Running Head: THE COMIC STRIP FOR PROMOTING SCIENCE LITERACY

The Comic Strip as a Medium for Promoting Science Literacy

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ABSTRACT

The objective of this action research project was to evaluate the use of comic strips in the science classroom as a methodology to promote science literacy by increasing opportunities for students to read about, think about and discuss science concepts and science issues. A curriculum of science themed comic strip warm ups was developed to provide students an opportunity to read, discuss, and respond to the content of the comic strips. During the course of the study, students created their own comic strips and wrote dialogue for comic strips which incorporated relevant scientific academic vocabulary. These activities created artifacts for analysis. Classroom discussions were audio recorded and transcribed. An experimental component compared comic strip treatments to lecture and note taking methodology. Scores were collected and student performance analyzed. Students' written responses were coded and analyzed. Representative samples and scores from rubrics indicated students were engaged in meaningful activities that promoted students' scientific literacy. Quiz and test scores provided quantitative evidence of the comic strip treatment increasing student performance, but only on very specific concepts introduced through curriculum lessons. Participants' survey responses indicated that students' perceived working with the comic strips to be fun and that the comic strips enhanced their learning.

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Chapter I

Introduction

In my classroom, warm-ups had traditionally involved the reading of text, taking notes from context, and the reproduction of drawings and concepts from the textbook. Other activities involved creating data charts or filling out portions of lab reports. Upon entering the classroom, students were expected to begin working on a warm-up posted on the front board. These warm-ups usually involved students working individually at their seats on a task related to the days' lesson. During this time, attendance was taken, individual questions answered and addressed, and the process of completing daily opening business was completed.

Depending on the skills involved; reading, writing, note taking, drawing diagrams, several students each period had trouble getting on task. These students resisted those activities which were challenging, difficult, or that proved tedious for them. What my traditional warm ups failed to allow for were the different learning style preferences of the students.

In addition, the standards-based focus of the curriculum did not allow sufficient time for students to read, think, or talk about science and science issues, which raised concern that I was not addressing my students' science literacy beyond the content standards. The comic strip curriculum used in this study was designed to have students reading silently and aloud, listening, discussing, analyzing and writing. The format was designed to incorporate several of these modalities into each activity during the warm up period. This format still allowed time for the presentation of required content. This was accomplished by transferring important warm up tasks to homework assignments, and revamping the type and quality of homework given. In this manner, the cartoon strip curriculum could be used in the classroom without a significant impact

on structured content lessons. Rather, the cartoon curriculum was intended to support the curriculum.

Promoting science literacy is a challenge facing science educators at all levels (Carrier, 2005; Creech & Hale, 2006; Fang, 2006). The demands of preparing students for standardized tests and covering content standards leave little time for science educators to teach the reading, listening and writing skills unique to their discipline, much less allowing students to have open discourse about the meaning of science, and the role of science in their everyday lives. Finding a way to capture the interest of a classroom with a wide variety of background experiences and learning styles was a separate but equally daunting task. However, the cartoon warm ups addressed in this study were one alternative to address this concern. Hapgood and Palincsar (2007) argued that "finding time for science instruction and literacy instruction does not have to be an either/or proposition," (p. 60). They further stressed that combining instruction and literacy can produce a better result. To help students become comfortable talking about scientific ideas and issues, as well as encouraging them to discuss the content presented in their lessons, educators must look for creative opportunities for students to discuss and debate science issues while still allowing time in class to cover the required content. Wallace (2004), stressed that students would be better served if they were given the opportunity to apply the language of science to their everyday experiences. The challenge is to identify whether talking about science as it relates to everyday life has a part in the current trend towards heavily weighted standardized testing and content standard instruction.

This objective of this study was to evaluate comic strips as a forum for students to think, talk, and write about science in everyday terms, thus supporting their science literacy, while making the content more accessible to the strengths of different learning styles. The genre of the

comic strip, with its blend of dialogue and images allows students to gain and interpret information in a unique and accessible format. A comic strip opens a window to our society through the stories it presents. Research has shown that students learn best when many modes of instruction are used. Multimodality is inherent to the comic strip format. Knain, (2006), underscores this notion when he states:

> Multimodality should be part of the model both as an aspect of the competence of science literacy that students are expected to acquire, but also as a valuable tool for developing science literacy, by enabling transformations across different modes of representation and different contextual presuppositions, in particular, between everyday and scientific contextual frames. (p. 659)

Although there have been several articles and studies about the use of comic strips in the classroom to promote literacy (McVicker, 2007; Morrison, Bryan, & Chilcoat, 2002; Weitkamp & Burnet, 2007; Wright & Sherman, 1999), no study specifically addressed an ongoing, daily comic strip that allowed students to become interested and involved in the "lives" of the characters and the ongoing content of the comic strip. It was noted in one study that one of the appealing aspects of narrative texts in science, specifically storybooks, was the inclusion of human and animals as characters. The presence of these types of characters involved students personally and emotionally in the text (Fang, 2006).

In this study, students were asked to read and respond to a daily comic strip featuring two lab rats. One of the objectives was to see if the students would develop an affinity for the characters, which might aid in keeping keep their interest while practicing science literacy. To accommodate different learning modalities, the strip was read aloud by the teacher for clarity, emphasis, and vocabulary. Students were asked to participate by taking on roles and reading the

dialogue of the two rat characters. Students discussed the strip in a classroom forum, evaluating the background information from the drawings. Only after the students had heard the strip read aloud and understood the setting were they allowed to write down their responses. Later in the study, more extensive activities involving comic strips were added to the curriculum.

The format of the study incorporated a daily warm up of reading and responding to a science themed comic strip featuring two lab rats. Students participated in this process by responding to the language, humor, dialogue, science issues, science content and character analysis addressed in each strip.

Purpose Statement

The purpose of this study was to evaluate the effectiveness of a science-themed comic strip to stimulate student interest in science and science issues and to provide a forum for students to respond, discuss, debate, and write about the content of the comic strips. Through the activities and the treatment components of this study the following research questions were addressed:

1. Does the use of a science themed comic strip promote science literacy by providing students a forum to think, talk and write about science and science issues?
2. Do comic strips presenting grade level content improve student performance?
3. What do students with different learning styles perceive as the benefits of the cartoon strip curriculum? What are the drawbacks?

Importance of the Study

Data in the form of student artifacts, test scores and representative samples collected during this study will give some insight into the effectiveness of using comic strips to promote scientific literacy. Participants' responses concerning the benefits and drawbacks of the activities

used in the study will aid in identifying students' perceptions regarding the value the comic strip format has for their learning.

Definition of Terms

Newton and Copernicus: A science themed comic strip featuring two lab rats named Newton and Copernicus. The strip incorporates science concepts and science issues in an ongoing storyline about the adventures and misadventures of two lab rats.

Science Literacy: Science Literacy has many strata of definitions. In this study, science literacy is defined as students thinking, reading and writing about science in a meaningful, productive way. The literature reviewed in this study presented a wide range of commentary on science literacy. Highlights of those commentaries included "Science learning is metacognition" (Wallace, 2004, p. 902). Perkins-Gough (2007) argued that "You need at least a familiarity and comfort with science to tackle many of the activities and issues of modern life . . . even though you don't need to know the details of every scientific conundrum, you need and awareness of what is and isn't science" (p. 9).

Carrier (2005) identified scientifically literate students as those students who were able to "demonstrate basic skills common to all literacy . . . in the language of the text" (p.5). She further defined scientifically literate students as those students who could "ask, find, or determine answers, to questions derived from curiosity about everyday experiences." The ability to describe natural phenomenon and predict outcomes, as well as the facility to read scientific texts with understanding, were also descriptors of a scientifically literate student (Carrier, 2005).

CHAPTER II

Review of the Literature

Literacy

For middle school teachers, there is now an expectation that literacy is the responsibility of all educators, not just those in the English or language classrooms, and that reading and writing in content areas is essential to promote literacy (Loranger, 1999; Paterson, 2007). Middle school principal Terry Quinn stated that “Literacy has to be a shared responsibility throughout the entire school” (Paterson, 2007, p. 12). Quinn organized a committee at his school with representatives from all disciplines who planned literacy and reading activities for all content areas. The issue of literacy education was also addressed by the Nation Middle School Association. That association’s official position was stated as follows: “Integrate reading through the curriculum, recognize the multidisciplinary nature of reading instruction” (p.12).

