the major differences in the content area knowledge of novices, in contrast to experts, were communicated as a lack of ‘integration’, little cross-linking of concepts, and a limited number of hierarchical levels depicted. Content area experts were more likely to display their knowledge organized into more hierarchical levels and using more structural complexity.

The idea that experts organize their content knowledge into complex, organized networks of information has powerful implications for instruction in classrooms. Thus, as this trend toward educational accountability by standardized testing continues to narrow classroom curriculums, practitioners need research on instructional strategies that foster the complex, organized thinking of experts. Further research (Bransford, Franks, Vye, & Sherwood, 1989; Simon, 1980) on expertise suggested the importance of providing students with learning experiences that specifically enhance their abilities to recognize meaningful patterns of information. Concern about the type of learning in which students are engaged is not limited to the immediate. The possible detrimental effects could quite possibly extend into their future learning as well. “In contrast to students who learn by rote, students who employ meaningful learning retain knowledge over an extensive time span and find new, related learning progressively easier” (Heinze-Fry & Novak, 1990, p. 461). However, Bransford et al. (2000) argued, “A teacher is put in a bind if he or she is asked to teach for deep conceptual understanding, but in doing so produces students who perform more poorly on standardized tests” (p.20). Classroom instructional strategies must have the capability of promoting multiple types of learning if teachers are to be effective in meeting the challenges of both standardized testing success and deeper, more meaningful learning for their students.

Graphic Organizers: Organizing Complex Knowledge

Graphic organizers have the ability to promote emphasis on meaningful learning (Roth, 1994) while, at the same time, retain the capability to support rote memorization of factual information (Rewey, Dansereau, & Peel, 1991). Graphic organizers present information in a way that helps students assimilate new knowledge with their prior knowledge base and organize that knowledge into meaningful, complex, conceptual patterns. David Hyerle (1996) extended this emphasis on meaningful learning a step further by suggesting that utilizing *only* language to communicate content knowledge is insufficient to accurately reflect complex content thinking. “Verbalizing and writing out ideas are only one way of representing thinking, and often this is a thin, linear veneer of students’ thinking about content” (p. 15). Hyerle argued there must be alternate modes to represent and communicate content knowledge that better reflect the complexity and organization of conceptual systems of information. He suggested graphic organizers as a useful tool to address the dilemma in which teachers find themselves as they strive to promote multiple types of learning.

> With *visual tools* (graphic organizers), students begin to visually integrate their own holistic forms with the tightly woven structures of information and thus interpret text. Visual brainstorming webs, task-specific organizers, and thinking process maps thus provide a bridge between their own forms and the structures that are embodied in the text but hidden in the guise of linear strings of words. (p. 15)

Heinze-Fry and Novak (1990) described how concept mapping (using graphic organizers) facilitates meaningful learning: “Concepts are not isolated, but rather connected together, showing interrelationships. Cross links are particularly powerful connections, which form a ‘web’ of relevant concepts, enhancing their anchorage and stability in cognitive structure” (p. 463). With this context in mind, this study will be guided by the following research question:

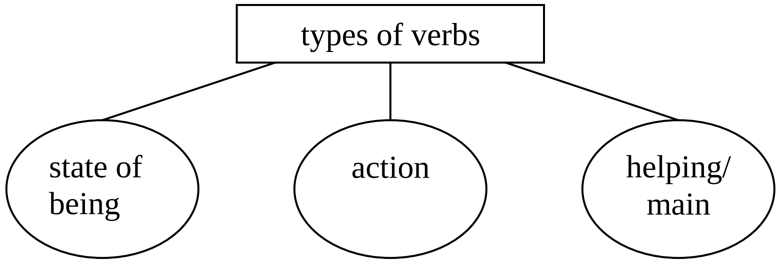
In what ways do the organization and complexity of student content knowledge change when graphic organizers are implemented as the basis for instruction?

Defining Terms

Graphic Organizers

Throughout the history of their development, graphic organizers have been and continue to be referred to by various names. Some of these include concept maps (Novak & Gowin, 1984), semantic maps (Heimlich & Pittleman, 1986), visual organizers (Clarke, 1991), and visual tools (Hyerle, 1996). Although these variations can be distinguished from each other by small details, the differences are minor and the purpose of all variations is consistently to promote meaningful learning. Consequently, the term graphic organizer (GO) will refer to all variations for the purposes of this study.

A GO can be any visual display of information arranged in a meaningful pattern. They have been defined as two-dimensional visual arrays showing relationships among concepts (Rice, 1994), visual displays to organize information (Meyen, Vergason, & Whelan, 1996), and spatial displays of text information (Robinson, Katayama, Dubois, & Devaney, 1998). For the purpose of this study, GOs are defined as visual representations of concepts, their component parts, and relationships among the parts. Although they have many applications, their main purpose is to help the learner connect new, unfamiliar information to his or her own prior knowledge making the new learning that takes place more meaningful, useful, and accessible. They offer a ‘visual map’ intended to aid students in organizing complex knowledge. One example follows here:



GOs have been referred to as both a strategy and a tool (Cliburn, 1990; Marzano, Pickering, & Pollack, 2001; Romance & Vitale, 1999). When a GO is used as the main focus of instruction during the teaching process and the instruction itself is driven by the GO design, it can be an instructional strategy. When used as a display of knowledge outside the process of instruction, as a note-taking device, or as an organizational frame in a collaborative context, a GO can be a tool. While the visual framework of a graphic organizer is a tool, when put into practice as the focal point of planned instruction, it can be a strategy in action.

GOs can be very simple, such as the previous example, or extremely complex including direction, interwoven connections, and labeled relationships forming intricate networks of related concepts. They can be used before, during, or after instruction as well as assessment. They can be teacher-created, student-created, or created collaboratively within a small group or whole class context. However, the overall purpose of GOs is to connect newly acquired information with prior knowledge constructing a network of organized, complex knowledge that is accessible to the learner.

Organization

The term organized has been defined ‘to arrange or form into a coherent unit or functioning whole’ (Merriam-Webster’s Medical Dictionary, 2002) and ‘to form into a coherent unity or functioning whole' (Merriam-Webster's Dictionary, 2005). *The American Heritage Dictionary of the English Language* (2000) defines organized as follows: 'to put together into an orderly, functional, structured whole.' This reference continues to detail the meaning of organized also listing 'a) to arrange in a coherent form; systematize, b) to arrange in a desired pattern or structure.'

Previous researchers have utilized the term organized in several ways that relate to this study. Several studies (Bransford, Franks, Vye, & Sherwood, 1989; Markham, 1992; Miller, 1956; Simon, 1980) comparing the similarities and differences between novice and expert knowledge discuss the characteristic of organization as applied to student conceptual understanding and the structure of student content knowledge. This discussion of organization is continued by numerous researchers throughout the documented history of research specifically on graphic organizer effectiveness. The term organized is consistently associated with concepts such as 'meaningful learning and patterns of information' (Ausubel, 1960, 1963, 1968; Novak & Gowin, 1984), 'non-linear thinking' (Hyerle, 1996), and 'patterns that allow for efficient retrieval and application' (Chi et al., 1981). The term organized has been consistently used within this study to mean arranged in a meaningful pattern that is accurately reflective of the knowledge it is meant to represent.

Complexity

Merriam-Webster's Dictionary (2005) defines complex as 'a whole made up of complicated or interrelated parts.' *Merriam-Webster's Medical Dictionary* (2002) defines complex as 'complicated in structure; consisting of interconnected parts.' *The American Heritage Dictionary of the English Language* (2000) states that complex means '(1) consisting of interconnected or interwoven parts, (2) involved or intricate, as in structure; complicated.'

Previous research has used the term complex in reference to several characteristics of student conceptual understanding (Cliburn, 1986; Hyerle, 1996; Markham, 1992). Some of these characteristics are student recognition of a high level of connectedness among pieces of information, interrelationships between concepts, the existence of an increasing number of components, and organization of those components into an accurately interconnected framework (Wallace, Mintzes, & Markham, 1992). Novak and Gowin (1984) consistently use language such as: connected together, showing interrelationships, and web of relevant concepts. This type of language refers, based on previously cited dictionary definitions, to the concept of complexity. Therefore, the term complexity is consistently used in this research to refer to the level of connectedness and interrelatedness of student content knowledge as it is impacted by the use of GOs as an instructional base.

Theoretical Framework: Constructivism

Constructivism, as a theory, emphasizes that knowledge is actively constructed by the learner as he or she connects newly acquired information from experiences with older, prior knowledge creating a network of related concepts (Hendry, 1996; Steffe & Gale, 1995). Thus, constructivism is an appropriate theoretical framework for the study of GOs. Constructivists understand that learning occurs when new knowledge is integrated with prior knowledge to form increasingly complex, organized networks of interrelated conceptual understandings. This construction process is believed to constitute 'meaningful learning' which requires a true *understanding* as opposed to just *memorization* of facts (Novak & Gowin, 1984). This issue of deep understanding versus rote memorization is what separates constructivism on one theoretical side from behaviorism on the other (Bransford et al., 2000; Eggen & Kauchak, 2001).

Although theories of constructivism vary slightly, most allow for multiple truths depending on the context or the individual perspective of the learner (Gergen, 1995; von Glasersfeld, 1995). Multiple subjective truths are formed depending on the social or individual context of a particular situation and each is the ‘correct answer’ for that context. Constructivists believe that since learners are actually constructing knowledge from their own experience, their resulting ‘reality’ is not necessarily identical to the reality of the external world. Each group or individual’s reality is slightly different as a result of their diverse prior experiences but correct because that is the ‘truth’ for them. No single, objective truth exists; just the individual or group constructions of meaningful understanding of the outside world (Hendry, 1996; Steffe & Gale, 1995).

Constructivists are concerned with the complex formation and organization of knowledge as learners process information. Emphasizing the connections between concepts and their components as well as connections with prior knowledge is of vital importance. The organizational structure depends on the individual or group meaning-making process and allows the learner to retrieve appropriate knowledge across contexts whenever he or she needs that particular information.

Although he did not use the term ‘constructivism,’ David Ausubel (1963), whose advance organizer has been credited as the forerunner of GOs, repeatedly utilized the phrase ‘to *construct* meaningful learning’ when explaining the original and continuing purpose of organizers. Heinze-Fry and Novak (1990) stated that concept mapping (using

GOs) facilitated meaningful learning by showing concepts as having connected interrelationships as opposed to being isolated from each other. Their research indicated that cross links forming a ‘web’ of relevant connections enhanced the anchorage and stability of all represented concepts in the cognitive structure. Clarke (1991) stated that visual organizers “support the construction of meaning from content among groups of learners” (p. 534). David Hyerle (1996) described GOs as “deeply rooted in constructivist theory” (p.vii). He asserted that visual tools (GOs) were one possible avenue toward encouraging students to connect and organize information and to discover complex interrelationships.

Although research findings in educational psychology clearly indicated the benefits of this emerging constructivist paradigm, according to Richardson (1997), a move away from behaviorism toward constructivism has not come easily in mainstream society and traditional schools.

> The information acquired from traditional teaching, if acquired at all, is usually not well integrated with other knowledge held by the students. Thus, new knowledge is often only brought forth for school-like activities such as exams, and ignored at all other times. (p. 3)

David G. Imig (1997) expressed his concern about this dichotomy stating, “Preparing young people for a world that sees knowledge as merely facts and figures presents a challenge for teachers using constructivist principles” (p. viii). Frank Smith (1998) discussed his similar perspective of the difference between traditional ‘teaching for memorization’ and constructivist ‘teaching for meaning’ in his appropriately titled, *The Book of Learning and Forgetting*. He described these two conflicting points of view as 'the classic theory' in which we learn naturally and involuntarily from the people around us all the time, and the 'official theory' in which learning is work and anything can be learned as long as sufficient time and effort are put forth. He related his 'classic theory' to constructivism and lamented the apparent inability of schools to let go of the control required to facilitate traditional memorization techniques and embrace a more relaxed, comfortable attitude toward the process of learning.

On the other hand, it is a very tenuous endeavor for constructivist educators to navigate between these two paradigms. Classroom instructional time is a limited commodity. Educators must find a balance between teaching to the mandatory, potentially punitive standardized tests, and teaching to promote the formation of complex, organized units of conceptual understanding whose benefits may not be fully realized until long after the high-stakes tests are over. In support of his promotion of GOs as a useful and timely tool for educators, Hyerle (1996) suggested, "The central problem that constructivist educators face is not a guiding theory, but concrete strategies and tools for institutionalizing these theoretical and practical understandings into more inclusive classrooms" (p. 15).

GOs can be a tool for constructivist educators to bridge the gap between the immediate statistical goals of many school officials and the long-term developmental goals of complex conceptual understanding (Cliburn, 1986; Hyerle, 1996). GOs can be accurate representations of informational text and intricate reflections of how that information is interconnected. They have the ability to show the individual bits of information students need to remember in order to be successful on traditional assessments but they can also clearly indicate how those bits of information are put together in relationship to each other. GO strategy has the potential to smooth the transition to constructivist learning by meeting the criteria of the previous paradigm (rote memorization of factual information) at the same time.

Summary

As education in the United States moves steadily in the direction of evaluation and accountability through standardized testing, teachers need to find ways to balance the need to prepare students for success on high stakes tests with the need to teach complex, organized, and interconnected systems of knowledge. Within our prevailing educational climate, researchers need to identify instructional techniques that will support a perspective of teaching and learning for success at multiple levels; for multiple purposes. This study seeks evidence to support the premise that, utilizing a constructivist theoretical framework, GOs can offer teachers a basis for instruction that extends student knowledge from rote memorization to complex, organized units of conceptual understanding.

Concepts are not isolated, but rather connected together, showing interrelationships.

(Heinze-Fry & Novak, 1990, p. 463)

Helping students to organize knowledge is as important as the knowledge itself.

(Bransford, 1999, p. 165)

Chapter 2

Review of the Literature

As cognitive learning theories began to develop and become popular throughout the 1950s, they influenced instructional practices that emphasized the organization and complexity of conceptual knowledge. A look at the historical development of GOs reveals that these strategies were influenced by this ongoing movement toward ‘meaningful learning,’ including recent adaptations by constructivists.

This review begins with a brief history of the original idea on which most variations of GOs are based. Next is a chronological listing of the various theorists who adopted this strategy/tool and altered or refined its appearance, component parts, or usage. Following these developments is an overview of recent research specifically addressing GOs as a strategy to facilitate the organization and complexity of student content knowledge. Finally, the possible contributions of this study are discussed in light of the previous research.

Historical Development

Origin

Most researchers agree that the foundation of GOs as a teaching strategy and a learning tool can be found in David P. Ausubel’s writings (1960, 1963, 1968). He referred to this teaching tool as an “advance organizer” (1963, p. 82) reflecting his intent that it should be presented to the learner prior to the introduction of new material. According to his plan, a key characteristic of this technique was that the concepts in each organizer, as well as each series of related organizers, be hierarchically organized from beginning to end. In other words, they would begin with general information and move toward more specific details.

He identified two types of organizers for two different types of information. The “expository” organizer illustrates for the student how completely unfamiliar information is connected to established knowledge. The “comparative” organizer promotes discrimination between students’ prior misconceptions and more accurate, newly presented information (1963, p. 83). Ausubel advocates that these types of organizers used before initial instruction will “…provide relevant ideational scaffolding, enhance the discriminability of the new learning material from previously-learned related ideas, and otherwise effect integrative reconciliation at a level of abstraction, generality, and inclusiveness which is much higher than that of the learning material itself.” (1968, pp. 330-331). Ausubel’s target purpose for using this strategy was to improve students’ reading comprehension by both activating prior knowledge and offering a summary of what to look for before actually reading the text.

Early Variations

Following Ausubel’s initial introduction, many educational psychologists and theorists latched onto his advance organizer strategy and added their own refinements. During the following decades, researchers and practitioners experimented with many variations while, in keeping with the cognitive theoretical trend of the time, retaining his original purpose to promote meaningful learning. By the late 1970s, over 20 different variations on Ausubel's original design could be operationally defined and studied for their effectiveness on learning (Baker, 1977; Dunston, 1992). Descriptions of some of the most commonly recognized models follow.

The term 'structured overview' was the first to come into use after the initial advance organizer (Baker, 1977; Barron, 1969; Earle, 1969). This variation replaced Ausubel's initial prose passage with an outline format. The purpose of linking new information to old, as well as the presentation in advance of the bulk of the learning, did not change from Ausubel's original advance organizer. The purpose of hierarchically organizing knowledge to promote meaningful learning also remained consistent.

Originated as a variation of the advance organizer (Barron, 1980) but a direct descendant of the structured overview, the term graphic organizer was introduced by Estes, Mills, and Barron (1969) as follows: "… a visual and verbal representation of the key vocabulary of a learning task in relation to more inclusive or subsuming vocabulary concepts that have previously been learned by the student" (p. 41). Its early structure focused on single vocabulary words and resembled a tree diagram. The purpose was to arrange and connect the key terms from a text in a way that would activate students' prior knowledge (Dunston, 1992). Up to that point in time, advance organizers, structured overviews, and graphic organizers were all intended as teacher-directed, pre-reading, instructional activities (Barron, 1969; Earle, 1969). Again, the idea of organizing knowledge and integrating it with previously learned information to promote meaningful learning continued to be the main purpose.

With the publication of their book, *Learning How To Learn,* Novak and Gowin (1984) made their mark on the development of this strategy by designing their own version of visual representations known as concept mapping. This version added the feature of labeled links between concepts in order to identify specific relationships. They expanded the purpose of the visual representations to include not only to make learning easier and simpler by connecting to prior knowledge, but also to be the catalyst for a different type of more meaningful learning. Theirs was a step away from traditional behavioral psychology and toward the construction of knowledge through experiential learning. This idea of assuring 'meaningful' learning, although presented in Ausubel's original work, was much more strongly emphasized and brought to the forefront by Novak and Gowin (1984). They define its importance as follows:

> To learn meaningfully, individuals must choose to relate new knowledge to relevant concepts and propositions they already know. In rote learning, on the other hand, new knowledge may be acquired simply by verbatim memorization and arbitrarily incorporated into a person's knowledge structure without interacting with what is already there. (p. 7)

Another notable difference with the emergence of concept mapping was the expansion into other subject areas. To this point, visual representations had been utilized almost exclusively in the area of reading/vocabulary comprehension. By suggesting that concept mapping might be a helpful strategy in science education specifically, Novak and Gowin opened the door to experimentation in all content areas.

Another variation introduced at about this time and distinguished by the representative term semantic mapping also became popular in the early 1980s using a visual display showing general information in the center and specific details radiating out in all directions (Heimlich & Pittelman, 1986). The main content area focus was still reading vocabulary and comprehension but suggestions for content area subjects were described.

As ideas about possible applications expanded, many practitioners and researchers began to experiment with using one of these models at various points during instruction rather than solely during pre-instruction (Dunston, 1992). Barron and Stone (1974) suggested post-instruction organizer use. Novak and Gowan (1984) gave directions for use as a post-learning evaluation tool. Heimlich and Pittelman (1986) instructed teachers to utilize semantic mapping for student study purposes, and various others adapted structures for use in pre-reading, during-reading, and post-reading tasks (Merkley & Jefferies, 2000). Although these researchers adjusted the visual display, instructional presentation time, and various content areas, the main purpose of organizing and integrating knowledge into complex, interconnected structures remained the same.

Recent Modifications

Over a period of time, geometric shapes were added surrounding the individual concepts or terms to the organizer display. The two terms that have retained popularity to the present are concept map and graphic organizer. Concept mapping can be differentiated by the specific labeling of relationships between concepts. Graphic organizer has become an umbrella term that refers to all visually displayed organizers in this discussion (Merkley & Jefferies, 2000).

Over the past decade or so, the study of GOs of all variations has increased dramatically. Although initially developed specifically to enhance reading comprehension, adaptations of this technique have been used in almost all subject areas. The field of science education has been involved in extensive experimentation for several decades in almost all disciplines of the subject area (Guastello, Beasley, & Sinatra, 2000; Heinze-Fry & Novak, 1990; Hewson & Hewson, 1983; Roth, 1994; Romance & Vitale, 1999;). Content areas involved in GO research other than science include social studies (Avery, Baker, & Gross, 1997), mathematics (Monroe, 1998), writing (Heimlich & Pittelman, 1986), and many other non-core academic disciplines. While originally intended for beginning readers/learners, GOs are now being used from pre-kindergarten through post graduate and adult levels (Avery et. al., 1997) as evidenced by the wealth of studies conducted at these levels. The purpose for and goals of this strategy still include but have also expanded well beyond Ausubel's original, singular hope to improve comprehension of text materials. GOs have proven themselves to be infinitely versatile as far as when and how they might be utilized to enhance a variety of types of learning.

The various designs that have developed through the years from Ausubel's original prose-style advance organizer continue to enhance meaningful learning for the two purposes he set out originally. Virtually every study or article written on this topic not only reports, but emphasizes the primary goal in utilizing any type of organizer as helping learners to connect concepts to prior knowledge and integrate all knowledge into organized structures. With Novak and Gowin (1984) driving the term 'meaningful learning' toward the forefront, the main goal of all forms of organizers continued to be the catalyst for this type of understanding as opposed to rote memorization (Clarke, 1991; Cliburn, 1990; Heinze-Fry & Novak, 1990; Romance & Vitale, 1999). That being the base of all organizer research, many researchers continued to concentrate on Ausubel's second intent: a comparison of concepts to dispel prior misconceptions and make room for newer, more accurate information. Hewson and Hewson (1983), as well as Sungur, Tekkaya, and Geban (2001), focused their work on this aspect.

Originally, the GO technique was meant to be teacher-designed and presented to the learner prior to instruction. Although this sequence is commonly utilized, often both of these aspects are altered for various reasons supporting the theory of social constructivism (Gergen, 1995). Many educators use collaborative mapping as a summary, review exercise, or integration activity during learning (Roth, 1994). Students work together in groups forming a community of discourse to construct a common understanding of concepts. Other educators tried out the effectiveness of GOs on student recall or, similarly, as study aids for upcoming testing of concepts supporting the previously popular paradigm of learning theory (Robinson, Katayama, Dubois, & Devaney, 1998). Still others used the simplicity or complexity of student-created maps to determine students' depth of understanding of a concept. This information could be gathered either before learning took place in order to determine what is already known , or after learning took place to determine the quality of the learning (Plotnik, 2001; Wallace, Mintzes, & Markham, 1992).

Research Results

Early Findings

As the first decade of GO use passed, the first research studies on their effectiveness were published reporting very disappointing results. Initially, the only type of organizer in use or under study was the pre-reading, teacher-constructed advance organizer presented to the learner and clarified through discussion. Dunston (1992) reported that many studies reported minimal to no significant effect on student comprehension. However, major problems in most of these studies bring their results into question. The treatment period ranged from 14 days to only 1 class period. Many studies provided no training in GO use or construction at all. Smith (1978) summarized that "the results of the studies have failed to show that the strategy does indeed facilitate learning of content material" (p. 62). Moore and Readence (1984) reported that research findings to date revealed only a small overall effect of GOs on learning from text. All of these researchers continued to point out that these results, up to this point in time, are from studies reviewing GOs solely as teacher-directed, pre-reading activities. Dunston (1992) described concerns on this issue as follows:

> Research studies couched in schema theory that present graphic organizers prior to reading use organizers that are constructed by the teacher/researcher. These organizers are developed according to the knowledge, understanding, and schemata of the teacher/researcher and may not activate the appropriate schemata in students. (p. 62)

This statement indicates that one problem with the measured lack of effectiveness of GOs in these studies may have been that teachers were using GO designs based on their own prior knowledge without taking into account that the students' prior knowledge was probably different. The results on effectiveness may have been very different had the teacher taken into account the students' prior knowledge or had the students been involved in constructing the GO.

Developmental Findings

During the 1980s as GO use itself expanded into different variables, so did the effectiveness research following it. After this point, study findings were separated into many categories with varying effectiveness results indicated for each.

The most immediately obvious variable in determining GO effectiveness seemed to be the timing of presentation to the learner. Both quantitative and qualitative data indicated that all GOs have some positive effect but, Moore and Readence concluded "graphic organizing that is conducted after presenting content seems to produce the most learning" (1984). On the other hand, Simmons, Griffin, and Kameenui (1988) examined that exact variable and found that presentation before or after reading had no effect on comprehension and recall of elementary students on immediate measures. The difference in these conclusions may be related to the *type* of learning that was assessed. Although GOs have originally and consistently been promoted to enhance *meaningful* learning, the later study includes both 'comprehension and recall' in its definition of learning. These contradictory findings seemed to warrant a look into other variables that might possibly cause such confusing results.

The age or academic ability of the learner has been identified as a useful variable in considering effectiveness. While some previous findings had indicated a higher level of effectiveness with younger students (as was Ausubel's original intent), later studies suggested the opposite might be true. Treatments at elementary and secondary levels produced small effects while university classes gave rise to moderate effects. These findings led to the conclusion that "learners' maturity may enhance the effectiveness of graphic organizers" (Moore & Readence, 1984). This information served to create even more confusion surrounding GO effectiveness.

Study results finally seemed to be in agreement on the effectiveness data based on who is involved in actually creating the organizer itself. Overwhelmingly, much greater gains were reported when students themselves were involved in some way in the creation or organization of their own model. They might choose which vocabulary words should be incorporated, draw connections between predetermined vocabulary words, or completely determine the arrangement of the entire organizer. Whatever their involvement, consistently more and better learning took place with the learner involvement variable present (Dunston, 1992; Roth, 1994). These results clearly support the theoretical basis of a constructivist framework to extend the type of learning to higher levels of thinking.

Another variable showing consistent results was the level of involvement with the concept of graphic organization afforded to students before they were asked to use the strategy in their own learning process. Those studies that provided learners with instruction and practice on how organizers work, how to construct them, or how they relate to connecting concepts in their own thinking consistently yielded much more positive results on learner gains (Dunston, 1992; Moore & Readence, 1984; Novak & Gowan, 1984). Novak and Gowan outlined extensive instructions on how to introduce students to concept mapping referring to student use of mapping as a “basic skill” (p. 40). This information calls into question the validity of the methodology of a large percentage of all previous research to date. If pre-instruction to students on creating graphic organizers is a key factor in their measured effect on student learning, most of the study results reported are incomplete not having included provisions to implement this important variable.

Another trend in data indicated that GOs produced higher gains with vocabulary knowledge than with comprehension. “Graphic organizers apparently direct learners’ attention more to vocabulary that to relationships among a unit of content.” (Moore & Readence, 1984) These findings reflect Ausubel’s (1963) original perspective that the GO technique is best for factual information and tends to inhibit the understanding of abstract concepts. The 1990s decade produced research to counter these claims. The most recent decade of research revealed that changes in the applications of GO strategies clearly benefited the development of abstract concepts.

Recent Findings: Complexity and Organization

Although researchers use diverse terminology (such as complex, divergent, abstract, or higher order) to describe student thinking, a few have begun to explore the use of GOs for the promotion of more complex, organized thought processes. Within the past decade, interpretations of data dealing with concrete (facts) versus higher-order thinking (meaningful learning) seem to be reversing the findings from earlier, more conflicting studies. Several researchers have reported very clear, positive results in measurements of the depth and breadth of learner thinking following the use of organizers.

For example, Mason (1992) reported striking differences in student content knowledge after students were exposed to concept mapping strategies during the instructional process. Conclusions from her two-year study of concept mapping used with middle school science students showed that mapping students demonstrated “insight into the interrelatedness of concepts” (p. 60) not present in non-mapping students. Roth (1994) reported that, as his high school physics students utilized GOs in collaborative groups, their understanding of the content expanded to become much more complex and interrelated. As the students negotiated with each other to design a GO that accurately represented their shared meaning, their own content knowledge adjusted to become more complex and clearly organized.

With regard to complex knowledge structures, Clarke (1991) specifically described visual organizers as having the capability to “focus student thinking on higher order thinking skills without shifting attention from subject area content” (p.526). He stated that various types of visual organizers can expand student thinking to reflect complex patterns instead of limiting them to just rote memorization of informational facts. He suggested that “visual organizers may give students reason to open the door to more complex, flexible, and creative thought” (p. 534).

Romance and Vitale (1999) suggested the use of concept mapping as an instructional strategy and a personal, organizational tool for students to “represent complex ideas, their organization, and their importance” (p. 81). Plotnik (2001) specifically lists “designing complex structures and communicating complex ideas” (p. 42) as purposes for concept mapping. GOs have even been used in brainstorming activities with the specific goal of sparking divergent thought processes (Clarke, 1991; Hyerle, 1996). These kinds of conclusions clearly indicate that GOs can support student learning beyond rote memorization and encourage students to think about the complexity and organization of their content knowledge.

With basic GO effectiveness well established in research findings, researchers have begun to move beyond initial discussions of evidence that GOs *have* an effect on student achievement, toward exploring the *kind* of an effect they have. Only relatively recently have studies begun to analyze data collected from alternate data sources to determine what this consistent indication of higher student achievement means. Wallace, Mintzes, and Markham (1992) utilized both quantitative and qualitative data collection methodologies in their investigation of the extent to which concept maps reveal changes in understanding. They examined both concept maps and scores from conventional tests. These two measures were completed before and after direct instruction. Results showed substantial changes in the complexity of knowledge as revealed through the concept maps even though conventional test items, in this case, indicated little achievement gain. Follow-up interviews with the participants who designed the most complicated maps corroborated this finding when they were able to generate the most scientifically accepted propositions about the chosen topic.

This more in-depth focus brings into question the *type* of learning students are engaged in when using GOs. With this in mind, some researchers have begun to shift their focus from static, end results to an examination of the process of the learning that takes place when GOs are used. In one example, Jones (1992) conducted research on the conceptual development of biological content knowledge over a 15-week semester. Periodic concept maps were used to track the gradual change toward higher complexity in the restructuring of student understanding as they gained additional knowledge throughout the course. At set intervals, students were asked to remap their understanding of a consistent concept providing a series of time-spaced pictures of the restructuring of the same content knowledge.

Another example is Roth's (1994) previously mentioned research with high school physics students. After the science content had been presented and within the framework of social constructivism, students participated in collaborative concept mapping activities in small groups with the purpose of clarifying, organizing, and enriching their own personal and shared construction of that science content. Roth explained that as the students worked together throughout the duration of the study to design hierarchically organized structures of related concepts, “Simple links and cross-links express the complexity of the embedded concepts” (p. 13). Throughout this year-long study and the process of learning using GOs, he found that using concept mapping as a collaborative student-directed technique led students to construct more complex, organized networks of conceptual knowledge. This new knowledge was also more intricately interconnected as indicated through the relationships within the resulting GOs.

Recent research also revealed that GOs enhance other aspects of meaningful learning such as transfer of knowledge and the identification of similarities and differences. These aspects are directly related to the complexity and organization of student knowledge. The transfer of knowledge gained in one context to application in a new context has been differentiated from just ‘remembering information’ in the same way that constructing meaningful networks of organized knowledge is differentiated from memorizing facts (Bransford et. al., 2000). In an article reporting on their action research study, Penn, Shelley, and Zaininger (1998) targeted improving the transfer of learning to new contexts as their goal in utilizing overview GOs as an intervention strategy. They identified students’ difficulty in transferring what they had learned to ‘real life’ situations as an emerging problem. Memorized, factual information alone was not successful in helping students apply their knowledge to new contexts and solve problems. Transfer was improved when students were able to use their organized and complex knowledge developed through the use of several intervention strategies including graphic organizers.

GOs likewise have the capability to improve students' ability to recognize similarities and differences. Based on his meta-analysis of research on effective instructional strategies, Marzano (2001) ranks the identification of similarities and differences as the single most effective learning strategy and maintains that it "might be the core of all learning" (p. 14). This vital thought process of identifying similarities and differences is the essence of the links and cross-links within the complex organizational structure of GOs. Armed with the ability to more accurately communicate the complexity and organization of their content knowledge through the visual means of GOs, students can better construct shared meanings as they negotiate and expand the structure of their own understanding with the community of learners around them.

Although the researchers discussed in the preceding paragraphs use diverse terminology and communicate varying stated foci in their discussions of student knowledge (complexity, organization, transfer, applying knowledge, problem-solving, identifying similarities/differences), their findings are bound together by the common focus of higher-level thinking processes as opposed to rote memorization of factual information. All of these researchers are concerned with instructional strategies that will encourage students to construct their own detailed, interconnected networks of content knowledge that are meaningful, and therefore, useful to them as they continually add new knowledge to their understandings throughout their ongoing learning process.

Significance of this Research Study

Decades of research have demonstrated a relationship between the use of GOs and gains in student achievement. Numerous studies have documented improved test scores in specific content areas including literacy (Alvermann & Boothby, 1986; Baumann & Bergeron, 1993; Griffin & Tulbert, 1995), science (Hawk, 1986; Horton, 1993; Mason, 1992; Sungur, Tekkaya, & Geban, 2001; Wallace et al., 1992), social studies (Avery et al., 1997; Doyle, 1999; Guastello et al., 2000), and mathematics (Monroe, 1998).

However, the use of standardized test scores as a measure of content knowledge has defined the meaning of student achievement in these studies (Wallace et al., 1992). Gains in student achievement produce very different results depending on the data collected and the analysis methods used. Quantitative researchers, who measured changes in student achievement through standardized test results, were assessing a narrowly defined type of factual information gain (Guastello et al., 2000; Novak, Gowin, & Johansen, 1983; Sungur et al., 2001). In order to assess changes in organization and complexity of student content knowledge, alternative methodologies specifically designed to examine these aspects must be employed. Qualitative methodologies are geared toward this purpose and are, therefore, the appropriate choice to answer the question put forth by this study.

Also related to the issue of quantitative versus qualitative methodology, most existing research on GO strategy has utilized quantitative data collection and analysis methods. These procedures produce excellent pre- and post- test treatment results that reveal overall gains in student achievement as a result of the intervention. What they cannot tell us is *how* the gains occur. Dunston (1992) suggested, “Researchers should no longer question if organizers work, but how and when they work" (p. 58). Few studies have documented the ongoing process of student interaction with GOs as they use them.

It is this potential to offer a broader overview of the developmental *process* of students interacting with GOs as an instructional strategy and a learning tool that sets this research study apart from the existing literature. Most researchers have previously framed their research to reflect a very narrow focus primarily utilizing quantitative methodological data collection to determine the effectiveness levels of GOs. Utilizing qualitative methodology throughout the learning process as opposed to limiting data collection to summative assessments will offer valuable information on *how* the presently available results on GO effectiveness were reached.

This study, likewise, has the potential to provide understandings about the *type* of knowledge promoted by the use of GOs. Several researchers have mentioned this issue (Mason, 1992; Wallace & Mintzes, 1990) but few have chosen to focus on it directly. Most studies have not differentiated between rote memorization and more organized complex networks of constructed knowledge. In order to move forward in our understanding of how GOs work during the learning process, we must first identify what type of learning is taking place.

In summary, this study offers to the existing literature:

- alternate data collection tools, as opposed standardized testing
- additional qualitative evidence to add to extensive quantitative
- a focus on determining the *type* of learning taking place instead of just the amount
- an exploration of the *process* of knowledge construction

With these potential contributions to the existing literature on GOs in mind, it bears repeating that this study will be guided by the following research question:

> In what ways do the complexity and organization of student content knowledge change when graphic organizers are implemented as an instructional strategy?

When the terrain that needs mapping is this complex, researchers need to bring an equally complex variety of research methods to the task if they want to be able to view the subject in its many forms. Education only starts to become understandable when it's approached from multiple perspectives. (Labaree, 2003, p. 15)

Chapter 3

Methodology

This chapter describes the qualitative methodologies that were used in exploring the organization and complexity of student knowledge and in answering the guiding question. Five sections are included: introduction, participants, role of the researcher, materials and procedures, and data collection and analysis.

Introduction

As discussed in the previous chapter, extensive quantitative research has been conducted on the use of GOs, resulting in convincing evidence of their effectiveness in promoting student achievement. Although these results clearly indicate the potential of graphic organizers as an instructional tool, they do not offer any information about *how* GOs promote student achievement. Most research in this area has adopted a pre/post-test experimental structure that measures how much change has occurred, but does not document the process through which student achievement occurs and the nature of student knowledge. Throughout previous research, assessment measures (primary data sources) have typically been standardized testing tools measuring a narrow band of factual information with little capacity to assess other types of knowledge. Consequently, we do not know much about how GOs affect students' abilities to construct more organized, complex networks of interconnected knowledge.

Little previous research has been conducted on GOs utilizing qualitative methodology. As a result, what we know about the use of GOs is largely limited, by methodological structures, to conclusions that GOs do support student achievement. Information about the process through which student achievement occurs and the nature of the resulting student knowledge is missing because the data collection methods employed were not designed to answer this kind of question.

Merriam (2001) described several characteristics that make qualitative research appropriate for answering the question posed by this research study. For example, qualitative researchers are typically interested in understanding the meanings that people construct and how they make sense of their world and their experiences in it. Thus, in order to understand students' thinking, appropriate data collection would have to take place where the learning takes place: in the classroom. Qualitative data collection usually involves extensive fieldwork in which the researcher spends a substantial amount of time in the natural setting of the study, in contact with the participants. The investigation of the process of change in student thinking throughout the data collection period required the researcher, herself, to be the primary instrument for data collection as opposed to a questionnaire, computer, or written test. This type of data generated an end product that is a rich, verbal description as opposed to numerical findings. All of these characteristics are decidedly qualitative in nature and offered the best chance for obtaining appropriate and valuable data to answer the guiding question.

This investigation into the process of change in student thought over a period of time was not a simple question that resulted in an easy, linear answer. The question itself was highly complex. This was an investigation that required a methodology that could accommodate and even encourage complexity and interrelatedness. Qualitative methodology has that capacity. Gerald Duffy (1991) proposed, “The complexities themselves are the heart of the matter…teachers should be encouraged to capitalize on the complexities rather than be protected from them” (p. 15). If we, as researchers, hope to expand our understanding of how learning takes place in the complex environment of the classroom, we also need to embrace these complexities by our choice of methodologies. As Labaree (1991) reminded us in his quote at the beginning of this chapter, only when we embrace the complexities from multiple perspectives can we hope to understand education.

Participants

The multiple perspectives of the participants in this study offered a variety of viewpoints focusing on the same phenomenon of constructing knowledge with the use of GOs. The participants included two classroom teachers, two classroom groups of students, and the researcher.

School Context

The school system in which this research was conducted has a policy of ‘total inclusion’ of all students with disabilities. This policy resulted in classrooms with an academically diverse student population. Regular classroom environments included students with identified learning, behavioral, emotional, and/or physical disabilities. Classrooms often included several special education teachers or aides who dealt with individual student needs during classroom instruction. Teachers reported that it was difficult to meet students’ academic needs in these diverse contexts.

The school itself was a small elementary school serving students in kindergarten through grade five. Geographically, it was located several miles from a small town in a rural area of the county which was, itself, relatively distant from large urban centers. Many of the students who attended this school came from a low socio-economic background. Most families had multiple children attending the school, yet parent involvement in school- related activities was reported by the teachers as being low.

The teachers reported that low socio-economic status and parent involvement issues contributed to the way students struggled academically and behaviorally. The teachers drew parallels to the research and theories of Ruby Payne (2001) stating that school success was often not valued at home, making it difficult for them to motivate children to participate in learning. The two teachers who participated in the study, Mrs. B and Mrs. H, described various ways that they had tried to deal with this situation but agreed that the students in the two study classrooms struggled academically and were unusually hard to manage behaviorally.

The selected classrooms were contexts in which GOs had not been utilized extensively as an instructional strategy, and probably not at all. Since the purpose of this study was to document the process of change in the construction of student knowledge as students learn to utilize GOs, it was important that they began the study having little or no familiarity with GOs. In order to document the change initiated by an instructional intervention, the intervention must be a strategy that is relatively new and unfamiliar to the participants (Reinking & Bradley, in press). By choosing participants and a classroom context in which the intervention had been used minimally or not at all, the researcher was able to establish a starting point or a ‘baseline’ from which to document change as data collection progressed throughout the length of the research study.

The third grade year was chosen because of its designation in the state of Virginia as the first year that students take the SOL tests at the end of the school year. This is a high-stakes, standardized evaluation tool that tests students in four core content areas. As previously discussed in the rationale for this research, this kind of situation often creates high stress for students as well as teachers and results in a classroom instructional focus geared toward rote memorization rather than higher level thinking (Amrein & Berliner, 2003; Barksdale-Ladd & Thomas, 2000; McMillan et. al., 1999). It was within this context that this researcher sought answers to the question guiding this study.

Student Participants

The student participants included two classrooms of third graders. Informed consent was obtained from all students verbally and from parents of all students in written form (Appendix A). From these classrooms, ten focus students were identified from which to collect more in-depth data. These students were chosen to reflect the diversity of the overall group including characteristics such as gender, academic success, ethnicity, and socio-economic status. They remained constant throughout the data collection process. The ten focus students (five from each classroom) were identified after spending some time observing in the classroom and with input from the two teacher participants.

Teacher Participants

Two third-grade classroom teachers were chosen to participate in this study. Written informed consent was obtained from both participants (Appendix B). Both teachers expressed a professional interest in learning more about the use of GOs. This was one criterion used to identify appropriate teacher participants. Both were comfortable at the prospect of having a researcher enter their classrooms for the duration of the study. They were willing to give up instructional responsibility in one subject for six weeks. The primary participating teacher, who was normally responsible for science content, was willing to discuss her observations and reflections of the students' learning with the researcher during interviews. The choice of teachers for this study was important because their comments and observations constituted one of the three vital data sources necessary for triangulation. This added to credibility when the data were analyzed and conclusions were drawn.

Mrs. B held a Bachelor's degree in elementary education. She had 8 years of teaching experience and was beginning to work on requirements to earn National Board Certification. She was responsible for teaching the third grade science content for both of the classrooms participating in this study. This role made her the primary teacher participant in the data collection. She was usually present during instructional activities related to this research and often took notes to help her remember significant incidents, observations, and quotes to report later during interviews.

Mrs. H also held a bachelor's degree in elementary education. She had 31 years of teaching experience and was looking forward to retiring at the end of the following school year. Although she did not observe this study's direct instruction or activities, her perspective was important in gaining insight about her students' typical learning process. The insights of both teacher participants were vital in establishing a baseline from which to measure changes and in identifying changes when they occurred.

Role of the Researcher

For the portion of classroom instruction that involved graphic organizers and science content, the researcher was the primary instructor while the classroom teacher assumed a supporting role either by observing, as described in the above section, or by supporting the instruction led by the researcher. It was the researcher's responsibility to design, plan, and provide all graphic organizers utilized for instruction and all activities, procedures, and lesson plans in which they were embedded. This was essential in order to ensure that the GO instructional strategy was utilized in a manner that would support higher-level thinking in the students. Merkley & Jefferies (2000) suggested that prior instruction for teachers on how the use GOs with students could be a determining factor in their effectiveness. Dunston (1992), whose critique of multiple studies conducted on GO strategy reported minimal effectiveness on student achievement, pointed out that most of the research included no training on GO use for teachers. Thus, the researcher's expertise in using GOs was an important factor in ensuring that the classroom instruction supported higher-level thinking.

At the same time, the researcher was observing in order to document events using field notes. Although the researcher actively participated by planning and delivering instruction, the activities of ongoing observation and data collection were well known to all of the study participants. In this role of 'Participant as observer' (Merriam, 2001), the researcher was able to interact closely enough with the participants to establish an insider's identity. From this position, the researcher was able to observe details that helped to capture the essence of the focus of this study. A total period of six weeks was spent in the field including preliminary work, instruction and data collection, and follow up visits. An average of five hours per day was spent in the school context. Appendix C provides more specific details about the research timeline in the field.

It was of vital importance that the normal sequence of curriculum was disrupted as little as possible. As a researcher and, consequently, a temporary guest in the classroom environment, respect was paid to the responsibilities and routines of all of the study participants. Substantial time was spent observing classroom procedures, learning daily routines, and making an effort to become part of the classroom community prior to actual data collection (see Appendix C for a more detailed timeline). Only by affording the research participants and their classroom/school environment the respect that they deserve was the researcher able to establish a strong identity as 'Participant as observer' within their context. Mutual trust had to be established in order to have been in a position to collect the data that resulted in rich, insightful findings (Seidman, 1998). This trust was demonstrated when several students chose to share personal stories about their lives outside the school context as well as painful experiences in other schools. Trust was also established by respecting a focus student's discomfort with the tape recorder during interviews by allowing him to turn it off.

Materials and Procedures

Curriculum and Instructional Context

GOs were introduced and consistently utilized on a daily basis for instruction in the content area of science. It is important to note that the focus of this research was on the instructional tool (GOs) as the basis for planning instruction and utilized to communicate content knowledge; not on the science concepts communicated through the strategy. The length of the instructional period and the magnitude of the science curriculum (based on the Virginia State Standards of Learning) taught was dependent on the specific classroom context chosen for the study. After the participants were identified, the researcher learned from the participating teacher which curriculum unit needed to be presented, which SOLs had to be included, and which concepts needed to be addressed (Appendix D). Regional requirements such as Virginia State SOL blueprint guidelines and locally designed pacing guides were followed in order to respect all research participants and their responsibilities, and to retain the regular flow of the annual planned curriculum. The length of the instructional unit (four weeks) was determined by this larger timeframe already established by state guidelines, school curriculum framework, and classroom teacher choices. A further reason for ensuring that the classroom routines and curriculum timeframes remained constant was to minimize the number of variables changed within the research situation. The fewer variables altered, the stronger the case for attributing findings to the GO intervention employed in this study (Reinking & Bradley, in press).