Paterson (2007) underscored the need for content area teachers to have a broader view of literacy. The discipline of science is no exception. Science teachers must teach the language and reading skills required for their students to succeed in science. Creech and Hale (2006) supported this idea when they stated that “reading is an essential part of science literacy. . . ” (p. 22). This broader view of literacy acknowledges that media such as cartoons, web pages, graphs, charts and even “body language” (p. 13) are viable tools for reaching students. These alternative methods of delivering content are valuable to students, and students should be given the opportunity to work with these types of media. Paterson (2007) noted that “reading involves thinking, making inferences, and making connections, and we [learners] read many things that are not traditional text” (p. 13). This demonstrated a need to expand the core meaning of literacy.

Teachers in content areas may not be comfortable teaching reading and writing skills. These same teachers will have the additional challenge of working not only with struggling readers, but also resistant readers. In her paper on resistant and struggling adolescent readers Lenters (2006) warned that "resistant readers risk becoming struggling readers" (p. 136). Lenters went on to explain that resistant readers felt themselves capable of reading, and that the act of reading itself was not the cause of their resistance. Rather, these resistant readers noted almost unanimously that "lack of interest in the reading materials they are provided" (p. 137) was at the core of their resistance to content reading. Students interviewed during Lenters' research offered this advice to content area teachers: ". . . choose interesting stuff. Don't try to make us read boring stuff," (138). One textbook evaluation reported by Perkins-Gough (2007) added support to that disgruntled students admonition, stating that "science textbooks covered many topics superficially and were full of disconnected facts" (p.13). They warned that students were likely to become bored with the lack of any real in-depth materials. If students are resistant, bored, or unmotivated to read, educators must look to other mediums to present content while addressing literacy.

Teachers and administrators will continue to face challenges in content area literacy. Loranger (1999) argued that our changing economy will place a higher emphasis on reading and writing skills as we transition from manufacturing to technology based careers. To address this issue, Loranger suggested that "reading in the content area is seen as a viable way to address that literacy crisis" (p. 239). Loranger's paper investigated a pilot program at one school where the focus question of the study was "how can reading in the content areas be taught effectively in the middle school?" (p. 239). Teachers in that study identified key areas to help their students succeed. These areas included differentiating between narrative and expository text, strategies

for using prior-knowledge, helping students with metacognition, (knowing how they learn) and teaching them study strategies.

The study data indicated that “an integrated approach to reading can be implemented in a middle school environment” (Loranger, 1999, p. 243). Recognizing that “the challenge of content area literacy” (p. 239) can be addressed, should offer encouragement to content area teachers who feel they are not capable of teaching reading, writing and literacy skills in their content area.

Science Literacy

Literacy within the content area of science is a complicated, multifaceted concept. There are many differing viewpoints as to what science literacy actually encompasses. Knain, E. (2006) commented that there has been progress in narrowing down what science literacy actually is. He noted that “. . . progress has been made in getting a clearer theoretical and empirical understanding of this concept.” He further stated that scientific literacy is no longer something to be dismissed “as a useful myth” (p. 656). But within the literature there exists a wide range of opinions concerning the definition of scientific literacy.

Many studies (Creech and Hale, 2006; Fang, 2006; Perkins-Gough, 2007; Wallace, 2004) presented sound arguments towards the understanding of what defines science literacy. Wallace (2004) listed “knowledge of scientific vocabulary, understanding the nature of inquiry in science, being able to use scientific concepts in everyday life, and being able to read and interpret scientific information in the popular press” (p. 901) as skills that demonstrated scientific literacy. Further, Wallace defined scientific literacy as skill where “reading and writing in the fundamental sense are essential for science learning . . . [and] . . . developing facility with reading and writing scientific texts is critical to developing scientific literacy in the broad sense”

(p. 902). In an interview with Alan Leshner, then CEO of the American Association for the Advancement of Science, Perkins-Gough (2007) quoted Leshner's belief that one needs "at least a familiarity and comfort with science to tackle many of the activities and issues of modern life. Even though you don't need to know the details of every scientific conundrum, you need and awareness of what is and isn't science" (p. 9). Creech and Hale (2006) noted: "we are learning that science literacy is not a fixed object . . ." and that students are ". . . evolving readers" (p.24). These diverse opinions underscore the complex task of defining science literacy.

Wallace (2004) presented a theoretical framework, the purpose of which was to create a model on which to base research on scientific literacy. Wallace states that scientific literacy is comprised of three related skills. The first of these is that a scientifically literate person can both read and write scientific texts. This person should also be able to argue scientific concepts at a fundamental level. The third skill is that of metacognition, the ability to self monitor learning.

The framework Wallace (2004) discusses is composed of three elements. The first element is "Authenticity in scientific language use" (p. 903). The idea behind this authenticity of scientific language is that a student should be able to speak from his or her point of view correctly using the vocabulary and concepts of the science he or she is discussing. Wallace stated that "when the child needs to use scientific language to express her own experience, she will be authentically communicating" (p.903). This action research project addresses a forum for students to talk about scientific ideas and issues. Without a basic understanding of the style of language students are using to communicate scientific understanding, the effectiveness of the format would have been diminished.

Multiple discourses are the second leg of the framework. The idea behind multiple discourses is that there are different levels of scientific language that can and should be used in

the classroom. Wallace (2004) cited “casual peer group discussion, or ‘bench work’ talk” (p.905) as one type of discourse. Wallace pointed out other types of discourse that would be more appropriate in other situations, such as a group presentation, a written piece of work, and the reading and use of text from a textbook. The implication of her study is that students need to be comfortable with all of these forms of discourse.

Wallace talked about the concept of a “third space” where what is spoken by one person is not precisely what they meant, and that the person who hears what is said will have a slightly different interpretation than the speaker. Wallace indicated that “in the science classroom, the implication is that neither the teacher’s meaning, nor the student’s meaning for an utterance is the correct meaning, but that learning will involve the negotiation of meaning until either there is a mutuality of meaning, or a new hybrid meaning is constructed” (p. 908). The implication of this third space is that science discourse must be thorough and accurate, and that misconceptions and preconceptions need to be dealt with in order for the student to achieve a scientific, or literate level of understanding.

Students in middle school science not only having to shift to reading informational text, instead of the more comfortable narrative texts of elementary school, but they also are faced with the challenge of learning and working with the language of science that is prevalent in the text they read in school and independently (Fang, 2006). In her study, Fang cited multiple key elements of scientific language that are different from the everyday language the students are used to reading, speaking and hearing. At this time, when students are expected to transition from learning how to read into the more challenging ‘reading to learn format’, they encounter a dramatic change in the type of reading materials they use. These texts are complex, dense materials where common words have different meanings and sentence structure favors a passive

voice. The use of the passive voice allows scientific writing to be more objective, but it removes several types of contextual clues, resulting in confusion for readers not trained in the reading skills required by scientific writing. Fang studied a wide range of language structures unique to science including: complex sentences, interruption construction wherein a noun is separated from its verb by a supportive clause, and the use of densely packed, lengthy nouns. Fang gave this example: “A tornado is a rapidly whirling, funnel-shaped cloud that reaches down from a storm cloud to touch earth’s surface” (p. 501) to underscore the idea of a densely packed noun.

Fang (2006) described strategies for educators to use to address this complex challenge. Such strategies for reinforcing scientific literacy included vocabulary building, noun expansion, sentence completion, paraphrasing, and sentence stripping. All of these approaches included methods to help students decode the complex language of science. In order for students to become scientifically literate, their reading must include scientific texts such as classroom textbooks and trade journals, as well as less traditional media (Creech & Hale, 2006; Zmach, et al., 2007).

The authors of another study (Zmach et al., 2007) warned that science teachers needed to take the initiative to get their students reading by giving students access to enjoyable, readable books and other texts. The motive behind this was to improve students’ ability to acquire strategies that would enable them to use their textbooks more effectively. The authors also admonished “researchers outside the classroom to reach out [to content area teachers] with support” (p.65). Their contention was that teaching reading was not to be considered an added chore for content teachers, but an expected process to promote content area literacy.

Visual Literacy

One of the intrinsic aspects of a comic strip is the blending of text and dialogue with visual background information. This background information can provide important context clues to help the reader interpret the text. Understanding the role of visual images supporting text is necessary to understand the value of the mixed medium of a comic strip. In a study which analyzed visual images in textbooks and news articles, Dimopoulos, Koulaidis, & Sklaveniti, (2003), disagreed with the premise that it is through the language of a culture that "messages and meanings primarily reside and that visual illustration is a relatively transparent and unproblematic window to reality." They further argued that visual images were "autonomous systems of communication. . . ." which have ". . . specific conventions embedded in their construction. . ." (p. 190). The authors implied that these conventions made images powerful and systematic communication tools. It could be argued that the same would be true for the images in a comic strip, that they communicate a great deal of information on their own, and even more when linked with text.