The researcher provided the science instruction within the same daily timeframe and schedule to which the classroom teacher had adhered previously throughout the school year in order to retain the normal flow of instruction and limit changes for the students. Researcher time in the field was originally planned to last for five weeks. This was extended one week due to several interruptions to instructional time during the initial five weeks including a school assembly, a music program, and a teacher workday.

Instructional Activities Using GOs

As noted earlier, the researcher was the primary instructor and taught the specified unit of science content using GOs as the main vehicle on which all instruction was based. The content was presented in a whole class format to each of two class groups with 18 students in each. Sample detailed lesson plans utilizing GOs as the basis for instruction are included in Appendix I. The researcher developed a collection of GOs and related activities addressing all information, skills, concepts, and thinking strategies necessary to communicate the specified science content (Appendixes F-H). Various types of graphic organizers were utilized during instructional activities every day in one or more ways. Examples included webbing for initial brainstorming, hierarchical for organized display of information, sequential for storyline, and cyclical for repeating patterns.

The following describes several examples of ways some of the GOs were used. The items listed in Appendix F1 were cut apart and each student was given a set of components in a ziploc bag. Font size was used (in this particular activity) as an individual scaffolding strategy if needed (most students did not notice it until it was pointed out). Students were encouraged to read the words and phrases, think about their meaning, and experiment with how they might fit together into a connected framework. Appendix F2 shows the GO that was collaboratively designed by the class during the lesson following the previously described sorting activity. The teacher/researcher facilitated this activity on the blackboard. Items included in Appendix F3 were also cut apart with one set for each student. Students were to experiment by moving them around their desktops eventually sorting them into two groups defined by whether or not they represented a natural resource. Other examples are included in Appendixes G and H. Other types of GOs were also utilized for tasks such as brainstorming, assessing student knowledge, story comprehension, and knowledge recall. These are examples of some, although not all, of the activities designed and utilized for instruction and are accurately representative of the overall lessons delivered.

The basic instructional collection designed prior to instruction was adjusted and expanded as the needs and contributions of the participants became evident during the learning process. For example, at one point, it became apparent that students in the second class were rushing into the classroom during the transition to try to “look at and remember” the exact GO designed and displayed by the previous class. This was one example of the kind of learning in which the students thought they were expected to participate. In response to this situation, GOs designed by the first class were immediately put away at the end of class. Also in both classes, various differing accurate arrangements were designed, displayed, discussed, and more overtly encouraged. Another example of adjusting the GO frameworks was when students copied the socially constructed design into their own folder. They were invited to incorporate alternate arrangements into the framework as long as they represented the information accurately. Graphic organizers designed by the students were also utilized as they learned to put the strategy to use on their own.

Other instructional strategies that the regular classroom teacher had typically practiced in teaching science (such as lecture, group collaboration, class discussion) were utilized with GOs in order to minimize changes other than the intervention under study.

Thus, graphic organizers were embedded within the instructional strategies routinely utilized previously by the classroom teacher.

Data Collection and Analysis

Data were collected in three distinct ways: field notes, student designed artifacts, and participant interviews. The researcher was in the school context five days per week an average of five hours per day across the six-week data collection period (See Appendix C).

Field Notes

The purpose in choosing this particular method of data collection was to create a sequential description of the on-going interaction between the participants and the graphic organizers. The resulting description served as an important data source in which to search for recurring themes that emerged during the learning process. Field notes have the ability to be less obtrusive in documenting events within the classroom context than some other methods of data collection. This supports the researcher's role as 'Participant as observer' and enhances the effort to sustain a normal classroom atmosphere. As suggested by Glesne and Peshkin (1992), notetaking in the school context was minimized until it was determined that it could be done without disrupting the atmosphere. Fieldnotes were an important data collection choice for this study because they documented what actually happened in the classroom.

Fieldnotes were kept in two forms: (a) short incidental notes jotted down throughout the instructional day within the research context, and (b) more extensive daily entries written after leaving the research context each instructional day. The purpose of the short notes was to capture important details that might be forgotten by the end of the day if not recorded immediately. Sometimes referred to by qualitative researchers as 'jottings' (Emerson, Fretz, & Shaw, 1995), these key words and phrases enabled the researcher to record reminders of significant actions and details that could be recalled and expanded upon later.

More extensive daily fieldnotes were written in the evenings after each day spent in the field. Emerson, Fretz, and Shaw (1995) discussed the importance of writing fieldnotes after the researcher has left the research environment in order that data collection remains inconspicuous to the participants. This also allowed the researcher to take time to gather thoughts and express them accurately. This activity was also enhanced by writing in a setting that was calmer and more conducive to reflection as opposed to a complex, active school environment. These daily fieldnotes were usually composed in an otherwise empty computer lab within several hours of leaving the school setting for the day. Occasionally when this immediate timeframe was not possible, fieldnotes were composed the following morning at the researcher's home.

Taking fieldnotes in both of these formats allowed for the changing perspectives and adjusting ideas of the researcher as the study developed. This plan also reflected the intended focus of the constant comparative methodology; embracing the idea that data collection and analysis is a progressive and dynamic process. Another reason for using both of these types of fieldnotes was that it provided an additional opportunity for the researcher to reflect the role of participant as much as possible while in the school context in order to develop an insider's role.

Early field notes helped to establish an initial baseline from which to document changes in the levels of organization and complexity of student knowledge being constructed during the learning process. Fieldnotes also allowed the researcher to collect data on candid reactions or behaviors of the participants that might not be reflected in their answers during interviews. Fieldnotes were taken to record data generated from on-going observations in the classroom context of the teacher, the students, and their interactions with GOs. Data gleaned from incidental, informal conversations with any of the participants throughout the study was also recorded through fieldnotes. Focus was placed on the evolving changes in the organization, complexity, and connections between concepts and parts of concepts. Fieldnotes included observations of the participating teachers' and students' conversations, questions, comments, reactions, non-verbal communications, and created artifacts.

Artifacts

Student artifacts provided one of the primary data collection sources in order to guarantee authentic evidence directly from the student participants. Artifacts are a visual means for students to communicate their knowledge that adds to the verbal form solicited during interviews with participants. These artifacts were especially appropriate because the focus of this study was on GOs which are of a visual nature. It also offered a means to establish triangulation between multiple, diverse data collection methods.

Although all students in the class were asked to illustrate their content knowledge by designing their own graphic organizers, examples of these artifacts were collected from the ten focus students for further examination and analysis. These sample graphic organizers were collected from the participants (with their permission) at intervals throughout the data collection period in order to analyze progressive changes across the learning process (Appendix C). The artifacts were accurately and consistently dated in order to document the process of change displayed by students individually as well as collectively.

A set of four artifacts was solicited from the student participants over the course of this study. (Appendices K-T) The situations, contexts, and directions for designing each were similar but slightly different. They appear to accurately reflect the participants' process as they learned how to work with GOs as a tool and gained new content knowledge. These sets of four sequential artifacts indicated the students' learning processes both collectively and individually. In each case, students were given as much time as they needed to produce an artifact as long as they continued to work.

Artifact 1. On the first day of instruction, students were asked to choose any topic in the content area of science that they liked best or knew the most about. They were to communicate everything they knew about this particular concept on one piece of paper in any form they chose. Some examples offered were paragraph form, a drawing, a list, a GO, or key words. There was a short discussion including student questions for clarification, teacher elaboration, and some students sharing their ideas of what concept they might chose. Although students were allowed as much time as they wanted, most were finished in less than five minutes. The purposes of this activity were to contribute to establishing a baseline (group and individual) from which to measure change in student content knowledge, to learn about the complexity and organization of current student content knowledge, and to discover how students chose to express their knowledge initially.

Artifact 2. After working with GO as an instructional strategy and an informational display during science class for one week, students were asked to restate the same knowledge they had displayed on the first artifact into the form of a GO on a separate sheet of paper. The original artifact was returned to them so they could remember their previous work. The purposes of this activity were to assess student understanding of how to use GO form, to check student understanding of the science content presented during class, and to measure changes in the organization and complexity of student knowledge.

Artifact 3. After working with GOs extensively during science class for almost four weeks, a third artifact was solicited from the student participants. In this instance, the researcher was called away to an unexpected emergency and left the prepared lesson and procedure for the classroom teacher to facilitate. Although directions were for students to design a GO reflecting their newly constructed science knowledge from recent class instruction, students were asked by Mrs. B instead to draw a picture of what they had learned. The purposes of this activity were to assess student understanding of how to use GO form, to check student understanding of the science content presented during class, and to measure changes in the organization and complexity of student knowledge. Because the directions were not carried out as intended, this artifact was less valuable in accomplishing its purposes and was given less weight during analysis.

Artifact 4. The final artifact was designed by each student during the last week in the field (week six). The instructions were for each student to communicate their content knowledge of a specific concept (managing the environment) by designing a GO. Although GOs were used throughout instruction to communicate content, none had been designed specifically on this particular concept. The purposes of this activity were to assess student understanding of how to use GO form, to check student understanding of the science content presented during class, and to measure changes in the organization and complexity of student knowledge.

Analyzing the artifacts. The specific purpose for generating artifacts was to learn more about the situation, person, and event being explored (Merriam, 2001). Data generated from analysis of these student-designed artifacts offered the researcher insight into the students' perspectives and thought processes that they may not have been capable of verbalizing themselves. Analysis of these artifacts was geared toward exploring the changes throughout the process with respect to organization and complexity in student knowledge through the use of graphic organizers. Wallace, Mintzes, and Markham (1992) identified the following characteristics in concept maps: number of correct relationships between concepts, levels of hierarchy, branchings, cross-link connections, and exemplars having a general-to-specific pattern. These characteristics were used during analysis to quantify the level of complexity and organization of each graphic organizer examined in the study.

Prior to the data collection phase of this study, two different rubrics were designed for the purpose of aiding in the analysis of collected student artifacts. One was based on Wallace, Mintzes, and Markham's (1992) original design used to analyze graphic organizers created by college students in three studies. The other was based on Benjamin Bloom's taxonomy of educational objectives and the updated revision of the taxonomy as interpreted in *A Taxonomy for Learning, Teaching, and Assessing* (Anderson & Krathwohl, 2000).

However, after the student artifacts were collected in this study, it was determined that neither of these designs was appropriate for use with all of the various types of formats in which students chose or were asked to communicate their knowledge. At various times, students shared their knowledge through drawings, lists of key words, sentences, paragraphs, or GOs. In order to analyze, compare, and visualize the sequence of individual student learning, a tool was needed that had the ability to accommodate all of these forms of knowledge expression.

Consequently, a new rubric (Appendix W) was designed to meet the specific needs of this particular study. It incorporated aspects of both previously designed tools but is applicable for use with various types of knowledge expression. Although it does include a space for assigning numerical ratings, it was not designed to quantify the value of the student artifacts, but rather to aid the researcher in understanding the student thought process as evidenced in the artifact. Sections of the rubric that were not particularly applicable to analyzing a specific artifact form were left blank. Thus, each rubric analysis of individual artifacts utilized different sections.

During analysis, one copy of the rubric was filled out for each individual student artifact gathered in data collection. Features listed on the rubric were counted and tallied. Incorrect information was noted when it appeared. Additional characteristics for each feature were noted after each tally row when further description was appropriate. Three completed examples are included in Appendix X.

The artifact analysis rubric was an important tool for data collection because, although it was not meant to produce statistical results, it gave the researcher a consistent framework from which to examine very diverse artifacts. Its design, created specifically to meet the needs of this study, offered the flexibility to reflect the individual uniqueness of each artifact, but also supplied a constant set of criteria that allowed the researcher to fairly compare the artifacts to each other.

Interviews

The specific purpose of interviewing was to understand the experiences of the participants and the meaning they made of those experiences (Seidman, 1998). Data collected from interviews aided the researcher in examining how the student participants constructed meaning using graphic organizers. Focusing on individual student constructions relates the stated constructivist theoretical base for this study to the perspective of the classroom as an extremely complex environment within which no single viewpoint could possibly be adequately reflective of reality. The varied perspectives of the students, the classroom teacher, and the researcher provided an opportunity to confirm emerging findings through triangulation.

All interviews in this study were informal and semi-structured (Merriam, 2001). They were audio-taped and later transcribed for analysis. A list of preliminary questions for the student interviews is included in Appendix U. Basic questions for the teacher interviews are listed in Appendix V.

Students. Each of the ten focus student participants was interviewed four times over the course of the research in the classroom. These interviews took place within the school building in one of two available empty classrooms not in use on that particular day of the week. Interviews were not conducted with all students on the exact same days due to time constraints. Sequential interviews were conducted with all students at about the same point in the process (within three days of each other) to allow comparison between the individual students' processes (Appendix C). The interviews were conducted within a few days following the design of each of the four artifacts. The length of each interview varied from 10 minutes to 45 minutes depending on which interview it was in the sequence, the personality of the each student, and how much each student chose to share on that particular occasion.

The first interview was conducted one to three days after students designed the first artifact. It had three purposes: (a) to allow the student participants to become more comfortable talking and sharing their thoughts with the researcher in a one-to-one situation, (b) to allow the researcher to become familiar with the participants as learners, and (c) to give participants a chance to talk about their experience in creating their first artifact for this research study. Most of these initial interviews were relatively short.

The second interview had a dual purpose: (a) to allow student participants to talk about their experience converting their prior knowledge on the first artifact into GO format, and (b) to get feed back on students' thoughts about learning using GOs as the basis for instruction. These conversations took place one to three days after students designed the second artifact. This places them still very early within the overall classroom instruction timeframe. Consequently, most conversations were still in the initial stages of depth and were somewhat short.

The third interview was intended to gain a broader perspective of the students' experiences and thinking processes as they interacted with GOs in various ways. This was approached from two directions by focusing conversations on content knowledge learned through instruction based on GOs as well as directly on student thoughts about working with GOs. Conversations and student thought was much more detailed and in depth than it had previously been.

The final interview had several foci. Students were encouraged to talk directly about their recently constructed knowledge of science concepts from classroom instruction. Likewise, students were asked to reflect on their own learning when viewing and comparing all four of their artifacts in sequence. Finally, they were again invited to talk about their thoughts about using GOs to learn science content.

Analysis focused on the level of organization and complexity described in the student's verbal explanation as well as how closely the knowledge demonstrated in the verbal explanation matched the knowledge illustrated through the student-designed graphic organizer. This provided a measure of credibility in the interpretation of these data sources.

Teachers. Mrs. H was interviewed once near the beginning of the six-week duration of the data collection period and once near the end. Multiple interviews with Mrs. B were conducted across the unit of instruction as recommended as a best practice in qualitative research (Seidman, 1998). Because Mrs. B was the person responsible for the science content and was present in the classroom on a regular basis during most of the study-related instruction, she was interviewed more often.

The first interview with each teacher focused on their perceptions of students' typical ability to organize their content knowledge into complex, organized networks of interconnected concepts. This served partially as a baseline from which the process of change in student content knowledge could be observed and documented. Subsequent interviews with Mrs. B focused on her perceptions of the process of change in student knowledge while using GOs. The closing interview focused on each teachers' perceptions of the kinds of changes that occurred in reference to the organization and complexity of student thought processes.

Data Analysis

The overarching data analysis method utilized in this research study was constant comparative (Glaser & Strauss, 1967; Merriam, 2001; Strauss & Corbin, 1991). Data analysis began as soon as the initial data was collected and continued throughout the data collection process as well as after it was completed. As the data were collected, transcribed, read, and reread, themes were identified. Bits of data were coded, sorted, resorted, and sometimes renamed as more data were added to the whole. In addition to themes and similarities, individual differences among the participants' interactions with the graphic organizers were also identified and highlighted for discussion.

Sometimes during the analysis process, initially identified themes were later combined together or split into separate categories. For example, during the initial stages of data analysis, simplicity was identified as a theme. As more data were added and analysis continued, it was determined that simplicity was actually becoming two distinct themes -- simplicity and efficiency. Conversely, cooperative socialization began as several separate themes that could not be labeled with an accurate title. However, as more data were considered and analysis progressed, these themes combined and contributed to forming the single theme of cooperative socialization.

Eventually, conclusions were drawn interpreting the meaning and relationship between the connecting themes and the differences. The constant comparative method has been described as a "process of moving back and forth between data collection and data analysis, with data analysis driving later data collection" (Leedy & Ormrod, 2001, p.

154). Throughout data collection, the researcher looked for indications of how student thought processes changed with respect to complexity and organizational structure during knowledge construction while using GOs.

The originators of this method of data analysis, Glaser and Strauss (1967), stated that constant comparative analysis is ideal for theories of “process, sequence, and change pertaining to organizations, positions, and social interactions” (p. 114). This perspective aligned with this study’s exploration of the sequential process of constructing organized knowledge. Another aspect of constant comparative analysis was that the process required the researcher to adjust thinking continually as new data were added to the findings. This characteristic of the analyst constantly questioning previous analysis throughout the entire procedure supported this study’s previously discussed respect for the complexity of the classroom context and the importance of taking that characteristic into consideration.

Establishing Credibility

While quantitative researchers usually discuss establishing strong validity and reliability with their methodological choices (Leedy & Ormrod, 2001), with few exceptions (Merriam, 2001), most qualitative researchers consistently use the term credibility when discussing issues of rigor (Glaser & Strauss, 1967; Leedy & Ormrod, 2001; Seidman, 1998) in qualitative research. Credibility refers to the level of rigor with which the research study was carried out and, consequently, the level of authenticity with which the findings and conclusions of the study can be accepted.

In order to establish strong credibility in this research study, the strategies of triangulation, member checks, and clarification of researcher bias were employed.

Triangulation between the three participant groups (the teachers, the researcher, and the students) was used to confirm emerging and conclusive findings (Merriam, 2001). This strategy provided support and substantiated findings that resulted in similar conclusions. For example, evidence of student motivation during GO activities was documented through researcher field notes, teacher interviews, and student interviews thus establishing triangulation for that finding.

Member checks consisting of confirming initial data and interpretations with the participants were conducted throughout the study (Merriam, 2001). Throughout the sequence of interviews, focus students were presented with their statements and ideas from previous interviews for the purpose of checking for accurate representation of their thoughts. In addition to using this practice for teacher input as well, teacher participants were given copies of both their transcribed interviews and initial data analysis to check for accuracy and appropriate interpretation. This practice minimized the possibility of mistakes and misinterpretations on the part of the researcher.

Clarification of pre-existing researcher bias at the outset of the study allowed that factor to be taken into realistic consideration when interpreting the conclusions drawn from the data by the researcher (Leedy & Ormrod, 2001). Whenever possible and appropriate, direct quotes from participants were used to support conclusions rather than offering only researcher interpretation. With the exception of one focus student who chose to keep his work, all student artifacts used to support conclusions are included in their authentic, original form in the appendixes.

Limitations

The Hawthorne Effect or reactivity (Leedy & Ormrod, 2001) may have been a factor with the potential to alter results in this research plan. The theory of the Hawthorne Effect was based on studies conducted by Elton Mayo between 1927 and 1932 in the Western Electric Hawthorne Works plant in Cicero, IL. The theory suggests that individual behaviors may be altered when participants know they are being studied ("The Hawthorne Effect," 2005). The participating teachers and students in this study were well aware that they were contributing factors in a research study as well as working closely along with the researcher as a mentor or a colleague. This knowledge sometimes causes participants to show improved performance or to adjust what they say to match what they perceive the researcher wants them to say.

This effect was minimized as much as possible in this study by several factors. The school and participants chosen to participate were in an area where many educational studies have been carried out due to their proximity to a research university. Consequently, they were somewhat accustomed to researchers and were less disturbed by their presence. The school and classroom choice was also based on the fact that they were previously unfamiliar with the researcher as an individual. Because of this lack of prior personal attachment, they were less likely to adjust their responses to support the researcher's goals (Leedy & Ormrod, 2001). Finally, the methodological design of the research study to include triangulation also helped to minimize findings that might have reflected evidence of this effect and seemed out of line with the other data sources (Leedy & Ormrod, 2001; Merriam, 2001).

Another important possible limitation in the research study is researcher bias with regard to graphic organizers as an instructional strategy. We, as researchers, are always searching to answer our own questions truthfully, although sometimes a strong previous belief may unintentionally interfere to some degree with that effort. This situation has been minimized as much as possible in this study through the methodological strategies of member checking. This practice was employed to ensure that data was reported accurately and was reflective of the true intent of the participants. In order for the data to indicate triangulation with other data sources, any data that was not in line with other sources was examined carefully (Merriam, 2001).

In conclusion, the insights and rich descriptive evidence provided by this methodological plan were needed. Added to the existing quantitative findings, they present another important piece toward our understanding of how GOs work. These qualitative findings offer a valuable glimpse into the learning process as it takes place, thus, supplementing findings obtained through pre/post measures. They also shed light on the nature of diverse individual student processes and how GOs influence the construction of each child's content knowledge.

Miss Bonkers rose. "Don't fret!" she said.
"You've learned the things you need
To pass that test and many more-
I'm certain you'll succeed.
We've taught you that the earth is round,
That red and white make pink,
And something else that matters more-
We've taught you how to think."

(Dr. Seuss, 1998, p. 25)

Chapter 4

Description of Findings

This chapter reports the findings of this study. First are descriptions of the process of each of the 10 focus students as they learned science content through the use of graphic organizers as an instructional strategy. Second, the perceptions of the two classroom teacher participants are reported. Finally, themes that emerged across the learning processes of the student participants are identified and described.

Individual Student Processes

Foxer

Foxer was a delightful male student whose intelligence was immediately obvious at the beginning of a conversation with him. He had an impressive vocabulary, a mature conversational style, and a broad knowledge base that he drew on and used with ease. He had a strong tendency to strike out unexpectedly on an unrelated tangent in the middle of a focused discussion. His conversation jumped around from topic to topic leaving the listener struggling to keep up with his line of thought. He expressed very strong opinions about most subjects. These opinions were often expressed as truth instead of one of many possible perspectives. He seemed to be in command of a large amount of information that was scattered and disorganized.

Written expression of his content knowledge did not reflect his extensive verbal articulation of the same knowledge. When asked to write everything he knew about a science concept of his choosing, he was able to produce only a title, one fact, and several opinions all in the form of incomplete sentences in almost illegible printing (Appendix K1). He stated in the interview about this assignment that he “was not into it”, did not like to write “a lot of words”, and was not pleased with how his words looked when he wrote in general.

As we worked with GOs in science class, Foxer’s written expression of his content knowledge gradually became more detailed, more factual and less opinionated, more organized, and easier to read. When asked to transpose the same information from his first attempt into the form of a GO of his own design, all of these stated characteristics were evident (Appendix K2). All of the opinions reflecting his personal perspective as opposed to factual were dropped from the information represented.

R-So what information do you have on this first one here, basically, that prey can hide from their arch foes called predators.
Foxer-I’m sorry I had that (“arch foes”) …
R-Well, that’s another opinion, isn’t it?
Foxer-Yeah.
R-So that’s basically all the information you have on there.
Foxer-Well, and this is sort of relative – they use it to survive.
R-OK, so that’s more information that wasn’t on the first one. Is there any other information that wasn’t …
Foxer-color and disguise
R-So you have lots more information on the GO?
Foxer-Yes, mm-hum.
R- …and what happened to you opinions?
Foxer-Um … they were go away.
R-They were go away?
Foxer-Mm-hum.

R-I can't find them on there. Isn't that interesting?

Although it did not seem obvious to him until questioned about it, his verbal descriptions also reflected more organized, complex thinking as he described why he made particular choices when designing the GO.

R-How do these look different? What do the shapes have to do with it?
Foxer-Nothing.
R-They have *nothing* to do with it? Why did you choose these three shapes to be the same and this one to be different? And this one to be a circle?
Foxer-Well, I like it that it looks better.
R-OK, well, then let's go on to this one here, your last one.
Foxer-Wait a second, I want to go back – I have a better answer.
R-OK.
Foxer-Um, if it … since you go down here, it's 'color', that's pretty much another, um, category to the thing. So since it's a category, and disguise isn't a category.
R-What is it?
Foxer-It's *part* of the category.
R-Oh.
Foxer-So the circle would represent a *part* of the category.
R-Oh! I see!
Foxer-So they're kind of different levels as you go down …but these are kind of the same?
R-So at each different level, you used a different shape or size to differentiate that from the other levels?
Foxer-Yep!

In designing his final artifact, Foxer chose to begin with a GO we had already initiated during class but had not completed (Appendix K4). Although he was encouraged to create a completely original GO, Foxer argued correctly that the earlier GO base framework was appropriate for the assignment and, therefore, he was allowed to proceed. He added a large number of informational details and arranged them accurately to reflect his knowledge within the visual display. This choice was consistent with his previous choices in which he preferred verbal expression over written expression.

Foxer was very enthusiastic about the use of GO during science class as well as in general. He enjoyed the symmetry of GOs and used a jigsaw puzzle as a metaphor to explain their use during instruction:

> Foxer-OK, um, it helps you learn more in a more short amount of time, and all that, and then, um, some parts of the GO, um, (faltering speech) …
> R-OK, you're saying some parts of the GO …
> Foxer-um, sort of add bits and pieces that, into like, um, that, in your head, from the main idea that you, the main idea you wanna learn … just like a puzzle! It's like a puzzle!
> R-How interesting! So you say the GO adds little bits and pieces … of information …
> Foxer-which, at the end of the lesson, piles up to make a bigger amount than in a regular science session.
> R-Wow.
> Foxer-like, just like a puzzle. Whenever you first have all those pieces, like, (groans) oh, you think to yourself, like those little tiny ones, and you think to yourself, this is gonna be a tiny puzzle. But you put them all together and it's so huge!
> R-How interesting! I have never thought of that before! Is there a difference in the pile of information?
> Foxer-Um, it's sorta like a different kind of puzzle, like a brand new kind of puzzle. It's like, um, all kinds of small, like, there's different small pieces, whenever you put 'em together into one big piece that connects to the other pieces of puzzle, like, um, one of those big ones.
> R-I see.
> Foxer-And um, and like sometimes, instead of just having all of those little small ones bunched up to make one of those big puzzle pieces, the big puzzle piece just drops in instead of the little pieces making it look bigger.
> R-OK. Well, let me rephrase it and let me ask you if this is, if I understand what you are saying. OK?
> Foxer-OK.
> R-What I understand you to be saying is that when you've got a big puzzle that you're trying to put together of little tiny pieces, that sometimes, using the graphic organizers is like putting together little clusters of smaller pieces and then, putting the clusters together?
> Foxer-Uh-huh, uh-huh!

Foxer understood that GOs help him put ideas together like a puzzle. He also stated that they allow him to express a large amount of information using a minimal number of words; a characteristic that he highly valued.

Buggy

Buggy was a very pleasant male student who initially presented as being average to low academically within his class group. His teacher reported that he struggled to achieve good grades on tests and report cards. He was very cooperative, anxious to please, and wanted to be helpful. His attention span during class was very short and he appeared to become distracted easily. He often chose to initiate conversations with classmates instead of becoming engaged in the instructional activities. His intent did not appear to be disruptive or purposefully rule-breaking but, instead, his interest was simply focused on things other than the instruction most of the time.

It was obvious during the first interview with Buggy that he was in command of a lot more knowledge than he had expressed on his paper. For example, his verbal explanation of complex machines immediately expanded to pick up the base knowledge on which his chosen topic of complex machines was built:

Buggy-Well, the reason I picked compound machines is that I like machines put together and all the machines put together is, work more than one machine. Then, more than one simple machine put together is, they can get the job done faster.

R-Mm-hum. Tell me some more stuff you know about compound machines or something that you put together.

Buggy-Well, a simple machine … well, I'll do the simple machines: pulley, lever, wedge, inclined plane, … … can't remember. A pulley, you have it attached to, like a crane, like it pulls it up then it moves it other places. And a lever can move it other places too at (unclear speech). Inclined plane helps you up with (unclear speech) and ramps are examples – and water fountain.

R- Can you tell me how some of those fit together?

Buggy-Well, inclined plane and maybe wheel and axle – wheel and axle is another one! – um, inclined plane is sitting on (unclear speech) you know when you have to push something up, you would have to pull it and it would be like a (unclear speech) on the bottom, like a train does when it's stopping? Well, if you didn't have a wheel and axle, you would be pulling up and that would be hard. So the wheel and axles on the big box and you push it up with a pulley. And you can have the pulley up here, the inclined plane, and the 2 wheel and axles and you could pull it up attached to the handle.

Although some of Buggy's text was obscured by his unclear speech, it was quite clear that his knowledge on this topic was highly detailed and organized. It was also clear that the complexity and organization of his knowledge, when expressed verbally, greatly exceeded what he expressed on paper (Appendix L1). After being asked to translate the same information into the form of a GO (Appendix L2), he was able to visually demonstrate an understanding of how his own knowledge was organized:

> R- (The tape recorder was not turned completely on so participants are repeating what was said earlier to catch it on tape now.) Tell me again what you said when I asked if the scientific information on both of your papers was about the same. You said, "Yes and no."
> Buggy- because, um, it just depends what you're doing and putting on the GO.
> R-Right. And you said that it's the same information on both things, but you said that the way that it's different is that this one (the GO) has … remember what you called that?
> Buggy-the main idea
> R-It has the main idea, and then this is like the …
> Buggy-Well, it's sorta the same idea, that's the main idea too.
> R-You said it was kinda like the title, didn't you?
> Buggy-Yeah, title, main idea, and the little paragraphs.
> R-and I think you also called it, "the big idea …
> Buggy- "and the little ideas"

Although Buggy perceived his GO display of information to be more organized visually than his prose form, he explained that he designed the arrangement of the GO because he wanted the appearance, as a whole, to look like a robot. The placement of information was not completely driven by the information itself.

Buggy's third artifact (Appendix L3) communicated almost no discernable visual organization of information at all. No connections between components were evident and few labels were offered. Even the main idea was not clear. Only three written words appeared on the entire display. When asked to (verbally) communicate his content knowledge on the concepts taught that day in science class, Buggy's description revealed an accurate, complex, organized understanding not evident on his artifact:

> R-Tell me what you know about sources of energy.
> Buggy-You can have fossil fuels … ????
> R-Well, that's a good start: fossil fuels …
> Buggy-fossil fuels,
> R-Tell me about that.
> Buggy-It takes a long time to make 'em, like millions of years, um, when you use it all up, you can't get non-reusable …
> R-OK.
> Buggy- Coal, oil, then, natural gas
> R-very good
> Buggy-Then, renewable is water, sun, nuclear energy, um, I'm not real …
> R-OK.
> Buggy-even though we went over it yesterday, I'm still not sure of what …
> R-and what does renewable mean? I think you remember it a lot!
> Buggy-It means that you can make more of it.
> R-OK.
> Buggy-and non-renewable is – you can't make more of it – or it takes a long time to make it.

All of this information was new and unfamiliar to the students previous to the GO instruction. Yet, his verbally expressed understanding is accurate, very well organized, and extensive. His explanation beginning with the main idea was clearly divided into smaller components of related information including accurate definitions of concepts. He described an organized structure of information accurately reflective of the facts.

The visual display of Buggy's final artifact (Appendix L4) was more complex and organized than any of his previous written attempts to express his content knowledge. The final artifact was much more reflective of the knowledge he had been able to express verbally from the beginning. The immature handwriting and frequent misspellings were still evident but the complex, organized content knowledge was clearly and accurately expressed in the form of a GO.

Peel

Peel was a relatively shy, quiet male who spoke so softly that he was often extremely difficult to hear both in his audio-taped interviews as well as in person. I often had to repeat what I thought he said in order be sure his ideas were represented accurately. Although a little timid at first, he was very cooperative in one-on-one situations for the purpose of this study. Conversely, he often refused to comply with directions and known expectations during whole class contexts. He struggled academically and was not earning good grades in school. When a lesson began, he often seemed to focus on something other than what was being taught. When talking with him one-on-one, he seemed to have isolated chunks of information about specific topics that interested him but a relatively poor command of general knowledge. The detailed knowledge he did talk about centered on his life experiences including people who were important to him.

Peel chose simple machines as the content for his first artifact (Appendix M1). Although his written display of information was very simple and included no details, it was complete to the level he was attempting to communicate and labeled accurately throughout. When asked to talk about this information, Peel gave a detailed description of each of the six simple machines including multiple examples and uses for each one. He was obviously in possession of much more detailed, complex information about this topic than the written form expressed.

In his first attempt to display his knowledge in graphic organizer form (Appendix M2), Peel seemed to be overly interested in making sure the completed GO design was “symmetrical.” He verbalized this desire and talked about how he had this in mind as a goal when choosing the shapes, connections, and hierarchical levels. Most of the shapes were still blank although he had no trouble explaining his plan of what keywords went in each one and where additional shapes should be placed. The overall appearance of shapes and symmetry seemed to be of greater concern to him than the information itself. However, his knowledge of the information was used as he thought through how to organize the GO in a symmetrical design with which he would be comfortable.

Peel added *lateral* connectors (in addition to the vertical connectors he had seen used during class) linking the 6 components with each other as well as their title/main idea above and examples below. He explained this choice by stating, “They’re all simple machines!” indicating that this fact connected them all with each other laterally as well.

As the study progressed and Peel gained more experience using GOs to represent information through guided practice, he began to focus more on the accurate arrangement of information and less on whether or not the resulting design might turn out to be symmetrical. This is evidenced by his choices to adjust connecting relationships after seeing them displayed from his own verbal description during a several post-interviews:

> Peel-trashing into a pond...
> R-There’s another one! Where would you put that idea?
> Peel-(adds to GO)
> R-(rechecks ideas and writes words for student – car exhaust, smoke stacks, trash in pond) OK, now are those organized properly there? Smoke stacks attached to polluting, car exhaust attached to polluting, and throwing trash into the pond attached to car exhaust?
> Peel-No.
> R-No? Why?
> Peel-That’s not supposed to go under there. (pond trash under car exhaust)
> R-Oh! Well, can you fix it? Where should the line go?
> Peel-(moves component and changes connection between components)
> R-Explain to me again why you changed this one. You had ‘throwing trash in the pond’ connected right to ‘car exhaust’ and THEN, connected to ‘polluting’. Why did you move that line?

Peel-Cuz I wanted to say something else – I wanted it to say ‘car exhaust’ and ‘throwing trash in the pond’ --- they don’t go together – it’s 2 different things!
R-OK, I see! So they’re not connected to each other but they’re both what?
Peel-polluting!

He was no longer concerned about making sure the design was symmetrical but was more interested in how the components were arranged and connected with each other. At the end of the study as Peel designed the final GO (Appendix M4), he was still not quite capable of drawing a complex framework to represent his knowledge without assistance. However, with minimal guidance, his results were not only accurate and complex, but included appropriately added details of information not originally presented by the instructor.

Subzero

Subzero also had a relatively quiet, unobtrusive demeanor. In conversing with him, it was apparent that he was very intelligent and already in command of a large amount of broad-based, well-organized science knowledge.

R-Can you tell me why you picked this topic and what you know about it?
Subzero-because I like dinosaurs-and I like different animals-I like animals a lot. And, um, I got a name for, like, all three of ‘em ... carnivores only eat meat like a t-rex or a raptor, and herbivores only eat plants, and an omnivore is like a plant-eater but sometimes they eat … the reason I want to do the animals is… what I know about those topics is that different animals eat different foods and we eat different foods too and everyone – animals eat different stuff.

R-What are we?
Subzero-Omnivores. Well, some of us are, well, vegetarians are herbivores. They don’t eat meat.

He was consistently very successful academically and seemed somewhat out of place in this particular context largely composed of struggling students. He kept mostly to himself throughout the days and interacted more often and more successfully with adults than with his peers.

Subzero's first attempt to communicate his knowledge was written in paragraph form using complete sentences and already reflecting a very well-organized understanding of the information (Appendix N1). When he attempted to display this same information in GO form (Appendix N2), the structure he created (components and connections) was not highly reflective of the conceptual information. The organization and connections did not reflect an understanding of hierarchical levels and relationships. Many of the important components were listed collectively instead of being sorted into separate geometric shapes therefore failing to indicate that they were separate ideas that, when put together, create a bigger concept. The numbers tallied on the analysis rubric dropped from 15 components with 5 identified levels of hierarchy in the prose paragraph to 7 components with only 3 levels of hierarchy in the first attempt at GO format. All of the geometric figures contained a large number of words and a broad range of information listed with few connectors. Despite the lower level of components and connections, all of the same information from the original paragraph form was included. The GO format even had several additional groups of information that were not on the original.

Subzero consistently articulated a very large amount of information during interviews on various topics related to whatever had been focused on in class. He was very capable of communicating his knowledge verbally and on paper using his advanced language skills. Sometimes, he expressed his knowledge in an organized structure and sometimes, he tended to go off on tangents of loosely related knowledge. Several times during interviews, he needed to be refocused back onto the original content knowledge. When asked to recall information displayed in class GOs from recent lessons, Subzero related not only complete and accurate knowledge of those, but also information from related content and literature books applied to those concepts.

A noticeable drop in visual complexity and organizational structure was evident on his third artifact (Appendix N3). This may have been at least partially caused by the 'drawing' form of communicating science content asked for by the teacher in my absence. Subzero's drawing reflected a large amount of information but it was represented in a very disorganized and confusing manner.

After having worked with GO strategy in class for several weeks, Subzero's last artifact (Appendix N4) contained the highest number of components (20), the highest number of hierarchical levels (5/6), and the highest number of connections (18) of any artifact examined in this study. This final display also contained various sizes and shapes of geometric figures that represented different subtopics, added term definitions, and examples for almost every component.

R-OK. Why did you choose to use some circles and some squares? Why didn't you just use rectangles for all of them?

Subzero-Because then I wouldn't have enough room to put any more…. And I put the squares for, like, the main categories and the circles for the stuff (points to lower hierarchical information).

R-Oh. So you used different shapes for different levels of your GO?

Subzero-Yeah.

R-OK, now why didn't you make the polluting examples a circle and the conserving examples a square? Why did you make those the same shape?

Subzero-Well, because they're ***examples*** *of* polluting, they're not really based on the categories.

R-OK **–** so there's a difference between ***examples*** and ***categories***.

Subzero-Yeah.

Subzero even applied his prior knowledge of the additional science concept of 'states of matter' (solid/liquid/gas) to sub-divide components in the natural resources content on which this GO was based.

R-There is the last GO that you did for me and I was just wondering if you could tell me about that.
Subzero-Well, I've got some like circles and like, some examples of (mumbling) and then, I put them into categories like the gas was smoke and factories, and I did liquids which is like oil and chemicals and stuff like that. Then polluting like us would be like trash, we put trash on the ground…

Subzero had a multitude of information at his disposal before ever being introduced to GO strategy. Despite this pre-existing command of information, he reported how his thinking had changed during the process of learning to utilize GOs. He perceived that using the GOs as an instructional strategy and an organizational tool changed not only how *much* he learned, but also the depth of his understanding and the structure of his resulting content knowledge.

R-Alright, now I'm gonna show you all of your work right from the very beginning when Mrs. Watson first came. There's the first thing you did for me. Do you remember that?
Subzero-Yeah.
R-You had a lot to say, didn't you? What happened?
Subzero-It's (mumbling)…
R-You ran out of space, didn't you?
Subzero-Yeah!
R-Ran out of paper even! OK, and there's the 2nd one you made, and there's the last one you designed. Now let's look at all 3 of those in a row, there. They all have a lot of information, don't they?
Subzero-Wanna know what looks different about them?
R-Yeah!
Subzero-Well, this one (3rd) has a lot more stuff on it, and on this one (2nd), you know I just put all squares cuz of the examples …
R-Oh, so you're saying you didn't ***separate*** the categories from the examples!
Subzero-Yeah!
R-… and then on the last one, you ***did*** do that. Hmmm, why do you think that is?
Subzero-...because I didn't know that much when you first started.

R-...about GOs?
Subzero-Yeah.
R-Hmmm. They all have a lot of information. What's the difference between the information on here (3rd) and the information on the other two?
Subzero-Cuz it isn't separated into different parts, and you know this one is just split up into just one part... you know it's one big...
R-like one big bunch?
Subzero-Yeah, but these are separated into little bunches, so you can learn more stuff about it --- if you just read that, you realize it's just all bunched together and you'd have to take your time and read through it over and over again.

Uranus

Uranus was a bright girl who, although very cooperative in one-on-one situations, sometimes chose to join the majority of her peers in acting out during whole class activities. She was very happy to participate in this project and seemed to enjoy talking to me about her knowledge very much. She demonstrated a broad base of prior knowledge and shared strong opinions as well. She was assertive although not in an excessively verbal or forceful manner. She was very businesslike and serious when discussing schoolwork and learning.

Uranus talked about knowledge in a linear, straightforward way. She always referred to knowledge as "facts" and to learning as "memorizing." She stated that her goal was to be able to look at a paper with information and "remember" as much as possible. She never referred to understanding/comprehension or the process of thinking/problem solving to figure things out.

Her first artifact (Appendix O1) was a neatly labeled drawing of the solar system. Although the directions to display everything you know on one piece of blank, white paper which was provided were very clear, Uranus was not satisfied with that limited amount of space. She added a piece of her own lined paper to write a numbered list of information (both repeat and additional) about the solar system. The list was accurately sequenced and correlated with a nine word sentence she used as a mneumonic device to memorize the names and order of the planets. Other facts were listed and numbered and she had titled the page ‘Facts about Planets’.

When Uranus first attempted to transfer this information into the form of a GO (Appendix O2), some of the complexity of her knowledge was lost. Having relatively little experience with this form of informational display at this point, she seemed to struggle with finding a design that accurately represented the connections and hierarchical levels. Despite this, her design did reflect four levels of hierarchy as well as the added complexity of utilizing different geometric shapes to indicate different levels.

She stated clearly and enthusiastically that she liked this strategy because of its clarity and order. The organization itself seemed to make her feel comfortable.

> Uranus-Cuz they’re not just, like, created on 1 piece of paper. Um, it’s like, you have the facts about 1 thing, and then you have a column about things that are under that category … … in a neatly order.
>
> Uranus-It’s neater and it’s easier to look at and read and stuff.

Although the third artifact (Appendix O3) was directed to be a ‘drawing or picture,’ Uranus drew a display of six pictures clearly organized into two separate columns each appropriately titled to describe the pictures below it. Uranus confirmed that she had a GO in mind when she designed this series of pictures. Her language when describing the process she went through indicates clear organization of information and sorting of concepts into groups.

> R-Tell me about what you drew.
> Uranus-Um, I drew 1 column of pollution and one column of conservation. And then I drew two lines like that made six…
> R-two lines across?
> Uranus-Yes, across like that. And I put three pictures on pollution and three pictures on conservation.

> Uranus was absent for several days and, consequently, was not able to complete the final artifact or interview.

Jackie Chan

Although he was somewhat soft-spoken, Jackie made it clear that he was very willing to help with anything I needed. He displayed a very cooperative, pleasant personality and made an obvious effort to do his best at whatever was asked of him. He was physically small compared to the rest of his peers and struggled with standard academic achievement. His speech pattern was somewhat labored as he struggled to enunciate but not to the point of evoking concerns of a disability in that area. His spelling skills were well below grade level and included a large amount of phonetically appropriate but clearly invented patterns.

Jackie's first artifact (Appendix P1) contained three sentences that communicated very little knowledge. The information that was described directly contradicted itself explaining that a cycle "ends with death" and, at the same time, a cycle "never ends." Jackie's talk about this information was unclear and repetitive.

> Jackie Chan-Well, I like cycles. I like something that keeps on going around and around. It's science because we're studying the animals and like how they surround (mumbling) and every single life cycle begins with babies. Then the end, it dies, and it's like, well, it's like a clock. It keeps on going on and on. And… (pause) It cycles around because it goes round and round and it has all types of cycles…

In communicating his knowledge, Jackie consistently seemed to paint a descriptive, visual picture with words as opposed to repeating factual, learned information as many of the other students did. His understanding of the concepts presented was much more abstract and based on his individual impressions than on memorized, repeated language and facts.

R-What does pollution mean?
Jackie Chan-Pollution is like a dark, dark sky that's not really dark but it's just smoke coming out of a factory.

R-Why is it bad?
Jackie Chan-Um… because it's … you can't see any… there won't be any sunlight … it's bad for your lungs…
R-OK, and what's conservation?
Jackie Chan-Conservation means like that is a happy place and that's… it's … it's not air polluted and it's not bad… it's just right.

He often seemed to struggle to find the right words to express what he was trying to communicate. This difficulty in constructing an accurate verbal description often resulted in frustration for Jackie as well as limited communication of concepts to me.

R-What does natural resources have to do with pollution and conservation?
Jackie Chan-Well, it has to do with conservation because like it's like stuff that we use and make sure and we use some stuff and make sure that we keep it … some things…

Although he visibly struggled to find words to communicate his knowledge, he preferred verbalizing over writing on paper which required the additional skills of spelling and legible handwriting.

Jackie's final artifact (Appendix P4) included 5/6 identified levels of hierarchy, 11 components (several components including multiple items), top to bottom organizational structure, and the largest number of written words he had produced since the beginning of data collection. At the beginning of the final interview when he was presented with the GO he had produced in the classroom, he verbalized a large amount of organized information that was not evident on the artifact. When asked about this situation and presented with a pencil, he extended the GO to reflect the knowledge he had just expressed verbally (as well as additional knowledge) that was very well organized and comparatively complex. When asked how he accomplished the task with such ease and such detail in the final display, he had no other explanation other than to state that he had “put his head to work.” When pressed further, he talked about connections to study in social studies class about Ponce de Leon but was not able to make the relationship clear to me. Nonetheless, the organized structure, amount of knowledge displayed, and the detail included were striking in comparison to Jackie’s previous work.

In looking over all of the four artifacts he designed, Jackie laughed at the first one that consisted of three sentences. He stated that it had “way less information” on it compared to the others. He talked about adding information he had learned in first and second grade to the second artifact (in GO format) and *not* thinking of adding the information to the first artifact (not in GO format). He recalled using a similar strategy called bubble maps in a previous year in school. He also asked for a pencil to add more information to one of the artifacts.

Trunks

Trunks was a third grade boy of Hispanic heritage whose personality reflected a very strong sense of self and control of decisions relating to himself. He was cooperative when he chose to be but often had to be asked several times or encouraged in some other way to accomplish requested tasks. He stated clearly that he did not enjoy school very much but talked a lot about going to school at night with his father to the local community college. He tended to do the minimum he could get by with on academic tasks as well as anything else that didn’t directly interest him. Although he easily agreed to participate in this research study, he offered very little feedback during interviews and put minimal effort into activities during class. It appeared that Trunks had at least a fair amount of knowledge and ability but very little interest or desire to communicate it to anyone.

Interestingly, in creating the first artifact, he chose to communicate his knowledge of cycles using a GO format (Appendix Q1). It included no written language except for the title of the concept but utilized consistent geometric shapes, arrows, and illustrations accurately. After working with GOs, mostly hierarchically structured, in classroom activities, he accurately reorganized the same knowledge into a similar format (Appendix Q2). This hierarchical format utilized written language to represent the components. Several very simple words were misspelled including the title (life syculs) which had been spelled correctly on the first artifact. Another example was the word 'they' spelled correctly in one component and incorrectly (thay) in the very next component. Despite these spelling mistakes, the content knowledge was correctly represented in both versions.

During interviews, Trunks' answers were always quick, to the point, and without detail or description. It seemed clear that his willingness to participate in these activities was limited to basic, direct answers without in-depth discussion.

> R-OK, can you just tell me about your drawing here that I asked you to do?
> Trunks-Yeah, it's a life cycle … of a frog and a snake.
> R-Cool! Can you tell me some more about it?
> Trunks-Well first, it starts with a egg, eggs, then it goes to a tadpole, then it goes …
> R-Can't remember the name? Just describe it for me.
> Trunks-Well, it grows front legs, then the tail comes off, then it's a frog.
> R-OK.
> Trunks-For the snake, first it's eggs, then it's babies, then it grows up.
> R-Cool!
> Trunks-That's all!

He demonstrated good recall and basic understanding of many studied concepts, but often mixed components from various, separate GOs together. He agreed good-naturedly when these generalizations were pointed out but remained completely unconcerned. Everything he created visually and expressed verbally were minimal, succinct, and to the point. His regular classroom teacher suggested that he doesn't want anyone to know he has ability because then, he might be expected to demonstrate it on a regular basis.

Although his final GO artifact (Appendix Q4) shows a few added details, his third artifact (Appendix Q3), a drawing, reflects the most detail and care of all of his work. On this task, he took the time and effort to divide the space into four distinct sections with a different scene in each. The whole display was constructed in relative detail first in pencil outline, then completed with appropriate crayon color. Each scene is labeled pollution or conservation. Despite this care taken, the size and placement of the sections are inconsistent, seemingly random, and not representative of any relationship among the components. It also includes several components from other GOs completed during class on other concepts that are not related.

Siberious Wilderus

As indicated by his choice of alias for this study, Siberious Wilderus was highly intelligent and in command of a vocabulary well beyond his years. He had a mischievous grin but was very tentative when asked to talk about specific topics. When focused and feeling cooperative, he was capable of verbally communicating an astonishing amount of content knowledge on a wide range of topics; some learned during class activities during this study and some from his own prior knowledge and personal interests. Despite these indications of exceptionally advanced intellectual capabilities, he has not been able to function well or to fit into the classroom context. He often displayed disruptive behaviors, and either was not able or not willing to communicate his knowledge through standard assessment methods.

This pattern of noncompliance had several direct effects on the type of data included for this study participant. Although detailed discussions about the artifacts created by Siberious Wilderus have been included in the data for this study, all but one (Appendix R) of the four artifacts, themselves, were returned to Siberious Wilderus at his request. In addition, this participant was consistently uncomfortable speaking when the tape recorder was in operation. He reached over and turned it off throughout the four interviews at least fifteen times. These incidences seemed to occur when he was asked to respond to a question that required some deep thought and to which an answer was not immediately obvious. The longest periods of time during interviews without his interrupting the recording were when he became involved with enhancing and adjusting a GO display with additional knowledge.

Despite the lack of concrete artifacts to refer to and his discomfort being audio-recorded, Siberious Wilderus did communicate a substantial amount of information about his experiences working with GOs during interviews. He reported that it was “easy” to transfer his original prose artifact to GO format. The following are some of his comments about the GO activities:

Siberious Wilderus-I think it’s an interesting and fun way.

Siberious Wilderus-You get to match the words and cause we usually don’t do that.

Siberious Wilderus-Instead of reading it, you… you *do* it instead of reading it.

When asked about science content taught during class through the third interview, Siberious Wilderus related a surprisingly large amount of knowledge that was well organized and clearly understood.

R-I would like for you to talk to me about sources of energy.
Siberious Wilderus-Sources of energy, um, the fossil fuels are oil, coal, and natural gas. There's wood, water, sun. There's also heat and light. Um,
R-OK, besides naming them, what else do you know about them? Why did you separate them like that?
Siberious Wilderus-(silence)
R-You said, "The fossil fuels are coal, oil, and natural gas." Why did you separate those from the others?
Siberious Wilderus-Well, cause those are the only fossil fuels so they would be separated from all the other ones.
R-OK, and what does that mean – that they're fossil fuels?
Siberious Wilderus-What do you mean?
R-How are they different from the other ones? Those fossil fuels?
Siberious Wilderus-They come from the ground.

On several occasions, Siberious Wilderus connected prior knowledge gained from other experiences to expand the content under study in this research. Sometimes, he was able to identify the source of the additional information (such as his second grade science class) and other times, it was unclear. At one point while talking about our curriculum of natural resources, he suddenly decided to expand the GO to include additional knowledge he noticed was related. This direction eventually resulted in his designing an inclusive GO reflecting five levels of hierarchy, the final level extended up from the top to include a broader main topic.

R-There is the last thing that you did for me.
Siberious Wilderus-I don't remember.
R-You don't remember? Well, here it is, right here. Can you tell me about that?
Siberious Wilderus-Well, the top part is resources of the world. And under the resources of the world are the *natural* resources of the world --- like, there are also *capitol* resources and (mumbling) resources.
R-Oh my gosh! Where would that go on there?
Siberious Wilderus-(turns off tape player again)
R-OK, show me – what are the other ones you're talking about?

Siberious Wilderus-Let's see, there is human resources and capitol resources.
R-OK. Now why didn't you put those down there before? Were you just thinking of them and then didn't put them down because that's not the part we're studying?
Siberious Wilderus-(nods head)
R-I love how you did that! That is just awesome! OK, tell me about the rest of this.
Siberious Wilderus-Natural resources, the polluting would be like poisoning water or filling the air with gas and the problem would be you're killing the animals. And if you conserve, you aren't polluting and it can save the world…
R-Wow! How many levels do you have on there?
Siberious Wilderus-1, 2, 3, 4, 5.
R-And you made that level up and you added this one in on the top of it!
Siberious Wilderus-Capitol resources would be machines… (continuing to add to the GO)
R-OK.
Siberious Wilderus-You can write this.
R-OK. I'm gonna make you draw the lines, though.
Siberious Wilderus-Human resources would be man-made machines and capitol resources, maybe machines make some other machines. In social studies, human resources are goods, well… resources can be goods, like… a good and a service? A good-you can hold, and a service is, like…

The complexity and depth of understanding described verbally and then, designed visually as a GO acted as a reflection of his thinking process. As I verbally talked through what he had drawn on the paper, he chose to readjust several connections and component locations so that the final product more accurately reflected his understanding.

Siberious Wilderus-I *have* to change one of them.
R-What do you want to change?
Siberious Wilderus-This one.
R-OK. Tell me why you're changing it. Well, let me see where you're changing it to. Will you tell me why?
Siberious Wilderus-Well, I don't know. I don't have a reason.
R-You don't have a reason.
Siberious Wilderus-Well, I'm thinking of one now.
R-OK, I can't wait to see where you decide to put it then.
Siberious Wilderus-(makes changes in structure)
R-You're gonna connect that directly to human resources instead of coming down off from that one. Right?
Siberious Wilderus-Right.
R-OK, and do you know why or just because that's where you think it belongs?
Siberious Wilderus-I think that's where it should belong… AND also, it connects to man-made machine.
R-Oh, it should? Why?

Siberious Wilderus-It can be… it can be a machine in goods and services.

Although his thinking process seemed clear from his talk and his written designs, he seemed to be unaware of his own process. His thinking process, articulated during the use of GOs, was inconsistent with his talk about learning during earlier interviews in which he consistently used the terms ‘remember’ and ‘memorize’. For example, when asked to explain how he determined if examples of natural resources fit correctly into the categories of renewable or non-renewable, Siberious Wilderus repeatedly answered that I had told him and he had remembered. Not only had he not been given information on which category was correct during in class, but he was sorting additional examples that *he* had added and were not even part of the presented curriculum from class.

In closing the last interview with Siberious Wilderus, he stated that he had a question for me.

R-OK. We’re just about done. Do you have anything else to say about GOs or any questions you’d like to ask me?
Siberious Wilderus-I have a question.
R-OK.
Siberious Wilderus-Why did you come up with GOs?
R-Mmmm, why do *you* think?
Siberious Wilderus-Mmm, because you thought it would be a good way to teach?
R-Mm-hmm. What do you think made me think that?
Siberious Wilderus-Um, it’s an easier and better… it’ll make things easier instead of writing them all down on one piece of paper?

His comments here were consistent with his previous interactions with GOs: He seemed to value them because they were easier, and there was not as much writing to do. He continued to be unaware of the complexity and organization of his own thought process and content knowledge.

Daisy

Daisy was an extremely quiet girl with an endearing, shy smile. Her appearance was somewhat disheveled, and her clothes and belongings worn. Although seldom disruptive, her participation in class was minimal and, on some days, nonexistent. She appeared to be completely uninterested in learning through participation in classroom activities and often had her own agenda of play near her desk during instruction. Several times she became belligerent when someone tried to force her to abandon her personal activities and join the class in an organized activity. During one-on-one interactions, she displayed a very sweet personality, thoroughly enjoyed the individual attention with an adult, and did make some effort to cooperate. She shared some personal information such as being the youngest of a very large number of children in her household. Her perception was that they were not nice to her, and she didn't like it at home. Daisy had experienced almost no academic success at school and was not really expected to do much by school personnel. If she chose not to listen or participate during class, her choice was accepted and her lack of engagement in learning was ignored. No individual support, encouragement, or attention toward her was observed for the extent of the time that this research was conducted in her classroom. Mrs. H suggested that the kind of knowledge she has is more like "street smarts" as opposed to academic knowledge.

Although her chosen content for the first artifact (Appendix S1) was simple machines, she named only one of the six. Some words were so badly spelled that they were not readable. She did (verbally) identify and accurately connect 1 example (clock) to the one component she named (wheel and axle). This addition provided three distinct levels of hierarchy, even though only one component was listed within each level. When asked to tell me about this knowledge, Daisy had difficulty even reading her own writing. With encouragement and scaffolding, she finally did read it but offered no explanation or additional information.

Her attempt to display this same information in GO form (Appendix S2) consisted of only a title (simple machines) and nine geometric forms of various shapes and sizes with nothing written in them and no apparent purpose for the chosen arrangement. Although all of these outline shapes were void of any written information, Daisy did trace around them very neatly and connect them in a way that was visually similar to what we had been doing in class. Also, this design indicated that she did participate in the whole class activity, which she most often does not. She offered no explanations or additions about her artifact even when pressed with multiple, reworded questions. She seemed perfectly comfortable answering with most of the time with silence, "um…," "I don't know," or communicating by moving her head. She seemed very content to just sit there and spend time with me.

The only spark of enthusiasm toward class or anything academic was when I asked Daisy, at several different points, what she thought about using the GO activities in class. She responded immediately each time with a big smile saying that they were fun. Although some of her answers indicated that she enjoyed the hands-on, manipulative puzzle activities the most, she was not able to talk about *why* they were fun.

> R-What do you think about using those shapes and putting our information in…
> Daisy-(breaks in) I think it's fun!
> R-You do? Why?
> Daisy-Um, …(silence)
> R-What's fun about it? What part is fun?
> Daisy-tracing …
> R-tracing around the cardboard shapes?
> Daisy-AND doing the puzzle!

R-Oh, the manipulative puzzle. What's fun about that? What do you like about it?
Daisy-Um, (mumbling) and doing the
R-It sounds like that one where you get to move the pieces is more fun than the one on the paper. Is that right?
Daisy-Yeah!

Subsequent conversation seemed to be centered on her trying to figure out what I wanted her to say so she could say it.

R-How do you think GO, either the ones where you get to move them OR the one we draw on the paper, Does that make the science information different … from how you've learned science before?
Daisy-(pause) It's easier.
R-You think it's easier? When we use the GO?
Daisy-(nods head)
R-How does it make it easier?
Daisy-Um, (silence)
R-…not this one here that you had to do by yourself but when we do them in class, I mean.
Daisy-I,… um,…(silence)
R-How does it make it easier? What makes you say it's easier?
Daisy-(silence)
R-Don't know?
Daisy-(shakes head)
R-OK, I've got 1 more question for you. How do you think using those GO affects the science information that we're trying to learn?
Daisy-Mmmm, …(silence)
R-Using those GOs is a little bit different from your science stuff before, isn't it?
Daisy-Yeah.
R-How do you think that affects how much or how well you learn the science information?
Daisy-(silence)
R-Or is it about the same?
Daisy-Yeah.
R-It's about the same?
Daisy-A little.
R-A little? So it sounds like the biggest difference is that you like to touch it with your hands. Is that the biggest thing that you see?
Daisy-Yeah.
R-OK.

Her 3rd artifact (Appendix S3) was a very simple drawing for which she had no explanation during the interview. She refused to participate in the activity during the class in which the last artifact was designed.

Throughout the course of the study, Daisy gradually became more and more verbal. Near the end, she was offering longer answers and making a clear effort to remember content, although she was seldom able to recall a great deal. Even with very leading, guided questioning, she was able to communicate very little of the science content that had been taught during class and appeared to spend most of her effort trying to ‘read’ me to determine what I wanted her to say, and guessing answers.

R-Which one is taking care of our natural resources? Pollution or conservation?
Daisy-pollution
R-Pollution is taking care of our natural resources? And conservation is not taking care?
Daisy-(mumbling)
R-If you go to McDonald’s and you have a McDonald’s bag with all of the trash, what happens if you throw it out the window of your car? Are you polluting, or are you conserving?
Daisy-conserving
R-conserving?
Daisy-polluting
R-Which one do you think?
Daisy-polluting

R-OK, what if I said smoke coming out of a factory smoke stack?
Daisy-on pollution
R-On pollution. Why?
Daisy-because it’s not taking care…
R-That’s right.
Daisy-…of our environment
R-What part of our environment does the smoke pollute?
Daisy-(mumbling)
R-our air. What about our cars driving around with exhaust coming out of them?
Daisy-not taking care of our cars?
R-Well, not necessarily our cars, but not taking care of our natural resources. Is that pollution or conservation?
Daisy-pollution

R-Yeah. You know how to sort those very well! What if we go out and plant a bunch of new trees?
Daisy-(mumbling)
R-Yeah, that's…conservation.
Daisy-(at the same time with researcher) conservation

Crazy

Crazy was shy, quiet, and tentative. Unless prompted, her usual response was to nod or shake her head nonverbally. Her teacher's response when asked specifically about her was to refer to her as "Poor Crazy" reflecting her perception of Crazy's very limited academic ability. Her teacher also related that her peers did not treat her with respect or consideration most of the time. She seemed very happy to participate in this study possibly because she understood that it involved several interviews with me during which she would have one-on-one attention. Throughout the study, she put much effort into trying her best to give me whatever was needed from her. She was very much a 'pleaser.'

Crazy's first artifact (Appendix T1) was a very simple pencil drawing with no written language or discernable content information represented. When asked to talk about the science content communicated in the picture, she talked about microwaves heating frozen food but was not able to determine an overall science topic for her design. She did state that she didn't "know that kind of science," and when pressed to elaborate what kind of science she was referring to, she included all of science.

With her second artifact (Appendix T2) next to the first, it became evident that her target science content was simple machines. She was able to accurately display her knowledge of several simple machines connected to a main topic in a three level hierarchical framework. The chosen geometric shapes and sizes did not reflect understanding of the organization of the concept, and she still inaccurately used the example of a microwave heating pizza as a simple machine.

She related working with the GOs in class to putting the parts of a car together. She also talked about a wheel chair but it was unclear if it had anything to do with putting parts together to create a complete concept or if the visual geometric shapes reminded her of what a car or a wheel chair outline might look like. During most of the early interviews, Crazy responded to questions either with silence or answering that she did not know or did not understand.

Crazy seemed to retain general impressions of things as opposed to specific, detailed information. She was able to describe the general plot of a story read aloud and understood that the theme had something to do with good things and bad things relating to the environment. She was not able to recall the terms pollution and conservation, the main characters' names, or any information at all about sources of energy. She did recall the term 'natural gas' from the GO on sources of energy but misused it to refer to the smog and air pollution in the story.

Both of Crazy's third (Appendix T3) and fourth (Appendix T4) artifacts indicated minimal science content information but did demonstrate that she had a clear understanding of opposed ideas. Her drawing (Appendix T3) showed two cars, one labeled "in a race" and the other labeled "not in a race." This aspect might not even have been recognized if not for comparison during analysis with her last GO (Appendix T4) which displays two distinct lists entitled 'Don't-polluting' and 'Do-conserving'. A long list of examples under each of the two titles were displayed but after the first two entries on each list, the topic strayed from the science content and moved to rules on manners and how to treat other people. Despite this loss of focus on the science content, the themes of Do and Don’t remained consistent throughout the list and the listed items were correctly sorted.

When encouraged to look over all four of her artifacts created for this study, Crazy added several more pieces of information and connections verbally. She talked about a car and a doorknob as examples of a wheel and axle in the context of a story about a time when she got stuck inside a closet because the doorknob broke. She told how her mother used a screwdriver to rescue her but did not connect that the screwdriver was used as a lever; the only other simple machine she had been able to name.

Crazy did give clear indication that she had the beginning of an understanding of how the GO structures represented the organization and complexity of content knowledge. Although she was seldom able to complete or create GOs with any detail, she understood what the goal was and how GOs were supposed to be used as a tool to display information. She simply lacked enough knowledge in the areas studied to be able to utilize them at the level that was asked of her.

R-OK. What do you think the lines are for – that connect the shapes?
Crazy-They’re just like, like telling you that it goes with that part and stuff.
R-OK. Can you draw lines anywhere you want to? Or do you have to draw them in a certain place?
Crazy-You gotta draw ‘em in a certain place.
R-Why?
Crazy-Cuz if you, like, mess it up, you put in right around the paper, it would be wrong. It wouldn’t be like a graphic organizer.
R-Why wouldn’t it be like a GO?
Crazy-Cuz, um, it wouldn’t look like it.
R-But it would still have the shapes and everything…
Crazy-Yeah, but it wouldn’t be connected in… the parts would be all screwed up and you’d probably have to do it all over again and put it the way …
R-So it has to fit together a certain way – to be right?
Crazy-Yeah, so the teacher knows it makes sense.

Classroom Teacher Perspectives

This section gives voice to the observations and thoughts of the two classroom teacher participants. This is important for several reasons. They had worked closely with these students for eight months. They were well equipped to help to establish a baseline from which to measure changes, to notice significant comments and events, and to offer another perspective informing these findings. From her experience and vantage point, Mrs. B, who usually teachers the science content, was able to notice subtle indications of changes in student thinking throughout the process of the instruction. Each of the teacher participants was interviewed about their student group's characteristics in order to establish a baseline level of achievement and typical group learning patterns from their perspective. Observations and perspectives on individual student participants have been embedded within the previous discussions.

Although both teachers' perspectives contributed toward the findings, only Mrs. B directly observed the instructional activities related to this study. This was because she had sole responsibility for the science curriculum and because the instruction took place solely in her classroom. Consequently, the findings on the GO instructional strategy beyond setting a baseline include her observations primarily.

Mrs. H

It was indicated numerous times that Mrs. H perceived that, with the possible exception of one student who had moved to the area recently, the students in her class fell into one of three categories: those who had few or no skills, those who had some skills but actively choose not to use them, and those who had skills but chose to use them "for evil." She cited an example of bringing crates of short biography stories to the classroom, making them available, encouraging students to read them by allowing them to choose their own title, and providing specific time for the activity. She reported that, instead of utilizing the opportunity to choose to read in the way she had intended, most of the students used their 'skills' to devise creative methods of avoiding the activity.

She stated that they, as a group, had made substantial academic progress since the beginning of the year, although she was doubtful that this progress would be evidenced on the high-stakes tests at the end of the school year. This opinion was based on her perception that most of the students would be unable to sit still long enough to take the test. The strategies to which she attributed most of this progress thus far were consistency (referring to classroom routines) and a highly structured teaching style. Her thought was that, because this group of students was so easily off task, chaos would ensue if she did otherwise. Her goal was to keep them busy working individually all the time.

Mrs. H's perceptions of the use of GOs for her particular students related directly to the characteristics that concern her most: their lack of individual structure, organization, and self-monitoring. Interestingly, she directly connected the use of GOs with a possible solution to the disorganization of her students' desks, materials, and classroom. This organization of physical items was her primary thought even though she was quite aware that the purpose for this study was to target student content knowledge.

Mrs. B

When asked about her class as a whole previous to the start of this study, the presence of a broad and diverse range of abilities, personalities, and learning styles was the most striking perception communicated by Mrs. B. She didn't talk about viewing the students in her class as falling into distinct subgroups defined by any common or differing characteristics or practices. Instead, she emphasized either how different *each* of the students were from each other, or noted similarities among the entire class as a whole. As she talked about some of the students individually, it was evident that she was familiar with each child's learning process, common struggles, and basic abilities. She described the class as a whole as being very active and 'hands-on' oriented reporting that they responded best to strategies that involve active participation and engagement at an individual level.

Mrs. B has previously viewed these students' science content knowledge as being somewhat "scattered." Based on her listening to how the students talk about their own science knowledge, she perceived them making an effort to connect with something they already knew in order to make sense of new information.

> Mrs. B-They will, in discussion, they will usually refer back to something that they are already familiar with. They'll make a connection to something else, and they'll drive from that, and it will remind them of something else.
>
> R-From listening to how they talk about their science knowledge, does it give you any clues as to how the facts and the information that they have on that topic are organized? Or not?
>
> Mrs. B-I think it's scattered, but I can see them pulling in different directions as far as, again, they're trying to make that connection. They're trying to make that association. They need something to hook up with to help it make sense.

As she observed the students participating in some of the GO activities utilized during the study, Mrs. B talked about being able to determine what these students were *thinking* by watching what they were *doing* which relates back to her statement that her students learn best when they are actively engaged in hands-on tasks.

> Mrs. B-Well, I think we can tell what they're thinking by what they're doing. And with activity, whatever it is that they're doing for the day, we watch them. We see how they manipulate the pieces that they're using – the GO that you gave them. Then, we can probably tell how they're thinking.

R-As you watch them *during* their process – the time that they're actually thinking through it and participating in the activities, what can you determine about their thinking?
Mrs. B-Well, that's just it – they *are* thinking!
R-How can you tell?
Mrs. B-They have a basis for thinking to occur because you have just given them a GO that they can use to put together their thoughts. They have a starting point. I *see* them thinking because they're rearranging the pieces.
R-OK, moving their pieces? Can you talk about that?
Mrs. B-Well, they're … categorizing things. They're looking to see if it matches, if it works, if it fits. Is it similar to what they just saw? Does it make sense? And so it's coming together and I *see* them thinking.

Later in the interview, Mrs. B contradicts herself on the effects of student talking during instructional activities. Although she begins by stating that it is "obvious" that if the students are talking and socializing, then they are not thinking, she immediately followed this comment with her observation that the students were comparing by looking at their neighbors' work in progress to get feedback.

Mrs. B-Well, that might be good because you can tell by them not saying a whole lot – there's not a lot of noise while this is going on. There's not a lot of chatting…
R-So what do you think that indicates?
Mrs. B-Well, that certainly indicates that they're thinking. A big red flag to me is when there's a lot of noise. They're talking and they're socializing and they're being distracted with other things. Obviously, thinking is not occurring. But when the room is quiet, when you see them moving the pieces of the GO, then you can tell that they're thinking. They have accomplished what you have set them out to do and they're successful with it.
R-OK. How is the student talk during GO activities, is it the same or different from their talk about science previously. Do you notice any difference in it?
Mrs. B-I've noticed them comparing. They will look at their neighbors – which is good. They're wanting to get feedback from their neighbors – such as "Am I doing this correctly?"

She suggested that socialization between students during the learning process helped them to clarify what they were learning individually.

Another observation Mrs. B noted often was a difference in the level of confidence displayed by the students during class. She was very cognizant of and excited about the distinct increase she perceived in her students' self-confidence.

> Mrs. B-Using the GOs like you have had them do, they are feeling much more confident when they are doing hands-on, rather than just come up with an answer, a broad answer, they have been that much more successful. They have felt … I hear them say, "I'm finished! I'm done! That was easy!" And so they're that much more productive because they have become confident.
> R-Right. And you know, that's *not* the focus of my study, but that's the thing…
> Mrs. B-But that's what's happening!

Many of the students who usually chose not to participate during class were some of the most involved in many of the GO instruction and activities. Mrs. B's suggestion to explain this was that, as stated in several of the descriptions of individual student processes, many of these students appear to have substantially more ability than they are willing or able to express in order to be successful in the school context.

Emergent Themes

Throughout the individual descriptions, several themes were consistent across students' processes. The following section identifies and describes these themes including motivation, simplicity, efficiency, visual hierarchical organization, reconstruction knowledge, and cooperative socialization.

Motivation

Motivation refers to students' heightened interest and involvement. Not only did Mrs. B mention a marked increase in student participation and engagement during the GO activities, but almost every focus student reflected this trend as well. This marked motivational difference in almost all of the students was also observed and noted in field notes. Drawing the GO frameworks, whether copying predetermined designs or creating their own designs, were often student described as being “fun”.

R-What do you think about using those shapes and putting our information in…
Daisy-(breaks in) I think it’s fun!
R-You do? Why?
Daisy-Um, …(silence)
R-What’s fun about it? What part is fun?
Daisy-tracing …
R-tracing around the cardboard shapes?
Daisy-AND doing the puzzle!

Buggy-They are fun, and it helps you remember what you’re putting down. Like that big one you put on the board, it would help a lot because one-you had to remember, like I was saying last time, it’s easier to write your ideas down …

R-All the different activities using GOs, what do you think about those?
Peel-I think it’s fun to do. It’s, um, because it’s like a challenge for us.
R-Oh really? It’s like a challenge for you?
Peel-Cuz you don’t have, like, you won’t have something like this to use.
R-Are you talking about the one where you move the...
Peel-Yeah.
R-… words around – so it’s a challenge for you to …
Peel-… not do it with anybody showing you.

Their desire to participate in learning activities changed. They repeatedly described participating in the individual sorting and manipulative organization activities as working with and solving “puzzles”.

Foxer-um, sort of add bits and pieces that, into like, um, that, in your head, from the main idea that you, the main idea you wanna learn … just like a puzzle! It’s like a puzzle!

Foxer-Um, it’s sorta like a different kind of puzzle, like a brand new kind of puzzle. It’s like, um, all kinds of small, like, there’s different small pieces, whenever you put ‘em together into one big piece that connects the other pieces of puzzle, like, um, one of those big ones. R-OK. Now, tell me about GOs. We’ve done a lot of them lately, haven’t we? What do you think about those?

Peel-Ummm, they’re … um … they’re fun to do, um, it’s like putting pieces together like a puzzle.
R-So, you like them?
Peel-Yeah.

R-Do you think that they help you learn better than without them or are they just kind of the same?
Peel-No, they're different.
R-OK, how are they different from the other ways that you learn?
Peel-It's learning and fun together.

Their talk during these activities was more consistent with student talk about 'playing' rather than academically-based school activities. They seemed to view the materials more as 'toys' that were a special treat to work with as opposed to vehicles promoting content information and thinking skills. Students consistently asked when they would get to participate in "the puzzle" activity again. Observations from field notes also reflected this student perception.

R (field notes)-The sorting/arranging activity was *very* popular and almost all students were highly engaged but it took them a very short time to complete the task.

R (field notes)-One particular student, who has obvious behavior/emotional issues and has not been engaged or motivated at all to this point, seems to like the 2 bags of manipulative materials very much/she has written her name on both planning to keep them with her when she leaves class/when I come to collect them for use during the following lesson, she asks if she can keep hers/I tell her she can as long as she brings them back to class for use each day.

R (field notes)-I do think that the severe behavioral issues were much more under control today than yesterday and it seems to be directly linked to times when manipulative GO materials are in the hands of the students

Simplicity

Simplicity refers to the ability of GOs to represent the same amount of information in a much more condensed visual display. Part of the motivational value as identified by multiple students was that fewer words were used. Connections and relationships were represented by lines and different ideas were included in geometric figures instead of defining these relationships with lengthy verbal explanation.

Uranus-I think it makes, like, the notes and stuff and the facts easier, you know, instead of just trying to get them all from one piece of paper or from the book.
R-How does it make it easier?
Uranus-Because you can, um, use stuff, like you can draw lines from one thing and you can write a fact about it instead of just writing about them all in words.

Subzero-Yeah, but you may forget because they're all bunched up and sometimes, if you read different stuff and they're all bunched up,...
R-OK, so you think these GO ones where the stuff is separated …
Subzero-Yeah!
R-…and sorted more, it's the same amount of information but it makes it ...
Subzero-like, doesn't take as much space.

R-How interesting! So you say the GO adds little bits and pieces … of information …
Foxer-which, at the end of the lesson, piles up to make a bigger amount than in a regular science session.

Many students felt their ability to write, including composition and legibility, was inadequate. Their avoidance of writing interfered with their ability to process information in other content areas, such as science. Having to do what they perceived as a lot of writing reduced their confidence and their success. The ability of GOs to display a large amount of content information that made sense in a succinct format reversed this trend. For example, Foxer explained:

R-So, you were *not* into this assignment (prose)?
Foxer-No.
R-OK. How about this one (GO)?
Foxer-Yes.
R-Why?
Foxer- Because it's a GO!
R-Why? So you're saying you were into this one because it's a GO but not this writing one?
Foxer-Yes, because you don't have to write as many words!
R-OK.
Foxer-I cannot write! You have no idea! I have the worst handwriting ever!
T-OK, so the GO is better. Is it just as much information?
Foxer-Yes.

Efficiency

As opposed to simplicity, which refers to the initial recording of information in visual form, efficiency involves the use of a previously designed GO for the purpose of reviewing information. Students pointed out that the GO characteristic of simplicity allowed them to scan over a large amount of information in a much shorter period of time. They appreciated this characteristic of efficiency as opposed to having to read and reread a length of prose to gather and connect needed information. They also mentioned GOs' benefits in reviewing previously learned content and reducing the amount of time required to accomplish a task. For example, Subzero explained:

> R-How is the knowledge that you have since we used GOs different from if I had had you read books and...
> Subzero-Like, how is it making the learning different too?
> R-Well, yeah, that would be good too!
> Subzero-Well, it makes the learning different because I know how they're all sorted and I can see the categories. If you take this on the back and write all the categories right then and there and wrote it all down, that would take time.
> R-OK, so do you mean that this is quicker?
> Subzero-Yeah.
> R-The GOs are quicker?
> Subzero-Yeah, it would take less time to finish.
> R-What can you see on the GOs at a glance that you can't see on this paragraph at a glance?
> Subzero-Well, I can see on the GOs that you can just see that the definitions and stuff are right there --- it's hard to see from the paragraph but you can see all that stuff on the GO.

> R-How do you know that amount of stuff?
> Foxer-Well, GOs – they help you learn more … in a shorter … OK, um, it helps you learn more in a more short amount of time.

Visual Hierarchical Organization

Another related characteristic that several students referred to was the hierarchical organization in many of the visual displays. A variety of types of GOs were utilized during instruction including webbing which radiates out from the center, sequential which indicates order, and cyclical which shows a repeating pattern, as well as the hierarchical design. But there was an expressed comfort with the neatness and order offered by the hierarchical structure particularly. Forms of information display such as lists, text, and drawings were labeled by several students as "sloppy."

R-Can you tell me some more about that – how it makes it easier for you to understand?
Uranus-It's in an organized way and it really helps me learning it in an organized way instead of just like, (in a different, funny voice) oh that's on the board – there's one thing – there's one thing and then you have it, like, all on one piece of paper and it's like a really sloppy.

R-Tell me about learning with the GOs.
Uranus-Um, I think that the GOs really, really help.
R-Why? What makes you think that?
Uranus-Cuz they're not just, like, created on one piece of paper. Um, it's like, you have the facts about one thing, and then you have a column about things that are under that category …
R-So you like it that they're placed on the paper, kind of …
Uranus- … in a neatly order.
R-OK. In a neatly order. How do you think that helps you learn? When they're 'placed on the paper in a neat order, what does that have to do with how you think about what you're learning in science?
Uranus-Um, so I can know all the things about one thing and then, I can move on to the next one, and then, like, the facts are all about things in that category.
R-OK, instead of what?
Uranus-Just like, when the teacher says just write it down and…writing it down, like, wherever you have room.
R-OK, do you mean, it's not in an organized … in the columns that you were talking about?
Uranus-Yeah! It's neater and it's easier to look at and read and stuff. I could look at the GO and remember it was like that instead of 'OK, this goes here and this goes here, this goes here and this goes here'.
R-OK. So you think even the knowledge in your head is different. When you get done learning the science stuff, you think the knowledge in head is even … more …
Uranus-…organized!

The terms main idea, categories, and examples were consistently mentioned by multiple students when referring to the visual levels of hierarchy in the GOs. The concept at the top was called the 'main idea' or the 'title'. Often but not always, a level called the 'definition' or 'description' followed. The third level was usually called the 'categories.' Students called the last level the 'examples' or 'details.'

R-OK, now why didn't you make the polluting examples a circle and the conserving examples a square? Why did you make those the same shape?
Subzero-Well, because they're ***examples*** of polluting, they're not really based on the ***categories***.
R-OK – so there's a difference between ***examples*** and ***categories***.
Subzero-Yeah.

Siberious Wilderus-Well, it tells you the same thing. It just … tells you in, like, order.
R-in order?
Siberious Wilderus –By what's more important.
R-Oh, I didn't notice that! …by which stuff is more important, huh? OK, what were you guys calling this thing up at the top in class?
Siberious Wilderus –main subject
R-and then this would be … what?
Siberious Wilderus –a definition
R-OK, and what do you have over here? Do you have more of those things?
Siberious Wilderus –Yes, you have about 6 or 7.
R-OK, 6 or 7 what?
Siberious Wilderus -6 or 7 examples.

Neither of the classroom teachers or I ever modeled these terms in reference to levels on a hierarchical framework to my knowledge. The students attached these names during class discussions and activities to clarify to each other as they were trying to find ways to discuss the organization of the components among themselves. This trend occurred independently among individual students as well as students picking up the use of these terms from each other and then utilizing them during their group communication.

R (field notes)-Both groups named the same hierarchical levels of the GO with the same labels: title, definition, category, and examples. They were not yet able to talk about or verbally explain their separation of the components into differently named hierarchical levels. They didn't seem to realize consciously that that's what they're doing.

Student – I want to switch natural resources and the definition.
Teacher – OK, let's try that.
Student – What?!
Teacher – What do you think about that?

Student – It's still OK.
Student – No, it's not the title!
Teacher – OK, put the title back at the top. Does that make you more comfortable?
Student – Yes!
Teacher – OK, I have 1 more question for you. What does the size of the letters have to do with these switching things we've been doing?
Student – They're all, um… the things.
Student – They're important.
Student – The title is the biggest.
Teacher – OK. What are the other ones?
Student – Examples.
Student – Yeah, the ones with the little letters are the examples…
Teacher – then, the ones with the bigger letters are…
Student – the 'categories'!

This trend was also involved in Jackie Chan's process but in a slightly different way. As stated previously, he has difficulty identifying and enunciating words in order to communicate what he wants to say. Although he did not use these common terms to identify levels of hierarchy nearly as often and as consistently the other students did, he was able to communicate his similar understanding *visually* by utilizing various geometric shapes and sizes to differentiate between levels (Appendix P4). He does attempt to verbalize this process although he is not able to be clear using only his words.

J-Well that, because we draw those because people know which one is conserving and not conserving… and like give them examples of conserving and other stuff…
R-Uh-huh. Why did you choose to make these different shapes? This level is one shape, and this level is another shape, and actually, this level here is a different shape, isn't it? Why did you make the shapes the same going across, and change them as you went down?
J-Well, because if that's square rectangles, like in the small rectangles I have, just like no one would see them. Things I have, like, The Lorax and in the circle give example…
R-The things in the circle give an example?
J-Uh-huh.

In some cases, the organization of student content knowledge became so complex, that it was much more easily understood as a visual display than through verbal communication. For example, Foxer relates:

R-OK. What do the lines mean? What do they represent?
Foxer-OK, like um, ‘camouflage’ is the main category. ‘A means of hiding from predators’ is a category inside a category.
R-So what are you telling me about the lines that connect all those?
Foxer- They connect one category to the things that are *in* the category and they can (mumbling) to the things inside the category if there’s another line from the thing that’s in the category to another box, and that means that would still be part of the category from the first thing it was connected to.
R-(struggling to keep up…) OK, so when you have one line that connects to …
Foxer- …um, like, if you connect this to this, and then, you still … then you make a line, and you could make it to, like, another thing, then that would still be part …

The activity of sorting, whether visual or kinesthetic, by comparing similarities and differences was highly valued. This kind of organizing was named consistently during numerous independent conversations as a “puzzle” and was discussed as though it were a game rather than an academic endeavor.

R-What do you think about the GOs we’re using in science class?
Foxer-I *like* ‘em! They really help organize stuff, like, you wanna figure out which group is which, like, the animal group, like, the ones that have the noses and the ones that don’t, and compare their, um, you can compare their differences and their, their sames.

This sorting task allowing students to construct knowledge by comparing was echoed by Mrs. B from her teacher perspective as well.

R-OK. How is the student talk during GO activities, is it the same or different from their talk about science previously. Do you notice any difference in it?
Mrs. B-I’ve noticed them comparing. They will look at their neighbors – which is good. They’re wanting to get feedback from their neighbors – such as “Am I doing this correctly?”

Reconstructing Knowledge

A theme related to visual hierarchical organization is the omission, adjustment, or addition of information as it was restated by students while working with GO structures. These types of changes were evident in many of the participants' processes as they transferred their knowledge from an alternate form into a GO design.

Non-factual information. In Foxer's first attempt at GO design (Appendix K2), he omitted previously included information that represented his opinion instead of factual knowledge. When it was pointed out to him and he was asked about this choice during an interview, he appeared to be completely unaware of making the adjustment.

> R-So you have lots more information on here (GO)?
> Foxer-Yes, mm-hum.
> R- …and what happened to your opinions?
> Foxer-Um … they went away!

Jackie Chan's verbal description of information relating to pollution and conservation involved a large amount of emotion as opposed to accurate scientific information. He struggled to communicate his factual knowledge without resorting to likening it to feelings.

> Jackie Chan-Pollution is… something that has… black comes out of something… like… like … and it's…
> R-Why is it bad?
> Jackie Chan-Um… because it's … you can't see any… there won't be any sunlight … it's bad for your lungs…
> R-OK, and what's conservation?
> Jackie Chan-Conservation means like that is a happy place and that's… it's … it's not air polluted and it's not bad… it's just right.

When he expressed this same knowledge through GO design (Appendix P4), he was better able to communicate his understanding of the factual information without resorting to a discussion of feelings or comparing the content to emotions.

Another adjustment made in Jackie Chan's transition of knowledge from prose to GO structure was that he recorded less directly contradictory information. His prose display (Appendix P1) indicated that life cycles have a beginning and an end, yet, they "never end." His following GO display (Appendix P2) reports that life cycles "go on and on" but does not state anywhere that they end.

Visual symmetry. At the beginning of this study before becoming familiar with the use of GOs, several students talked about designing their GO framework specifically to facilitate visual symmetry. A symmetrical display made them feel much more comfortable than a design that was not balanced visually. Their process was to begin with the special design, shapes, and connecting lines, then force the information to fit into the symmetrical framework they had created. This process often resulted in an inaccurately organized display.

R-How do you make those decisions? What kind of box to use and what where you're gonna put it?
Foxer-The only thing I try to do is be symmetrical.
R-OK. You try to be symmetrical? Why is that?
Foxer-I don't know. I just think symmetry is, um, looks really good.

Peel-And I'm gonna put stuff off to the sides but it's gonna be, like, 4 simple machine up here and 2 simple machine down here.
R-Oh! Now, what made you decide to do that?
Peel-Um… uuum… well, one of them is it'll make it look symmetrical.
R-Oh, you wanted the whole graphic organizer to be symmetrical?
Peel-Yeah.
R-Why did you want it to be symmetrical? Why did you think of that?
Peel-Um… (silence)
R-No reason for that?
Peel-No.
R-You just … you like things to be symmetrical?
Peel-Yeah.

Near the end of the study after having worked with GOs and gaining an understanding of their purpose and usefulness, these same students seemed to forget about their need for a symmetrical design and began to let the information they needed to display guide the organizational design of their GO.

Amount of knowledge communicated. Throughout the collected artifacts, students who had been able to communicate very little of their content knowledge through other means were able to communicate *more* content knowledge through the GO form. This is most clearly evidenced by the sequential comparison of the first and second artifacts of Foxer (Appendices K1 and K2) and Buggy (Appendices L1 and L2). Other examples of students who began to communicate a substantially larger amount of information in subsequent GOs as the study progressed were Peel, Jackie Chan, and Crazy. This trend was also recognized and pointed out by Mrs. B.

> Mrs. B-Well, OK, here's the deal. With the GOs, it is a tool to facilitate their thinking. Without the tool, how do they get from what they know to what they need to put on paper? It's almost as if they need something to *channel* their thinking. Is it that they know the information and they're not quite sure how to show what they know because they don't… what are they using to work with? And so the GOs provide a means to where they could facilitate that knowledge.
> R-OK, the word you're making me think of is 'vehicle'.
> Mrs. B-Yes! Yes!

Mrs. B's talk during interviews often came back to this ability of GO structure providing her students with an alternate means of communicating what they knew. This concern of hers refers back to the issue discussed in many of the individual student descriptions that a substantial percentage of her students are not able to demonstrate their knowledge through conventional means within the public school norms resulting in a lack of success for many.

Incorporation of prior knowledge. Several students became so absorbed with the GO format of displaying their knowledge that they were inspired to expand their design in multiple directions to include information recalled from recent class instruction as well as additional related prior knowledge from other sources. They were able to independently make connections between pieces of information acquired from various sources at various times throughout their prior learning experiences. Siberious Wilderus, in the context of working with GOs, talked about recalling related knowledge learned in a previous grade level and connecting it to the content we were learning in class at that time.

R-We've done a whole bunch of GOs. Last time I talked to you about GOs, the ones that we had done—(cut off)
Siberious Wilderus-Conservation and pollution!!
R-OK, what about them?
Siberious Wilderus-Conservation is when you take care of your um, um, of the natural environment. And polluting is when you put oil in water and kill fish or make acid rain or throwing out stuff and it could kill you.
R-Right! And we didn't even talk about that! How did you know all that?
Siberious Wilderus-By myself, from the second grade!

As Crazy designed her GO on the opposed concepts of pollution and conservation (Appendix T4), she expanded her list of components to include other social behaviors accurately sorted into the same two 'good' and 'bad' categories as her understanding of the original concepts. Subzero added a substantial number of additional components including examples gained through independent learning making his finished GO structure (Appendix N2) much richer in detail than his original prose format. Jackie Chan talked about adding information he had learned from reading books from the library to his GO display based on science class content.