In their research the authors noted that these two formats (textbooks and news articles) are ". . . the most important. . ." formats used to communicate information about technology and science to ". . . non-specialized publics. . . " (p. 189). Their study analyzed the visual images which were incorporated into these types of texts. They noted in their findings that the ratio of text to images in a textbook compared with a magazine or news article was nearly ten times greater (Dimopoulos, et al., 2003). School science textbooks analyzed averaged "11.1 images/1000 words" (p. 201). Of those images, the authors found that "eighty nine percent" of the images were realistic. The authors noted that these numbers were intrinsic to the communication of the related text, concluding that the inclusion of images was a powerful way to help students understand the abstract ideas presented in science classrooms. When addressing

the actual function of the visual images tied into the text, the authors suggested that illustrations are employed to help non-specialists, or lay readers by showing them pictorial models of the appearance and structure of scientific artifacts (Dimopoulos, et al., 2003).

Dunsworth and Atkinson (2007) studied the role of an animated agent, a character on a computer screen which interacts with the learner while they are engaged in computer based instruction. While comic strips are static, as opposed to the mobility of a graphic character on a computer screen, some comparisons are valuable for consideration. Their research suggested that the behaviors of the onscreen character mimics modes of non-verbal communication. They argued that "agents capable of these behaviors are considered powerful additions to multimedia learning environments" (p.678). Their research inferred that this is done by combining both verbal and non-verbal communication forms.

Dunsworth and Atkinson (2007) continued with the idea that learners are capable of "dual channel information processing" (p.678). This is attributed to the cognitive ability of a learner to get input simultaneously from visual and auditory clues. When presenting the comic strip curriculum in this study, the dialog was always read aloud by the teacher and then repeated by students while the class followed along. In this manner, the students were hearing the dialogue of the characters as well as viewing the background context of the cartoon strip before they were asked to respond to the strip. The authors noted in their study that ". . . when words and images are involved in the instruction, verbal information delivered in an auditory rather than a visual mode decreases the cognitive load and increases the size of working memory because our cognitive architecture can receive information from both auditory and visual channels simultaneously" (p. 697). This implied that using comic strips with students might be more effective if the dialogue was read aloud while students looked at the pictures.

One of the interesting findings of the animated agent study was that the use of the onscreen agent yielded a large effect in terms of students' success in answering retention questions (Dunsworth and Atkinson, 2007). The study suggested that this improvement was the animated agent's ability to "carry motions such as speech, gazes, gestures or pointing on the screen" (p. 687). They speculated that by adding the animated agent, the role of the computer changed from a tool that delivered information to a "social character that bears personal features to induce social responses" (p. 687). Although the characters in the comic strip used in this study were rats, not human characters, and static, not animated, they did mimic the same motions mentioned above, speech, gazes, gestures, pointing, and because the were given human-like emotions and intellect, they may have engaged students in the same manner.

Visual literacy can be supported by incorporating the visual and communicative arts. Learners take in information visually from the complex society around them (Flood & Lapp, 1998; Lin, 2003) and are multi-media consumers of visual information.

Flood and Lapp (1998) described a brief case study, summarizing the morning activity of one child in a San Diego elementary school. They described the media that filled her day as she read her cereal box, listened to her mother's directions in Spanish, and admired her favorite bookstore on her way to school. She observed friends playing a video game, read billboards, and conversed in English about an upcoming fieldtrip to the zoo. Upon her arrival at school, she observed students practicing a dance routine while anticipating her Internet project. The authors of the study argued that it is necessary to "broaden our notions of acceptable literacy texts" (p343). They further noted that a large number of educators have "hierarchies of acceptability for the visual and communicative arts" which were in conflict with the types of media the students would encounter in the real world and in the workplace.

Flood and Lapp's (1998) argument stressed that there seemed to be an "irrational loyalty to reading and writing" (p. 343). The tendency was to resist incorporating other visual arts that might impede on the progress of reading and writing. The authors speculated that by perpetuating this resistance to integrate information and forms of display, the schools would continue to miss out on teaching the knowledge learners need to function in society. Weitkamp and Burnet (2007) argued that comic strips were one of the communicative arts that were ill favored and excluded from the acceptable hierarchy. They further stated that comic strips had much to offer in terms of visual literacy and that comics had been unfairly maligned. Lin's (2003) article on literacy instruction supported the idea that education should be more willing to embrace new and different formats for increasing visual literacy. She summarized the challenge of incorporating more modes of visual literacy by suggesting that the changes in technology are creating more and different methods of transmitting knowledge. She further argued that:

> When we expand our methods of literacy instruction by including TV, drama, multimedia, comics, and other formats, we may be able to reach more students in the language arts classroom and meet students' different learning styles than would be the case using purely traditional teaching methods. (Lin, 2003, p. 4)

Lin's argument added some credibility to this study's objective of incorporating comic strips into the curriculum and evaluating the perceptions of the comic strip curriculum among students with different learning styles. With this basic understanding of the complexity and diversity of what is involved in the process of addressing science literacy, it was appropriate to focus in on the specific area of study of this action research project; comic strips as a medium for instruction.

Comic Strips in the classroom

Research has indicated that comic strips in the classroom can be a great teaching aid for English Language Learners (Carrier, 2005; Glaeser, Pierson, & Fritschmann, 2003; Serious ESL Lessons, 2005). Carrier addressed the difficulties of English Language Learners, especially in their frustrations with science literacy. Her study noted that English language learners who may seem casually fluent with their peers, and capable of conversing with other students, struggled with writing about science content, and were unable to verbalize their understanding. The author determined that the "puzzling decline in classroom literacy abilities is that the language used in science and other content areas is different from conversational language" (p. 6).

When considering comic strips as a serious intervention for ESL students, the author noted that "carefully selected comic strips can become great teaching aids for ESL instructors" (Serious ESL Lessons, 2005, p.1). The article also stressed that comic strips were beneficial "because they provide brief conversations in English with pictures that help convey the meaning of the words" (p.1). For a visual learner, especially one who may be below grade level in reading, or a kinesthetic learner who resists reading, the pictures in a comic strip reinforcing the concepts could potentially make the content more accessible. The article argued that cartoon [comic] strips are effective: "it's not just aural or visual, it's both" (p. 1). One could fairly extrapolate that comic strips can benefit not only ESL students, but also auditory and visual learners.

One of the objectives of this study, beyond equitably addressing the learning styles of my students, was to stimulate discussion about science concepts and science issues. Dahbany Miraglia, an ESL teacher, shared the following thoughts during an interview. She explained that she used ". . . cartoons to elicit rather than to lecture" (Serious ESL Lessons, 2005, p.1). She

added that giving cartoons [*comic strips*] to the students "lets them talk about how they feel, what they think" (p. 2).

The use of comic strip conversations has been studied in special education, addressing the limited verbal abilities of certain autistic children. This study noted that "children with limited verbal skills benefit from comic strip conversations because they rely on extensive use of visual materials" (Glaeser, Pierson, & Fritschmann, 2003, p.15). The researchers further noted that "although originally developed to help students with autistic spectrum disorders, these techniques can be applied to any student with below-average verbal language ability" (p.15). Students in the study were able to express their feelings about playground issues they were having by drawing and creating conversations in comic strip format. Using comic strips as a medium to convey understanding and information for a general education population could have equivalent benefits for students who struggle to express their ideas.

The value of using concept cartoons was discussed by Kabapınar (2005) in a study which evaluated the use of cartoons in a constructivist approach to teaching science concepts. He cited the findings of a previous study by Keogh and Naylor.

> The concept cartoon approach in teaching science enhances motivation, provides a purpose for practical work, minimizes classroom management problems by the focused discussion that keeps the pupils on task, enables finding out students' ideas prior to teaching, and provides a manageable way to plan and carry out the teaching according to students' ideas. (Kabapınar, 2005, P. 137)

Since a classroom warm-up activity is most effective when students are on task and engaged, these findings validate the intrinsic value of investigating the comic strip as an instructional tool. The logic behind incorporating the comic strip into the curriculum was further

supported by Wright and Sherman (1999). Their articled offered three arguments for the inclusion of comic strips in a language arts classroom. The first argument they offered was supported by their findings that there was a ". . . wealth of research to indicate children's interest in comic media," (p. 1). They felt it could be reasoned that children would respond positively and engage in those activities which interested them. They also noted that comic strips are widely available, citing the number of newspapers in circulation. This argument addressed the idea that comic strips were a relatively inexpensive resource. Their research also indicated that comics often have a low reading level and simple language structures. The value of this aspect is that comic strips would have a wide appeal, and would be more accessible to low performing readers and language learners.