While designing his final GO (not available to view), Siberious Wilderus decided to expand his GO structure 'up', to include a broader spectrum of content, in addition to the usual 'down', including smaller details. The spectrum of the GO assigned and the content taught during class was limited to 'natural resources'.

R-Tell me about this.
Siberious Wilderus-Well, the top part is resources of the world. And under the resources of the world are the *natural* resources of the world --- like there are also *capitol* resources and *human* resources.
R-OK, show me – what are the other ones you're talking about?
Siberious Wilderus-Let's see, there is human resources and capitol resources.
R-OK, tell me about the rest of this.
Siberious Wilderus-Natural resources, the polluting would be like poisoning water or filling the air with gas and the problem would be you're killing the animals. And if you conserve, you aren't polluting and it can save the world…
R-Wow! How many levels do you have on there?
Siberious Wilderous-1, 2, 3, 4, 5.
R-And you made that level up and you added this one in on the top of it!
Siberious Wilderus-Capitol resources would be machines…(continuing to add to the GO)

Adjustments to knowledge structure. In many instances as students interacted with or reviewed their GO structures, they adjusted the content, placement, or connections of various components they had previously designed. As Peel reviewed the structure he designed (Appendix M4), he noticed that the organization and connections displayed did not reflect his understanding of the information. He quickly made the adjustments necessary to correct the situation.

R-Now where would those three things go if you were to write those down on this? – not necessarily the words but what shapes and lines you would put?
Peel-(drawing)
R-Good! So if polluting is that …
Peel-trashing into a pond...
R-There's another one! Where would you put that idea?
Peel-(adds geometric shapes and connecting lines to GO)
R-(rechecks ideas and writes words directed by student-car exhaust, smoke stacks, trash in pond) OK, now are those organized properly there? Smoke stacks attached to polluting, car exhaust attached to polluting, and throwing trash into the pond attached to car exhaust?
Peel-No!
R-No? Why?
Peel-That's not supposed to go under there. (pond trash under car exhaust)
R-Oh? Well, can you fix it? Where should the line go?
Peel-(moves component and changes connection between components)

During a subsequent interview, Peel was even able to talk afterward about why he chose to make these changes. He clearly described that the arrangement and connections of the components in the first organized structure did not accurately represent what he wanted to communicate.

R-Explain to me again why you changed this one. You had ‘throwing trash in the pond’ connected directly to ‘car exhaust’ and THEN, connected to ‘polluting’. Why did you move that line?
Peel-Cuz I wanted to say something else – I wanted it to say ‘car exhaust’ and ‘throwing trash in the pond’… they don’t go together. It’s two different things!
R-Oh, OK! So they’re not connected to each other but they’re both… what?
Peel-polluting!

Similar adjustments were made by Siberious Wilderus during his process of designing. He noticed organizational inaccuracies after designing the structure as he reviewed them visually. Then, he made the necessary adjustments so that the design accurately reflected the knowledge he was trying to communicate.

Siberious Wilderus-Human resources would be man-made machines and capitol resources, maybe machines make some other machines. In social studies, human resources are goods, well… resources can be goods, like… a good and a service? A good-you can hold, and a service is, like…
R-What’s gonna go here?
Siberious Wilderus-Um, goods. Goods would go (mumbling)
R-Services you have connected right up to capitol resources. But this one you have connected to man-made machines and THEN, human resources. Can you talk about that?
Siberious Wilderus-I *have* to change one of them.
R-What do you want to change?
Siberious Wilderus-This one.
R-OK. Tell me why you’re changing it. Well, let me see where you’re changing it to. Will you tell me why?
Siberious Wilderus-Well, I don’t know. I don’t have a reason.
R-You don’t have a reason?
Siberious Wilderus-Well, I’m thinking of one now.
R-OK, I can’t wait to see where you decide to put it then.
Siberious Wilderus-(makes changes in structure)
R-You’re connecting that directly to human resources instead of coming down off from that one. Right?
Siberious Wilderus-Right.

R-OK, and do you know why or just because that's where you think it belongs?
Siberious Wilderus-I think that's where it should belong… AND also, it connects to mad-made machines.
R-Oh, it should? Why?
Siberious Wilderus-It can be… it can be a machine in goods and services.

Cooperative Socialization

Cooperative socialization refers to the interactive nature of student communication while working with GOs. The common language for hierarchical levels shared among the students is one example of a clearly elevated level of cooperative socialization evident during the times when GO strategies were utilized. This socialization was displayed in several contexts. During teacher-guided class discussions, students offered multiple ideas aloud and constantly adjusted the prevailing class understanding by talking through their questions with each other. When posed with a question from the teacher pointing out a possible inconsistency in their thought process of the organizational display of information, they repeatedly shared, analyzed, and evaluated ideas until the class was able to collectively determine accurate and inaccurate designs. Some students began to verbalize their own thought processes aloud as they negotiated with themselves on how to incorporate new information with their existing knowledge. This allowed the other students to follow along and understand how their peer arrived at their final understanding.

R (field notes)-Another GO was immediately started on the board as a model (pollution-conservation). The students were to turn to the next clean page in their folders and begin copying this format. They had no trouble at all and most were very engaged by the tracing around the shapes while, at the same time, talking and listening to the ongoing discussion of new information as we organized it, worded it, and recorded it in a correctly reflective display. The GOs in the two classes were not exactly the same since they were both socially constructed by the participants as we talked through the content.

Teacher-Why do you think the letters are different sizes?

Student 1-the rows across!
Student 2-the ones at the top are bigger and the ones at the bottom are smaller
Student 3-they get smaller as it goes down

Teacher-What are some other natural resources we can put up here?
Student 1-Air!
Student 2-No, air is not a fuel! … (looks on the figure the teacher is building on the board to see she has listed it on an even hierarchical level with 'fuels' instead of under it) Oh! I see! OK.

The existence of multiple correct organizational designs of the same content information was of great interest among the students. This common interest created an atmosphere that promoted positive socialization and non-judgmental idea exchange. Sometimes, additional details were added to the originally presented information, always accompanied by a discussion of how and where this new information should be accurately attached to the existing GO. (for complete transcript, see Appendix F)

Teacher-Put 1 finger on water and 1 finger on animals and switch 'em.
Student-Wrong! That can't make sense!
Teacher-That doesn't make sense? Why?
Student-Cuz water isn't a living thing.
Student-Because then you have big letter under a big letter.
Teacher-Well, what if I just go back to my computer and make the letter size fit? Would it still make sense?
Student-(mumbling and discussion)
Teacher-Can we put animals up here even with air, soil, water, living things, and fuels?
Student-No! Cuz animals isn't a 'category'.
Teacher-OK, I got another one for you. I want you to switch the definition of natural resources with sunlight.
Student-What?! (LOTS of laughing)
Teacher-Is that funny?
Student-Yup!
Teacher-Why is that funny?
Student-Sunlight ain't a definition for all natural resources.
(Many students uncomfortable leaving those switched)
Teacher-OK. Put it back.
Student-I want to switch natural resources and the definition.
Teacher-What do you think about that?
Student-It's still OK.
Student-No, it's not the title!

Teacher-OK, put the title back at the top. Does that make you more comfortable?
Student-Yes!

Discussions almost always included explanations of *why* certain arrangements were or were not accurately reflective of the content. Individuals, as well as pairs/groups working together to find an accurate organizational pattern for the task at hand, frequently checked visually and/or verbally with their peers to see if others' solutions were consistent with their own or to see if someone else had designed an additional, alternate way to represent the information accurately. Sometimes, individuals or pairs/groups would go back and make adjustments to their original design after listening to another idea. Many groups negotiated back and forth several times in an effort to create an organizational design that incorporated everyone's understanding.

The nature of the socialization that took place among these students during the GO activities was different from their typical classroom interaction in several ways. Although there was often a difference of opinion during discussions, the situation never escalated into anger or confrontation as was often the case during other instructional times. Instead, the students listened intently to each other's ideas, and then decided whether or not to allow their own understanding to be influenced by them. Students often expressed ideas that differed from each other to various degrees, but never gave any indication of feeling a need to arrive at the exact same answers, as was the case in many other activities. The socialization observed truly was *cooperative*.

In summary, each focus student's individual process of learning through the use of GO instructional strategies was different. Each had their own distinct interactions with GOs and responded to them based on their personal knowledge, academic needs, and motivation. Despite these individual varying processes, six clear themes were evident.

The data indicated patterns across individual processes including motivation, simplicity, efficiency, visual hierarchical organization, reconstructing knowledge, and cooperative socialization.

Researchers should no longer question if organizers work, but how and when they work.

(Dunston, 1992, p.58)

Chapter 5

Discussion

This chapter discusses the significance of the findings described in the previous chapter. Two types of findings are discussed: those that contribute to answering the guiding question, and those that are beyond the scope of the question. A discussion of limitations and the strategies utilized to minimize their effect follows. Finally, implications for both practice and future research are suggested.

Answering the Guiding Question

This study was guided by the research question: In what ways do the organization and complexity of student content knowledge change when graphic organizers are implemented as an instructional strategy? The results of this study suggest that while using GOs as an instructional strategy, student content knowledge was expanded to include informational structures that were much more complex and organized.

Evolving From Listing Facts to Complex Networks

Novak and Gowin (1984) defined complexity using language such connected together, showing interrelationships, and web of relevant concepts. While using GOs in this study, many students began to talk about their knowledge as connected components held together by an overarching main idea as opposed to a list of unrelated facts. Rather than simple recitation of factual information, they gradually began to express their knowledge as more of a connected network of interrelated parts. For example, during a class discussion about arranging the components of a GO on natural resources, the students experimented with switching components within the informational structure. When parts were switched in a way that resulted in an inaccurate display, the students reacted by laughing, insisting on putting the parts back immediately, and saying that the inaccurate design “did not make sense.” They distinguished between arrangements in which the components reflected the information accurately and arrangements in which the connections were incorrect (Appendix J). These findings support those reported by Mason (1992) who explained that students exposed to ‘mapping’ during instruction demonstrated “insight into the interrelatedness of concepts” (p. 60).

Clarke (1991) described visual organizers as a strategy that can expand student thinking to reflect complex patterns of content knowledge beyond rote memorization of factual information. Bransford (2000) wrote about this same characteristic of GOs, their ability to extend beyond remembering information to constructing meaningful networks of organized knowledge. Findings from this study support these perspectives. The student participants integrated both their own prior factual knowledge as well as new information to talk and to think about multiple concepts in an organized, connected way. Although the learning process of almost every focus student reflected this aspect, the sequential artifacts designed by Uranus (Appendices O1 through O4) and Subzero (Appendices N1 through N4) demonstrated it very clearly as they began with lists of facts, and ended with connected networks. Their process of learning and the resulting knowledge reflected far more complexity than simple memorization of facts. In working with the GO designs, most of the students clarified and expanded their understanding of the content as well as reinforcing the basic factual information.

This accommodation and integration of new knowledge with prior knowledge led students to reorganize and reconstruct their personal understandings of concepts. They experimented with the level of reflected accuracy of various differing designs. They began to compare and contrast the parts of the design, thus, noticing that their placement within the knowledge structure was just as important as the parts themselves. For example, Crazy designed her final artifact by sorting and adding components of her own choosing into two categories by their characteristics (Appendix T4). She was able to apply her understanding of how to analyze each component from her own prior knowledge determining where it fit accurately within the GO framework. This supports Marzano's (2001) premise that the identification of similarities and differences is one of the most effective learning strategies.

This kind of thought process is completely different from the process of memorizing where components belong under various categories. By practicing the ability to sort components by analyzing their similarities, differences, and general characteristics, students developed the ability to apply their knowledge and this process of deduction to other tasks. In doing this, they transferred the ability to analyze and solve problems on their own from one learning task and used it effectively in another. The importance of this activity allowing students to apply their learning to new contexts beyond gaining memorized, factual information was noted by Penn, Shelley, and Zaininger (1998). In their action research with seventh grade math and social studies students, they listed GOs as one of several strategies found to be effective in supporting transfer.

Hierarchical Organization

Organization has been defined as put together into an orderly, functional, structured whole (The American Heritage Dictionary of the English Language, 2000). As the students in this study began to experiment with adding and reorganizing the components of their GOs, they gradually placed more importance on determining the particular level of hierarchy on which each component fit. This became a vital part of their process in their effort to accurately reflect their understanding of the concept. Their socially cooperative ‘naming’ of each of the levels (title/main idea, definition, categories, and examples/details) indicated a growing understanding of the importance of the *placement* of the components within the hierarchical levels.

Ausubel (1963, 1968) discussed the importance of the hierarchical arrangement of information within organizational tools. He wrote about the importance of information being organized from general to detailed. Novak and Gowan (1984) discussed learning with GOs in terms of moving from broad to specific. The phenomenon of the student participants in this study valuing the hierarchical levels to the point that they chose to spontaneously create their own names to identify each level indicates how strongly they identified with the arrangement. Their discomfort with the visual arrangements that did not represent the information accurately indicates their understanding that the arrangement of and connections between the components are inseparable from the meaning of the knowledge represented. For example, during the transcribed class discussion of the students negotiating a GO design on natural resources (Appendix J), the loudest objections occurred when components were switched between hierarchical levels which, in most cases, caused the display to reflect the information inaccurately. Most of the students reacted by laughing or yelling to the teacher to put the components back where they fit on the appropriate levels quickly. The students understood the relationship between placement on an appropriate hierarchical level and accurate reflection of meaning.

At other times when it was appropriate for specific components to move or be expanded from one level to another, most of the students demonstrated through class discussion or interviews that they understood that situation as well and were able to accomplish a new design accurately. For example, Siberious Wilderus expanded his framework (described in Chapter 4) to accommodate his relevant additional prior knowledge by readjusting the named levels. He expanded his framework to include an additional hierarchical level at the 'top' or the title so that the previous 'title' was then placed at the second level along with other components expanding the scope of the entire framework. Peel moved components between levels (Artifact M4) until he was satisfied that they fit together to match his understanding.

Reconstructing Knowledge

Some GO sorting activities, such as differentiating between examples of renewable and nonrenewable energy sources, sparked some students to think about *why* one component belonged in a specific category. They compared the categories, recalled the criteria to define each category, and then determined where the example went based on their thought processes. Those students used their own knowledge to categorize components and develop an accurate visual structure without memorizing where each example went. This, again, supports the research of Penn et al. (1998) in which they reported that memorized, factual information alone was not successful in helping students apply their knowledge and solve problems. They named GOs as one effective strategy in addressing the problem of transfer of student learning to new contexts. In this instance, no matter what new previously unsorted energy source students were presented with, they were able to apply what they knew and transfer that understanding to the new task in order to accurately sort the components.

Romance and Vitale (1999) and Plotnik (2001) have suggested that GO strategies have the potential to enhance student learning by representing complex ideas in an organized structure reflecting the importance of each idea (component). All of these themes support the premise that students' thinking processes moved toward more complex, interconnected structures. These kinds of structures reflect a process of critical thinking and problem solving as opposed to rote memorization. For example, Siberious Wilderus stated during an interview as he was looking over his artifact that he *had* to move one of his components to another location and an alternate connection. Since the GO he was working with was of his own design, his choice was not initiated by previously memorizing a specific organizational design but by noticing that the placement and connecting lines did not reflect his understanding of the concept.

This was evident during the individual focus student interviews as well as the class group discussions/activities. Instead of a linear transfer of predetermined information to be memorized and repeated back, these interactive GO lessons led students to negotiate with themselves and with their peers on content issues such as: where components belonged on the GO, how they should be connected to other components, which specific components could and could not be switched still retaining accuracy, and if there were any alternate designs that would also accurately reflect the information. There was much explanation, application, synthesis, analysis, and evaluation of all of the possible designs when multiple answers were discovered. Most of the students were quick to describe their own thinking process in coming to their solution as well as express curiosity as to how their peers came up with alternate designs. Foxer and Buggy both discussed various accurate design options for their displays during individual interviews. Students perceived that it was not only acceptable, but intriguing to have a different answer than a neighbor. As long as each student could explain his or her design and back it up, both answers could be correct.

These three themes together (from listing facts to complex networks, hierarchical organization, and reconstructing knowledge) support the theory that the use of GOs helped students to develop knowledge that consisted of less rote memorization and more higher level thinking. Novak and Gowan (1984) wrote about using GOs to support ‘meaningful learning as opposed to rote memorization.’ Mason (1992) found that student who used GOs in college-level science demonstrated an “insight into interrelatedness of concepts” (p. 57). Wallace, Markham, and Mintzes (1992) suggested that using GOs enhances a deeper understanding of content for students. Mason (1992) and Hyerle (1996) both talked about learning moving from memorization toward meaningful; linear toward complex when utilizing GOs as an instructional strategy. However, these studies were conducted with secondary or college students. From this study, findings support those perspectives but extend their scope beyond the secondary/college levels to include elementary contexts. Likewise, the findings from this study add to previous research by documenting the process of learning with GOs as it takes place. This provides a more complete picture of how students acquire more complex, organized knowledge as they interact with GOs as an instructional strategy.

Outcomes Beyond the Scope of the Question

In addition to the evidence addressing the specific research question set forth at the beginning of this study, data analysis resulted in several themes outside the scope of the guiding question. They included motivation, simplicity and efficiency, cooperative socialization, communicating knowledge, assessment.

Motivation

Students immediately and consistently perceived all GO activities as ‘drawing,’ ‘games,’ or ‘puzzles’ as opposed to school-based academic learning activities. This was especially evident during interviews with Daisy, Foxer, and Peel. Their attitude toward participating in these activities was completely different than their attitudes toward other instructional activities. For example, many students asked during informal conversations when they would ‘get to do the puzzle activity’ again during class. These incidents are consistent with findings noted by Horton et al. (1993) who reported a positive effect on the attitude of students in his meta-analysis of the effectiveness of mapping. Other researchers, who specifically focused on effective motivational strategies such as Alvermann and Boothby (1982), Carroll and Leander (2001), and Marzano et al. (2001), list GOs as one effective tool toward that end. Despite the fact that this phenomenon has been noted in earlier research, the unexpectedly high level of motivational value was not reported to the degree that it was evident in this study. Several specific characteristics of GOs contributed to this positive student attitude.

Hands-on manipulatives. There seemed to be a difference in student motivation between the GO activities that involved hands-on manipulation and those that did not. For example, Daisy chose to participate during class in the hands-on manipulative activities in which the components were moved around on students' desks to determine an accurate design. Although she reported during interviews that she liked all of the GO activities including both drawing them on paper as well as the ones with moveable parts, observations revealed that she was more engaged during the hands-on GO activities than any other classroom activity. This was also the case for several other students in the classroom who consistently displayed behavior problems during class such as talking back and refusing to follow directions as reported in field notes discussed earlier. Many researchers have documented the value and effectiveness of utilizing hands-on manipulative activities to enhance student learning (Hinzman, 1997; Jones, Andre, Kubasko, Bolinsky, Tretter, Negishi, Taylor, & Superfine, 2004; Rust 1999). These findings concur and provide strong support for the motivational value of this type of activity.

Simplicity and efficiency. The simplicity and efficiency that GOs utilize in representation of knowledge was mentioned repeatedly by many of the focus students. These characteristics allowed students who struggle with issues such as legible handwriting, sentence structure, spelling, self-confidence related to writing, and a dislike of writing a lot of words to work successfully with their science knowledge without being handicapped by literacy issues.

For example, it was evident from other activities that Peel and Jackie Chan were uncomfortable with performing some of these literacy skills. They participated in few other classroom activities involving writing, but they were always excited to do the GO activities. Berry, Guzy, Keelan, Kolinski, and Kuknyo (1999) reported that while using GOs along with other tools, reluctant writing students exhibited more confidence and less apprehension during writing activities. This study supports their findings and, further, better isolates the GO strategy from the other additional tools utilized in the previous study.

Foxer and Buggy both talked specifically during interviews about how bad they thought their writing skills were and how much they liked the GOs activities because writing requirements were minimal. This perspective reflects the findings of Alvermann and Boothby (1982), suggesting that GOs were motivational ‘because they contain very few words.’ The verbalized reports of individual participants along with the documentation of student conversations and class discussions provide strong evidence to substantiate this finding. The example of these two student participants is particularly important in light of their obvious ability and knowledge (as evidenced by their verbal descriptions and observations by Mrs. B) but their inability to date to communicate it in a way that results in success in their school context.

Cooperative Socialization

The reconstruction of knowledge, discussed previously, caused students to communicate in a continuing effort to create a visual display that reflected their own knowledge and understanding of the content. The nature of the socialization that took place among the students during the GO activities was different from their typical interactions in several ways. Although there were often differences of opinion during discussions of content, conversation never escalated into visible anger or confrontation as was often the case at other times. Instead, students listened intently to each other's ideas, and then decided whether or not to be influenced by them. During class and small group discussions involving GOs, students often expressed ideas that differed from each other to varying degrees but they never felt the need to arrive at the exact same answers, as was the case in other activities. They understood that while there are some organizational designs that do not accurately represent the content, there were alternately many different designs that *were* correct. Their final designs did not all have to look the same to be right. This realization may have contributed to developing a growing respect for differences, an important prerequisite in cooperative socialization.

Students also realized that their representational designs were dynamic. They could continue to adjust to incorporate all participants' ideas. Also, discussion did not come to an abrupt and final end when an accurate design was thought to have been found. Students continued to interact and negotiate beyond finding an acceptable, correct answer. For example, several students such as Peel and Foxer often used interview time to review their design from class, seek more input, and make adjustments. This outcome reflected and further supported Roth's (1994) conclusions from his research with high school physics students. As was the case in this study at the elementary level, Roth's students collaborated and negotiated with each other in order to eventually arrive at a design that accurately represented their shared meaning.

Vehicle to Communicate Knowledge

Almost every student participant was better able to communicate his or her content knowledge when using a GO framework. Students who struggled with spelling, writing, or even just the motivation to *try* to communicate knowledge were much more successful in accurately demonstrating what they knew. During the time it took them to complete the task, they didn't have to worry about the communication skills (spelling and writing) that had previously confounded/complicated their ability to show how much science content they knew and understood. With the frustration of trying to spell or having to write gone or at least minimized, the students were able to focus their entire attention on content knowledge. This theme was further reinforced by Mrs. B who stated from her observations that using the GO frameworks and organizational designs offered these learners a tool with which to "channel their thinking" or "a means to facilitate that knowledge."

Although Alvermann and Boothby (1982) talked about the motivational advantage of GOs because fewer words are utilized to communicate knowledge, they did not specifically apply this characteristic to the possibility of GOs offering reluctant writers an alternate vehicle to show what they know about content without the additional requirement of writing skills. Several other researchers (Novak & Gowan, 1984; Plotnik, 2001; Wallace, Mintzes, & Markham, 1992) have suggested that GOs may be valuable as an assessment tool. Novak (1991) suggested that GOs reflected learners' knowledge better than traditional forms of testing. The data from this study offers strong support to substantiate the use of GOs as an assessment tool. However, this study furthers our understandings by offering evidence at the elementary level as well as evidence from multiple data sources through multiple collection methods.

Limitations

Although this study's findings offer valuable insights, there are several limitations to consider that may have influenced the results of this research. These issues are discussed in the following section as well as procedures implemented in an effort to minimize their effects.

Hawthorne Effect

As mentioned in Chapter 3, the possible influence of the Hawthorne Effect (Leedy & Ormrod, 2001) needs to be taken into consideration. The excitement of a new and different teacher in the classroom and the knowledge that students were participating in activities specially designed to carry out research may have skewed results in a positive direction. The enthusiastic, high-energy teaching style of the researcher/instructor is an important factor to consider in measuring change. Both groups of students were accustomed to a much more low-key, textbook-oriented, traditional style of classroom instruction from their regular teachers. Any types of activities that were more exciting, engaging, or student-centered would have had a positive effect on student motivation, as well as other findings discussed in this study. While the GOs as the focus of this research certainly contributed to the results, to attribute the full effects to the GO-driven instruction alone would be overstating their influence.

Researcher Bias

In any research study, the possibility of researcher bias needs to be taken into consideration. In this particular study, researcher bias may have been a significant factor that needs to be examined carefully within the process of considering results. The researcher was a career classroom teacher of 23 years experience having utilized instructional strategies based on GOs. This strong commitment to their effectiveness with students is evident throughout the study and is certainly a factor that may have enhanced positive findings. In this case, the researcher was also the classroom instructor. The instruction was carried out by an individual possessing years of experience specifically with classroom instruction driven by GOs.

While this phenomenon is always a factor to some degree, multiple efforts to minimize this limitation were utilized. Three distinctly independent data sources (including students, teachers, and researcher observations) were utilized in order to establish triangulation. Also contributing to the reliability of these findings was the use of multiple data collection methods including student artifacts, participant interviews and researcher field notes. A final strategy employed to minimize researcher bias was frequent member checks. These were carried out by the researcher with the student participants from one interview to the next as well as with the teacher participants throughout the data collection period. One follow-up member check with the two teacher participants was conducted following interview transcription, identification of themes, and other preliminary data analysis.

School Context

This study was conducted in a school system within close proximity to a major research university. The atmosphere was one that may have been more open to experimenting with nontraditional ideas in educational contexts. It was a context found after many previous rejections for permission to conduct this research in other locations. One of the reasons for this situation was the fact that the study called for a grade level and time of year that involved an imminent high-stakes testing series. The superintendent of the school system in which the research was conducted had historically modeled an attitude of awareness of and respect for the mandatory standardized testing but not of panic or fear in response to it. Because of his leadership and example, the comfortable and open perspective of most practitioners in this school system may have enhanced the findings to some degree. This situation may also limit these findings applications to other school contexts.

Implications

Many implications can be discussed in light of these findings. Both practitioners and researchers can be guided in their future practice by the directions indicated in these findings.

Practice

Sufficient instruction and practice. It was clear as the data collection progressed that the students in this study needed to be taught how GOs worked before they were capable of utilizing them to their full potential. At the beginning of the study, many students were more concerned with issues unrelated to the information that needed to be represented such as symmetry, personal opinions, feelings, and the resulting visual display resembling the general shape a specific item. As their experience with GOs increased, they gradually became more focused on designing the visual display to accurately represent their understanding of the science concepts.

Students also needed practice using GOs before they were capable of understanding how they worked and what their benefits were. As was evident in almost all of the sequential student-designed sets of artifacts from this study, it took students several weeks to gain enough competency working with GOs for them to be of benefit as a tool toward enhancing their learning. It was necessary for them to actually work with GOs in various ways before they began to focus less on irrelevant issues (such as design symmetry, opinions, and emotions) and more on the knowledge itself and how components fit together.

Avery, Baker, and Gross (1997) specifically discussed this contributing factor in their research on ‘mapping’ with secondary social studies students. Several previous researchers also mentioned the issue of providing sufficient practice for students (Dunston, 1992; Moore & Readence, 1984; Novak & Gowan, 1984). Consistently more positive data on learner gains were reported when students were provided with instruction and practice with GOs. However, these studies involved participants that were almost exclusively secondary or higher education level. This research offers evidence of the importance of prior instruction and practice for students at the *elementary* level. Another consideration is that conclusions have been drawn by comparing data *between* studies involving various levels of instruction in the use of GOs. Findings from this study offer support for the conclusions of these researchers, but draw these conclusions from within one research context instead of comparing results from several studies that may have been affected by differing variables.

GOs are a tool for which skill is required in order to be utilized effectively. Just like other learning tools or strategies such as outlining or taking notes, students must practice the skill and understand how to use it as a tool before its benefit can be realized. Based on how students may have practiced ‘learning’ in prior years, they may jump to the conclusion that GOs are simply another method of memorizing a predetermined set of information without sufficient instruction/practice. This assumption is important because it has the potential to negate any benefit toward *meaningful* learning, which was the original and consistent purpose of GOs.

A final piece of this issue to be considered is the reality that most research on GOs does *not* mention the issue of instruction and practice with participants before data is collected. Since these studies discussed above (Avery, Baker, & Gross, 1997; Dunston, 1992; Moore & Readence, 1984; Novak & Gowan, 1984) have documented evidence of the effect on the results of student gains, it makes sense that the presence or lack of instruction/practice has had an effect on all research results conducted on GOs. How may the consideration of this variable have changed the results and conclusions drawn from other studies?

GOs as an assessment tool. As discussed in the previous section, it became clear as data collection progressed that many of the focus students who had not been historically successful in the school context when assessed through traditional means were able to communicate a large amount of complex, organized knowledge by using GOs as a vehicle. Some of the most striking moments during this research occurred during interviews with individual focus students when both the researcher and the student participant realized that the student was in command of a lot more content knowledge than previously thought. For example, despite the fact that he was not usually successful as assessed by standard school grading practices, Jackie Chan's independently designed final GO (Artifact P4) reflected his correct and complete understanding of the concept of pollution and conservation. Also surprising to the researcher was the level of complexity and interconnectedness with knowledge originating from sources other than recent classroom instruction. Siberious Wilderus' final GO (described in Chapter 4) included an extensive amount of additional knowledge from other sources as well as an accurate, complex display of information presented in the classroom curriculum. Almost all of the focus students were successful in communicating *more* knowledge as well as knowledge that was more *complex and interconnected* than their typical classroom assessments reflected.

This potential toward usefulness as an assessment tool was also supported by Mrs. B who talked about the idea that GOs offer students a means of “channeling” their thoughts. Based on her underlying concern that many of her students were not experiencing success in school because they were unable to demonstrate their knowledge through conventional methods, she talked about GOs as being an alternate means of communicating what they knew. This evidence further supports the work of Wallace, Mintzes, and Markham (1992) whose results found student gains when they were assessed using concept maps whereas no gain was measured as indicated on standardized test scores. This characteristic as a vehicle for communicating knowledge has the potential to be extremely important in classrooms, especially for those students who have substantial content knowledge but are not capable of expressing it through conventional means.

Individualized instruction within the classroom context. It is not a new idea that GOs are an instructional strategy that has the potential to enhance student learning (Dunston, 1992; Hyerle, 1996; Marzano, Pickering, & Pollack, 2001; Moore & Readence, 1984). What is clearly indicated from this particular study is that GOs accomplish this enhancement of student learning in different ways with each different type of learner. The 10 focus students who participated in this research were extremely diverse in learning style, school achievement level, and motivation. Despite these differences, it is clear that the GO strategies did benefit every student, although each in a different way according to each learner's individual needs.

For example, Daisy was motivated to participate during classroom activities, a behavior that was not typical for her. While intellectually capable but not successful by regular classroom standards, Foxer and Buggy were able to express their extensive knowledge visually as well as orally. Already successful in the classroom setting, Subzero and Uranus were able to express their prior knowledge with appropriate complexity as opposed to a list of disconnected factual information. Siberious Wilderus was able to communicate and connect his related knowledge that extended beyond the content presented during class. Peel discovered that he had a lot more knowledge than he realized and his self-confidence was boosted to the point of positively affecting his motivation to learn. All of these things occurred in response to the same instruction offered to all students. Perhaps this is the greatest advantage of all in using GOs -- they have the potential to help teachers address the differing needs of diverse learners within the context of the same classroom.

Future Research

Appropriate implementation and use. While this and prior research strongly support the premise that GO strategy enhances student learning, the *type* of learning that takes place is dependent on the *way* the strategy is implemented and utilized in the classroom. It would be very easy for a teacher who had no experience or instruction in effective GO usage to design a series of frameworks to represent specific student content knowledge to target, give the pre-designed visual structures to students, and have them memorize the information in that form. While the two teacher participants were interested and supportive of the GO activities used during instruction, neither demonstrated a clear understanding of the connection between the instructional strategy and the goal of higher level thinking in the students. Mrs. H's first thoughts were of the potential benefit of GOs to organize her students' desks and materials; not their knowledge. Mrs. B resorted to familiar picture drawing in her directions to communicate student knowledge despite the researcher having left directions for students to design a GO. Both asked to keep copies of the GO structures designed for the study so they could make posters to display for students the next year rather than guide the students to create them.

Dunston (1992) states in her critique of multiple studies conducted on the effects of GOs that most were conducted solely on teacher-constructed frameworks presented to students. Most included no training on GO use and employed very short treatment periods. This scenario could completely neutralize the benefits of cooperative socialization, reconstruction of knowledge, and student communication of their understanding of the content as well as some part of the student motivation. Examining this variable may even call into question the accuracy of conclusions drawn in earlier research about the effectiveness of GOs on student achievement. Merkley and Jefferies (2000) mentioned this issue as a factor that may determine effectiveness, but did not explore it in depth.

Teachers need instruction and the resulting awareness of the connection between *how* GO strategies can be utilized in the classroom and the specific effects those choices have on the *type* of student learning that takes place. What things need to be considered in developing appropriate teacher education on GOs relating to the purpose, usage, and influences on student learning?

Interdisciplinary immersion. Most previous research investigating the effectiveness of GO strategy has been designed to have a narrow focus on one specific content area. For example, Baumann and Bergeron (1993), Clarke (1991), Dunston (1992), and Smith (1978) narrowed their research to literacy. Mason (1992), Roth (1994), and Guastello et al. (2000) focused on science. Avery et al. (1997) considered only social studies instruction and Monroe (1998) addressed only mathematics instruction. In order to accomplish the purpose and timeline parameters required to conduct this study, it was similarly necessary to limit the student knowledge involved in the study to science content.

Despite these facts, one of the main purposes of GOs is to aid in seeking out and highlighting the *connections* between bodies and components of knowledge, which are seldom clearly separated by distinct lines between content areas. This study reflected respect for the connectedness of content areas by including history/social science and reading curriculum related to the designated science curriculum (Appendix D). The overlapping knowledge was reflected in GOs guided by the researcher/teacher and used in instruction as well as the children's literature selected to support both content areas (Appendix E). Many of the students demonstrated this interdisciplinary perspective through their own GO designs. For example, Subzero and Peel included story characters in their GOs on conservation/pollution (Appendixes N4 and M4), and Siberious Wilderus expanded his GO on natural resources to include human resources and capitol resources (described on page 78).

Although many schools separate core content areas from each other through time schedules and separate teachers, the use of GOs by teachers in *all* content areas may be a link between them. This strategy could counteract the student (and teacher) misconception that clear lines separate knowledge into neatly divided subject area categories. This sort of connection across content areas would allow teachers to review and reinforce content from other classes in addition to their own; showing students that *all* knowledge is connected. Research needs to be conducted in contexts that include the same student population across multiple content areas so students are immersed in and experts at utilizing GOs as a tool for learning. Once they understand how GOs work and accomplish the initial ability to use them effectively, the possibility of multiplying the benefit for the same student population across the curriculum could be investigated.

Struggling learners. Although some studies such as those conducted by Doyle (1999) and Mastropieri, Scruggs, and Graetz (2003) have reported findings on using GOs specifically targeting students diagnosed with learning disabilities, further investigation into these types of student populations is warranted. With the current national climate influenced by requirements toward basing important educational decisions for individual students on high-stakes test results, GO strategies may offer an additional, underutilized instructional tool with which to enhance student understanding and support student confidence through success.

Remediation plans mandated by the federal No Child Left Behind legislation are required of all participating school systems. Since this plan provides for no accommodations for special needs students during standardized testing, failing students are required to participate in remediation programs that include extra time on additional academic instruction. Suen, Sonak, Zimmaro, and Roberts (1997) suggest that concept maps function as scaffolds to supporting learning. GOs may offer these students an instructional option that addresses their needs of self-confidence through success, motivation to participate and learn, and identification of important core content information.

Academically diverse classroom populations. This study suggests that GOs are an effective strategy to use with a wide range of learners. However as discussed above, much of the existing research on the effectiveness of GOs has been conducted in classroom contexts that include a relatively narrow type of student academic population. Research contexts have often targeted a specific grade level, content area, or achievement level. Similarly to the above list of content area groups and learning disabled students, findings from many researchers such as Guastello, Beasley, and Sinatra (2000) who targeted low-achieving inner-city seventh graders and Roth (1994) focused on high-achieving, upper middle class high school physics students can be applied only in highly specific situations and populations.

In order to gain an accurate picture of the potential of GOs as the basis for instruction in the real world of classroom instruction, future research needs to target more academically diverse contexts. The recent common practice of inclusion of special needs students in regular classroom environments is causing teachers to face broad differences in student ability. Many teachers are expected to be responsible for addressing a spectrum of diverse academic levels within the context of their own classrooms. Few have the training to effectively deal with this situation. Based on the findings of this study in which the academic levels of the student population were extremely diverse, subsequent research on this issue is needed to identify specific ways to use GOs effectively to address academically diverse student populations.

Process-not product. Roth (1994) used multiple methods of data collection in his study examining process when GO strategies were used during instruction. Several researchers such as Wallace, Mintzes, and Markham (1992) and Jones (1992) targeted process but mostly through quantitative methods. Other than these few, the bulk of previous research has consistently utilized the pre/post achievement comparison format. Measurements were taken before and after the use of GOs, compared, and the differences reported and discussed. This design has the capability to accurately indicate *how much* learning occurred during the data collection period, but it does not have the ability to determine the process of *how* learning occurred or the nature of that learning.

Considering the current national climate in education which continues to move in the direction of narrowing curriculum and instructional strategies as discussed in Chapter 1, future research needs to focus on the *process* of learning as it is taking place and move away from a simplistic pre/post measurement. This type of design will offer insights on *how* GOs work and the *kind* of learning that results from various activities that utilize them. Answers to these questions can give practitioners a better idea of how to maximize the benefit of GOs beyond rote memorization to support higher level thinking processes.

Connection between GOs and sorting. In his research on effective instructional strategies, Marzano (2001) ranks the identification of similarities and differences as the single most effective learning strategy and suggests that it “might be the core of all learning” (p. 14). Other than Marzano, few researchers have discussed a connection between GOs and sorting activities. The process of identifying similarities and differences in order to determine by characteristic whether items do or do not fit together in groups is the basis of what is commonly referred to as ‘sorting’ activities. This same process is the essence of the links and cross-links within the complex organizational structure of GOs.

The relatedness of these two concepts based on the same thought process needs to be investigated. Inquiry could focus on whether they already overlap in definition/usage or if each is a distinct strategy that enhances the other. More information on these strategies could not only benefit researchers in clarifying previous findings on each strategy, but also practitioners in utilizing them to their full potential in classrooms.

Concluding Statement

Research has been conducted on the use of GOs in all content areas, in various contexts, at all points throughout instruction, and with all ages of learners. GOs have been utilized as an advance organizer, an instructional strategy, a tool toward creativity and knowledge acquisition, a visual representation of text, a vehicle to communicate knowledge, a study guide, and an assessment. Perhaps versatility is the greatest asset and the greatest obstacle of GOs at the same time. This versatility has often caused conflicting data and confusing findings as researchers and practitioners continue to experiment with GOs in diverse contexts and situations.

Two things are clear from the evidence to date: (a) GOs hold huge potential to positively affect student learning, and (b) we need to learn more about the process of *how* GOs affect student learning. From their origin with Ausubel (1963, 1968) through Novak and Gowan (1984) and recently, David Hyerle (1996), the purpose of GOs has been and remains ‘to promote meaningful learning.’ Few instructional strategies have the ability to support a spectrum of student learning from basic memorization throughout constructing organized, complex knowledge.

Considering the current national climate which has resulted in a narrowing of the curriculum, and consequently, a narrowing of student learning toward rote memorization, we must explore the apparent potential of GOs to address all of these multiple concerns. Classroom instruction that addresses the needs of all of the participants in public education including politicians, taxpayers, administrators, teachers, parents, and most importantly, students *is* possible. An instructional tool/strategy that motivates students to participate in learning, produces increased student learning as measured by multiple means, possesses the versatility to support various types of learning, and demonstrates the capacity to address differing student needs within the same classroom context needs to be utilized to its fullest. GOs offer one of many effective solutions to support student learning for standardized tests as well as student learning for problem solving and higher-level thinking.

In essence, GOs can be a tool through which students can construct knowledge that is meaningful and useful; 'expert' knowledge (Bransford et al., 2000). By the same token, GOs can be used by teachers as a strategy to promote the construction of 'expert' knowledge in students. Only when knowledge is organized into complex networks in a way that allows it to be accessed can it be meaningful or useful. David Hyerle (1996) reminds us:

> Many systems --- like a social system, moral code, ecosystem, solar system, or the human mind-body system --- have the qualities of being dynamic, overlapping, elegantly complex, and interrelated. Thus, *if* we want our students to understand and make predictions about interdisciplinary, nonlinear systems, we are not

> providing the needed tools for them to effectively meet what we and the world expect (1996, p. 12).

If we expect our children to be able to function in the future as productive, responsible citizens of the world, then we must offer them the tools and model the strategies that will support them in constructing the expert knowledge they will need. We must teach them how to process information, organize concepts, and communicate knowledge. We must teach them how to learn; how to think.

References

Allington, R. L. (Ed.) (2002). *Big brother and the national reading curriculum: How ideology trumped evidence.* Portsmouth, NH: Heineman.

Alvermann, D., & Boothby, P.R. (1982, September). *A strategy for making content reading successful: Grades 4-6.* Paper presented at the annual meeting of the Plains Regional Conference of the International Reading Association, Omaha, NE.

Alvermann, D., & Boothby, P.R. (1986). Children's transfer of graphic organizer instruction. *Reading Psychology: An International Quarterly, 7*(2), 87-100.

The American Heritage Dictionary of the English Language (4th ed.). (2000). Retrieved on September 20, 2005 from http://dictionary.reference.com/search?q=complex

Amrein, A. L., & Berliner, D. C. (2003). The testing divide: New research on the intended and unintended impact of high-stakes testing. *Peer Review, 5*(2), 31-32.

Anderson, L. W., & Krathwohl, D. R. (2000). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives.* Reading, MA: Addison-Wesley.

Ausubel, D. P. (1960). The use of advanced organizers in the learning and retention of meaningful behavior. *Journal of Educational Psychology, 51,* 267-272.

Ausubel, D. P. (1963). *The psychology of meaningful verbal learning.* New York: Grune & Stratton.

Ausubel, D. P. (1968). *Educational psychology: A cognitive view.* New York: Holt, Rinehart, & Winston.

Avery, P. G., Baker, J., & Gross, S. H. (1997). "Mapping" learning at the secondary level. *The Clearing House, 70,* 279-285.

Baker, R. L. (1977). Meaningful reception learning. In H. L. Herber & R. T. Vacca (Eds.), *Research in reading in the content areas: The third report* (pp. 32-35). Syracuse, NY: Syracuse University, Reading and Language Arts Center.

Barksdale-Ladd, M. A., & Thomas, K. F. (2000). What's at stake in high stakes testing: Teachers and parents speak out. *Journal of Teacher Education*, *51*, 384-397.

Barron, R. F. (1969). The use of vocabulary as an advance organizer. In H. L. Herber & P. L. Sanders (Eds.), *Research in reading in the content areas: First year report* (pp. 29-39). Syracuse, NY: Syracuse University, Reading and Language Arts Center.

Barron, R. F. (1980). *A systematic research procedure, organizers, and overviews: An historical perspective.* Paper presented at the meeting of the National Reading Conference, San Diego.

Barron, R. F., & Stone, V. F. (1974). Effect of student-constructed graphic post organizers upon learning vocabulary relationships. In P. L. Nacke (Ed.), *Interaction: Research and practice for college-adult reading.* Twenty-third Yearbook of the National Reading Conference. Clemson, SC: National Reading Conference.

Baumann, J. F., & Bergeron, B. S. (1993). Story map instruction using children's literature: Effects on first graders' comprehension of central narrative elements. *Journal of Reading Behavior, 25*(4), 407-437.

Berry, S., Guzy, J., Keelan, K., Kolinski, E., & Kuknyo, K. (1999). Improving children's writing. (Master's thesis, Saint Xavier University, 1999).

Bloom, B. S. (1956). *Taxonomy of educational objectives. Handbook I: Cognitive domain.* New York: McKay.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.

Bransford, J. D., Franks, J. J., Vye, N. J., & Sherwood, R. D. (1989). New approaches to instruction: Wisdom can't be told. In S. Vosniadou & A. Ortony (Eds.), *Similarity and analogical reasoning.* Cambridge, UK: Cambridge University.

Carr, S. C. & Thompson, B. (1996). The effects of prior knowledge and schema activation strategies on the inferential reading comprehension of children with and without learning disabilities. *Learning Disabilities Quarterly, 19,* 48-61.

Carroll, L., & Leander, S. (2001). Improving student motivation through the use of active learning strategies. (Master's thesis, Saint Xavier University, 2001)

Chi, M. T. H., Feltovich, P. J., & Glaser, R. (1981). Categorization and representation of physics problems by experts and novices. *Cognitive Science, 5*, 121-152.

Clarke, J. H. (1991). Using visual organizers to focus on thinking. *Journal of Reading, 34*, 526-534.

Cliburn, J. W. (1986). Using concept maps to sequence instructional materials. *Journal of College Science Teaching, 15*(4), 377-379.

Cliburn, J. W. (1990). Concept maps to promote meaningful learning. *Journal of College Science Teaching,* ( ), 212-217.

Darling-Hammond, L., & Wise, A. E. (1985). Beyond standardization: State standards and school improvement. *Elementary School Journal, 85,* 315-336.

deGroot, A. D. (1965). *Thought and choice in chess.* The Hague, the Netherlands:

Mouton.

Doyle, C. (1999). *The use of graphic organizers to improve comprehension of learning disabled students in social studies.* (ERIC Document Service No. ED427313).

Duffy, G. G. (1991). What counts in teacher education? Dilemmas in educating empowered teachers. In J. Zutell & S. McCormick (Eds.), *Learner factors/teacher factors: Issues in literacy research and instruction* (pp.1-17). Chicago: National Reading Conference.

Dunston, P. J. (1992). A critique of graphic organizer research. *Reading Research and Instruction, 31*, 57-65.

Dye, G. E. (2000). Graphic organizers to the rescue! Helping students link and remember—information. *Teaching Exceptional Children, 32*, 72-76.

Earle, R. A. (1969). Use of the structured overview in mathematics classes. In H. L. Herber & P. L. Sanders (Eds.), *Research in reading in the content areas: First year report* (pp. 49-58). Syracuse, NY: Syracuse University, Reading and Language Arts Center.

Eggen, P. D. & Kauchak, D. P. (2001). *Strategies for teachers: Teaching content and thinking skills* (4th ed.). Needham Heights, MA: Allyn and Bacon.

Emerson, R. M., Fretz, R. I., & Shaw, L. L. (1995). *Writing ethnographic fieldnotes.* Chicago: University of Chicago.

Estes, T. H., Mills, D. C., & Barron, R. F. (1969). Three methods of introducing students to a reading-learning task in two content subjects. In H. L. Herber & P. L. Sanders (Eds.), *Research in reading in the content areas: First year report* (pp. 40-47). Syracuse, NY: Syracuse University, Reading and Language Arts Center.

Fisher, D., Frey, N., & Williams, D. (2002). Seven literacy strategies that work. *Educational Leadership,60*(3), 70-73.

Gergen, K. J. (1995). Social construction and the educational process. In L. P. Steffe & J. Gale (Eds.), *Constructivism in education* (pp. 17-39). Hillsdale, NJ: Lawrence Erlbaum Associates.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research.* Hawthorne, NY: Aldine de Gruyter.

Glesne, C., & Peshkin, A. (1992). *Becoming qualitative researchers: An introduction.* White Plains, NY: Longman.

Gordon, S., & Reese, M. (1997). High stakes testing: Worth the price? *Journal of School Leadership, 7*, 345-368.

Griffin, C. C., & Tulbert, B. L. (1995). The effect of graphic organizers on students' comprehension and recall of expository text: A review of the research and implications for practice. *Reading and Writing Quarterly, 11,* 73-89.

Guastello, E. F., Beasley, T. M., & Sinatra, R. C. (2000). Concept mapping effects on science content comprehension of low-achieving inner-city seventh graders. *Remedial and Special Education, 21,* 356-374.

Guth, N. D. (2000). *The influence of state curriculum standards and accountability testing on fifth grade literacy instruction: The perspectives of three teachers and six students.* Unpublished doctoral dissertation, George Mason University.

Hawk, P. (1986). Using graphic organizers to increase achievement in middle school life science. *Remedial and Special Education, 70,* 81-87.

The Hawthorne Effect: Mayo studies motivation. (2005, August). *Envision Software*.

Retrieved August 5, 2005, from http://www.envisionsoftware.com/articles/Hawthorne_Effect.html

Heimlich, J. E., & Pittelman, S. D. (1986). *Semantic mapping: Classroom applications.* Newark: International Reading Association.

Heinze-Fry, J. A., & Novak, J. D. (1990). Concept mapping brings long-term movement toward meaningful learning. *Science Education, 74*, 461-472.

Hendry, G. D. (1996). Constructivism and educational practice. *Australian Journal of Education*, *40*(1), 19-45.

Herman, J. & Golan, S. (1990). *Effects of standardized testing on teachers and learning – another look.* (CSE Technical Report No. 334). Los Angeles: Center for the Study of Evaluation, University of California at Los Angeles.

Hewson, M. G., & Hewson, P. W. (1983). Effect of instruction using students' prior knowledge and conceptual change strategies on science learning. *Journal of Research in Science Teaching, 20*, 731-743.

Hinzman, K. P. (1997). Use of manipulatives in mathematics at the middle school level and their effects on students' grades and attitudes. (ERIC Document Reproduction Service No. ED 411150).

Hoffman, J., Assaf, L., & Paris, S. (2001). High-stakes testing in reading: Today in Texas, tomorrow? *The Reading Teacher, 54,* 482-492.

Horton, P. B. (1993). An investigation of the effectiveness of concept mapping as an instructional tool. *Science Education, 77,* 95-111.

Hyerle, D. (1996). *Visual tools for constructing knowledge.* Alexandria, VA: Association for Supervision and Curriculum Development.

Imig, D. G. (1997). Foreword. In V. Richardson (Ed.), *Constructivist teacher education: Building a world of new understandings* (pp. vii-viii). Bristol, PA: Falmer.

Jehlen, A. (2003). High-stakes questions. *NEA Today, 21*(6), 8-11.

Johnston, P. (1998). The consequences and the use of standardized tests. In S. Murphy (Ed.), *Fragile evidence: A critique of reading assessment* (pp. 89-101). Mahwah, NJ: Lawrence Erlbaum.

Johnston, P., Afflerbach, P., & Weiss, P. (1993). Teachers' evaluation of the teaching and learning of literacy and literature. *Educational Assessment, 1*, 91-117.

Johnston, P., Guice, S., Baker, K., Malone, J., & Michelson, N. (1995). Assessment of teaching and learning in "literature based" classrooms. *Teaching and Teacher Education, 11*, 359-371.

Jones, J. (1992). *Conceptual development in introductory biology: A longitudinal study.* Unpublished master's thesis, University of North Carolina at Wilmington.

Jones, M. G., Andre, T., Kubasko, D., Bokinsky, A., Tretter, T., Negishi, A., Taylor, R., & Superfine, R. (2004). Remote atomic force microscopy of microscopic organisms: Technological innovations for hands-on science with middle and high school students. *Science Education, 88,* 55-61.

Koczor, M. L. (1984). *Effects of varying degrees of instructional alignment in posttreatment tests on mastery learning tasks of fourth grade children.* Unpublished doctoral dissertation, University of San Francisco, California.

Labaree, D. F. (2003). The particular problems of preparing educational researchers. *Educational Researcher, 32*(4), 13-22.

Leedy, P. D., & Ormrod, J. E. (2001). *Practical research: Planning and design.* Upper

Saddle River, NJ: Prentice-Hall.

Markham, K. M. (1992). The structure and use of biological knowledge of mammals in novices and experienced students. M. S. Thesis, University of North Carolins at Wilmington.

Marzano, R., Pickering, D., & Pollack, J. (2001). *Classroom instruction that works: Research based strategies for increasing student achievement.* Alexandria, VA: Association for Supervision and Curriculum Development.

Mason, C. L. (1992). Concept mapping: A tool to develop reflective science instruction. *Science Education, 76,* 51-63.

Mastropieri, M. A., Scruggs, T. E., & Graetz, J. E. (2003). Reading comprehension instruction for secondary students: Challenges for struggling students and teachers. *Learning Disability Quarterly, 26*, 103-116.

McMillan, J. H., Myran, S., & Workman, D. (1999). *The impact of mandated statewide testing on teachers' classroom assessment and instructional practices.* Paper presented at the annual meeting of the American Educational Research Association, Montreal, Canada.

McNeil, L. M. (2000). *Contradictions of reform: The educational costs of standardization.* New York: Routledge.

McLaughlin, M. W. (1994). Educational policy, impact on practice. In M. Aiken (Ed.), *American Educational Research Association Encyclopedia of Educational Research* (pp. 375-382). New York: McMillan.

Merriam, S. B. (2001). *Qualitative research and case study applications in education.* San Francisco: Jossey-Bass.

Merriam-Webster's Medical Dictionary (2002). Retrieved September 20, 2005, from http://dictionary.reference.com/search?q=complex

Merriam-Webster Online Dictionary (2005). Retrieved September 20, 2005, from http://www.m-w.com/cgi-bin/dictionary?book=Dictionary&va=complex

Merkley, D. M., & Jefferies, D. (2000). Guidelines for implementing graphic organizers. *The Reading Teacher, 54,* 350-364.

Meyen, E. L., Vergason, G. A., & Whelan, R. J. (1996). *Strategies for teaching exceptional children in inclusive settings.* Denver, CO: Love.

Miller, G. A. (1956). The magical number seven, plus or minus two. Some limits on our capacity to process information. *Psycological Review, 63*, 81-87.

Milloy, M., Winams, D., Jehlen, A., Loschert, K., & O'Neil, J. (2003). No child left behind? *NEA Today, 21*(8), 20-26.

Monroe, E. E. (1998). Using graphic organizers to teach vocabulary: Does available research inform mathematics instruction? *Education, 118,* 538-541.

Moore, D. W., & Readence, J. E. (1984). A quantitative and qualitative review of graphic organizer research. *Journal of Educational Research, 78,* 11-17.

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform.* Washington, DC: Government Printing Office.

No Child Left Behind (n.d.). Retrieved April 22, 2003, from http://www.nclb.gov/

Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn*. Cambridge: Cambridge University Press.

Novak, J. D., Gowin, D. B., & Johansen, G. T. (1983). The use of concept mapping and knowledge vee mapping with junior high school science students. *Science Education, 67*(5), 625-645.

Payne, R. (2001). *A framework for understanding poverty.* Highlands, TX: Aha Process.

Penn, C., Shelley, S., & Zaininger, L. (1998). *Enhancing transfer of learning among seventh graders*. (ERIC Document Reproduction Service No. ED 422117).

Piaget, J. (1952). *The origins of intelligence in children.* New York: International Universities Press.

Piaget, J. (1978). *Success and understanding.* Cambridge, MA: Harvard University Press.

Plotnik, E. (2001). A graphical system for understanding the relationship between concepts. *Teacher Librarian, 28(4),* 42-48.

Reinking, D., & Bradley, B. A. (in press). Connecting research and practice using formative and design experiments. In N. Duke & M. Mallette (Eds.), *Literacy research methods*. New York: Guilford Press.

Rewey, K. L., Dansereau, D. F., & Peel, J. L. (1991). Knowledge maps and information processing strategies. *Contemporary Educational Psychology, 16*, 203-214.

Rice, G. E. (1994). Need for explanations in graphic organizer research. *Reading Psychology: An International Quarterly, 15*, 39-67.

Richardson, V. (1997). Constructivist teaching and teacher education: Theory and practice. In V. Richardson (Ed.), *Constructivist teacher education: Building a world of new understandings* (pp. 3-14). Bristol, PA: Falmer.

Robinson, D. H., Katayama, A. D., Dubois, N. F., & Devaney, T (1998). Interactive effects of graphic organizers and delayed review on concept application. *Journal of Experimental Education, 67*, 17-31.

Romance, N. R., & Vitale, M. R. (1999). Concept mapping as a tool for learning. *College Teaching, 47(2)*, 74-85.

Ross, B., & Munby, H. (1991). Concept mapping and misconceptions: A study of high school students' understanding of acids and bases. *International Journal of Science Education, 13*, 11-24.

Roth, W. –M. (1994). Student views of collaborative concept mapping: An emancipatory project. *Science Education, 78*, 1-34.

Roth, W. –M., & Roychoudhury, A. (1992). The Social construction of scientific concepts or the concept map as a conscription device and tool for social thinking in high school science. *Science Education, 76*, 531-557.

Rust, A. L. (1999). A study of the benefits of math manipulatives versus standard curriculum in the comprehension of mathematical concepts. (ERIC Document Reproduction Service No. ED 436395)

Sabers, D. S., Cushing, K. S., & Berliner, D. C. (1991). Differences among teachers in a task characterized by simultaneity, multidimensionality, and immediacy. *American Educational Research Journal, 28*, 63-88.

Sclafani, S. (2002). No child left behind. *Issues in Science and Technology, 19*(2), 43-47.

Seidman, I. (1998). *Interviewing as qualitative research: A guide for researchers in education and the social services.* New York: Teachers College.

Shannon, P. (2001). *Becoming political, too.* Portsmouth, NH: Heineman.

Shepard, L. A. (2002). The hazards of high-stakes testing. *Issues in Science and Technology, 19*(2), 53-58.

Shepard, L. A., & Dougherty, K. C. (1991, April). *Effects of high-stakes testing on* *instruction.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Simmons, D. C., Griffin, C. C., & Kameenui, E. J. (1988). Effects of teacher constructed pre- and post-graphic organizer instruction on sixth grade science students' comprehension and recall. *Journal of Educational Research, 28,* 15-21.

Simon, H. A. (1980). Problem solving in education. In D. T. Tuma & R. Reif (Eds.), *Problem solving and education: Issues in teaching and research.* Hillsdale, NJ: Erlbaum.

Smith, A. L. (1978). The structured overview: A pre-reading strategy. In J. L. Vaughan, Jr. & P. J. Gaus (Eds.), *Research on reading in secondary schools (vol. 2).* Tucson: University of Arizona, Reading Department.

Smith, F. (1998). *The book of learning and forgetting.* New York: Teachers College Press.

Smith, M. L. (1991a). Put to the test: The effects of external testing on teachers. *Educational Researcher, 20*(5), 8-11.

Smith, M. L. (1991b). *The role of testing in elementary schools.* Los Angeles, CA: Center for Research on Evaluation, Standards, and Student Testing.

Smith, M. L., & Fey, P. (2000). Validity and accountability in high-stakes testing. *Journal of Teacher Education, 51*(5), 334-344.

Smith, M. L., Edelsky, C., Draper, K., Rottenburg, C., & Cherland, M. (1991). *The role of testing in elementary schools* (CSE Tech. Rep. No. 321). Los Angeles: Center for the Study of Evaluation, University of California at Los Angeles.

Stahl, N. (2003, April 21). Funding issues associated with no child left behind act.

Message posted to nrcemail@asu.edu

Steffe, L. P., & Gale, J. (1995). *Constructivism in education.* Hillsdale, NJ: Erlbaum.

Strauss, A. L., & Corbin, J. M. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* Newbury Park, CA: Sage Publications.

Suen, H. K., Sonak, B., Zimmaro, D., & Roberts, D. M. (1997). Concept map as scaffolding for authentic assessment. *Psychological Reports, 81*, 714.

Sungur, S, Tekkaya, C., & Geban, O. (2001). The contribution of conceptual change texts accompanied by concept mapping to students' understanding of the human circulatory system. *School Science and Mathematics, 101,* 91-112.

Triplett, C. F., Barksdale, M. A., & Leftwich, P. (in press). *Children's perceptions of high stakes testing*. Manuscript submitted for publication.

Turner, J. (2003). Roanoke county superintendent discusses law with school board. *The Roanoke Times.*

Von Glasersfeld, E. (1995). A constructivist approach to teaching. In L. P. Steffe & J. Gale (Eds.), *Constructivism in education* (pp. 3-15). Hillsdale, NJ: Lawrence Erlbaum Associates.

Virginia Department of Education (n.d.). Retrieved April 22, 2003, from http://www.pen.k12.va.us/

Vygotsky, L. (1978). *Mind in society: The development of the higher psychological processes.* Cambridge, MA: Harvard University.

Wallace, J. D., & Mintzes, J. J. (1990). The concept map as a research tool: Exploring conceptual change in biology. *Journal of Research in Science Teaching 27*(10), 1033-1052.

Wallace, J. D., Mintzes, J. J., & Markham, K. M. (1992). Concept mapping in college science teaching: What the research says. *Journal of College Science Teaching, 22*, 84-86.

Wineberg, S. S. (1991). Historical problem solving: A study of the cognitive processes used in the evaluation of documentary and pictorial evidence. *Journal of Educational Psychology*, *83*, 73-87.

Appendix A

February, 2004

Dear Parents,

I am a graduate student at Virginia Tech and would like to conduct a research project in your child's classroom this school year. This is an exciting opportunity for your child to contribute to our understanding of what teaching tools and methods work best. What we find out in this study will help teachers to be more effective with each student.

This project will be focused on a teaching tool called graphic organizers. There are some examples attached. The teacher will use graphic organizers in various ways and in all subject areas over a four week period during February and March of 2004. He/she will also teach the students how to create and use them on their own. Since research already supports their effectiveness in promoting student learning, I want to explore the process of student think toward more complex and organized knowledge.

In order to study this process, I will collect information in several ways. I will be part observer and part participant in your child's classroom as I collect information by watching and talking to the students. I will also collect samples of the graphic organizers they design to analyze how they have learned.

I plan to allow each child to choose a different name as their 'project name'. Your child's identity will be kept confidential and will not be disclosed in the study report. There is no foreseeable risk to your child as a participant in this study. In fact, you and your child's cooperation may result in great benefit to the teaching field by helping us find out which methods work better than others and why.

No participants in this study will receive any money. You or your child has the right to refuse or withdraw from participation in the study at any time while still remaining a member of the class. If you have any questions or concerns about participation in this study, please contact me at 965-8918. Thank you for your support!

Sincerely,
Carol E. Watson

I agree to allow my child, ___________________, to participate in this study.

____

signature and date

Appendix B

February, 2004

Dear ,

Educational research has always had the potential to offer teachers better and more effective ways to accomplish our goal of meeting the needs of each student. I would like to offer you the opportunity of being a part of a project with just this kind of potential. As a doctoral graduate student at Virginia Tech, I would like to conduct a research study in your third grade classroom during February and March of 2004. This project will be focused on a teaching tool called graphic organizers. A graphic organizer is a visual representation of a concept, its component parts, and how they are connected. The purpose is to help students connect new ideas to prior knowledge making their learning more meaningful. Some examples are included. You will be asked to use graphic organizers in various ways, in several subject areas throughout the four week research period. You will also be asked to teach the students how to create and use them on their own. I am interested in exploring the changes in student thought processes toward more organization and complexity when working with graphic organizers.

In order to find out these things, I plan to collect information in several ways. I will be observing student behavior in the classroom as well as documenting informal conversations with them throughout the study. I will also be documenting your perceptions of what is happening. I will ask students to let me borrow examples of the graphic organizers they design so I can analyze them.

I plan to allow each child to choose a different name as their ‘project name’. All students’ identities will be kept confidential and will not be disclosed in the study report. There is no foreseeable risk to any of the participants in this study. In fact, cooperation may likely result in great benefit to the teaching field by helping to find out which methods work better than others do.

No participants in this study will receive any compensation. All participants have the right to refuse or withdraw from participation at any time. If you have any questions or concerns about this study, please contact me at 965-8918. Thank you for your consideration.

Sincerely,
Carol Watson

I voluntarily agree to participate in this research study.

signature and date

Appendix C

Timeline for Fieldwork

Monday	Tuesday	Wednesday	Thursday	Friday
4/5	4/6	4/7 -visit with 2 teachers -conference with school principal	4/8 -short classroom visit	4/9 -observation and socialization
4/12 -observation and socialization	4/13 -informal discussion to get acquainted -1st artifact collected	4/14 -student interviews -1st day of instruction	4/15 -student interviews -instruction	4/16 -student interviews -instruction
4/19 -instruction	4/20 -instruction -2nd artifact collected	4/21 -school-wide assembly (no class)	4/22 -student interviews -instruction	4/23 -student interviews -instruction
4/26 -student interviews -instruction	4/27 -school-wide music program (no class)	4/28 -instruction	4/29 -instruction	4/30 -teacher work day (no class)
5/3 -instruction-3rd artifact collected	5/4 -student interviews -instruction	5/5 -student interviews -instruction	5/6 -student interviews -instruction	5/7 -instruction
5/10 -instruction -final artifact collected	5/11 -student interviews	5/12 -student interviews	5/13 -student interviews	5/14 -final follow up

Daily science instruction lasted 40 minutes for each of the two class groups.

Appendix D1

Primary Curriculum

Virginia Standards of Learning (Science)

3.11 The student will investigate and understand that natural events and human influences can affect the survival of species. Key concepts include

a) the interdependency of plants and animals;
b) the effects of human activity on the quality of air, water, and habitat;
c) the effects of fire, flood, disease, and erosion on organisms; and
d) conservation and resource renewal.

3.11 The student will investigate and understand different sources of energy. Key concepts include

a) the sun's ability to produce light and heat energy;
b) sources of energy (sunlight, water, wind);
c) fossil fuels (coal, oil, natural gas) and wood; and
d) renewable and nonrenewable energy resources.

Primary Science Concepts

Natural Resources
Sources of Energy
Forms of Energy

Appendix D2

Secondary Curriculum

Virginia Standards of Learning (History/Social Science)

3.12 The student will recognize that Americans are a people of diverse ethnic origins, customs, and traditions, who are united by the basic principles of a republican form of government and respect for individual rights and freedoms.

3.7 The student will explain how producers use natural resources (water, soil, wood, and coal), human resources (people at work), and capital resources (machines, tools, and buildings) to produce goods and services for consumers.

Virginia Standards of Learning (Reading)

3.3 The student will apply word-analysis skills when reading.
a) Use knowledge of all vowel patterns.
b) Use knowledge of homophones.
c) Decode regular multi-syllabic words.

3.5 The student will read and demonstrate comprehension of fiction.
a) Set a purpose for reading.
b) Make connections between previous experiences and reading selections.
c) Make, confirm, or revise predictions.
d) Compare and contrast settings, characters, and events.
e) Identify the author’s purpose.
f) Ask and answer questions.
g) Draw conclusions about character and plot.
h) Organize information and events logically.
i) Summarize major points found in fiction materials.
j) Understand basic plots of fairy tales, myths, folktales, legends, and fables.

3.6 The student will continue to read and demonstrate comprehension of nonfiction.
a) Identify the author’s purpose.
b) Make connections between previous experiences and reading selections.
c) Ask and answer questions about what is read.
d) Draw conclusions.
e) Organize information and events logically.
f) Summarize major points found in nonfiction materials.
g) Identify the characteristics of biographies and autobiographies.
h) Compare and contrast the lives of two persons as described in biographies and/or autobiographies.

Virginia Standards of Learning (Oral Language)

3.1 The student will use effective communication skills in group activities.

a) Listen attentively by making eye contact, facing the speaker, asking questions, and summarizing what is said.
b) Ask and respond to questions from teachers and other group members.
c) Explain what has been learned.

3.2 The student will present brief oral reports.

a) Speak clearly.
b) Use appropriate volume and pitch.
c) Speak at an understandable rate.
d) Organize ideas sequentially or around major points of information.
e) Use grammatically correct language and specific vocabulary to communicate ideas.

Appendix E

Instructional Resources

Literature (fiction)

Brother Eagle, Sister Sky
By Susan Jeffers
The Lorax
By Dr. Seuss
The Heron
From Project WET Resource Book

Literature (non-fiction)

Energy and Fuels
By Troll Associates

Other Resources

-pictures cut from various publications
National Geographic
Ranger Rick
Good Housekeeping
-heron hand puppet

Appendix F1

Natural Resources Manipulative GO

NATURAL RESOURCES

materials that are found in nature and that we use to survive and to live better

oil/petroleum

plants

coal

natural gas

animals

living things

fossil fuels

sunlight

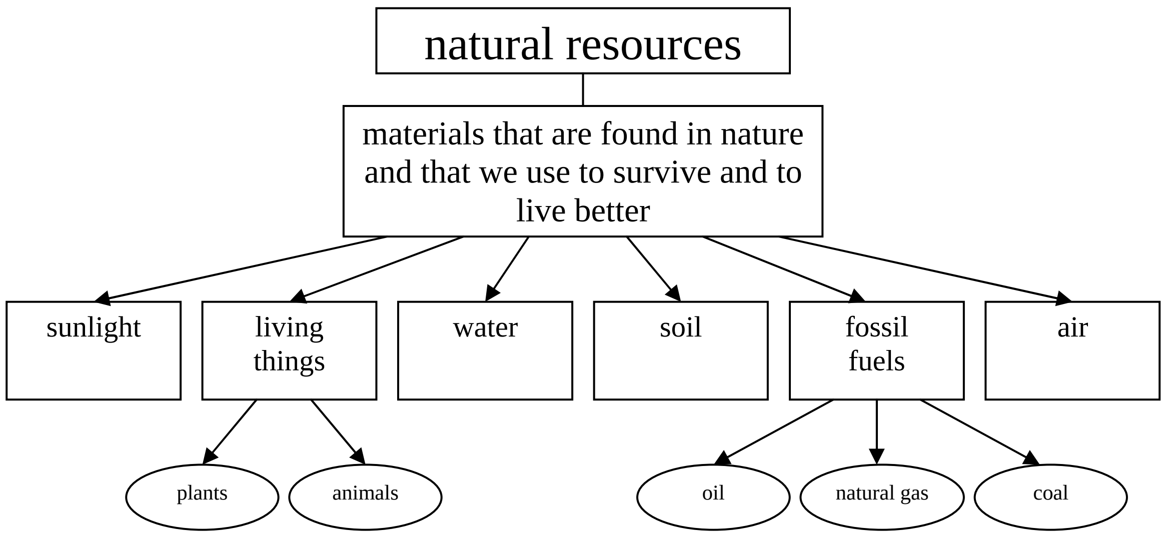
air

water

soil

Appendix F2

Natural Resources GO
(one possible correct arrangement)



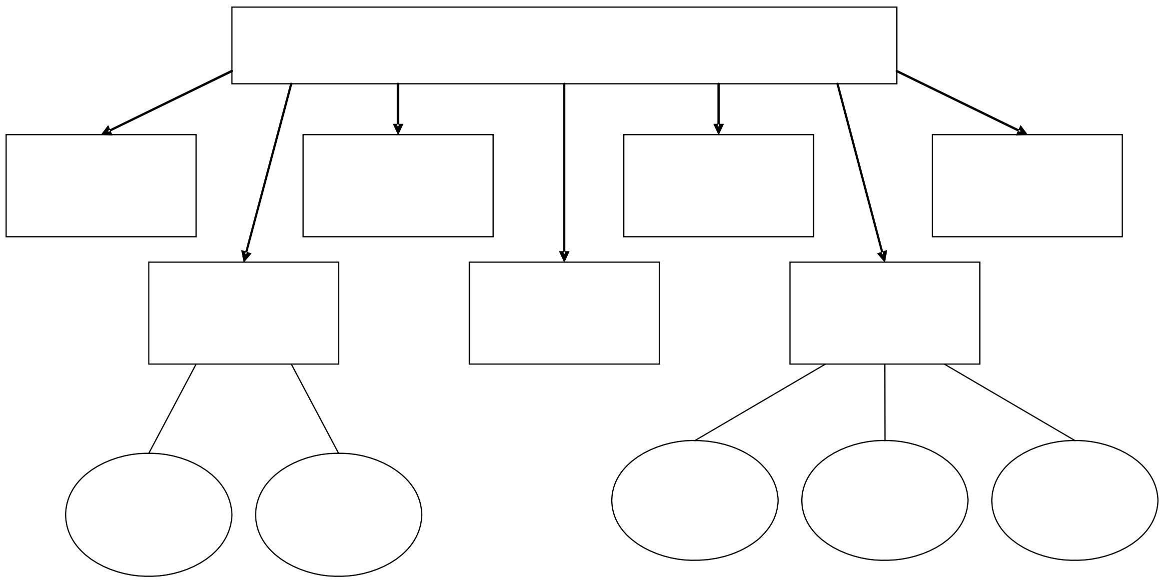
Appendix F3

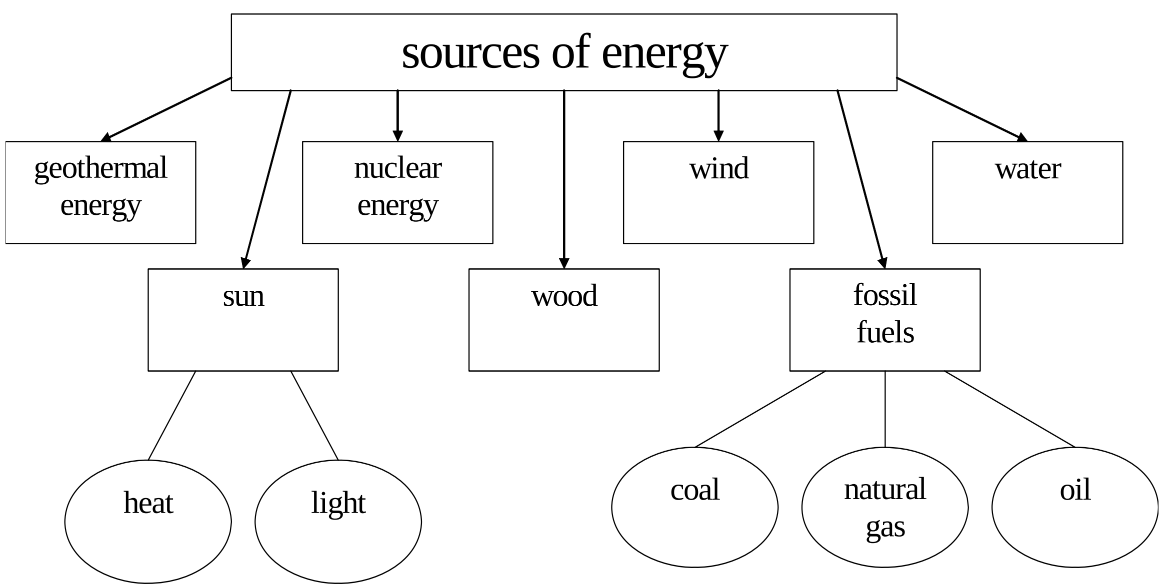
Natural Resources Sort

animals	coal	air
microwave	trees	car
natural gas	water	soil
light bulbs	rocks	food
cement	wind	tape
plastic	paper	fish
oil/gasoline	people	TV

Appendix G1

Sources of Energy GOs





Appendix G2

Sources of Energy Manipulative GO

SOURCES OF ENERGY

geothermal energy	water	sun
nuclear energy	wood	heat
fossil fuels	light	coal
natural gas	wind	oil

Appendix H1

Forms of Energy GO/Sort

FORMS OF ENERGY

renewable
non-renewable

(words to sort)

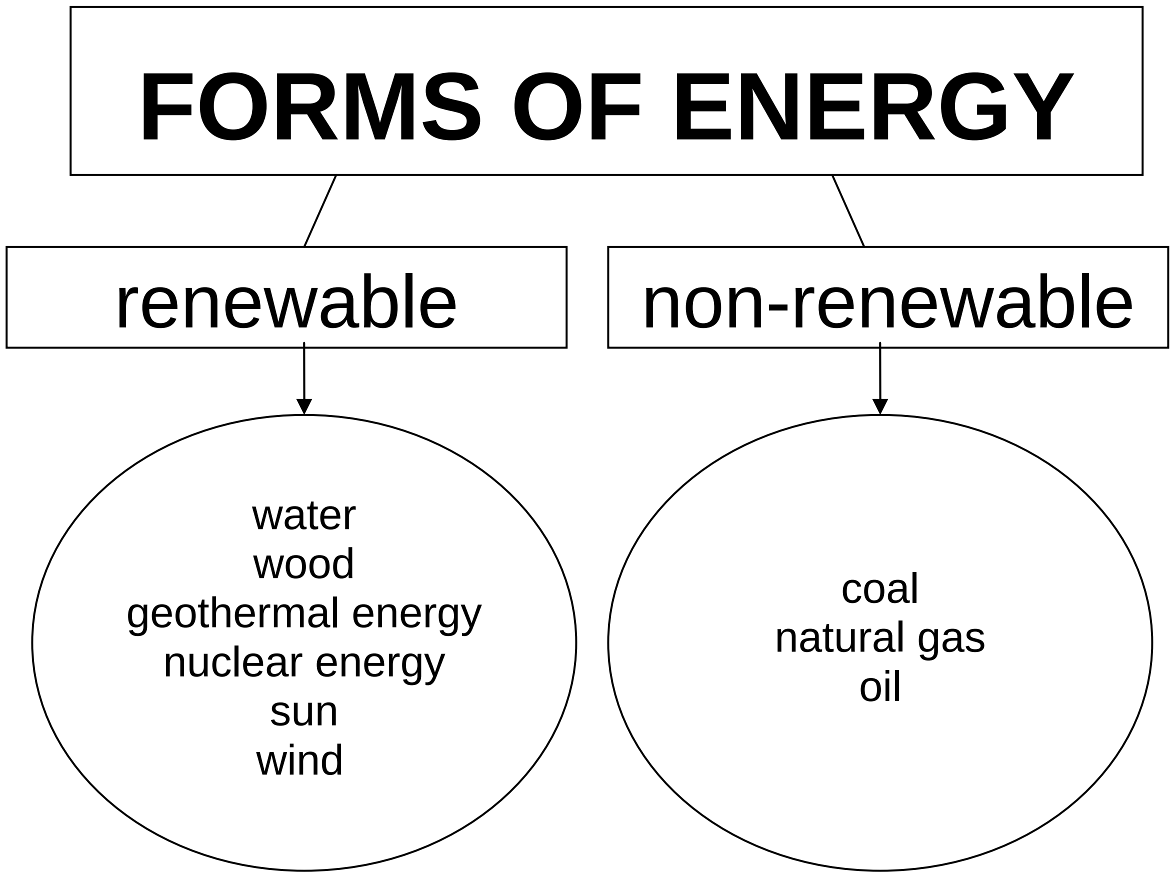
geothermal energy	wood	coal
natural gas	wind	sun
nuclear energy	oil	water

(examples of pictures used to sort)

wind mills	river current	trees
an erupting volcano	a coal mine	a geyser
a nuclear power plant	hot springs	the sun
a gas stove burner	a gas station	sunlight
an oil refinery	a pinwheel	a wood fire
a locomotive engine	solar panels	erosion

Appendix H2

One Possible Accurate Arrangement for Forms of Energy GO/Sort



an erupting volcano
wind mills
river current
trees
a geyser
sunlight
a wood fire
erosion
solar panels
a pinwheel
hot springs
the sun

a locomotive engine
an oil refinery
a gas stove burner
a gas station
a coal mine

Appendix I1

Lesson Plan for 4/14

VA SOLs/Curriculum **Science** The student will investigate and understand that natural events and human influences can affect the survival of species. Key concepts include a) the interdependency of plants and animals; b) the effects of human activity on the quality of air, water, and habitat; c) the effects of fire, flood, disease, and erosion on organisms; and d) conservation and resource renewal. **History/Social Science** The student will explain how producers use natural resources (water, soil, wood, and coal), human resources (people at work), and capital resources (machines, tools, and buildings) to produce goods and services for consumers.
Main Concept(s) -resources -natural vs. man-made -natural resources
Learning Objectives Students will: -identify and list individual objects in the classroom -begin to categorize objects -discuss the where objects come from -begin to understand concept of man-made vs. natural
Materials -white board and markers -laminated pictures of various objects
Procedures -direct student attention to 5 or 6 pictures taped to the board -guided discussion of nature of pictures-similarities and differences, origins, uses -socially construct shared meaning of resources (write on board) -guided discussion of natural vs. man-made resources (apply to displayed pictures) -students discuss and sort 8-10 pictures (in groups of 4) -each group shares their process and conclusions with the class
Assessment - student discussion /teacher observation -individual/small group student sorting choices and reasoning -(eventual) teacher-made assessment

Appendix I2

Lesson Plan for 4/15

VA SOLs/Curriculum **Science** The student will investigate and understand that natural events and human influences can affect the survival of species. Key concepts include a) the interdependency of plants and animals; b) the effects of human activity on the quality of air, water, and habitat; c) the effects of fire, flood, disease, and erosion on organisms; and d) conservation and resource renewal. **History/Social Science** The student will explain how producers use natural resources (water, soil, wood, and coal), human resources (people at work), and capital resources (machines, tools, and buildings) to produce goods and services for consumers.
Main Concept(s) -resources -natural vs. man-made -natural resources
Learning Objectives Students will: -recall and explain concepts or resources and natural vs. man-made -understand the difference between natural and man-made -define and understand what natural resources are -identify and name examples of natural resources
Materials -white board and markers -laminated pictures of various objects -magnetized sorting pockets -GO sorting desk placemats -sorting words (Appendix F3) -student scissors -individual ziploc bags of posterboard geometric shapes
Procedures -activate prior knowledge through discussion of previous class activities -student-led concept review (resources and natural vs. man-made) -pass out pictures-students sort into 2 pockets on board (including reasoning) -students sort words into 2 circles of GO framework on desk placemats (natural resources/**not** natural resources -student sharing and guided discussion of choices -begin GO design (title and definition) for natural resources on board (Appendix F2)-students copy on paper using individual ziploc bags of posterboard geometric shapes
Assessment -student discussion/teacher observation -individual student sorting choices and reasoning -(eventual) teacher-made assessment

Appendix I3

Lesson Plan for 4/16

VA SOLs/Curriculum

Science

The student will investigate and understand that natural events and human influences can affect the survival of species. Key concepts include

a) the interdependency of plants and animals;
b) the effects of human activity on the quality of air, water, and habitat;
c) the effects of fire, flood, disease, and erosion on organisms; and
d) conservation and resource renewal.

History/Social Science

The student will explain how producers use natural resources (water, soil, wood, and coal), human resources (people at work), and capital resources (machines, tools, and buildings) to produce goods and services for consumers.

Main Concept(s)

-resources
-natural vs. man-made
-natural resources

Learning Objectives

Students will:

-recall the general meaning and understanding of natural resources
-recognize and organize the earth's major natural resources
-understand how our natural resources are related to each other

Materials

-white board and markers
-moveable GO components (Appendix F1)
-student scissors

Procedures

-activate prior knowledge through discussion of previous class activities
-students cut components apart and experiment with organization to represent their content knowledge
-guided discussion of components and relationships
-student-driven discussion of placement and organization of components
-guided discussion of interchangeability of some components and reasoning behind it
-challenge to design 4 different correct arrangements of the components (groups of 4)
-groups share with class and support their designs and reasoning

Assessment

-student discussion/teacher observation
-individual student organizational choices and reasoning
-(eventual) teacher-made assessment

Appendix I4

Lesson Plans for 4/19

VA SOLs/Curriculum

Science

The student will investigate and understand that natural events and human influences can affect the survival of species. Key concepts include

a) the interdependency of plants and animals;
b) the effects of human activity on the quality of air, water, and habitat;
c) the effects of fire, flood, disease, and erosion on organisms; and
d) conservation and resource renewal.

History/Social Science

The student will explain how producers use natural resources (water, soil, wood, and coal), human resources (people at work), and capital resources (machines, tools, and buildings) to produce goods and services for consumers.

Main Concept(s)

-resources
-natural vs. man-made
-natural resources

Learning Objectives

Students will:
-recognize and organize the earth's major natural resources
-understand how our natural resources are related to each other
-match concepts of natural resources to real life examples

Materials

-white board and markers
-individual ziploc bags of posterboard geometric shapes
-laminated pictures of various objects
-magnetized sorting pockets

Procedures

-activate prior knowledge by asking about manipulative activity in previous class
-guided construction of complete natural resources GO-modeled on board/students copy on paper using posterboard geometric shapes but may adjust individual designs as long as they reflect accurate information (Appendix F2)
-guided discussion of components and relationships
-student-driven discussion of placement and organization of components
-sort pictures into pockets for components on board
-brainstorm other examples and list under component pockets

Assessment

-student discussion/teacher observation
-individual student organizational choices and reasoning
-(eventual) teacher-made assessment

Appendix J

Transcript of Classroom Discussion

Student-It doesn't matter how much they're mixed around, they're still the same thing.
Teacher-They're still the same thing? What do you mean?
Student-They're just organized differently.
Teacher-But if we organize them differently, doesn't that change the information on the GO?
Student-Well, yes and no.
Teacher-OK. What do you mean?
Student-For some of 'em.
Teacher-Oh. For some of 'em?
Student-Like if you switch living things and fuels, animals and plants aren't fuels.
Teacher-OK, everybody do that – switch living things and fuels.
Student-No! It doesn't make sense!
Teacher-How can we make it make sense?
Student-Switch 'em back!
Teacher-No, you can't switch 'em back. What else can you do?
Student-You can switch the other ones.
Teacher-What other ones?
Student-The coal, all the animals and those examples…
Teacher-All the fuel examples?
Student-OK, go ahead and do that. Make it right but you can't switch the categories back.
Teacher-OK, now I'm gonna throw you off! Put 1 finger on water and 1 finger on animals and switch 'em.
Student-Wrong! That can't make sense!
Teacher-That doesn't make sense? Why?
Student-Cuz water isn't a living thing.
Student-Because then you have big letter under a big letter.
Teacher-Well, what if I just go back to my computer and make the letter size fit? Would it still make sense?
Student-(mumbling and discussion)
Teacher-Can we put animals up here even with air, soil, water, living things, and fuels?
Student-No! Cuz animals isn't a 'category'.
Teacher-OK, I got another one for you. I want you to switch the definition of natural resources with sunlight.
Student-What?! (LOTS of laughing)
Teacher-Is that funny?
Student-Yup!
Teacher-Why is that funny?

Student-Sunlight ain't a definition for all natural resources.
(Many students uncomfortable leaving those switched)
Teacher-OK. Put it back.
Student-I want to switch natural resources and the definition.
Teacher-OK, let's try that.
Student-What?!
Teacher-What do you think about that?
Student-It's still OK.
Student-No, it's not the title!
Teacher-OK, put the title back at the top. Does that make you more comfortable?
Student-Yes!
Teacher-OK, I have 1 more question for you. What does the size of the letters have to do with these switching things we've been doing?
Student-They're all, um… the things.
Student-They're important.
Student-The title is the biggest.
Teacher-OK. What are the other ones?
Student-Examples.
Student-Yeah, the ones with the little letters are the examples…
Teacher-Then, the ones with the bigger letters are…
Student-the 'categories'!
Student-That's what I was trying to say.