In summary, the authors' stated that the having students create comic strips was a valuable way to promote not only literacy, but higher level writing and thinking and the skills required to attain those levels. The readability of a comic strip, because of the visual clues, the text presented as conversational dialogue, and the students' natural affinity for the genre, would provide added motivation for students to become engaged in the exercises from the curriculum (Wright and Sherman, 1999).

McVicker (2007) developed several points advocating the use of comic strips as a text structure for teaching reading. She cited that "a picture extends the meaning of text for the reader" (p. 85). Tied in to Bloom's taxonomy, this interpreting of the words and pictures simultaneously, what Bloom would define as synthesis, "raises the bar of ability to a higher order thinking skill" (p.85). The new connections a reader would make as they read and analyzed the pictures would increase their comprehension.

In her article, the author also commented on a report from the International Reading Association. The association stated that making a difference in the classroom would require instructors to approach teaching in new ways. Comic strips, according to the author, are one way to create that sense of something different (McVicker, 2007). McVicker suggested that "using a comic strip as an alternative text structure for reading alters the child's view of traditional text structures," (p. 86). She further suggested that struggling readers might be more easily engaged by comic strips, as they are "humorous, visual, and limited in text" (p. 86). These qualities, she contended, might alleviate children's negative feelings about reading.

The study also pointed out a quality of comic strips that might be overlooked when being considered for instructional purposes. Comic strips include what McVicker (2007) referred to as the "traditional literary discourse triangle: the addresser, the addressee, and the referent" (p.87). It is this interaction among the characters, dialog, and storyline that gave the comic strip an instructional value worthy of investigation.

One of the reasonable arguments against the use of comic strips in the classroom was the fact that "it can be difficult to validate outcomes of popular culture experiences in terms of teachers' goals and objectives" (Morrison, Bryan & Chilcoat, 2002, p.758). The authors noted that other teachers welcomed such resources, and recommended that these pop-culture modes of information and instruction should be used with both middle school and high school audiences in all disciplines. The authors offered three reasons that supported this recommendation. The first reason was that popular culture has a huge impact on the social lives of middle school students. The use of this medium could make a connection between the extremes of the school experience and real life. Their second reason suggested that students were exposed to these mediums anyway, and that they would benefit to be trained to be "critical consumers of media messages,

having developed the ability through exposure to accurately appraise media content for quality and accuracy" (Morrison, et al., 2002, p.759). The third reason states the obvious, that ". . . popular culture is popular. Students do enjoy it!" (p. 759). The authors championed the idea that comic books were a form of literature students enjoyed, and further suggested that if students had the opportunity to write their own comic books and the chance to share them with their peers, students would engage in "greater literary exploration that they otherwise would, due to the comics' popular and easily accessible format" (p.759).

Comic Strips in the Science Classroom.

Two studies in the research did not deal directly with comic strips in the science classroom, but rather examined the use of cartoons in the teaching of physics. While observing video clips from various cartoons, students watched for examples in the cartoons that either followed or violated the laws of physics (Rogers, 2007; Perales-Palacios & Vilchez-Gonzalez, 2005). The research methods employed and some of the findings from the studies helped clarify the unique challenges that the field of science is faced with in presenting abstract ideas. It was also of value to have investigated research on different media to help understand different methods that have been used to support visual and science literacy.

Perales-Palacios and Vilchez-Gonzalez (2005) investigated to find out if using cartoons would be "motivating and invigorating the classroom" (p. 1650). They also looked at using cartoons as a tool for assessing the learning that was going on and for documenting the ideas students had regarding a given phenomenon. The researchers' presented clips from cartoons and asked students and teachers to view selected cartoon episodes and to "identify the unreal phenomena" (p. 1650).

As the study progressed through the next stage, students were instructed to record in their journals their observations of any "physical law or laws that, in their judgment, would provide the basis for the physical phenomena that they had identified" (Perales-Palacios and Vilchez-Gonzalez, 2005, p. 1651). In the advanced stages of the study, the research looked into the use of cartoons as "a tool for problem-solving and the assessment of learning" (p. 1653). Once these preliminary stages had been assessed and evaluated, the project was continued using a larger sample of pupils that would allow for the inclusion of control and experimental groups (p. 1654). Perales-Palacios & Vilchez-Gonzalez concluded that "cartoons can represent a resource in the classroom for identifying the pupils' previous ideas, as well as for making an assessment on their learning" (p. 1668). This suggested that the use of comic strips in the classroom may demonstrate the same potential as an assessment tool.

Finding new ways to capture students' attention and to get them engaged was a common strand of most of the research relating to visual literacy and the use of comic strips and other media in the classroom. In a separate study on cartoons and the teaching of physics, Rogers (2007) stated that "books, cartoons, movies, and video games provide engaging opportunities to get both science and non-science students excited about physics" (p. 38). His commentary underscored the positions of many of the previous studies. In his research, students not only observed popular cartoons and cinema, but they also used sophisticated computer software to track the motion of objects or characters within the clips. With this software, students were able to quantify the scale and motion of the object they were observing in the video clip to determine the physics of the motion, and ascertain if the motion behaved within Newtonian laws of motion.

Rogers (2007) concluded that this type of activity did engage both his science and non-science students, but cautioned that the sophistication of his honors physics course probably

could not be translated into a regular education course. This was due to the difficulty level of the software, and also to the difficulty of accumulating resources and finding the time required to prepare the video clips for analysis by the software. What was of value in both the Rogers and the Perales-Palacios and Vilchez-Gonzalez (2005) studies, was their common conclusion that students had an affinity for the cartoons, and for the use of popular media in the classroom.

Weitkamp and Burnet (2007) researched the use of a comic strip in UK primary science classes. They pointed out that comic strips have been overlooked by educators because "as a genre, they are perceived as low brow, being neither art nor literature, and they are condemned for their outlandish use of fantasy" (p. 1911). But the authors argued that comic strips have certain qualities which may prove beneficial in the classroom. Students who read comics may become more familiar with reading informational texts such as newspapers and other non-fiction periodicals.

Weitkamp & Burnet (2007) suggested that comic strips may actually enable students to better understand science, stating that "comic strips . . . can be used effectively to provoke thinking about science and health related issues" (p. 1912). They further indicated that presenting scientific principles by combing both text and images ". . . seems likely to convey a concept more easily than words alone."

In the study, participating teachers found that the comic strip format kept the students attention, especially the boys in the classroom. Children made sense of what they read by using all of the visual and verbal information in the strips. Other observations noted that low level readers were able to participate by looking at the pictures, and one pointed out that "it engaged the ones who were interested in the visuals to read" (Weitkamp & Burnet, 2007, p. 1921). The

authors research supported the use of comics as valuable for “reading comprehension, visual literacy, and punctuation, among other functions” (p. 1921).

In a manner similar to the comic strip used in this action research (Newton and Copernicus) the Chemedian comic strip used fantasy elements to create an interesting format for the presentation of scientific principles. Weitkamp and Burnet suggested that the response to the cartoon strip supported the notion that “children often respond positively to activities that are different from the usual classroom routine” (p. 1922). The use of a daily comic strip as a warm up in a science class was originally considered because of its unusual format.

Learning Styles

In order to consider any evaluation of the appeal comic strips might have for students with different learning style preferences, a basic review of the literature was appropriate. There are multiple learning style models that researchers have developed for use in identifying a student’s preferred learning style. In the most familiar model, learners are categorized as visual, auditory, kinesthetic, or a combination of these three. “Learning styles are. . . related to physiological factors: visual (seeing/picture), Auditory (hearing), and Kinesthetic (touching/physical)” (Vincent & Ross, 2001, p.9).

Vincent and Ross (2001) offered this definition of a visual learner. They suggested that “visual learners have vivid imaginations, learn by seeing images . . . and find verbal instructions difficult” (p.10). Some suggested strategies for teaching the visual student included, “using video equipment, providing assignments in writing; and using charts and pictures” (p.10).