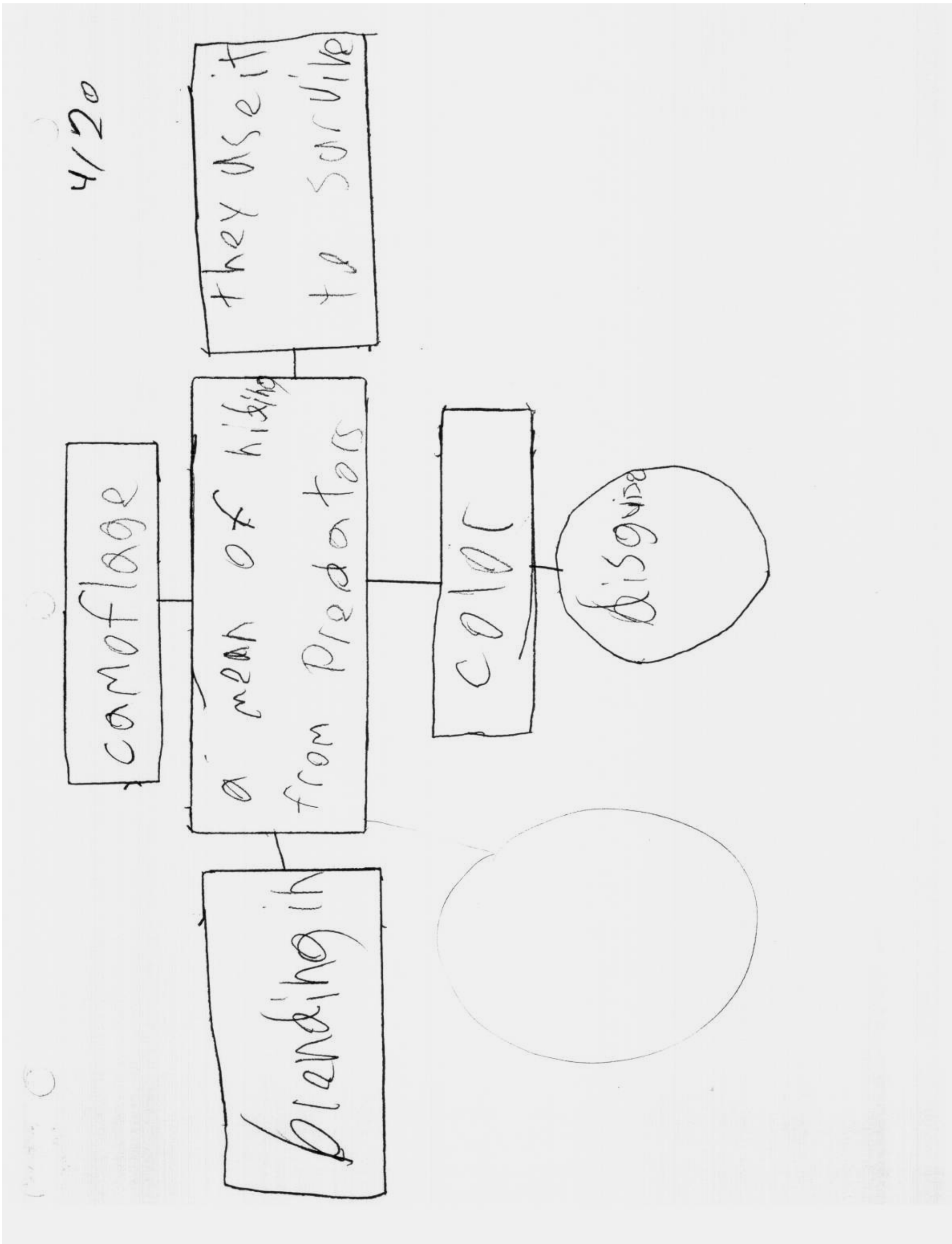
Appendix K1

[redacted]

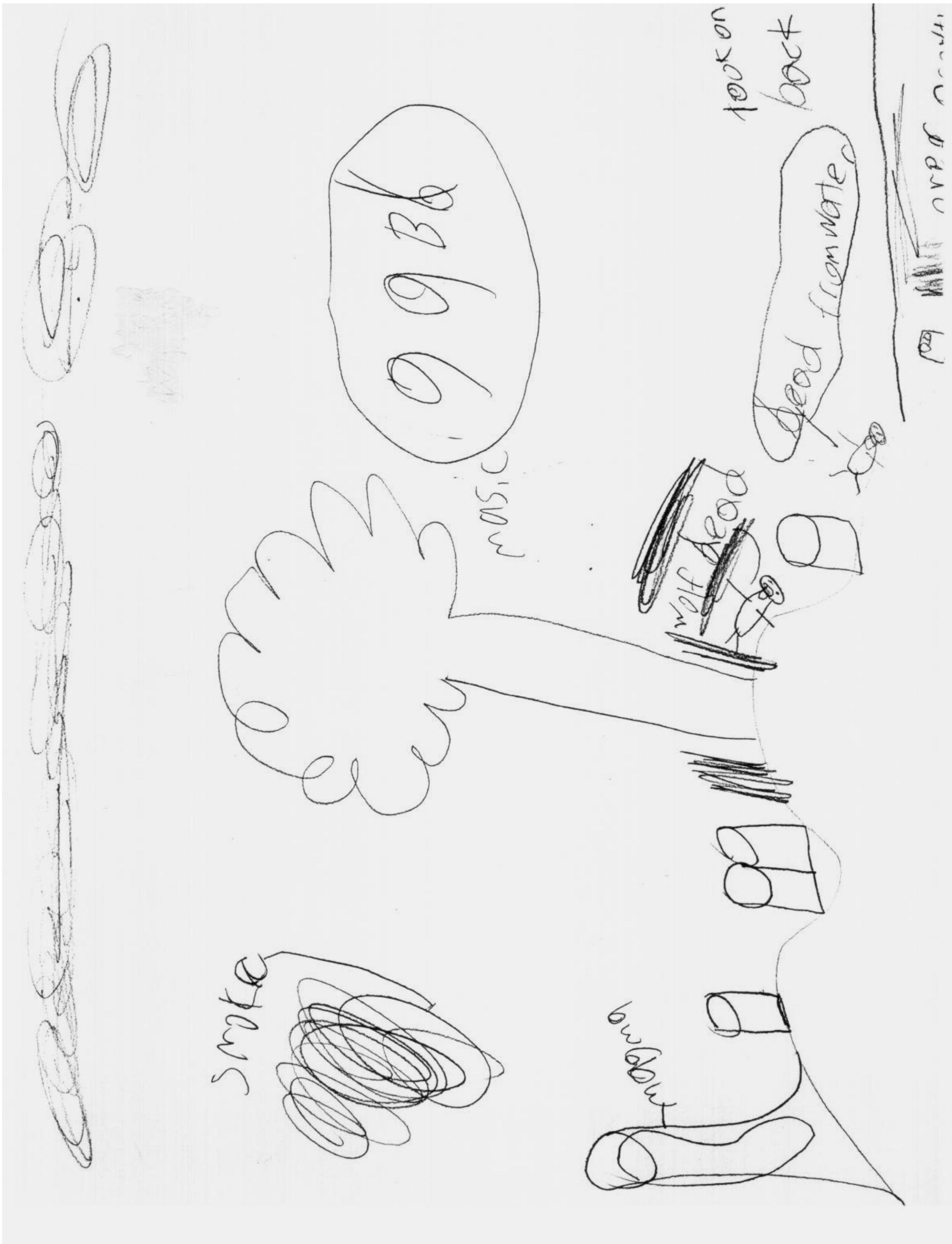
camaflage

can hide prey from their arch
foes called predators. to
(prey) other animals they are
evil but predators eat
prey to stay alive.
not done

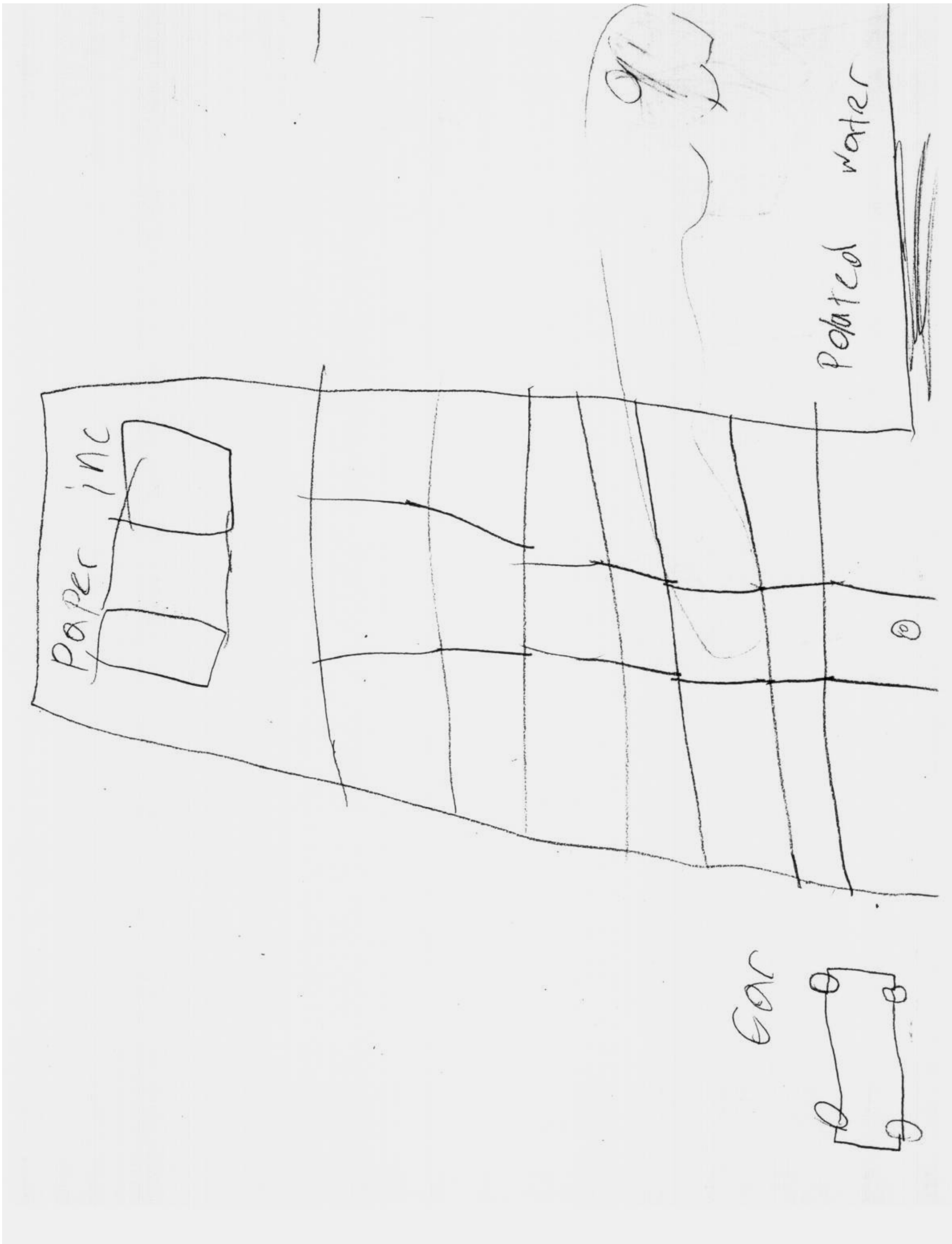
Appendix K2


4/20
camoflage
a mean of hiding from Predators
they use it to Sorvive
color
disguise
blending in

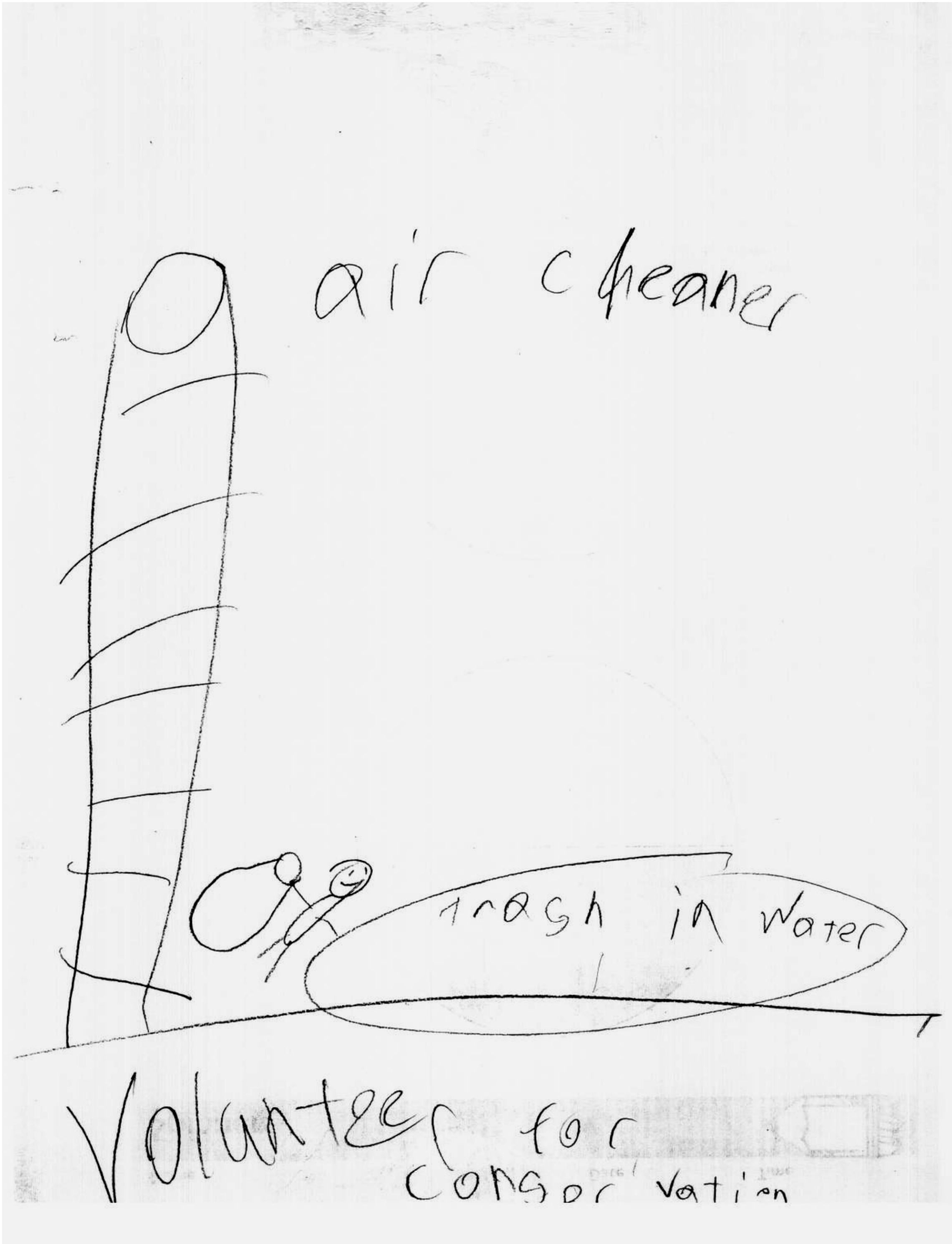
Appendix K3a



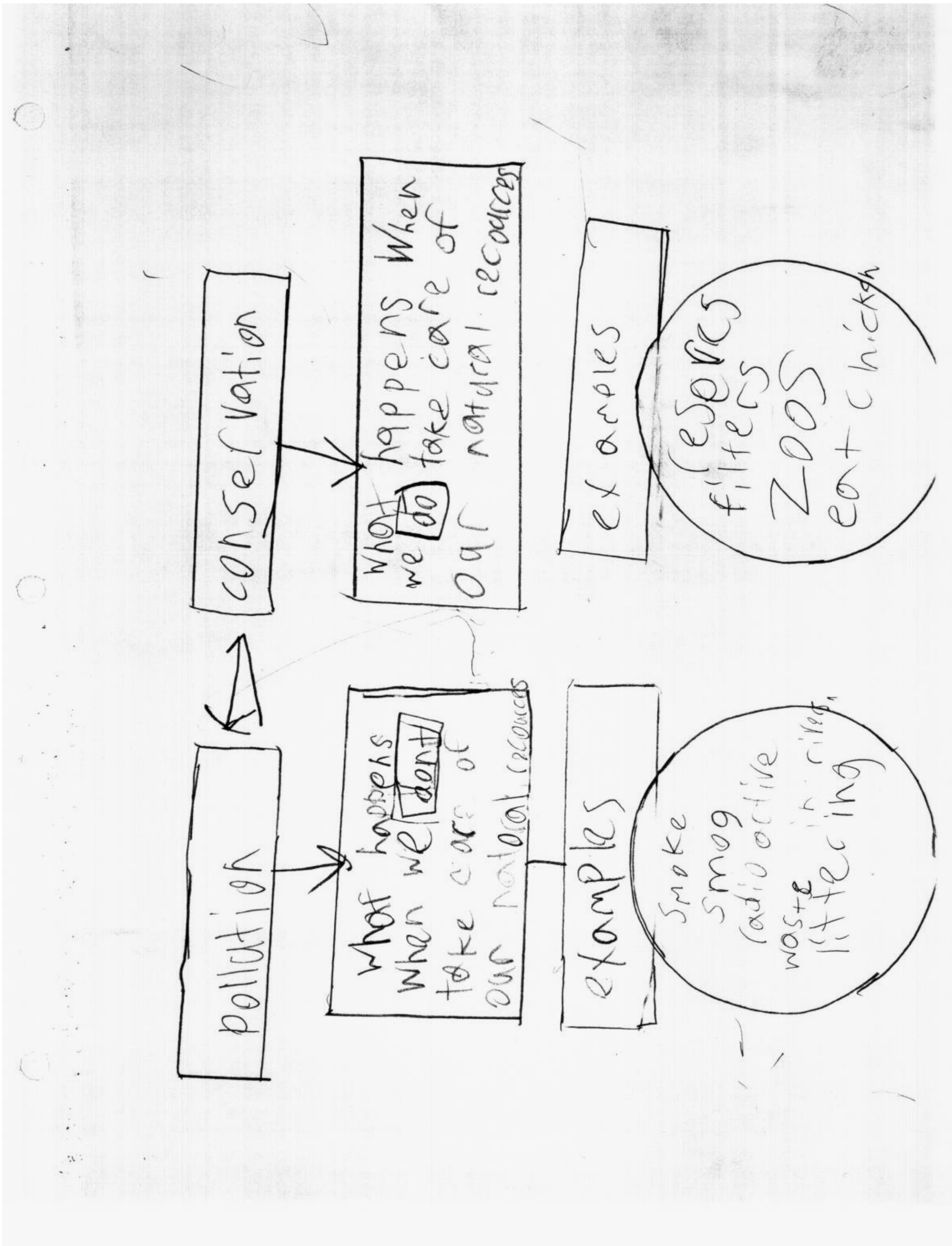
Appendix K3b



Appendix K3c



Appendix K4


pollution
What happens when we dont take care of our natural recources
examples
Smoke
Smog
radioactive waste
littering
conservation
What happens when we do take care of our natural recources
examples
reserves
filters
Zoos

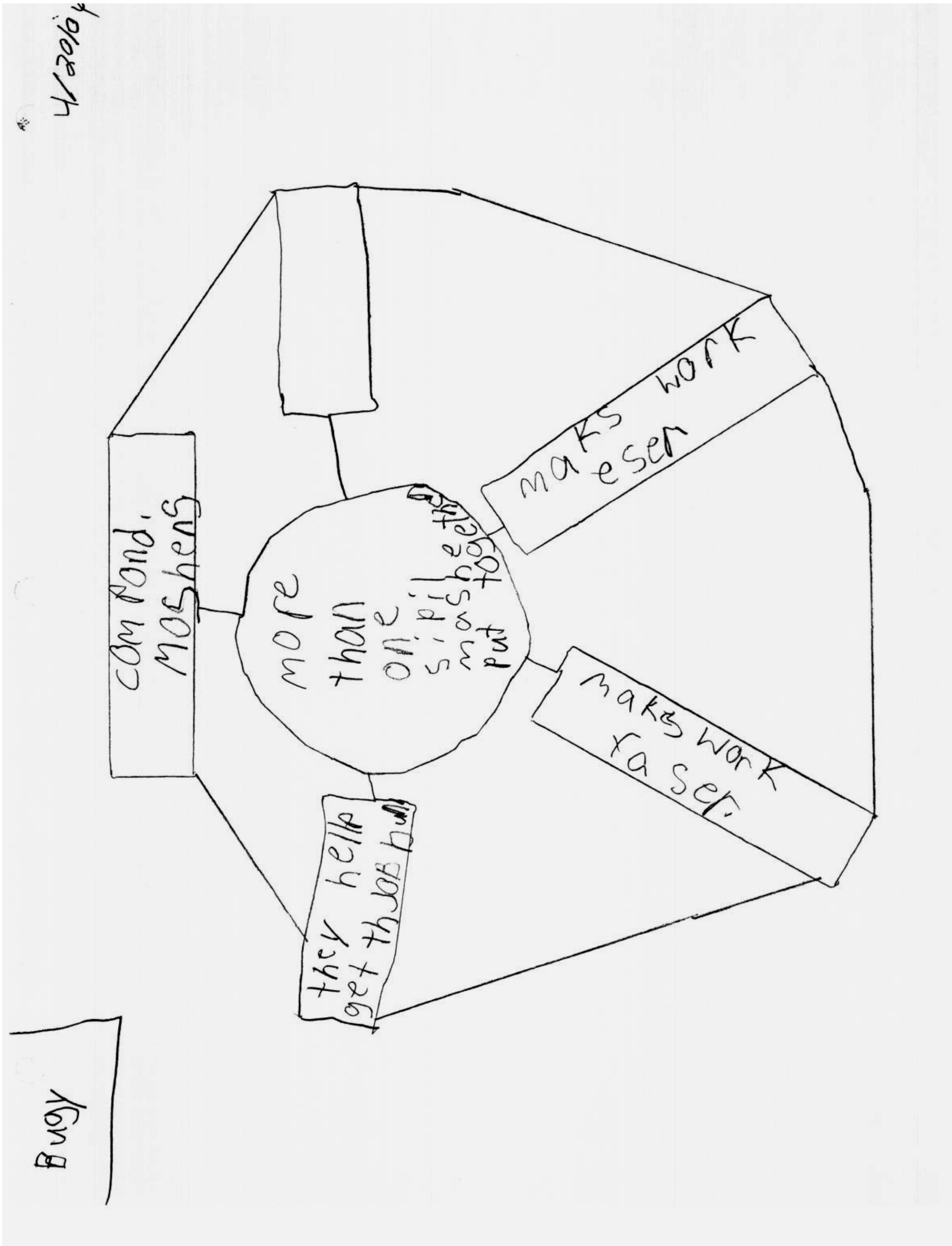
Appendix L1

Bugy

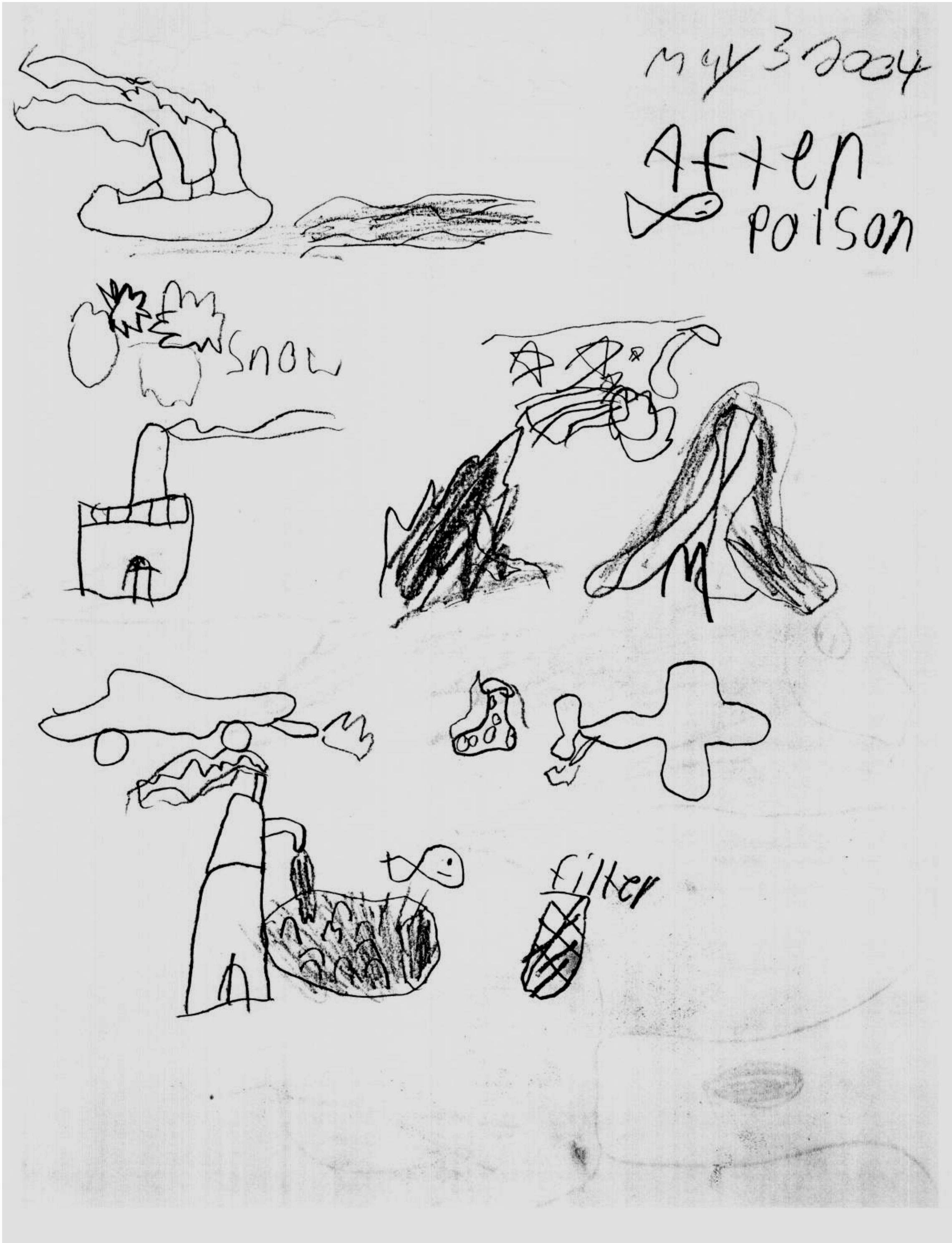
more than one Skill
mashen put together
they hap get the
Job don and you
can get
don faster. the Job
is an exapil her
fan. ...

Comptond mashen

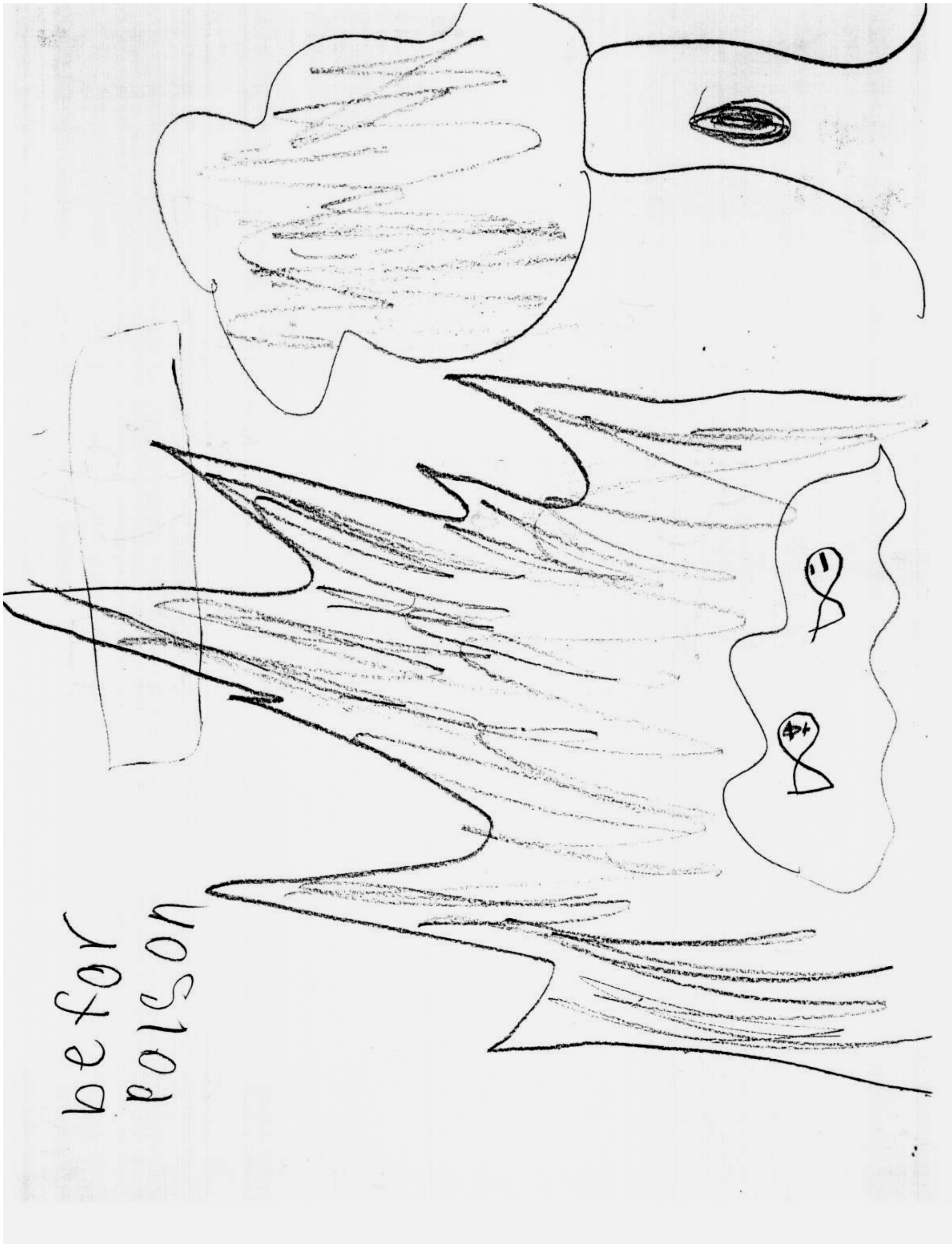
Appendix L2


com pond. moshens
more than one
maks work eser
maks work fa ser.
Bugy

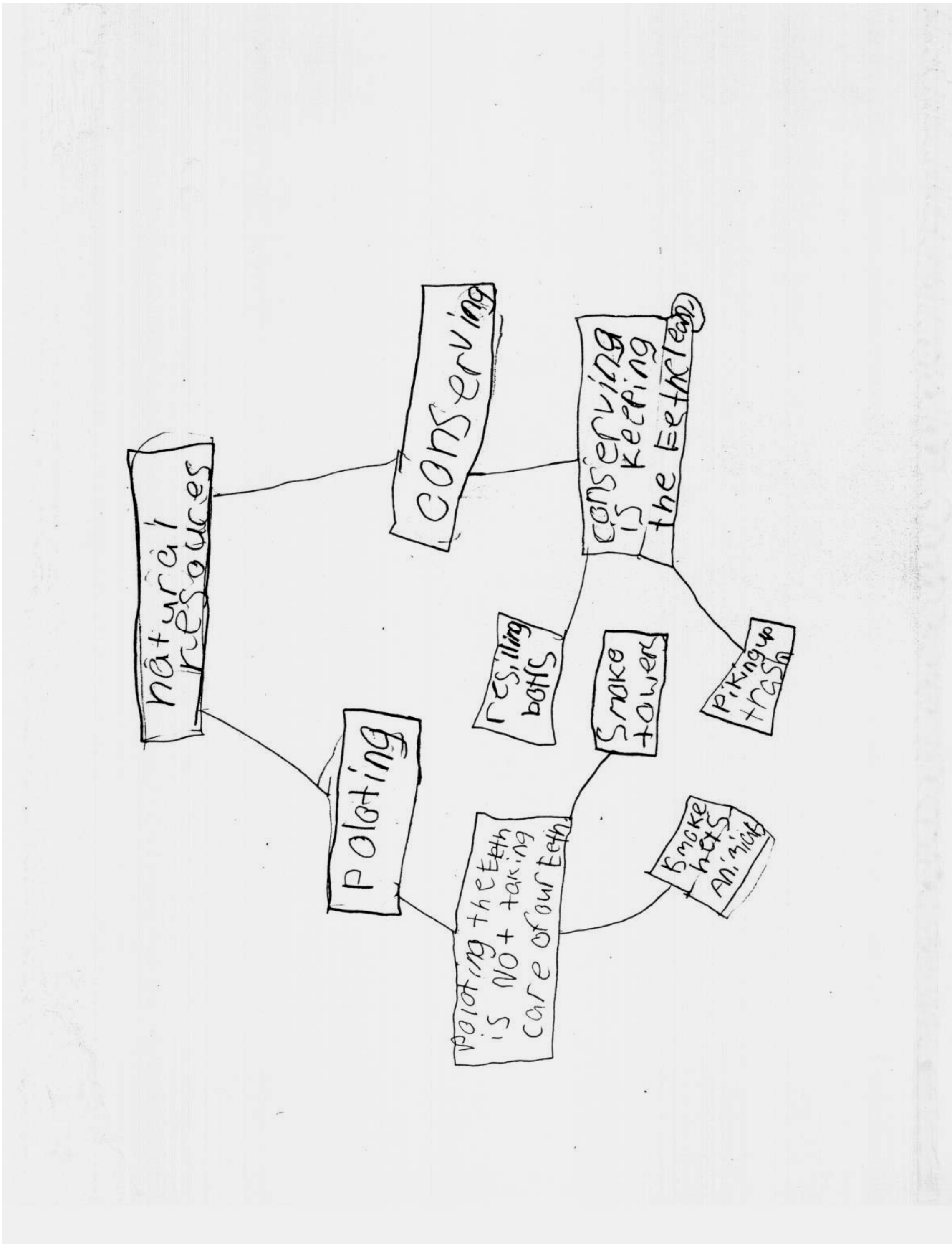
Appendix L3a



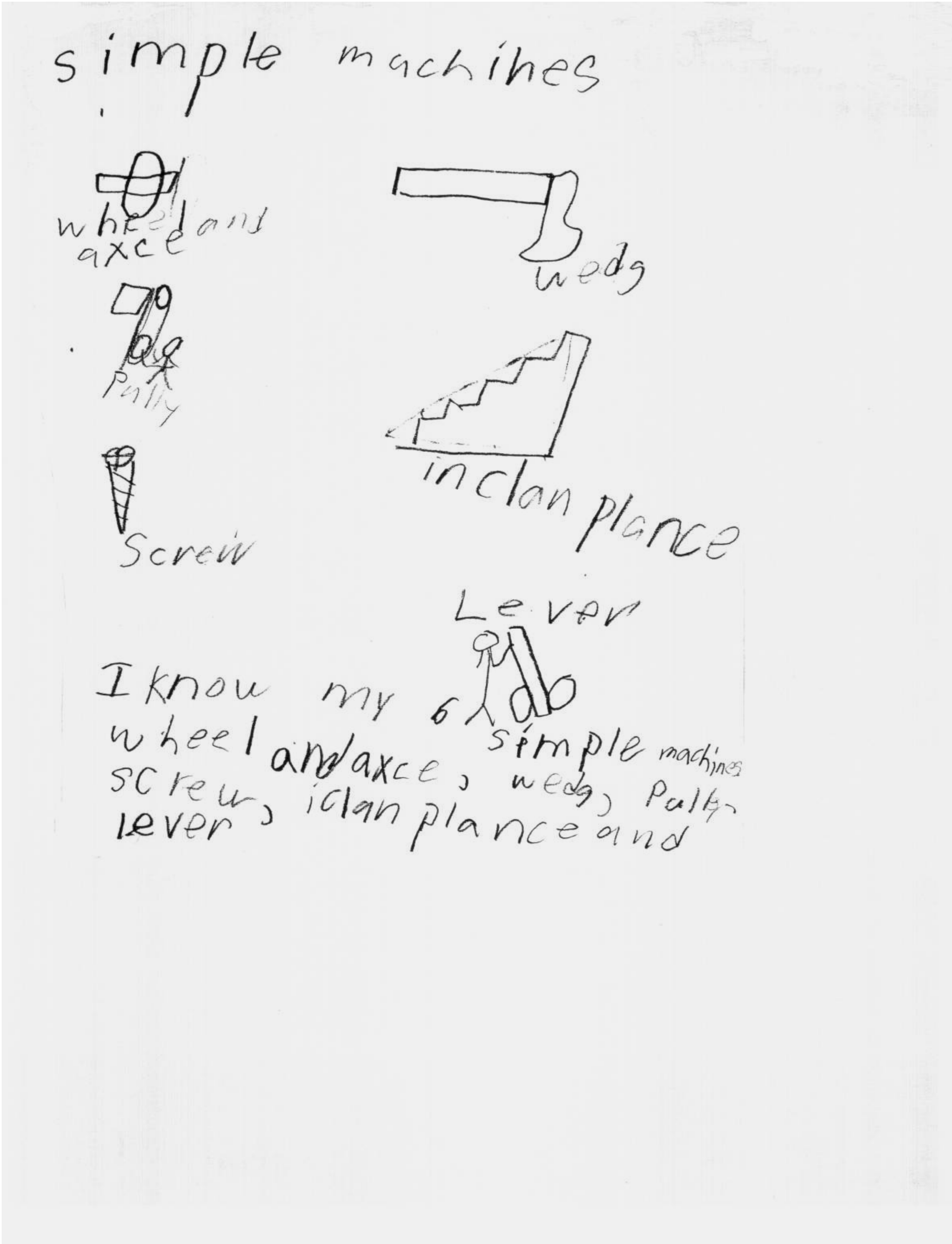
Appendix L3b



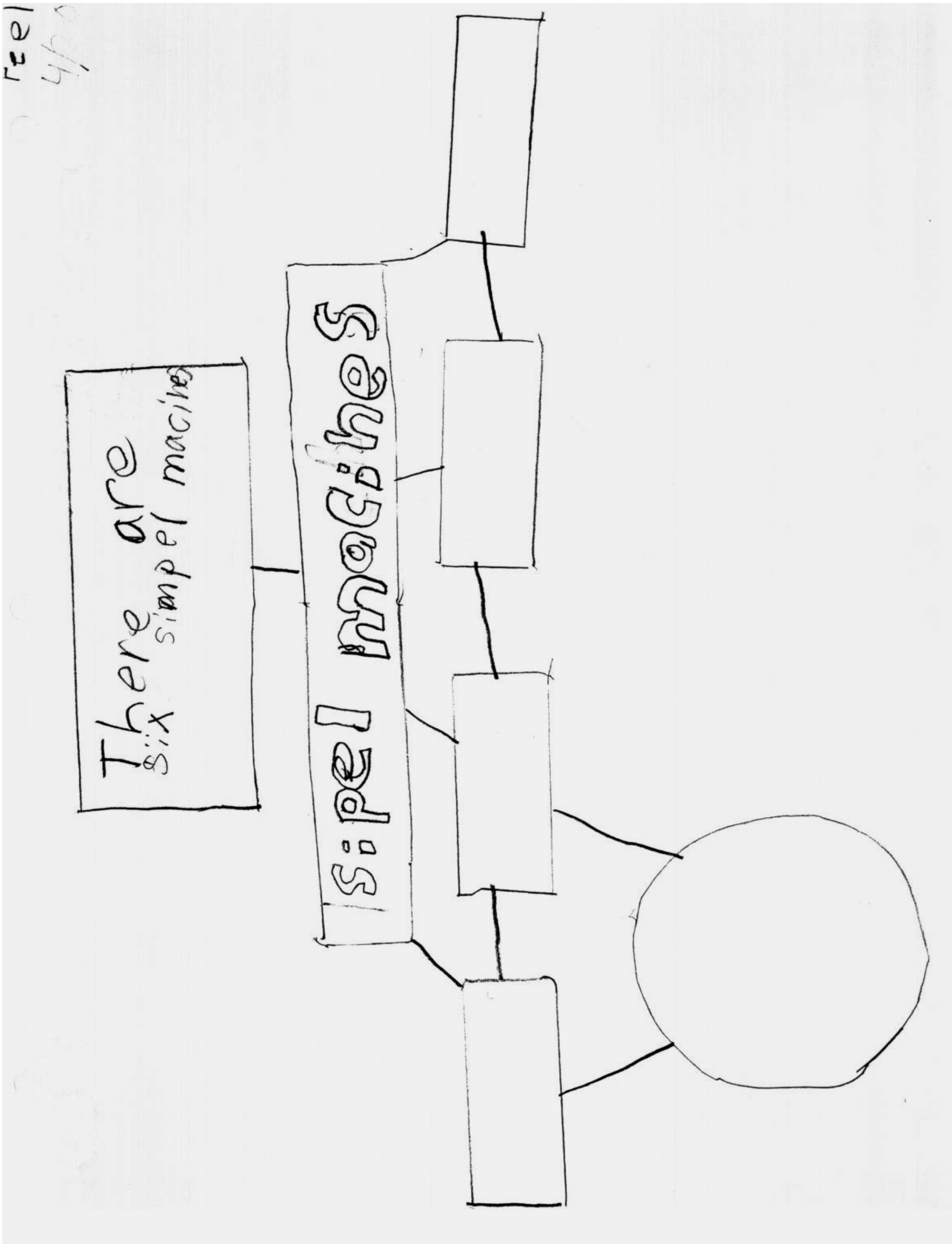
Appendix L4


natural resouces
conserving
conserving is keeping the Eeth clean
Poloting
smoke towers
piking up trash

Appendix M1


simple machines
wheel and axce
wedg
Pully
inclan plance
screw
Lever
I know my 6 simple machines wheel and axce, wedg, Pully screw, iclan plance and lever,

Appendix M2

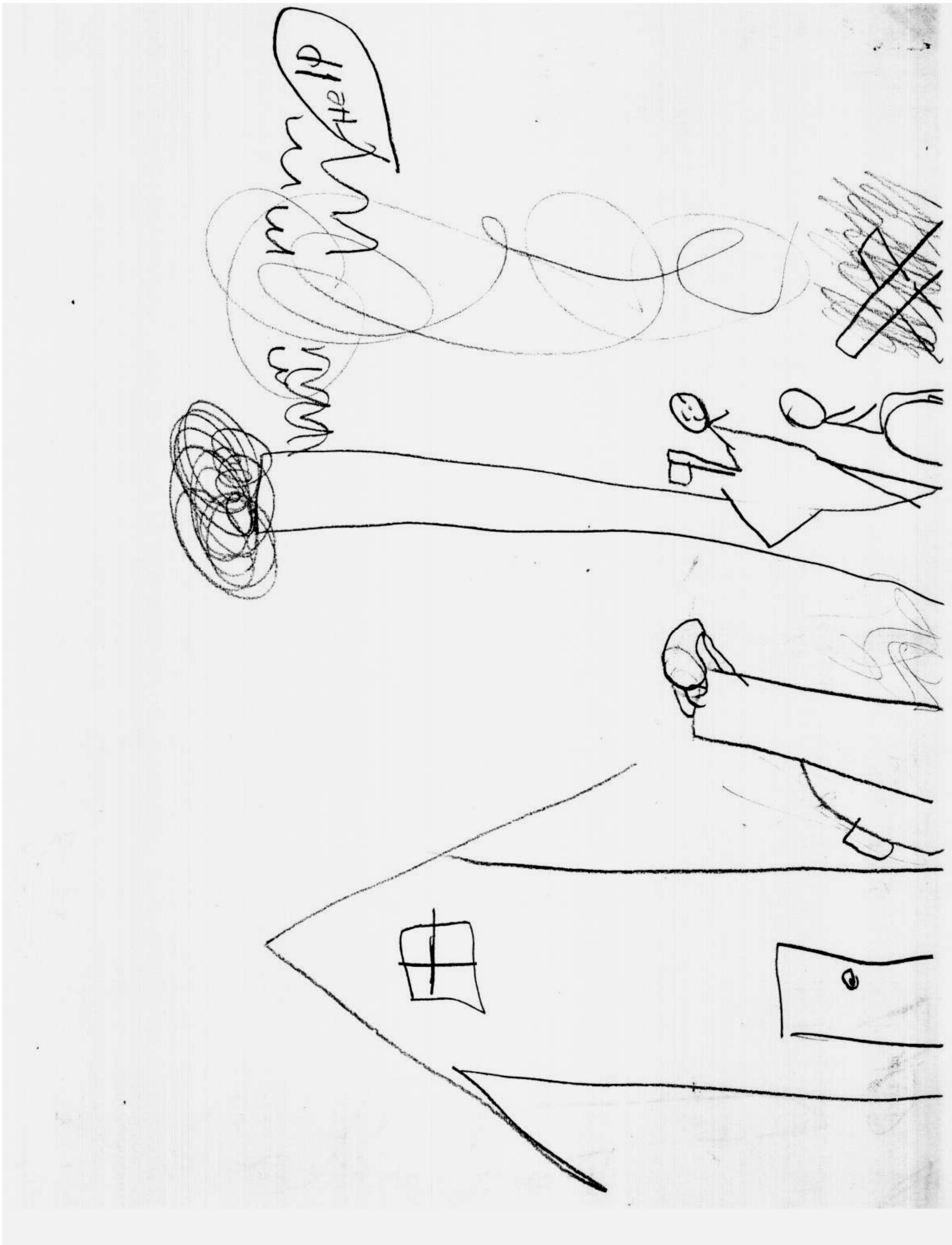


Appendix M3a

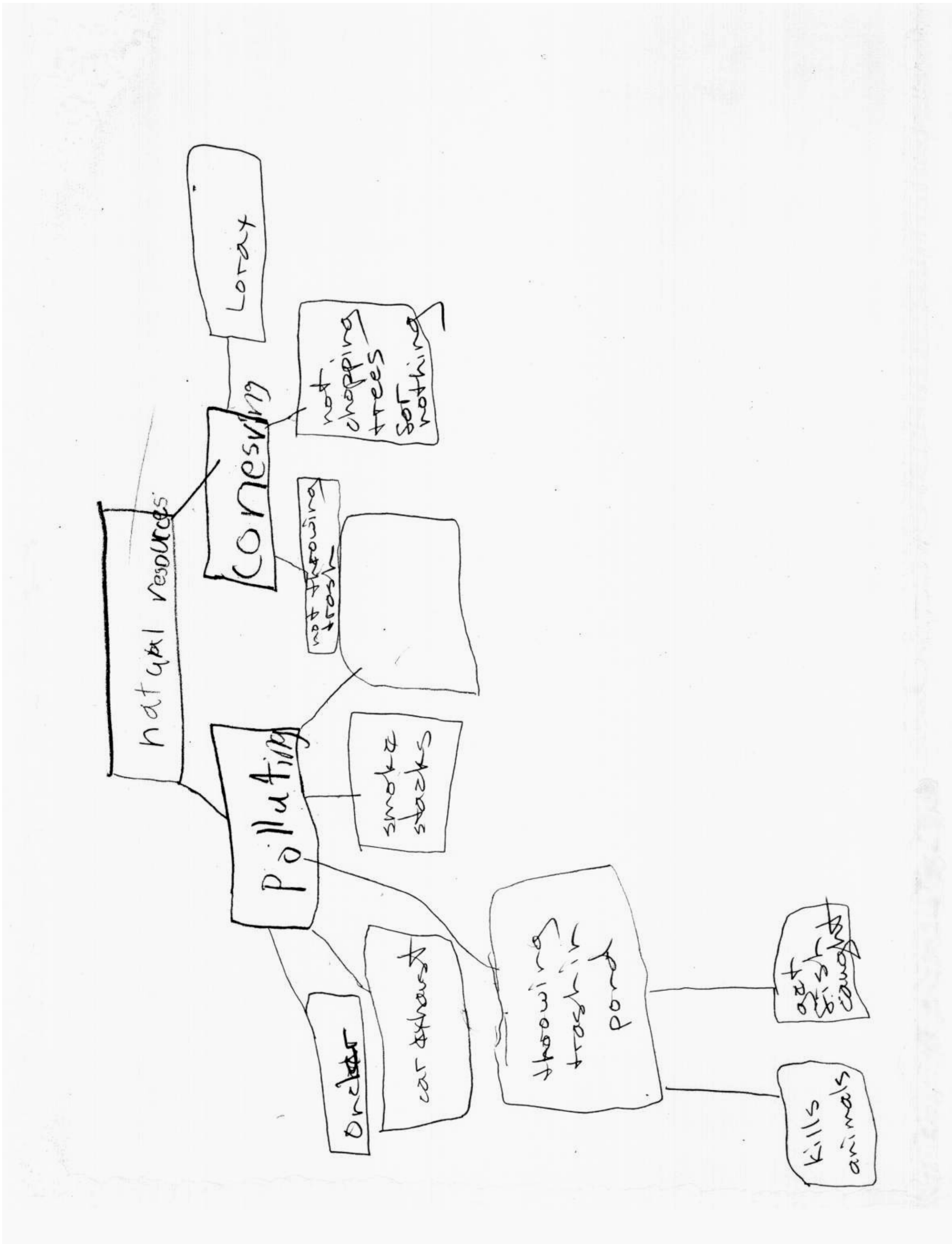
My picker is about
Pollution.