The auditory learner has different needs. Vincent & Ross (2001) noted that “auditory students prefer the auditory sense. They enjoy talking, have difficulty with written instructions . . . and must hear to understand” (p.10). When teaching the auditory learner, teachers “need to

provide as much auditory stimuli as possible," (p.10). Verbal reinforcement, group activities, class discussions and reading aloud are beneficial strategies for auditory learners (p.10).

The article next addressed kinesthetic learners, stating: "kinesthetic or tactile students prefer the tactile sense," (Vincent & Ross, 2001, p.11). They elaborated that such students "are poor listeners, they learn by doing, express their emotions physically, and usually have outgoing personalities".

When considering the needs of this learning style, teachers should incorporate tactile, hands on projects, allow students the opportunity to move about the room, and incorporate writing, drawing and notes as an integral part of the lesson (Vincent & Ross, 2001). Even if a teacher only had this basic range of three learning preferences in the classroom, it would be desirable to find a way to deliver content to this variety of student styles efficiently. The objective of this study was to determine if the use of comic strips in a properly designed lesson format would have attributes that made the comic strip curriculum conducive to addressing these multiple learning styles. Comic strip attributes used in this study were: reading silently, reading aloud, text reinforced with visual images, drawing, creativity, and written responses.

Multiple Intelligences

Another model viewed learning styles in terms of multiple intelligences. The theory behind multiple intelligences "defines intelligence as the capacity to solve problems or to fashion products that are valued in one or more cultural settings" (Vincent & Ross, 2001, p. 4). First introduced in 1983, "Gardner's multiple intelligences theory provided a new way of looking at intelligence" (p. 4). The seven original categories are listed below:

Linguistic: the capacity to communicate effectively in writing or orally.

Logical-Mathematical: the capacity to work with numbers and high order thinking.

Visual-Spatial: the capacity to learn through graphic images.

Musical: the capacity to think/express in musical forms.

Body-Kinesthetic: the capacity to use body movement in learning and expression.

Interpersonal: the ability to understand and interact with other people.

Intrapersonal: the ability to understand themselves and pursue their own interests. (p.5)

Although this action research study did not categorize students into the learning styles of the subgroups into Gardner's multiple intelligences, the comic strip format and curriculum design should accommodate many of these intelligences through its multi-modal design.

Global/Analytical

Another learning styles model was one that identified students as either global or analytical learners (Whitefield, 2005). Whitefield discussed the Dunn and Dunn model, which was based on five different stimuli that can elicit student responses. Some of the traits of an analytical learner included a need to complete work, preference for step by step tasks, and a need for sequence in building towards a concept and in getting feedback. Some of the traits of a global learner include a need for concepts before details, an ability to multi-task, a preference for group learning and a desire to be presented with lessons of interest to them (Whitefield, 2005).

The identification and support of learning styles

In his article on identifying and supporting learning styles, Pitts (2002) argued that "anybody that works in or with today's classrooms knows that teachers are under heavy pressure to cover a lot of material" (p.3). Pitts stressed that teachers are constantly aware that test scores are expected to rise. Pitts further noted that "teaching to [*each*] student's learning style will improve test scores" (p. 3). There are many instruments available for teachers to use to evaluate learning styles. However, Pitts countered that "these inventories, as good as they may be, take up

too much of the teachers' time to be used effectively" (2002, p. 5). This creates a dilemma for teachers. Knowledge of learning styles is beneficial to teacher and student, but identifying learning styles can be a daunting task. His suggested that a simple instrument that is easy to administer and evaluate would prove to be the most beneficial for teachers to implement (Pitts, 2002).

The review of the current literature identified literacy as the responsibility of teachers in all content areas. Literacy is not solely the role of the language arts teacher. Science literacy is a complex concept, and should be understood and promoted by science teachers in the science classroom. Students' visual literacy skills can be reinforced with well chosen, interesting texts that are supplemented with relevant graphics. Comic strips can be used effectively in the science classroom to promote science literacy skills by taking advantage of their use of text and visual clues, as well as the natural affinity students have for the medium.

CHAPTER III

METHODOLOGY

Participants

This action research study involved 141 eighth grade science students who attended Vista Delgado Middle School. The students were all members of the Voyagers Team. Teams are small learning communities within the larger student body who share common English, math, science and history teachers. Vista Delgado Middle School (pseudonym) is a public school in northern Los Angeles County. All 141 students returned an informed consent form (see Appendix A) and were included in the study.

The study group was composed of the following ethnicities: 67% White Non-Hispanic, 23% Hispanic, 2% Black, 2% Korean, and 1% Filipino. The remaining 5% included individuals representing several ethnic backgrounds. The demographics of our school changed over the last two years, with a noticeable increase in ethnic diversity. Only a small percentage of the students on campus have been identified as English language learners, and those students were placed on a CLAD/Inclusion team and were not represented in this study. Regardless of ethnicity, the overall population of the Voyagers Team would be classified as coming from middle to lower middle income families.

The main study group contained 57 males and 84 females ranging in age from 12 to 14 years. Students in this main study group participated in all of the qualitative phases of the study. From the main study group of 141 students, two large subgroups were created for the experimental component of the study and five subgroups were identified for more in-depth analysis of the impact of the comic strip curriculum on students with different learning styles. These subgroups were selected by identifying students' learning style preferences.

Experimental subgroups

The experimental component of this study required the creation of two subgroups. These two subgroups were created out of the main study group by combining four of the team's five science periods into two experimental groups (see Table 1). This combination produced two groups that were close to one another in population size. Two periods created a pool of 59 students (Group A), the second two periods created a pool of 57 students (Group B). Each group functioned as the control group in one trial and the treatment group in a second trial.

Class periods in subgroup	Subgroup Label	Total Students per subgroup
Period 4 + Period 5	Group A	59
Period 2 + Period 6	Group B	57

Table 1: Experimental subgroups

Learning style assessment subgroup identification

Each student on the team took three learning style assessments. The tests used for this purpose are listed in Table 2. These assessments were used to identify subgroups of students with different learning style preferences. The assessments were taken in science classes on three different dates, approximately one month apart. Each assessment had a different format.

Date	Name of Test	Source	Type
9/17/07	Learning Style Assessment	ulc.arizona.edu	online survey (see Appendix B)
10/19/2007	What's your learning style?	Marcia Connor	PDF document (see Appendix C)
11/22/09	Modality preference inventory	Middlesex Community Technical College	PDF document (see Appendix D)

Table 2: Learning style assessments

Participants took the first learning style assessment on line. This assessment was made available through the website at ulc.arizona.edu (Mencke & Hartman, 2007). The second

assessment was a hand scored PDF file downloaded with permission from “What's Your Learning Style?” at agelesslearner.com (Conner, 2005). The third assessment was “Learning Styles Modalities Preferences Inventory” (Middlesex Community Technical College, 2007). For purposes of triangulation, three assessments were used to get a more valid result. Students were identified as to learning preference by analyzing the results from their learning style preference surveys in two different ways. The first method of analysis compared the results of the three tests, ranking visual, auditory and kinesthetic preference and determining the order of preference for each student. The second method of analysis combined the raw scores of all three tests. If the raw score totals agreed with the preference rankings, the assessment was considered viable.

If both methods of analysis indicated the same learning preference, the students were assigned a value (V1, V2, V3) based on their scores and placed in that group. For example, a V3 was rated with a high visual preference, and a V1 was rated with a slight visual preference. Then, to create workable study groups, the students were sorted from high preference to low. The top 21 from each category were selected to create the visual, auditory and kinesthetic groups. Thirty students strongly matched the criteria for the two style (2style) group, showing equivalent preference for two or three learning styles. The remaining students created the core group. Table 3 lists the five study groups based on the criteria mentioned above.

Subgroup Name	Learning Style Preference	Number of Students	Females	Males
Visual	Visual	21	14	7
Auditory	Auditory	21	11	10
Kinesthetic	Kinesthetic	21	16	5
2style	Results show equal preference for two or three styles	30	17	13
Core	Only a slight preference for 1 style or insufficient data to determine	48	26	19

Table 3: Learning style preference subgroups

Students referred to in the study are identified by their gender, a random number, and their learning style group. For example, (F15V) would be female #15 assigned to the visual subgroup. These identifiers were used primarily in the classroom discussion transcripts.

MATERIALS

Curriculum

The curriculum to be used in this research was a collection of lessons based on a comic strip featuring two lab rats. The curriculum was developed as an independent study project at California State University Northridge during the summer of 2007. The curriculum incorporated 34 different lesson plans. Most of these lessons were used as warm ups during the study period. Six lessons were designed for extended classroom activities. Two of the lessons were used for treatment comparison. One of the lessons was used specifically for an extended class discussion which was audio recorded in four of the five classes.