Appendix M3b

Appendix M3c



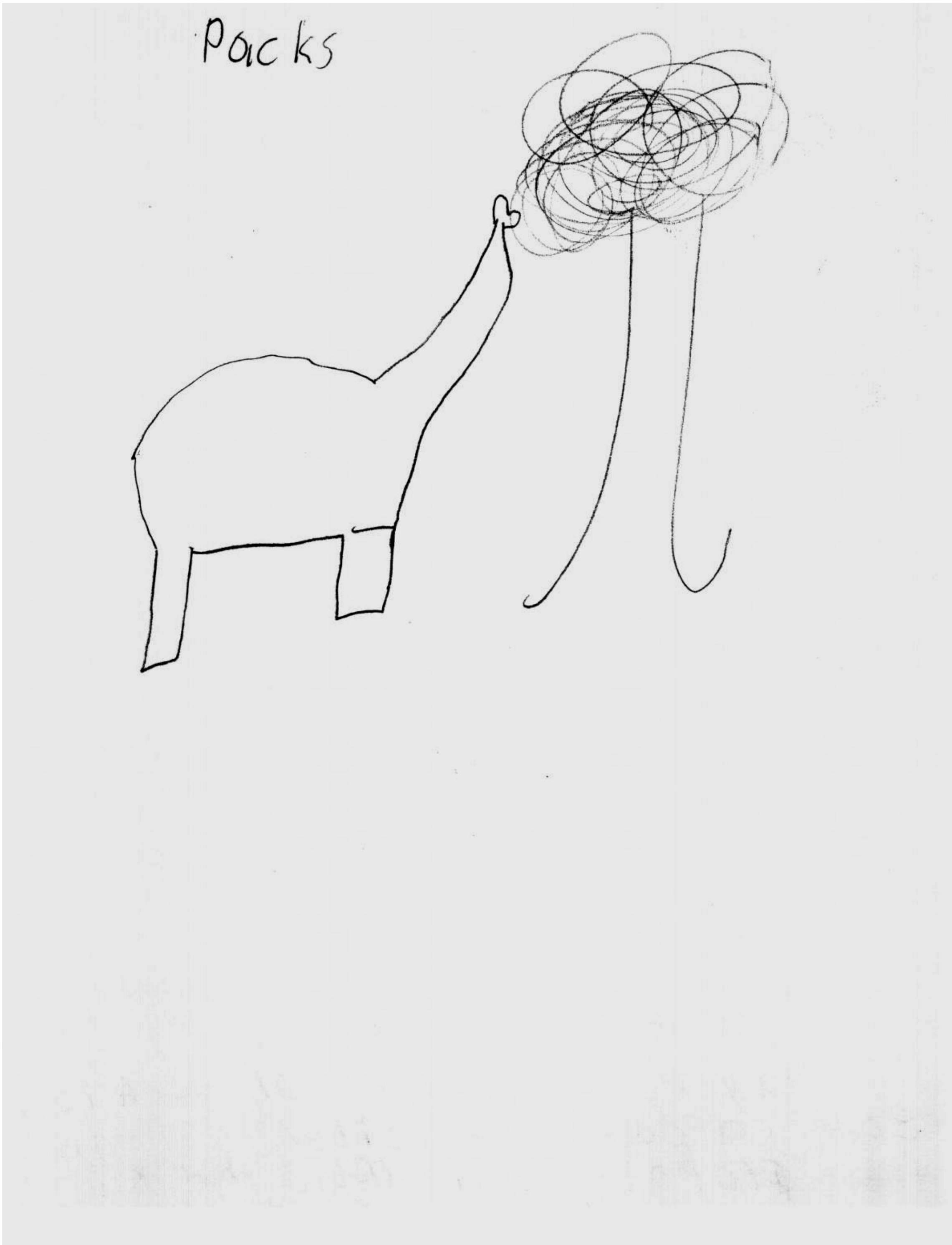
Appendix M4


Lorax
not chopping trees
smoke stacks
car exhaust
kills animals

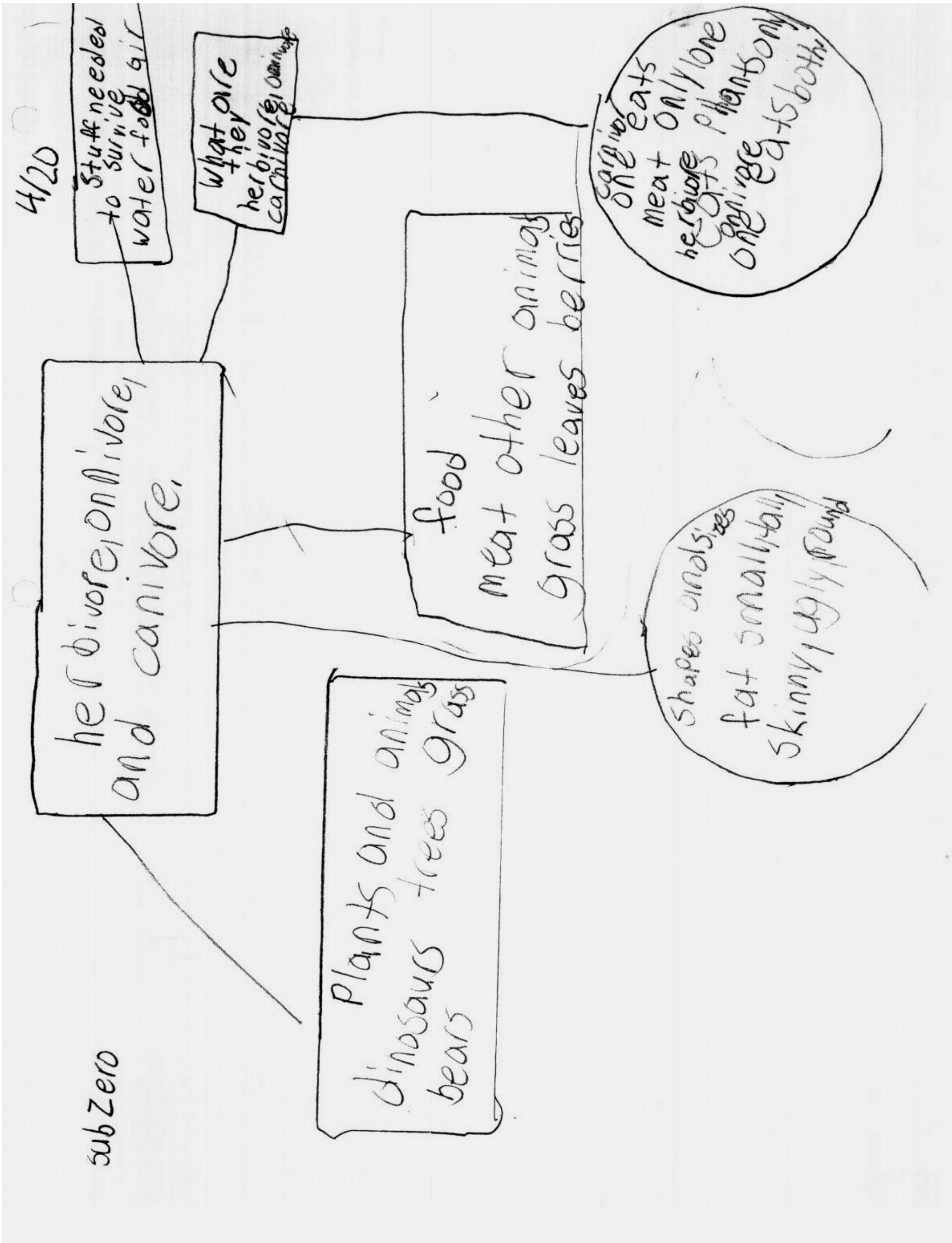
Appendix N1a

zhang fei SuB zero
an herbivore is
an animal that only
eats plants, Maybe like
Brauntosaurus or another
species of dinosaur. There
are 2 more words that go
with herbivore. They are carniv
and omnivore. A carnivor is
a animal that eats
only meat like a Raptor
or a t-rex, last but not
least is a omnivore an
omnivore eats both plants
and meat like a Bear. A
Bear eats Berries and it eats
may be a rabbit or two. A rap.
eats carcases of other animals
they probably got more than kill

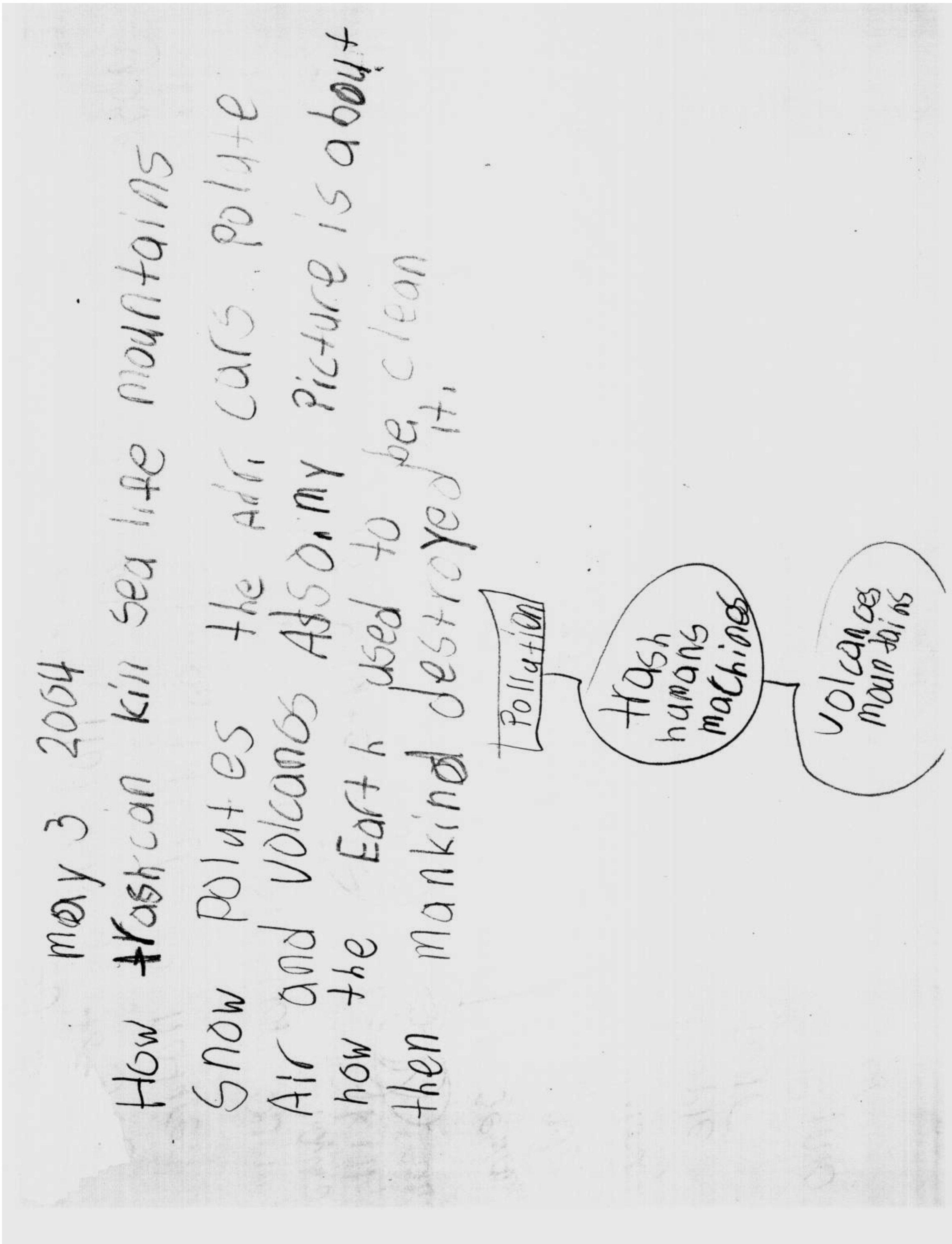
Appendix N1b



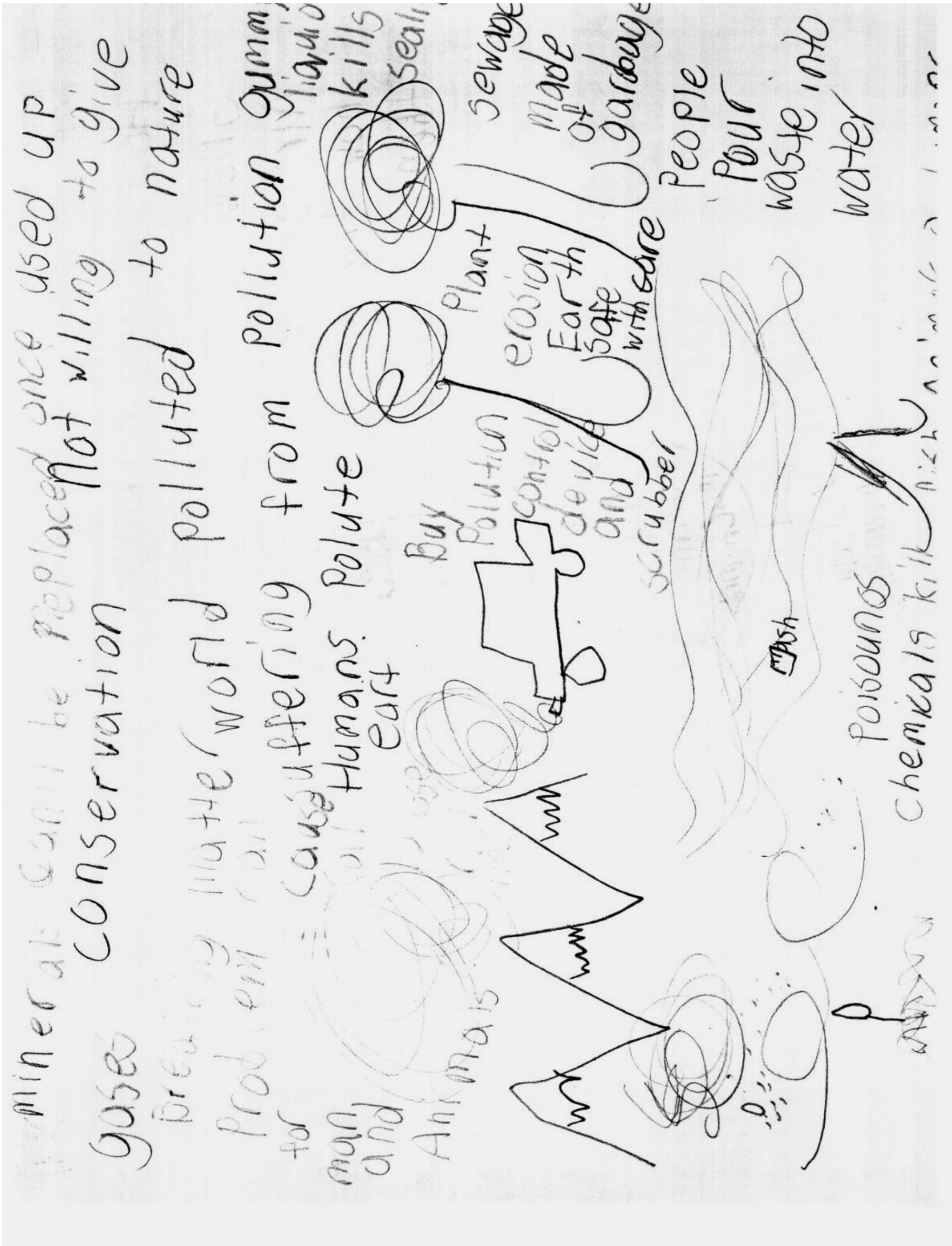
Appendix N2


4/20
Stuff needed to survive water food air
What are they herbivore, carnivore
herbivore, omnivore, and canivore,
food meat other animals grass leaves berries
shapes and sizes fat small tall skinny ugly round
Plants and animals dinosaurs trees grass bears
sub Zero

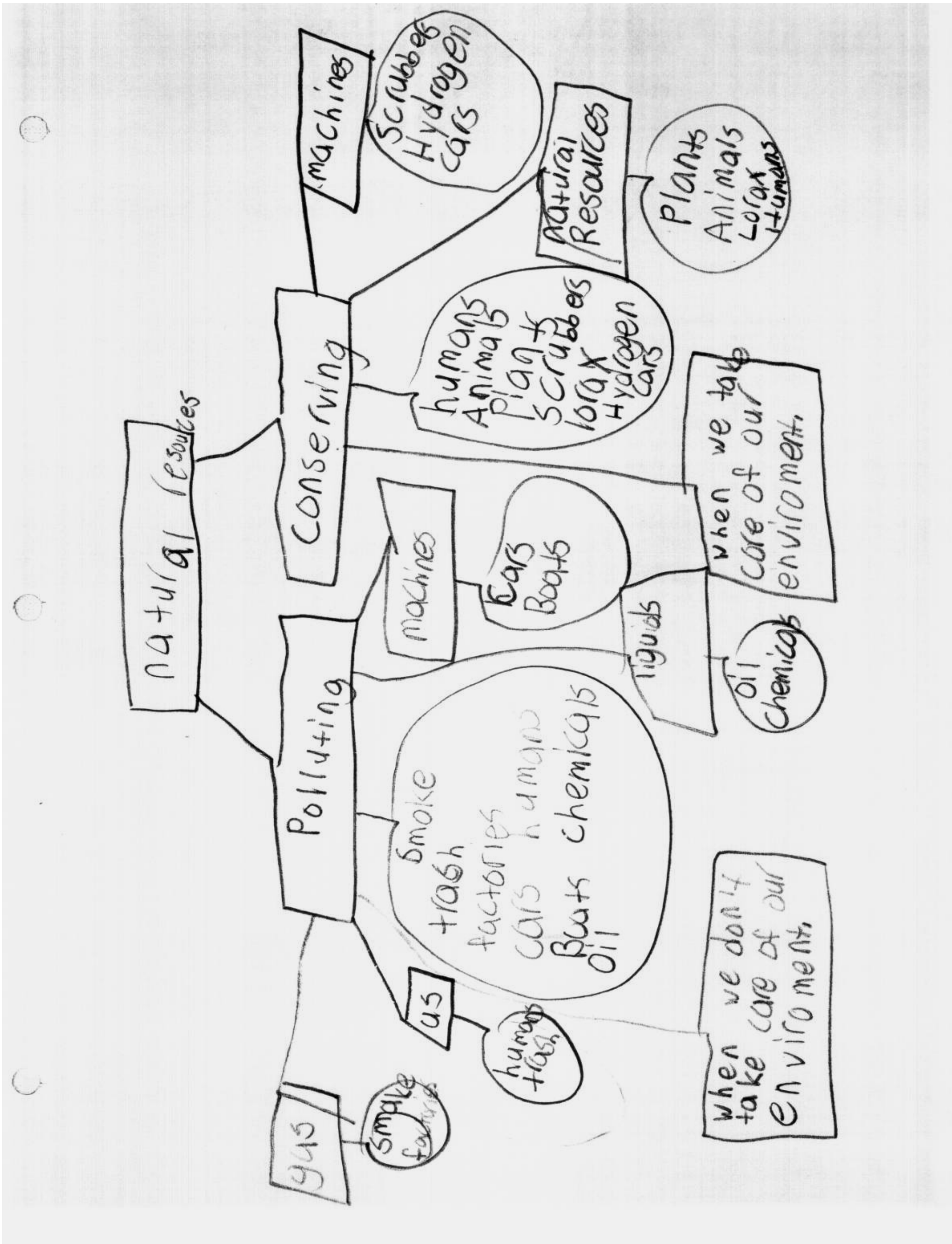
Appendix N3a



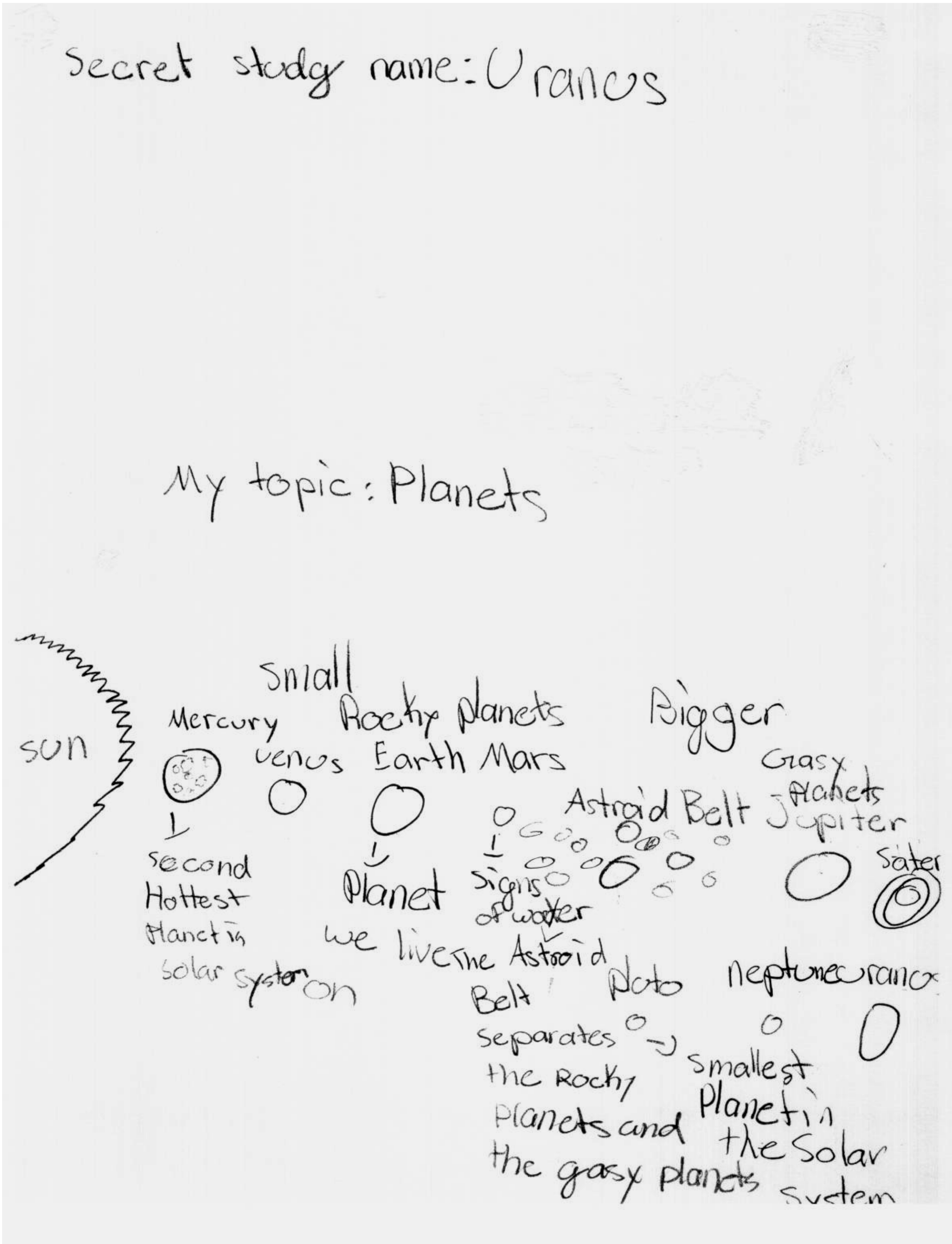
Appendix N3b



Appendix N4


natural resources
Conserving
Polluting
machines
Scrubbers Hydrogen cars
Natural Resources
Plants Animals Lorax Humans
humans Animals Plants Scrubbers lorax Hydrogen cars
when we take care of our enviroment.
machines
cars Boats
liquids
oil chemicals
Smoke trash factories cars Boats oil humans chemicals
us
humans trash
gas
when we don't take care of our enviroment.

Appendix O1a



Appendix O1b

Facts about Planets

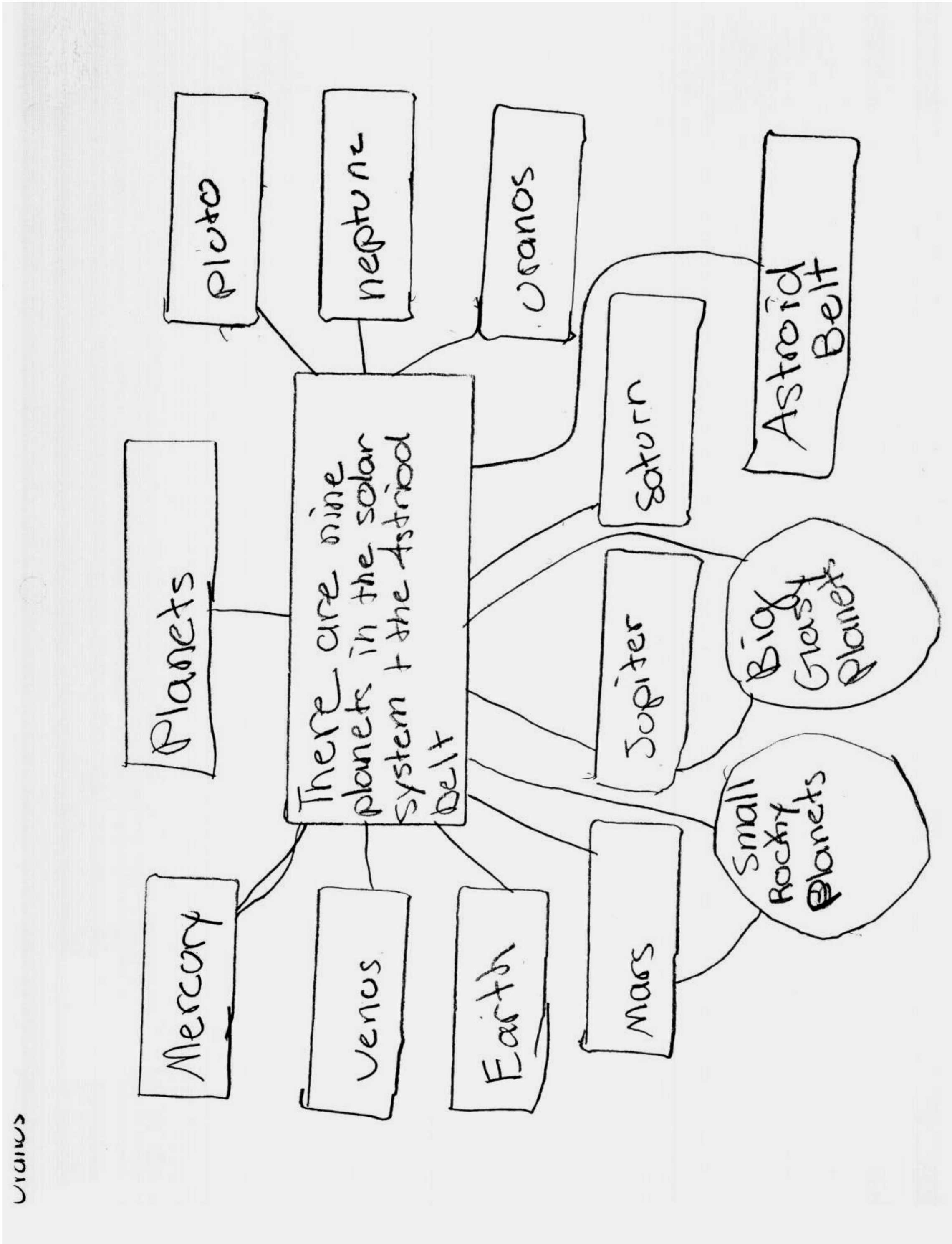
① Mercury	My	All the planets
venus	very	are in that
Earth	ejacated	order and after
Mars	Mother	Mars comes the
Jupiter	Just	Astroid Belt
Satern	Served	
Uranos	us	
neptune	nine	
Ploto	Pizzas	

② Earth has Air, Water and you can't walk on it. even if you try you will fall through

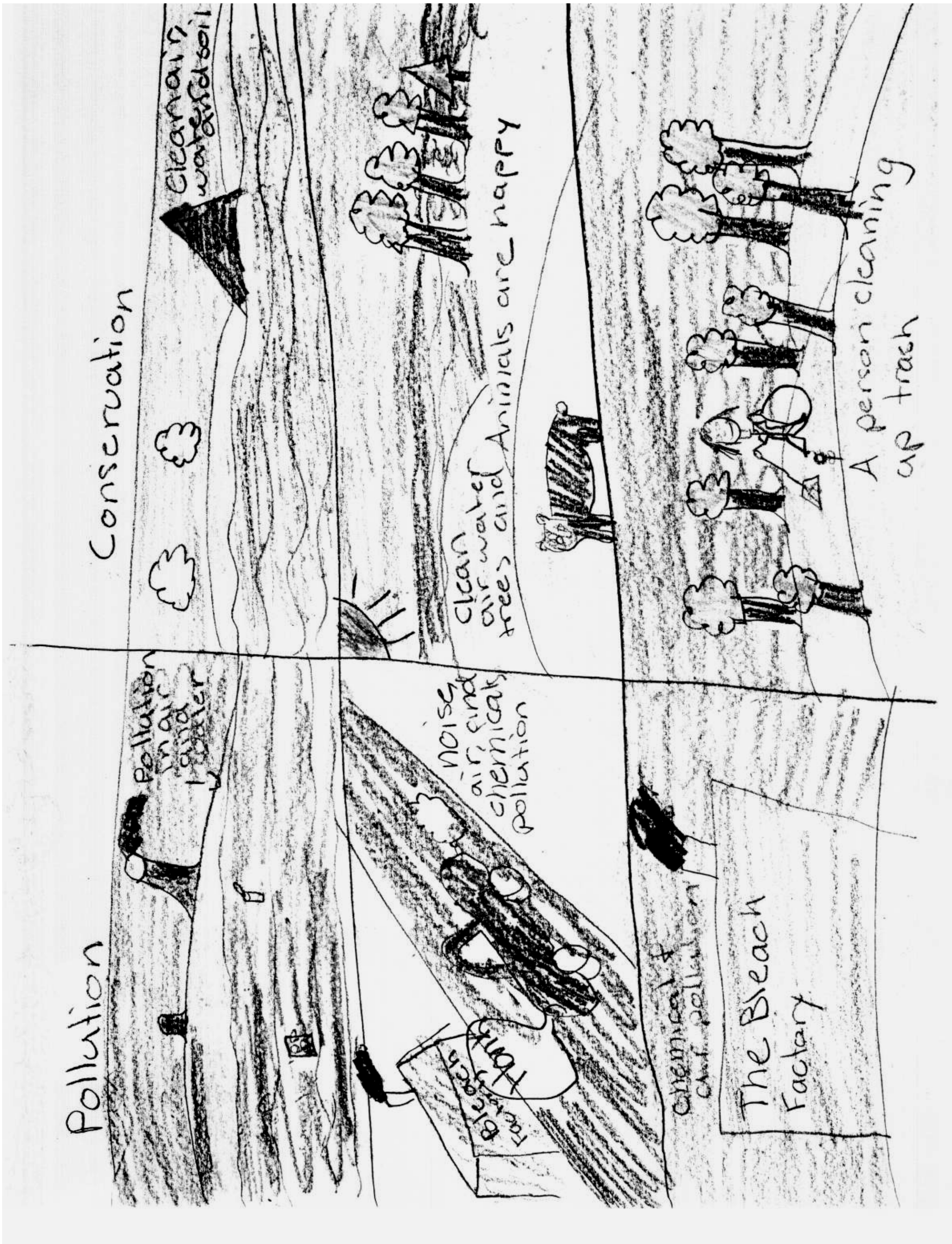
③ Sientest say there are signs of water on Mars

④ There are exatly nine planets in the solar system

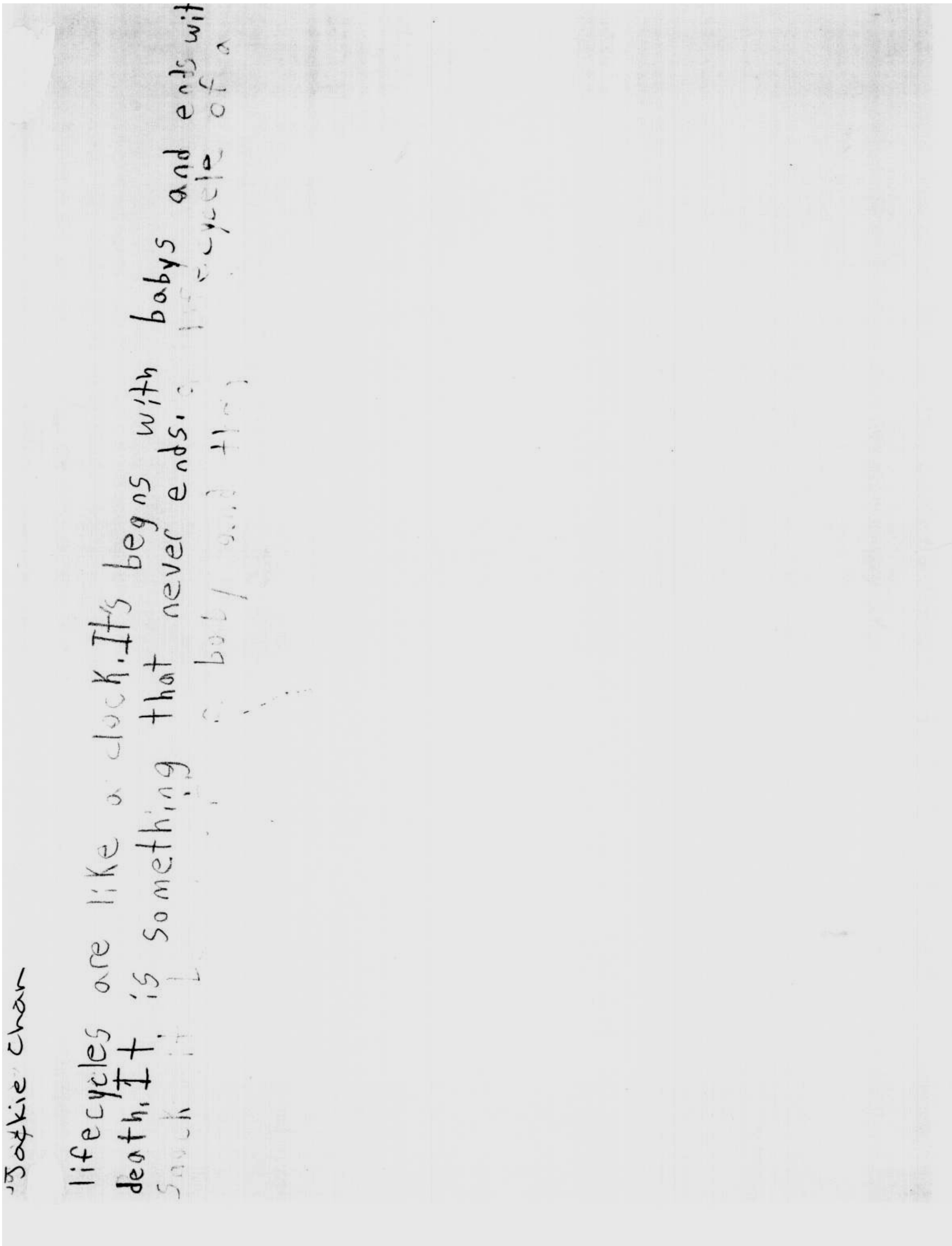
Appendix O2


Pluto
neptune
Uranos
Astroid Belt
Planets
There are nine planets in the solar system + the Astriod Belt
Small Rocky Planets
Mercory
Venos
Earth
Mars

Appendix O3


Pollution
Conservation
Clean air, water and soil
Clean air water trees and Animals are happy
A person cleaning up trash
noise, air and chemicals Pollution
The Bleach Factory

Appendix P1

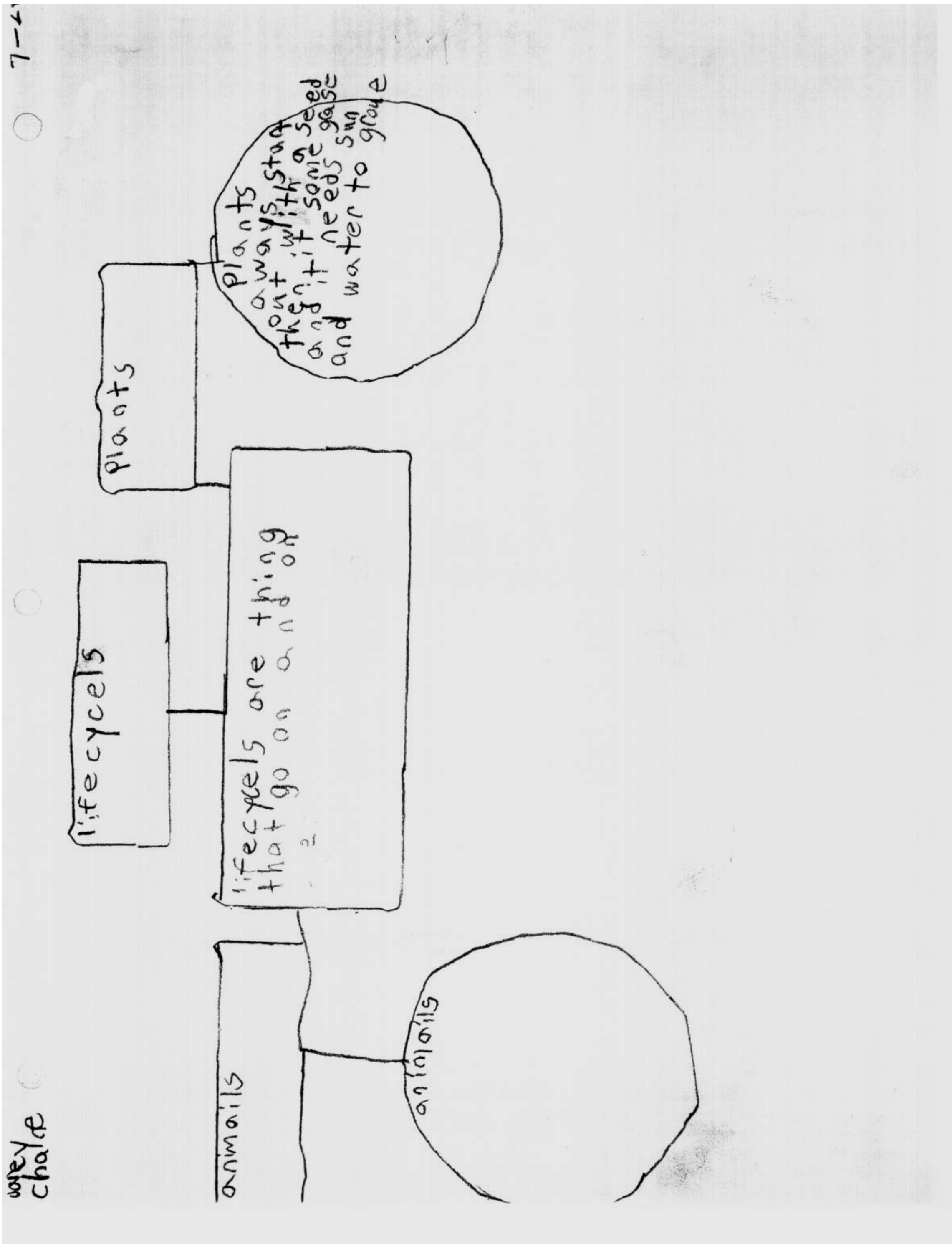


Jackie Chan

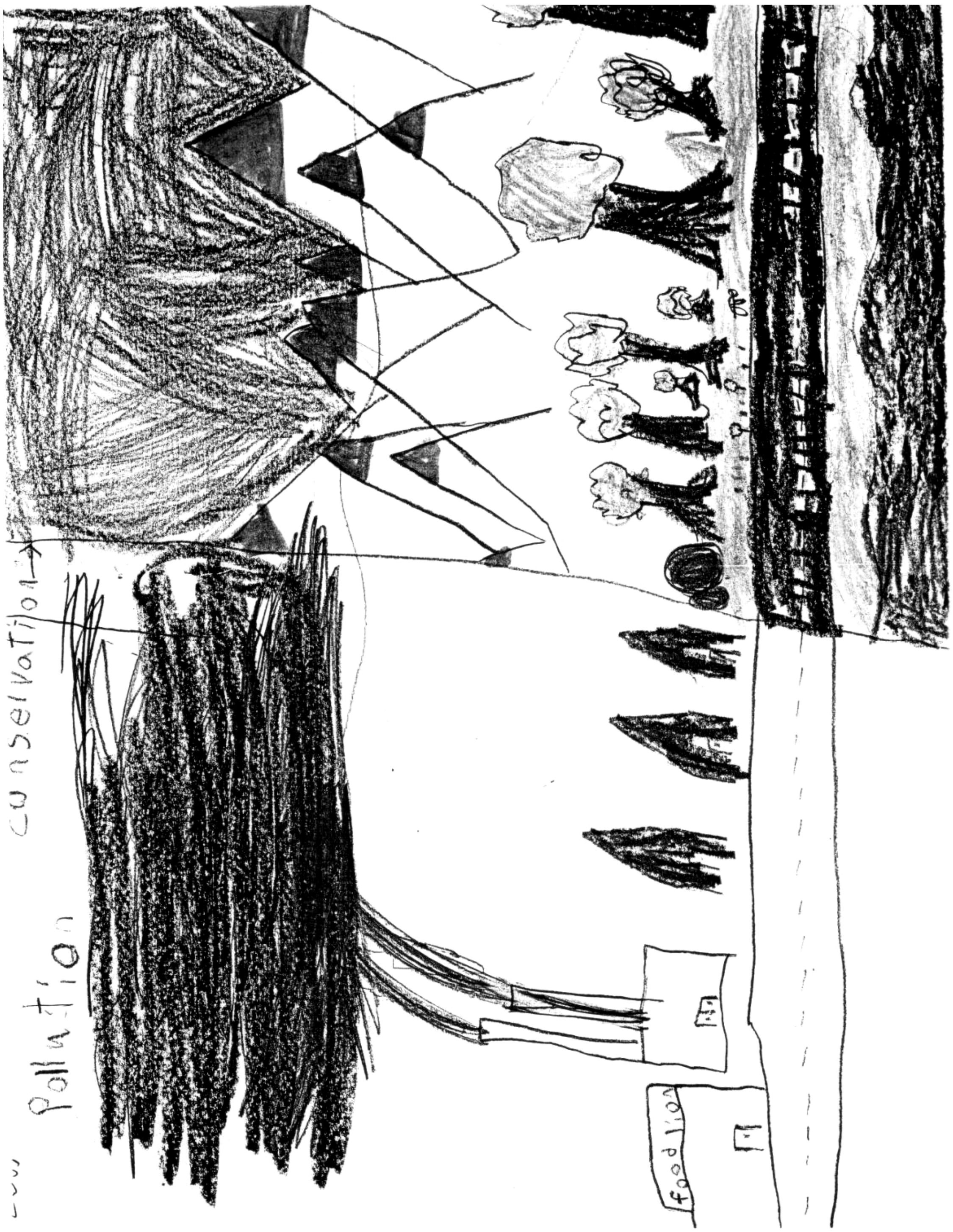
lifecycles are like a clock. It's begns with babys and ends with death. It is something that never ends.