The storyline in the comic strip series used revolved around the adventures of two lab rats. In addition to the narrative about the experiences of the two lab rats, the lessons in the curriculum covered a range of scientific issues, (i.e. ethics of animal testing) as well as scientific concepts addressed in Eighth Grade content standards. Each lesson included one or more comic strips reproduced at the top of the page, followed by questions for the students to respond to. Each lesson had a lesson guide for the instructor with a prescribed format for presentation.

Procedures

Length of the study

The study took place over the course of four months during the fall semester of 2007-2008 (September – December). The first phase occurred early on during the semester, when

students first learned how to work with the cartoon strips. Other activities were spread out at intervals over the course of the study.

Data Collection

The study had four strands of investigation divided into four distinct phases. Each phase used different activities and assessments to address the three research questions.

Phase One

The first phase dealt with the students becoming familiar with the curriculum and the characters. Using a comic strip each day as a warm up activity, the students were introduced to the characters, the setting, the plot and the theme of the cartoon strip. During this portion of the study, data was collected through the written responses of the students to the questions posed with each. The students written responses were collected from them at the end of the study so their responses could be analyzed. Over the course of the first month, 23 lessons with written responses to the comic strip content were collected from each student.

This collection provided a large data base of qualitative data to select from and analyze. During the lessons, I walked around the room, made observations of what was happening and listened to conversations among the students. Noteworthy observations were recorded in the field notes. At the conclusion of each set of six lessons, students were given short multiple choice assessments related directly to the content of the strips. These were given to collect a comparative sample of how the learning style subgroups compared with each other on assessments related to the content of the curriculum.

Phase Two

The second phase of the study compared two trials with two different cartoon strips using the two, two-class subgroups. In the first trial the treatment group (Group B) interacted with a

comic strip. The comic strip introduced ionic bonds. The control group (Group A) received the same content and drawings, but the information was presented to them by the teacher, using the more traditional whiteboard and note taking format. Group A did not have access to the cartoon strip.

The next day, students in both the control and treatment group were given a five question short answer assessment on the previous day's lesson. Similar questions about the same subject matter also appeared on the chapter test given one month later. Students' isolated responses were analyzed to look any impact on student performance from the use of the comic strip to introduce a topic.

During the second trial of phase two the control and treatment roles of the two subgroups were reversed. Group A interacted with a cartoon strip introducing the concept of an exothermic reaction. Students in Group B received the same content through lecture drawings and notes given by the teacher. Group B did not have access to the cartoon strip. Two days later, students in both the control and treatment group were given a five question short answer assessment on the exothermic lesson. Similar questions about the same subject matter also appeared on the chapter test given one month later.

Phase Three

Phase three had students involved in writing dialogue, to put the concepts they had learned into a conversation. During phase three of the study, students were allowed to work alone or in pairs to create a comic strip. Students were encouraged to use the rat characters in their comic strip. At this point in time, they students had a good grasp of the personalities of the two main characters, and were urged to incorporate the personalities of the rats into their strips. They were also encouraged to make the strip humorous while keeping the content accurate.

Students were allowed to choose a topic from a list of current academic vocabulary concepts. They then created a comic strip in which one character taught a second character about their chosen concept. The comic strips were evaluated using a rubric on a scale of 1-9 points, evaluating the accuracy and sophistication of the students' work.

The list of vocabulary terms the students chose their topic from was also introduced in class as part of the regular instruction. Questions about the vocabulary terms were included in the chapter test. Students' scores (right or wrong) on their specific vocabulary concept question from the test were compared to their cartoon strip score and their overall quiz score to see if their comic strip work had an effect on their performance on their isolated vocabulary question.

A second related activity was introduced in phase 3. Students were given a cartoon strip in which the storyline was told entirely with graphics. They were given the task of writing a dialogue for the rats in the strip. The students were given a list of academic vocabulary that they had been working with and were instructed to correctly incorporate as many of the terms as they could into their dialogue. The dialogues were evaluated by counting the number of terms used correctly and by recording the number of errors or misconceptions they had in their dialogue. This activity provided a unique perspective on students' use of science literacy in writing.

Phase Four

Phase four of the study was designed to provide qualitative data as to the way students spontaneously thought and responded to the content of the cartoon strip. Using the same techniques as they learned from phase one, students read the series of six cartoon strips and analyzed the background information. Then a tape recorder was turned on and the students engaged in a live discussion of the content of the cartoon strip. In this activity, students' thinking

processes were called on as they responded spontaneously to the shifts in the conversation. Conversations from four classrooms were transcribed for analysis.

End of study

Each student participated in an exit survey. The survey was tallied and the results coded for analysis. A small focus group of 7 students was interviewed. The group was composed of students who had visited the Newton and Copernicus website to read more on their own. Students were asked to discuss their motivation and their opinions about the comic strip curriculum. The conversation from that interview was recorded and transcribed for further analysis.

Summary of Data Collection

The comic strip curriculum used in this study was specifically designed to be used as warm up activities at the start of the science period. Warm ups were read, discussed and analyzed as a class activity. Students all received copies of each lesson wrote their responses on them and kept them in a designated section of their science notebook. At the end of the study, all of the warm ups were collected. In addition to the curriculum, students created their own comic strips, wrote dialogue for a comic strip, took quizzes and tests that were in whole or in part related to the comic strip content, and participated in classroom discussions. Selected data from the project was entered into a spreadsheet for coding and analysis.

Triangulation

For purposes of triangulation, each of the research questions was evaluated with the instruments shown in Figure 1. Instruments were identified by phase and purpose. Some of the phases addressed only one of the research questions. Other phases incorporated activities that provided data used to address more than one research question.

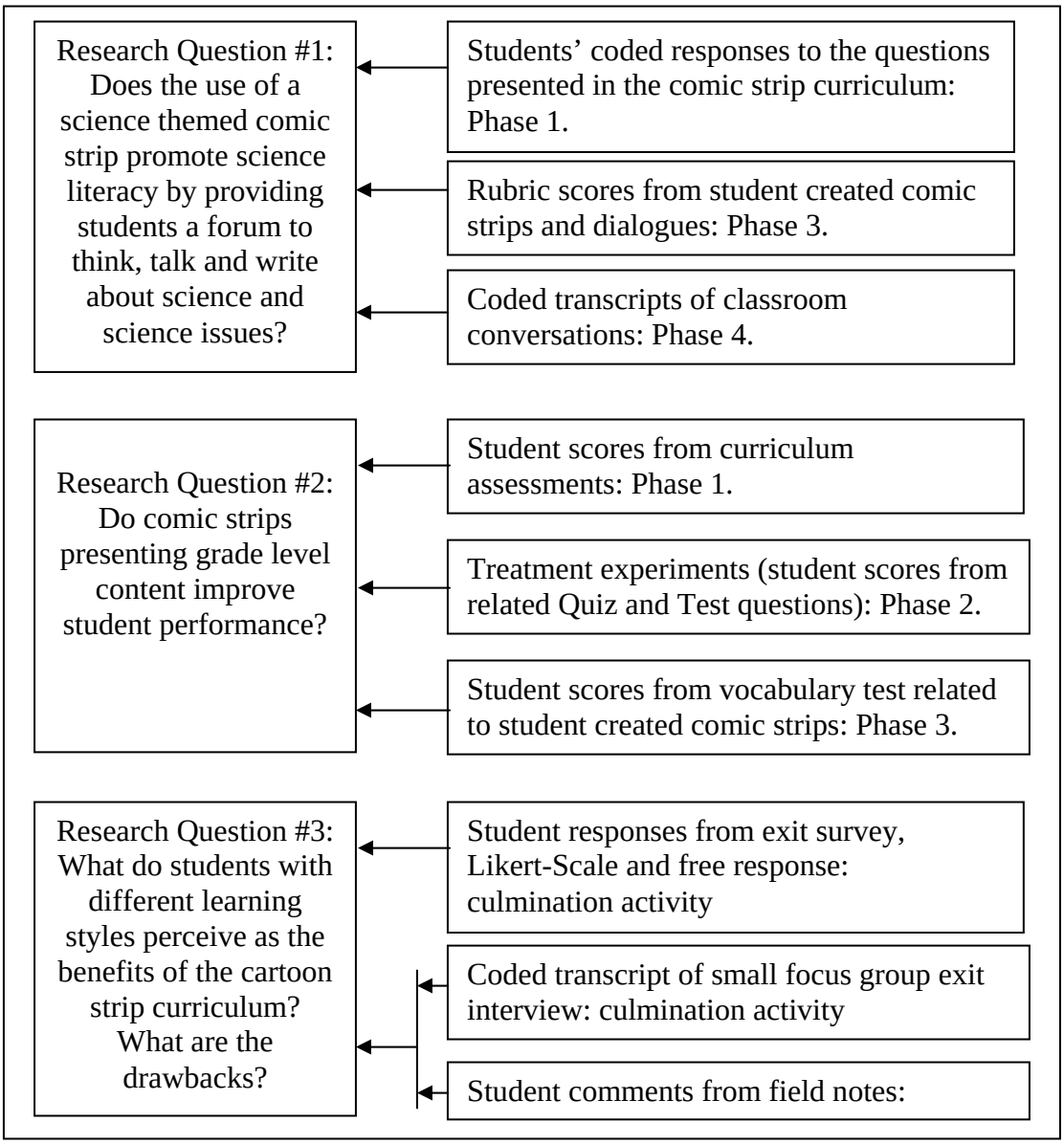


Figure 1: Triangulation methods applied to research questions.