Snack it [illegible] baby [illegible] lifecycle of a

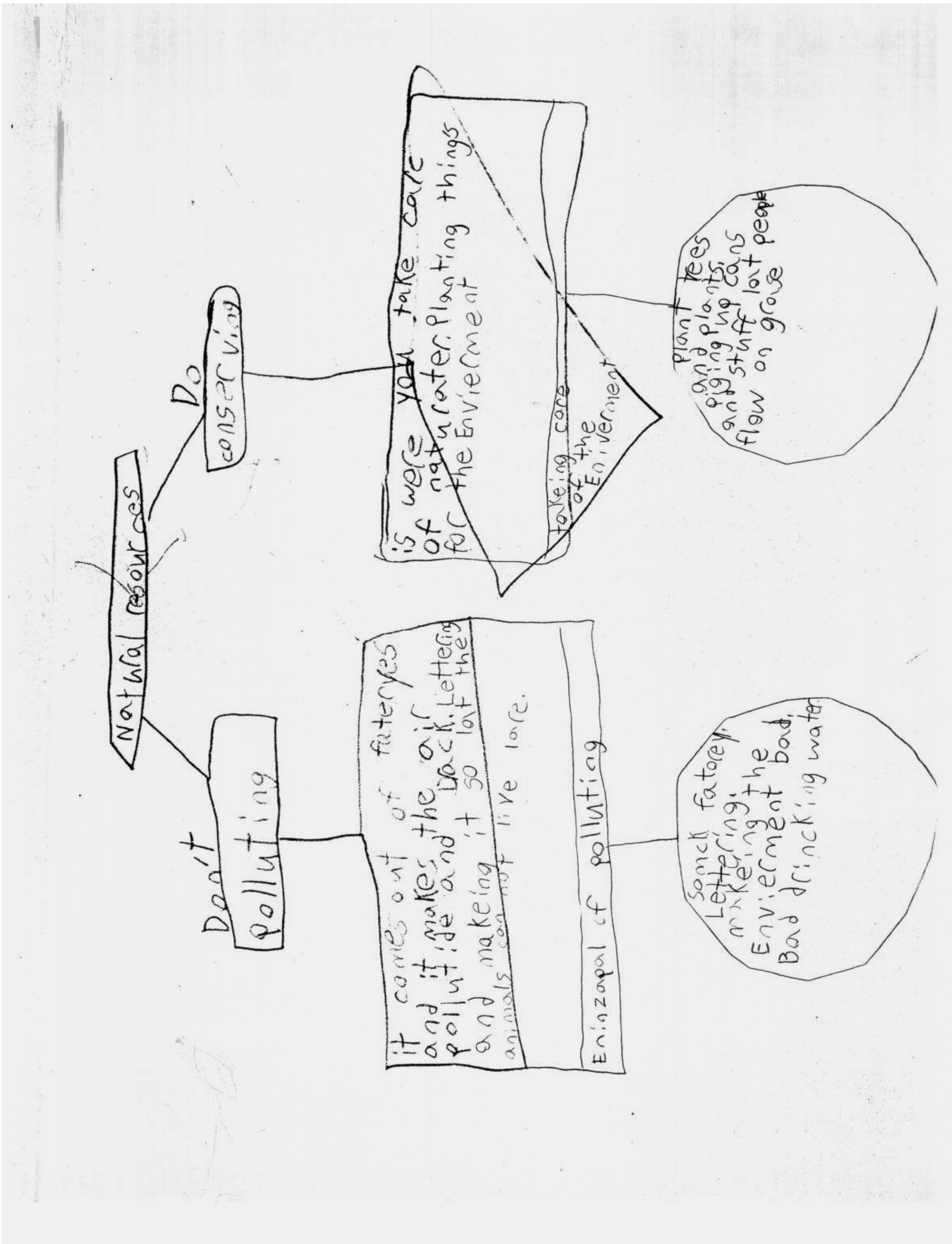
Appendix P2



Appendix P3



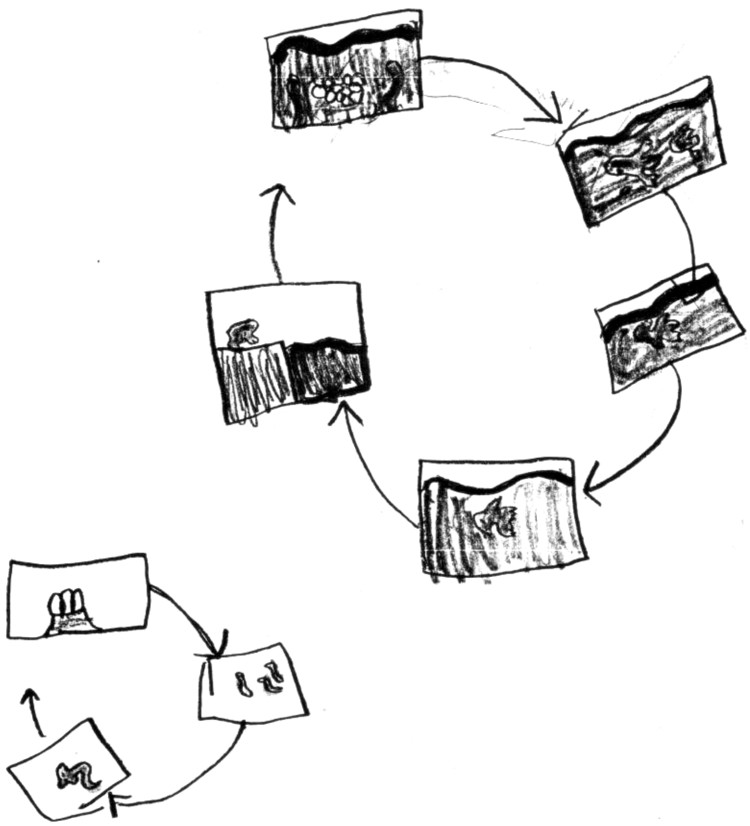
Appendix P4



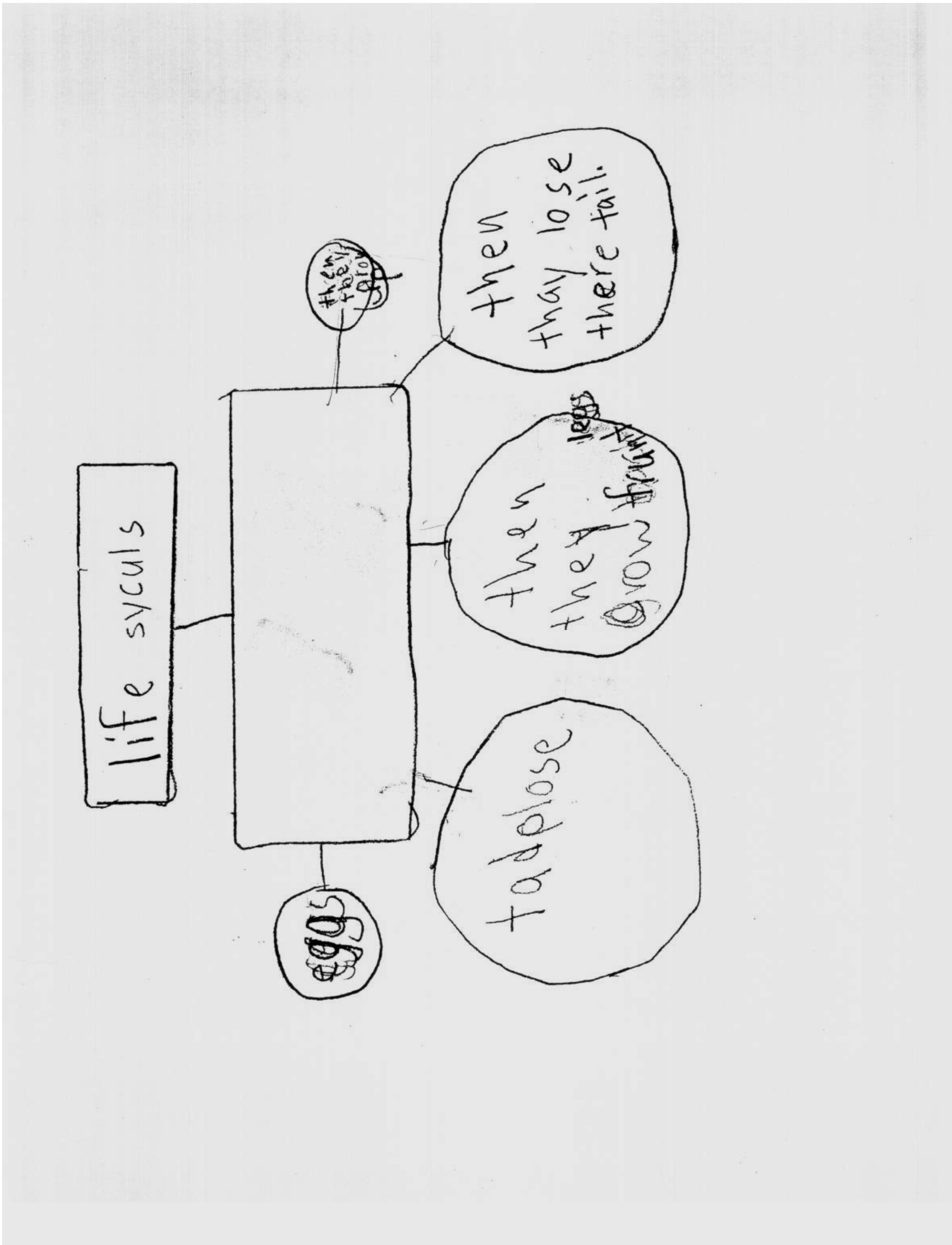
Appendix Q1

Lifecycles

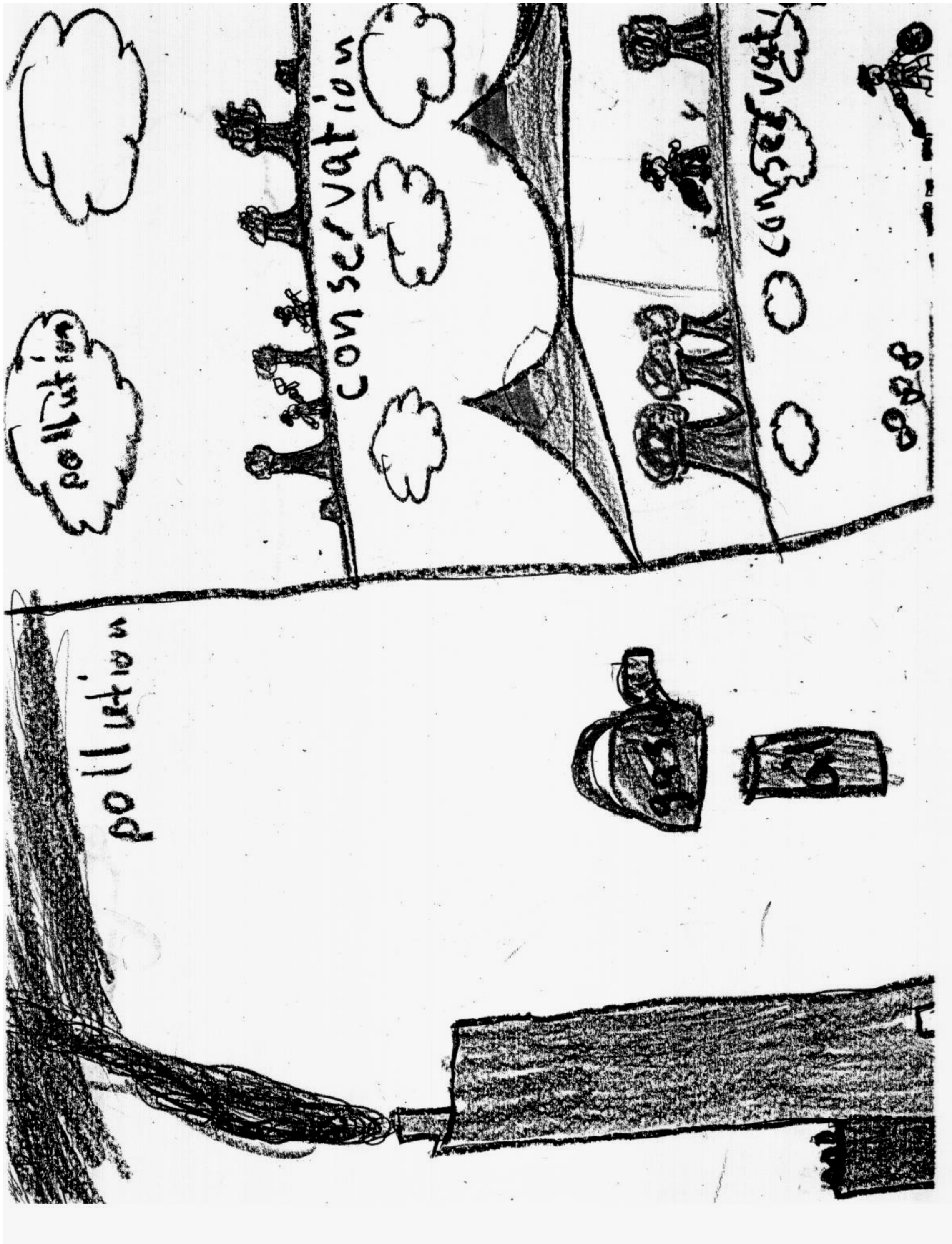
trunks



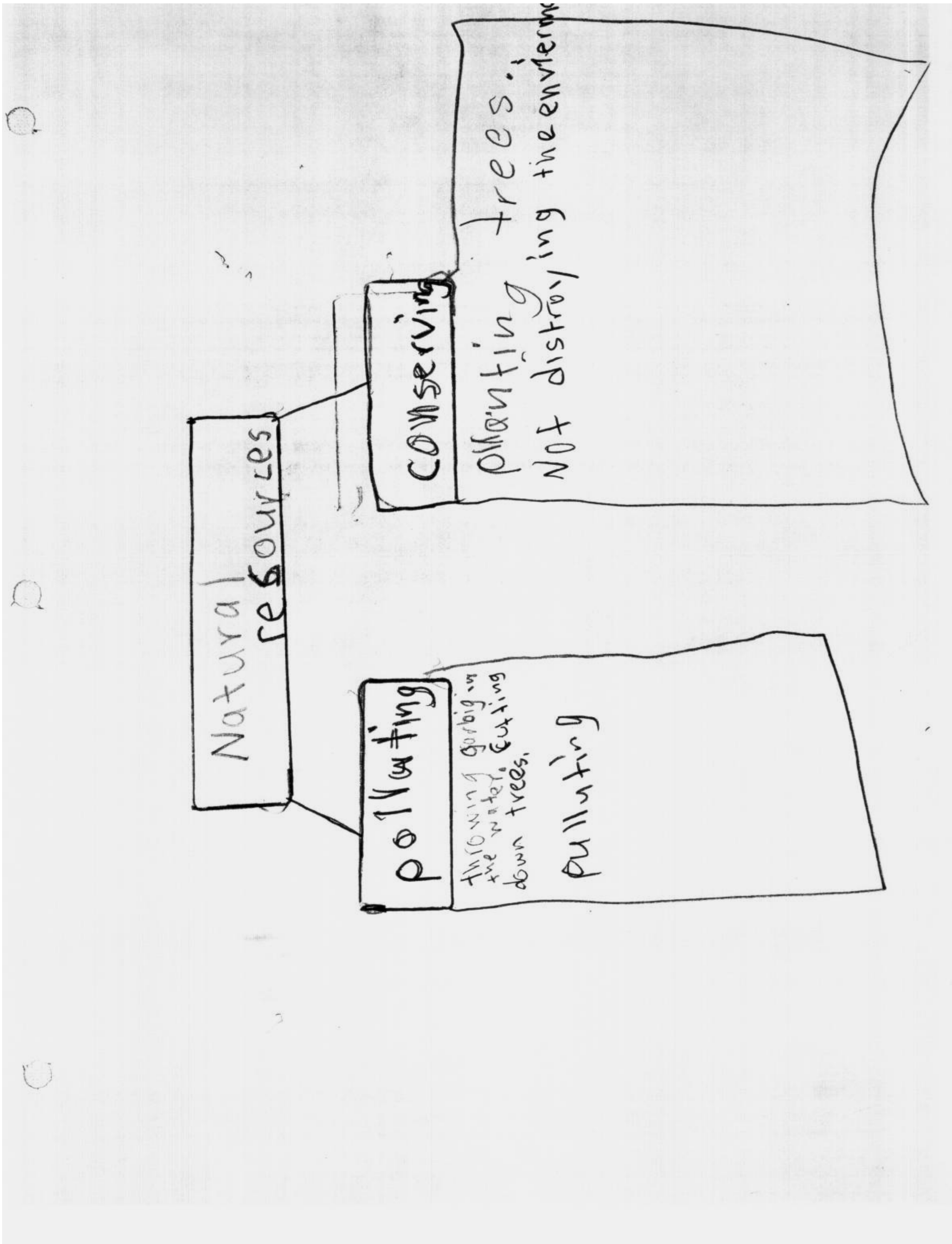
Appendix Q2


life syculs
eggs
tadplose
then they grow legs
then thay lose there tail.

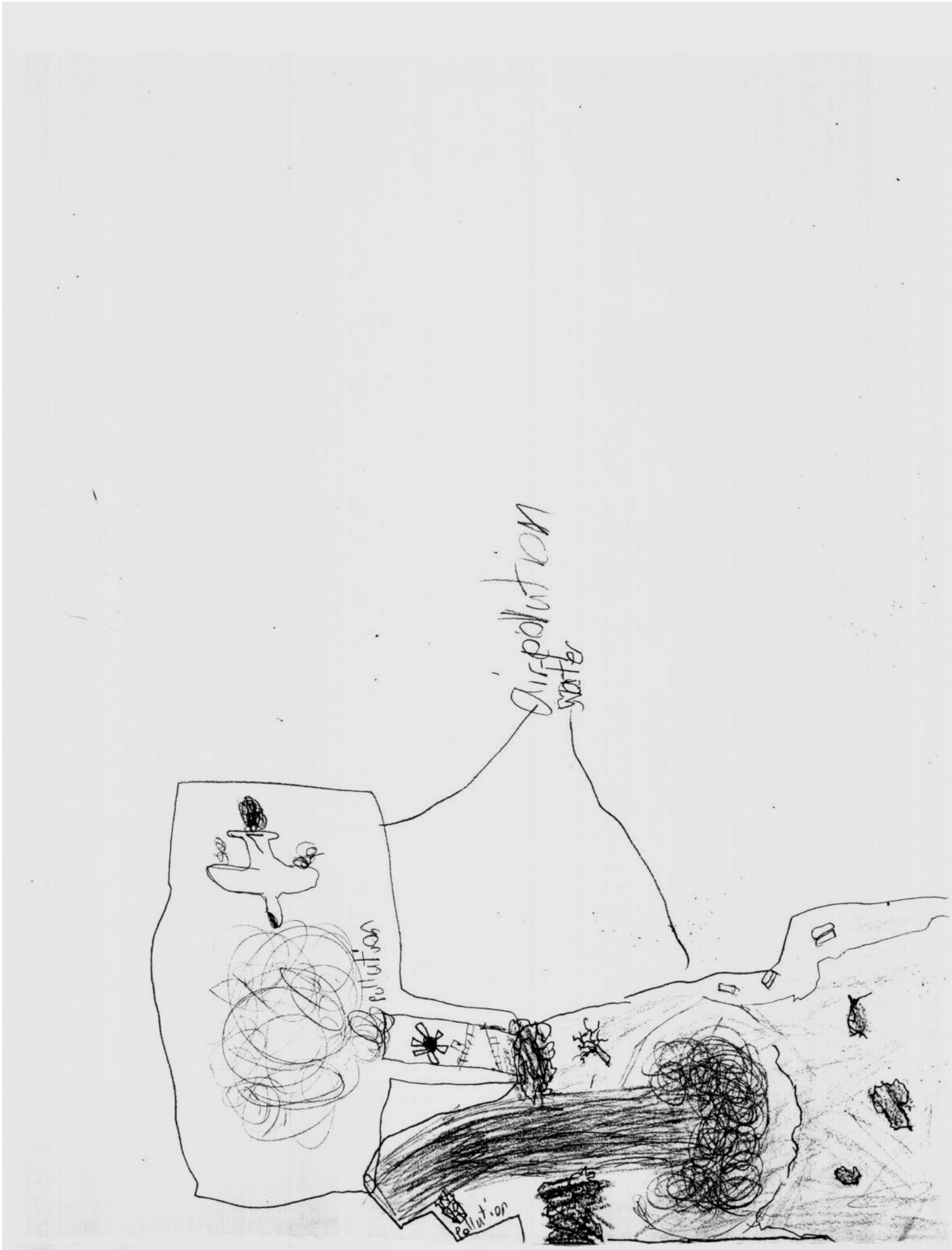
Appendix Q3



Appendix Q4


Natural resources
conserving
throwing garbig in the water, cutting down trees,

Appendix R1



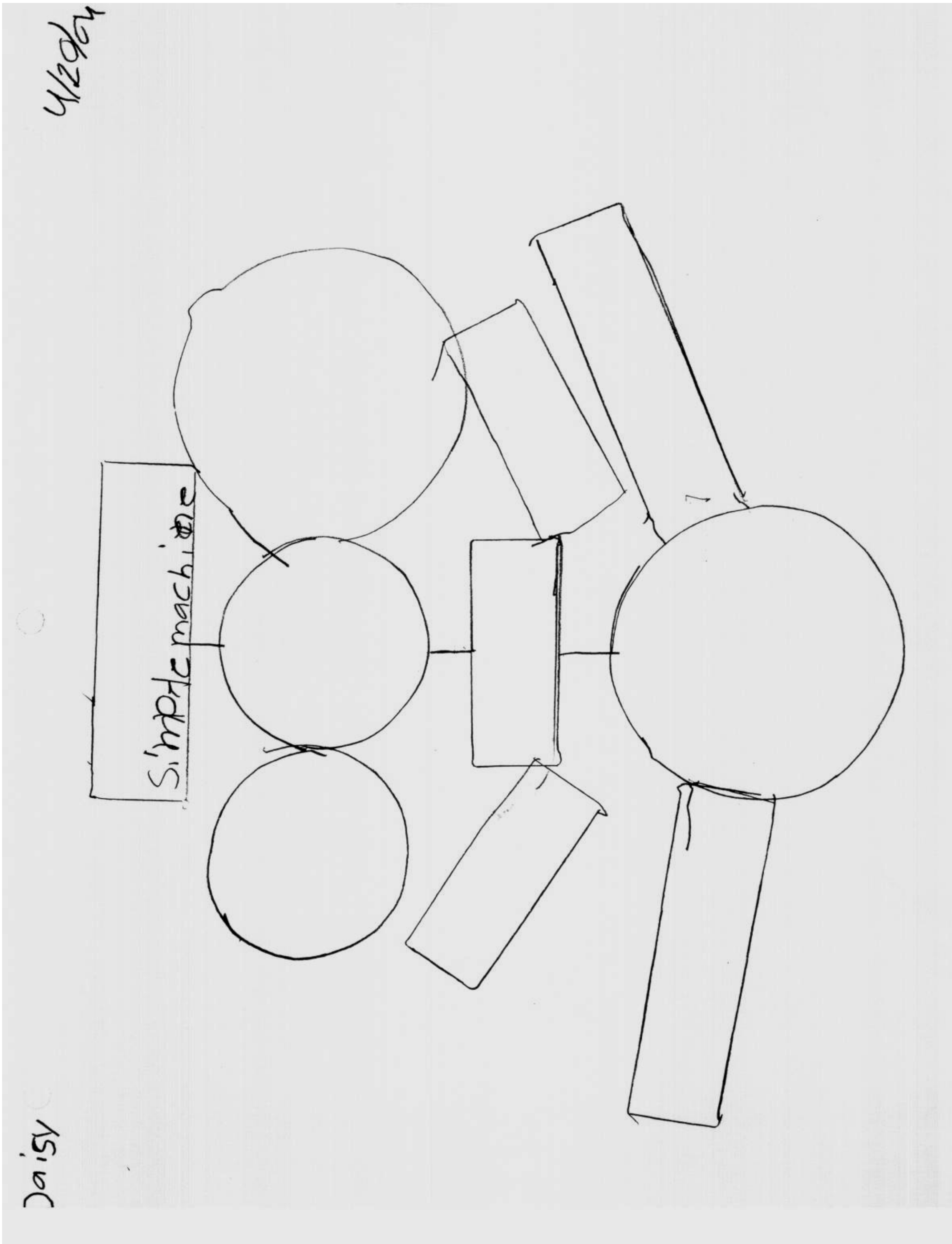
Appendix S1

[redacted]

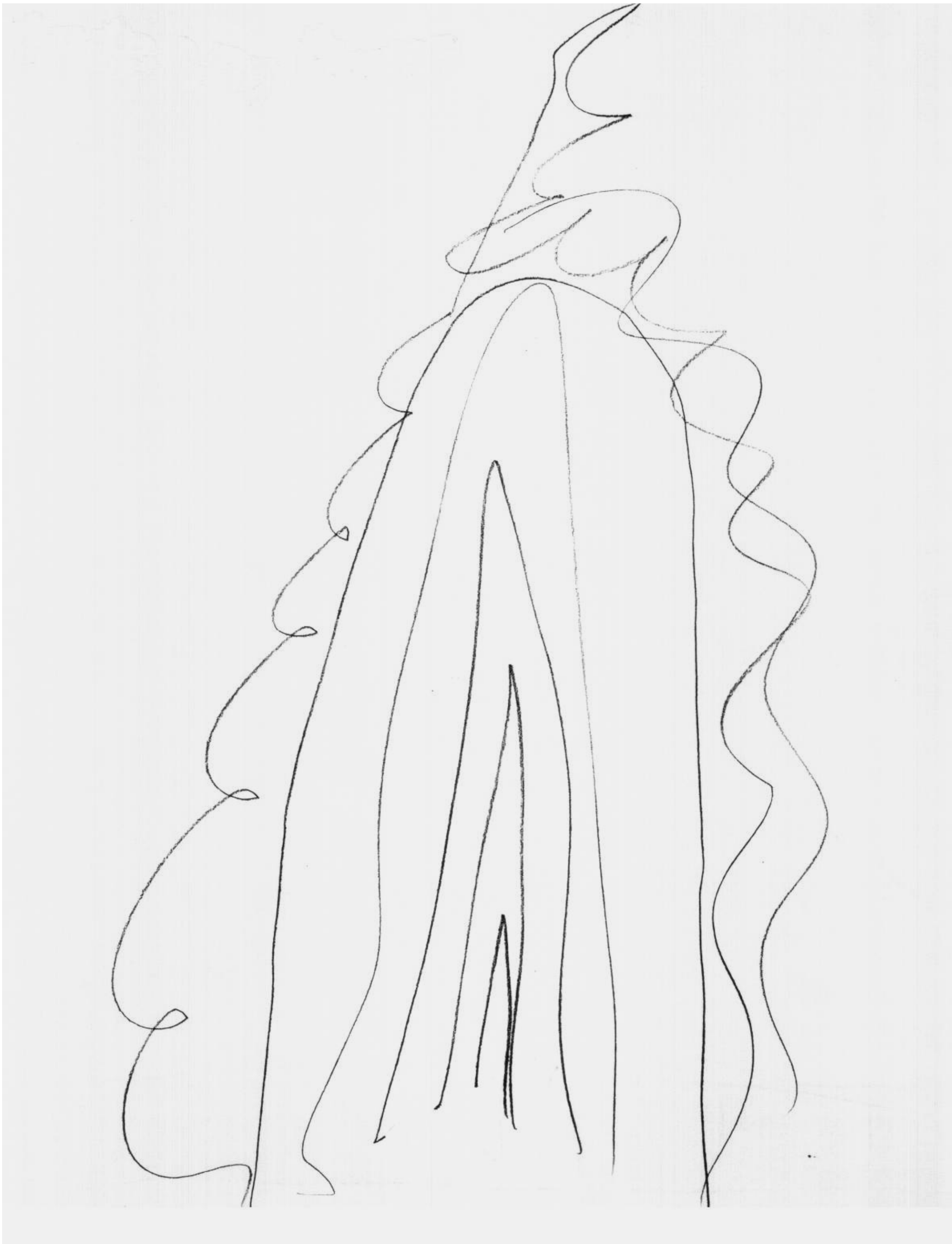
Diasy

Simple machines
inow machines
are afalcrum
and a famep
is a farcrum
a Clock is
a wheel anaxeul

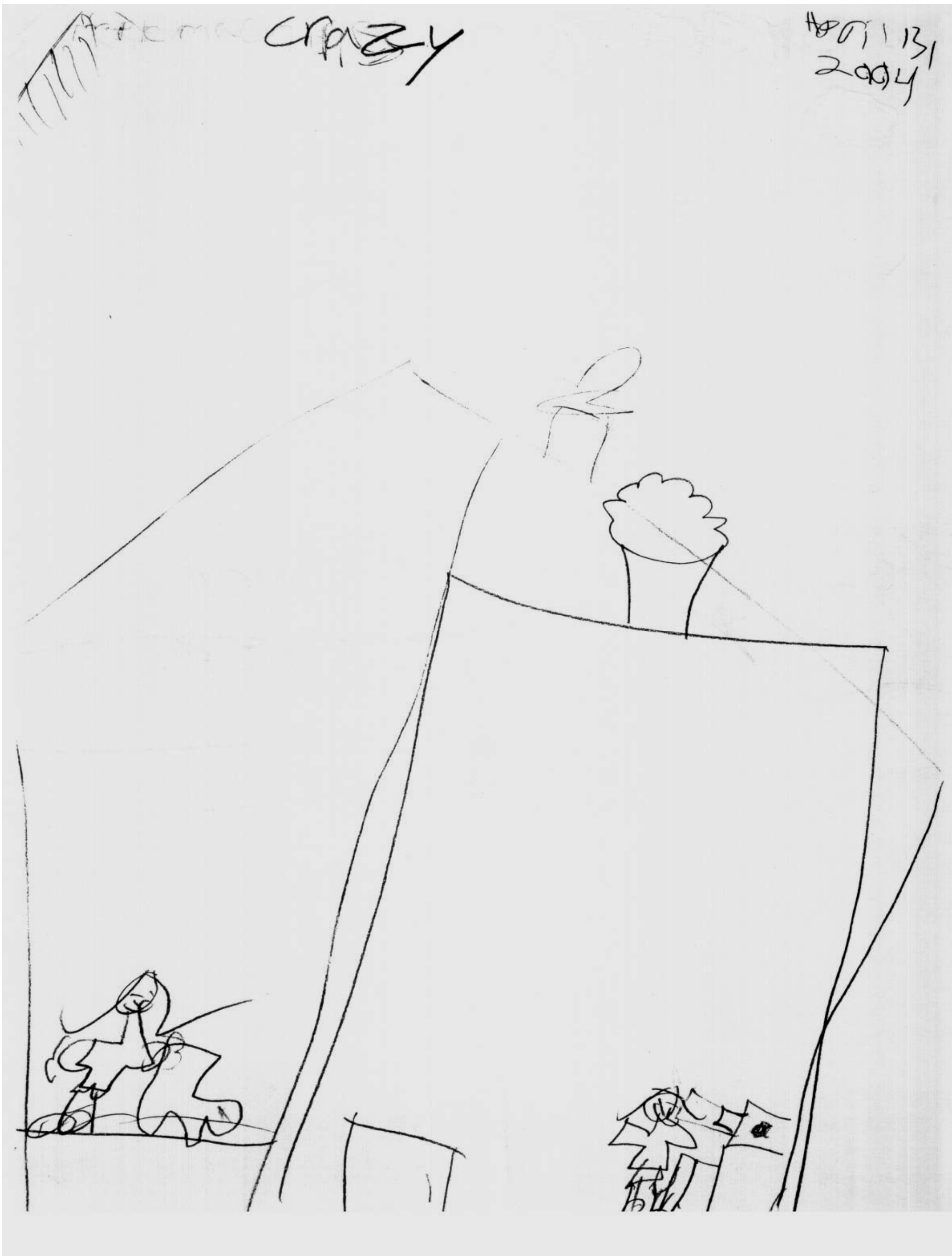
Appendix S2



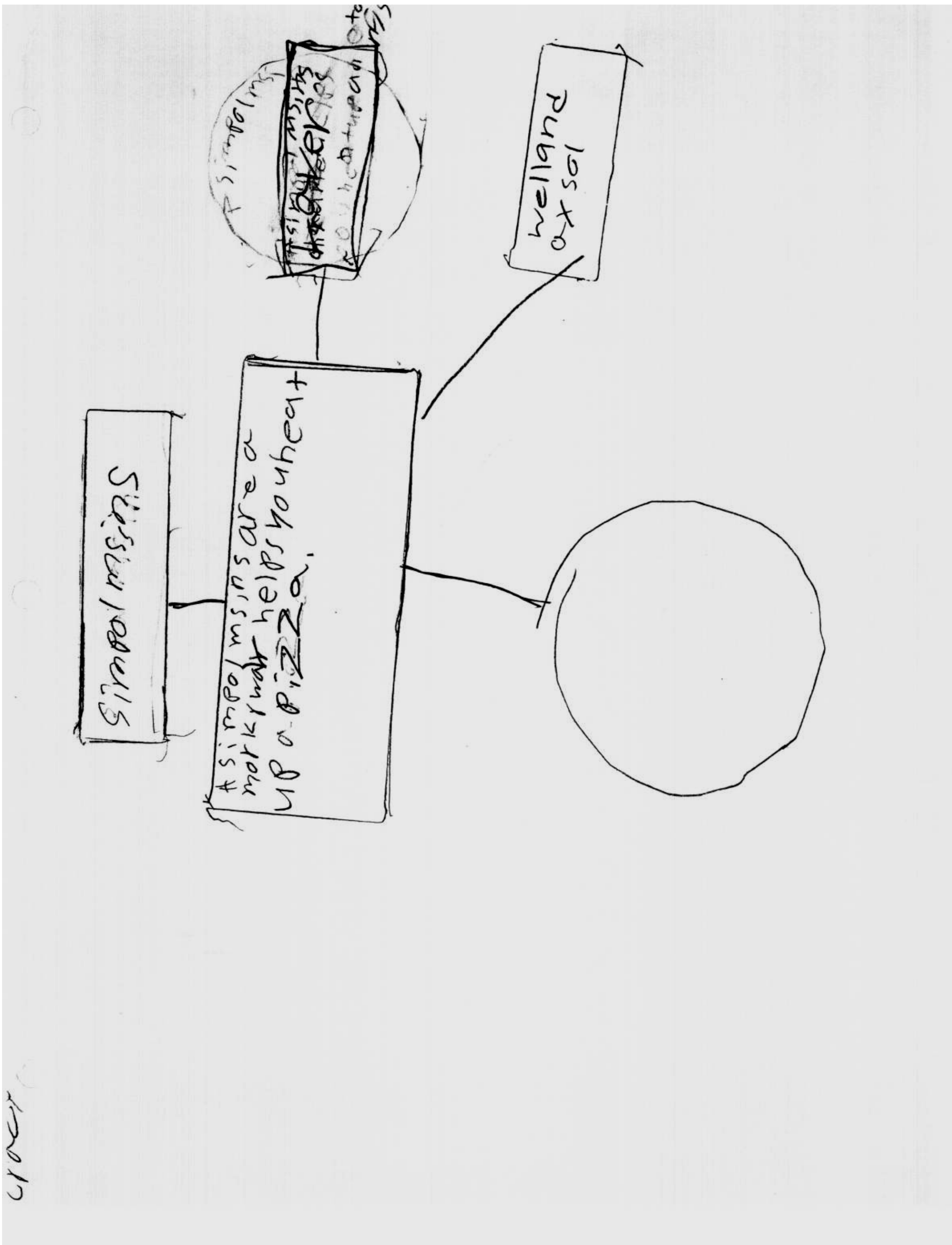
Appendix S3



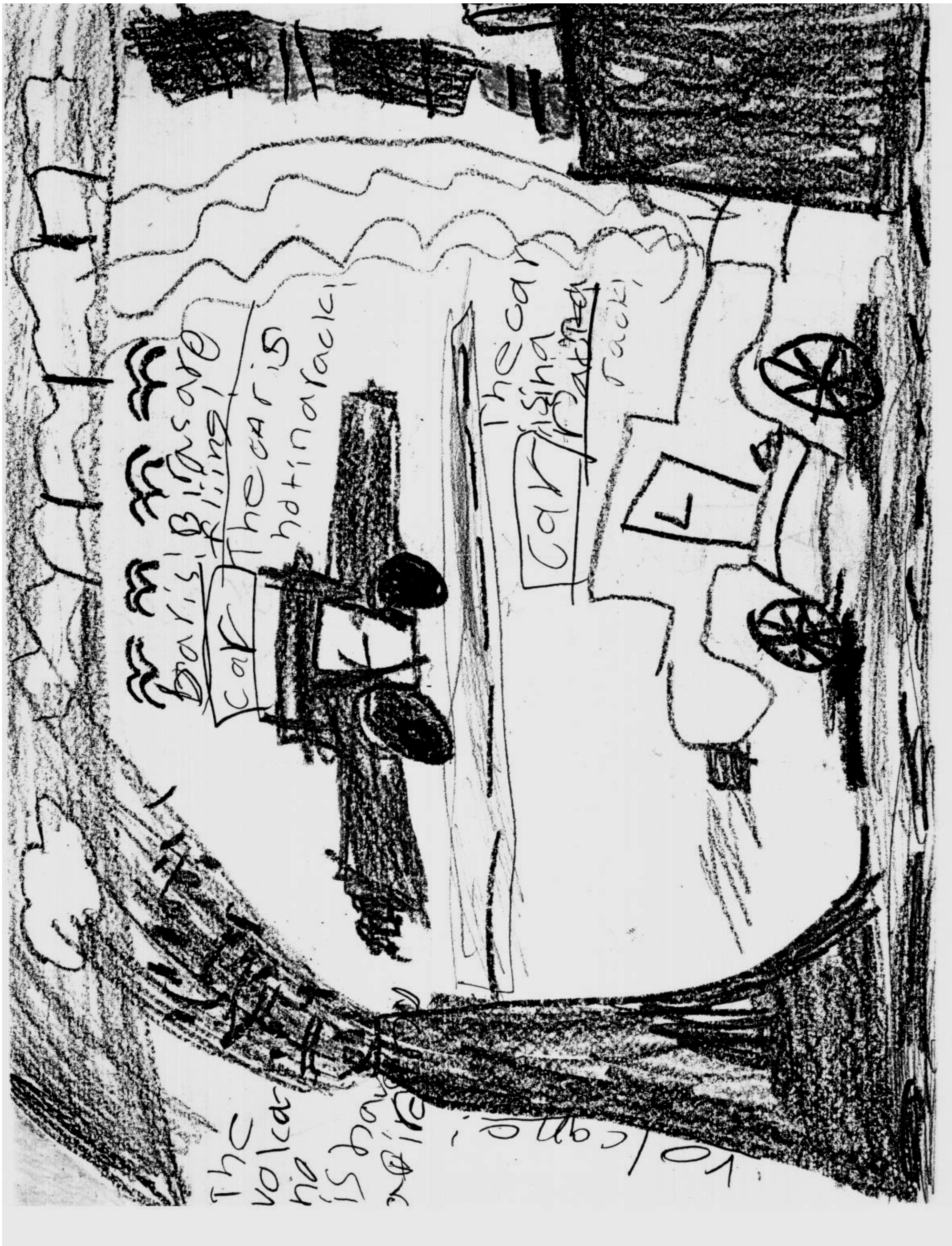
Appendix T1



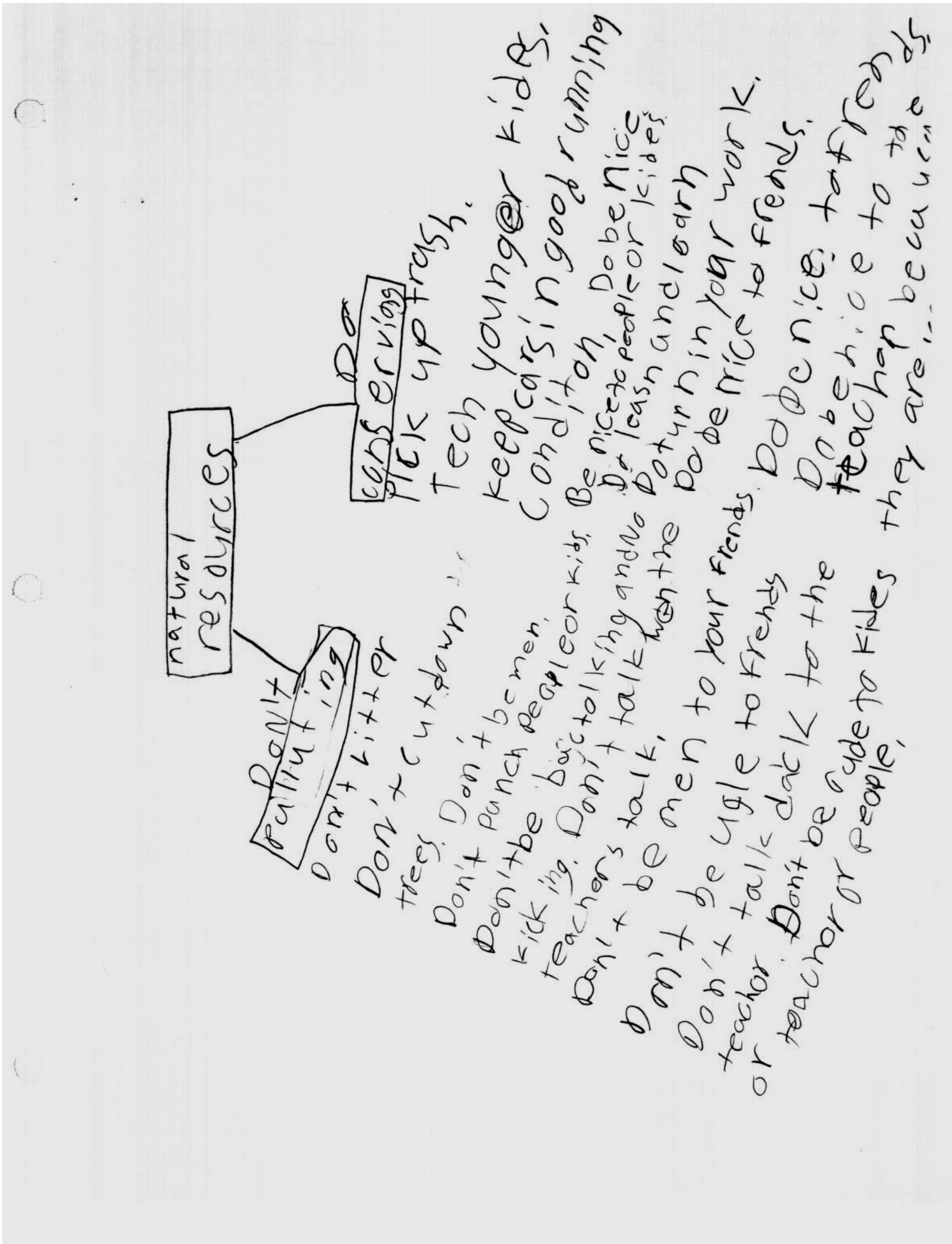
Appendix T2



Appendix T3



Appendix T4


natural resources
Don't
Do
Pick up trash.
Don't litter
Don't be men to your frends
teacher they are ...

Appendix U

Student Interviews

Used in the initial interview:

1. How do you let people know what you know?
2. What did you think about using the graphic organizers during class?

Consistently used at each interview:

1. Tell me about your graphic organizer.
2. How did you decide what words to put on the organizer?
3. How did you know where to put the words?
4. What did you think about showing what you know by using a graphic organizer?
5. Why did you/didn’t you like making the graphic organizer?

Used in the final interview:

1. Do you think about what you know differently when you’re using a graphic organizer?
2. How is your thinking different?

Appendix V

Teacher Interviews

Used in the initial interview:

1. What things did you notice as the students first were introduced and began to work with graphic organizers?

Consistently used at each interview:

1. How would you describe the students' content knowledge right now in relation to remembering factual information versus constructing networks of organized, related concepts?
2. How do student behaviors and/or work products give you insights into what their knowledge looks like?
3. What do you notice about how the students talk about what they know?

Used in the final interview:

1. Has the structure of the students' knowledge changed over the course of the study?
2. How has it changed?
3. What indications do you see of this change?

Appendix W

Artifact Analysis Rubric

characteristic	total #	# correct	supporting observations
components			
levels of hierarchy			
components in each level			
connections within curriculum			
connections to other knowledge			
other characteristics			

participant - artifact designation - date -

Appendix X1

Sample Artifact Analysis Rubric

Artifact Analysis Rubric

characteristic	total #	# correct	supporting observations
components	15		
levels of hierarchy	5		
components in each level	1 3 3 4 3		
connections within curriculum	14		-MANY words indicating connections -2 more words that go with -like a ...
connections to other knowledge	2		-raptor kills more (quantity) -because hunt in packs
other characteristics			-very well-organized using words -excellent command of language AND science info

participant - Subzero artifact designation - ① prose date - 4/13/04

Appendix X2

Sample Artifact Analysis Rubric

Artifact Analysis Rubric

characteristic	total #	# correct	supporting observations
components	14		
levels of hierarchy	4		-levels apparent but not organized in clearest display
components in each level	1 / 1 / 10 / 2		
connections within curriculum	16		-some components connected in multiple ways
connections to other knowledge			
other characteristics			-various geom. shapes utilized to differentiate levels correctly

participant - Uranus　　artifact designation - ② GO　　date - 4/20/04

Appendix X3

Sample Artifact Analysis Rubric

Artifact Analysis Rubric

characteristic	total #	# correct	supporting observations
components	8	13	-last level has multiple examples within 2 components
levels of hierarchy	4		
components in each level	2 / 2 / 2 / 8		
connections within curriculum	7		
connections to other knowledge	yes		-some 'opinions' expressed w/questionable fact base
other characteristics			-same base design as whole class

participant - Foxer   artifact designation - CO-4   date - 5/10/04