Analysis

The question of promoting science literacy with comic strips was evaluated with qualitative data. The artifacts generated in the study included students' written responses to the comic strip curriculum, their own comic strips and dialogue from phase three, and portions of the exit survey. Short written responses from the curriculum were coded in a spreadsheet by

common answers or trends and organized by order of frequency. More in depth student responses were evaluated with rubrics and ranked by students' performance on each task. Transcripts of classroom discussions were coded by common responses, topic and themes.

The analysis of student performance was based on quantitative data from assessments, quizzes and a chapter test. Scores of treatment groups and control groups were recorded in a spreadsheet and the results were analyzed. Analysis of scores was done by calculating mean scores, finding the standard deviation, and when appropriate, running statistical T-Tests.

Student perceptions of benefits and drawbacks of the comic strip curriculum were analyzed using a Likert-Scale end survey, an open ended survey, and from student comments recorded in field notes and from a small focus group. Likert-Scale responses were displayed graphically when appropriate. Open ended survey responses were data coded in a spreadsheet and ranked by frequency. Field note comments were pulled directly from context and were anecdotal. The transcript of the small focus group was data coded by common responses, topics, and themes.

Chapter IV

Findings

The data accumulated during the course of this research was collected in four different phases. Each phase had a different theme and objective, and subsets of data within each phase were analyzed to address one or more of the following research questions.

1. Does the use of a science themed comic strip promote science literacy by providing students a forum to think, talk and write about science and science issues?
2. Do comic strips presenting grade level content improve student performance?
3. What do students with different learning styles perceive as the benefits of the cartoon strip curriculum? What are the drawbacks?

For clarity, the phases were evaluated sequentially, and the data was organized in terms of how it addressed the applicable research questions.

Phase One: Daily Warm-ups

Phase 1 of the study focused on science literacy. In these activities, students responded to written questions after that days' cartoon strip had been read, analyzed and discussed. This provided the forum to think, talk and write about science and science issues addressed in the first research question. Student responses were collected from selected lessons from the cartoon strip curriculum. From those lessons, specific questions were selected for analysis. Student responses provided data which was coded to be organized and evaluated. Representative samples of student responses were isolated and transcribed.

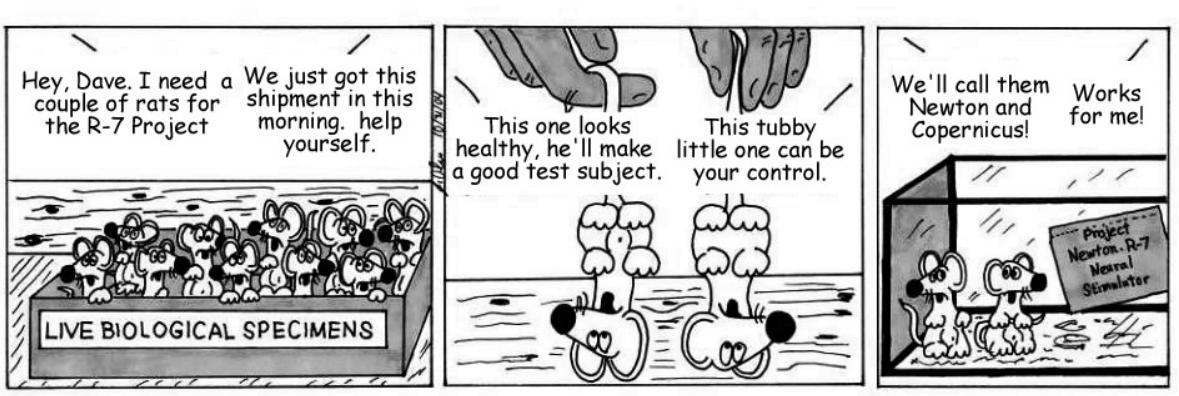
Five curriculum lessons were selected to evaluate students' science literacy skills. The lessons provided a range of student responses to different issues and concepts presented. Where

appropriate, students' spelling and grammatical errors were recorded intact, which provided a more authentic artifact for evaluating writing and language literacy skills.

Lessons one and two

Students were introduced to the comic strip curriculum with Lesson 1 (see Appendix E). This lesson covered the terminology and clues to look for in each of the comic strips: panels, dialogue, uppercase, lowercase, and background information. The students were then introduced to the characters and the storyline with Lesson 2 (see Appendix F).

Lesson 2 introduced the students to the two lab rats who were the main characters of the cartoon strip series. Figure 2 shows the first strip students interacted with. From the context, the implication was that the two humans discussing the rats work in some sort of a laboratory setting. Students' were asked to respond to the following questions. What do you think Dave's job is? What about the person asking for "a couple of rats?"



What do you think Dave's job is?
What about the person asking for "a couple of rats?"

Figure 2: Comic Strip from Lesson 2

The most common response for Dave was "a scientist". Other lab related jobs identified were animal tester, lab assistant, and management (see Table 4). Several students came up with

the job description of “rat seller.” 26 students placed Dave out of the lab setting as a pet store owner/worker or delivery guy. The second person in the strip was identified by 80 students as a scientist. Other lab related jobs applied to this person included assistant and animal tester. 15 thought that this person was a student or possibly a teacher. The two off prompt curiously explained what the phrase “a couple of rats” meant.

Dave’s Job	Other Person
42 scientist	80 scientist
16 rat seller	13 student
11 lab assistant	11 assistant
10 pet store worker	7 animal tester
10 animal tester	5 a person is doing a science project
10 person in charge of the rats	2 teacher
10 delivery guy	2 customer
9 science teacher	2 off prompt
6 shipment manager/office worker	1 pet shop owner
6 pet store owner	18 no data/no response
4 laboratory worker/technician	
7 No Data/No Response/other	

Table 4: Student responses from Lesson 2, Question 1

The first question provided qualitative data as to the manner in which students used the dialogue, setting and background information in the cartoon strip to evaluate the possible job descriptions of the two humans in the comic strip (see Table 4). From the context, a majority of the students identified Dave’s occupation as a scientist, technician, animal tester, lab assistant or person in charge of the rats. These responses are best supported by the context of the images and dialogue. Nine students assumed Dave to be a teacher, which is not an unreasonable assumption.

Students who identified Dave as a “rat seller” used the context clues to determine that he was the person to go to for biological specimens. Those who identified him as a rat seller, or breeder, seemed to demonstrate reasonable assumptions based on the context. Even “delivery

guy" is not outside the broader context of the strip however, the responses missed the context clues in the dialogue which implied that the two individuals were colleagues.

Those 17 students who identified Dave as a pet store owner or pet store worker demonstrated a naïve perception of the differences between a laboratory rat and a pet store rat. As students shared their responses with the class, their misconceptions allowed for discussion about the breeding, genetic variation, and differences between lab rats and pet store rats. Over 100 students identified the second person as a scientist, or as working in a lab/education related field. The number of students with no response to the second question more than doubled.

Continuing with the comic strip found in Figure 2, students were asked to respond to two additional prompts related to animal testing. These questions asked the students to think about and respond to a controversial science issue. As research question number one focused on the comic strip as a forum to promote science literacy, discussion of issues in science seemed an appropriate topic for analysis.

The highest positive response to this series of questions was that animal testing helps prevent humans from being harmed by the testing. Students also identified finding cures, learning about animals, and learning in general. The most common response to the negatives of animal testing was that animals would die, be killed, or that they would be harmed. Life in captivity was also a common response. A few student comments provided curious, insightful responses that demonstrated a different way of thinking about the prompts.

Table 5 lists common student responses by the number of times each response was coded. Students' responses to the positives and negatives of animal testing indicated that many students were disturbed by the idea of animals being tested, while many of them could see the positive aspects of using lab animals for testing products. A little more than ninety percent of the students

identified the fact that humans would not be harmed when rats were substituted in the testing. 39 students also were aware of value of product testing and safety concerns that can be addressed with animal testing. 39 students also cited finding cures for diseases as a plus. Student responses demonstrated a basic level of understanding of the value and purpose of animal testing.

5a: What are the positives of animal testing?		5b: What are the negatives of animal testing?	
# responses	Response type	# responses	Response type
129	no humans harmed	90	animals harmed, injured, get sick
39	cures	94	animal could die or be killed
33	learn about animals	42	life in captivity/whole life in cage
29	learn something	33	animal abuse/cruelty/tortured/suffers
26	other	29	other
23	product okay	12	insightful responses
16	safe		• *we treat animals like dirt*
8	less expensive with animals		• *the animals won't like it*
3	insightful responses		• *things are tested that don't need to be*
	• *prove a point you have brought up*		• *just throw away the animal*
	• *it can rule out certain possibilities*		• *It'll maybe cause a riot to who ever cares about them*
	• *you get answers for questions you have*		• *it may not even help because the reaction a small rat has to something may be different than the reaction a human has to it*
			• *animals die for someone to have hairspray, animals are tortured and locked up just for our pleasure*
			• *everything*

Table 5: Student responses from Lesson 2: Question 5

The responses to the negatives of animal testing indicated the level of sensitivity students had towards the humane treatment of animals. The greatest responses showed students to be very concerned about animals being killed, harmed, or abused in some way. Forty two students identified the idea of a rat being kept in captivity its entire life to be negative.

Students demonstrated a rather uniformed understanding of the source of lab rats (life in captivity/whole life in cage). Student responses showed concern that the rats would never be

free, but did not recognize that rats are bred for the specific purpose of being used in research. Discussion at the end of the session allowed for clarification of some of these ideas.

Lesson Five

The comic strip from Lesson 5 from the curriculum (see Appendix G) portrays one of the rats removed from the cage sitting on a pan balance. The text and background context indicated the rat was being prepared for some type of procedure. The two part question from the curriculum asked students to draw on their science literacy skills to think and write about the comic strip, expressing what it made them think about and how it made them feel.

The text of the question was: "What does Newton's situation make you think about? How does it make you feel?" Student responses were recorded by rank in Table 6. The highest response to their thoughts regarded the rat's unpleasant situation. Many said the picture made them think about animal testing, others that it was cruel. Several were reminded of medical procedures. Nearly half of the students felt sad, nervous or mad.

Three students felt very strongly that the scientists should have to go through the procedure. Eleven wondered what would happen next in the storyline.

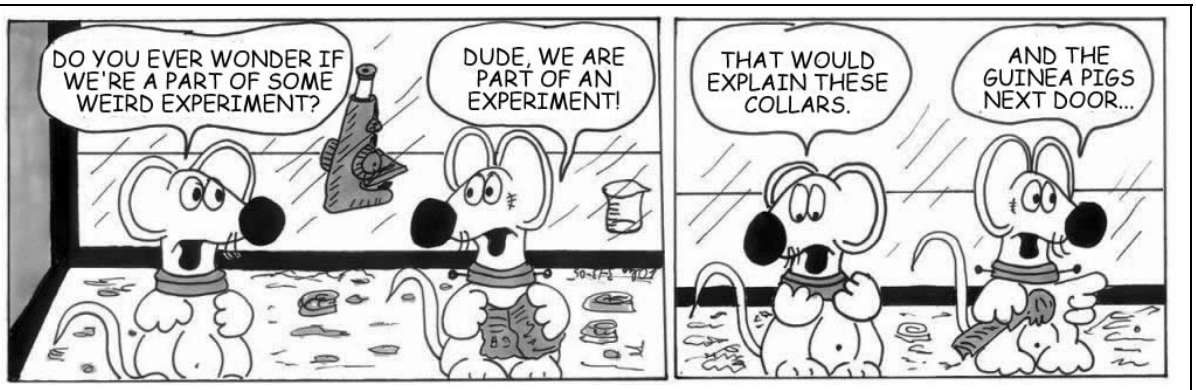
What does Newton's situation make you think about?		How does it make you feel?	
#	Response Type	#	Response Type
34	The unpleasant situation of the rat	53	It makes me feel sad for him
17	Animal experimenting or testing	15	It makes me feel nervous
15	Think it's cruel	9	It makes me mad
12	Surgery or other medical procedures	8	It doesn't make me feel anything
11	Wonder what will happen next/why	7	I don't feel animal testing is right
8	Rat will be hurt or killed	5	It makes me feel curious
3	Makes them think about nothing	4	Makes me feel weird, disturbed
3	Felt vindictive		
17	All other responses	9	All other responses
21	No response/data	31	No response/data

Table 6: Student responses from Lesson 5, Question 5

In terms of emotional response to the second part of the question, 77 students responded with an emotional response of sad, nervous or mad. Four responded with weird or disturbed. Five students expressed curiosity

Lesson Sixteen

After working with the curriculum for several weeks, the students were presented with the strip found in Lesson 16 (see Appendix H). Students were asked to respond to two separate but related questions. The questions (see Figure 3) led students to analyze the text of the conversation, and also background and context clues.



Why would Copernicus wonder if they were part of "some weird" experiment?
What other information (conversation and background) supports Newton's theory that they are part of an experiment?

Figure 3: Comic Strip from Lesson 16

In terms of science literacy, responses to the first question demonstrated that students used information related to previous strips and to the experiences of the two rats to determine why Copernicus was wondering about their situation. Sixty one students listed the experimental collars and 53 observed that other rat, Newton, had been repeatedly taken from the cage (see Table 7). Students recalled information and made observations based on what they had read and what they inferred from the background information. Thirteen stated that Newton was smarter and 11 commented on the weird things that were happening to the rats.

In response to the second question from Lesson 16, students demonstrated scientific literacy by correctly using academic vocabulary to identify pieces of lab equipment. From the context and background information, 87 students correctly identified and labeled the pieces of lab equipment. Fifty three students identified the guinea pigs next door from the dialogue as an indication that experiments were going on. Thirteen students incorrectly identified the microscope as a magnifying glass and the beaker as a cup. Four students observed a context clue, the rat Newton holding the piece of paper as if he were reading it.

Why would Copernicus wonder if they were part of "some weird" experiment?		What other information (conversation and background) supports Newton's theory that they are part of an experiment?	
#	Students' written responses	#	Students' written responses
61	Listed the collars worn by the rats	87	lab equipment: correctly identified
53	Observed that Newton was often taken out of the cage.	53	Reference to guinea pigs next door
		16	Other responses
26	environment (cage, equip)	15	collars
15	other responses	13	incorrectly identified lab equipment
13	Newton was getting smarter	10	listed cage
11	Weird things happened to them	4	rat appears to be reading paper
8	no response	5	lab/other
		16	no response

Table 7: Comic Strip from Lesson 16

Lesson Twenty One

The comic strip in Lesson 21, (see Appendix I), followed up on a previous lesson in which the cage door had been left open and the rats had climbed out of their cage. In Lesson 21, the rats wandered completely around the outside of the cage and found themselves back at the cage door where they had started. Students were asked to respond to the prompts listed in Figure 4. Students' science literacy skills of inference and use of prior knowledge were demonstrated in many responses. Other responses raised questions about their reasoning, prior knowledge and misconceptions (see Table 8).

What natural behavior of rats might have caused this to happen?
Why might rats have a tendency to do this?

Figure 4: Comic Strip from Lesson 16

Twenty six students responded to the first part of the question identifying the rats' natural behavior as staying by the wall. Almost the same number of students attributed the behavior to the fact that the rats weren't very smart. Eight students believed the natural behavior to stay by the wall came from the rats going in circles on the exercise wheel. Many students felt that rats might have a tendency to stay by the walls to be protected from predators. These students responded based on prior knowledge, as this behavior had not been discussed in my classroom.

What natural behavior of rats might have caused this to happen?		Why might rats have a tendency to do this?	
#	Student responses	#	Student responses
26	Their natural behavior is stay by the wall	24	protected from predators
		16	they are trapped in a cage all day
25	they aren't very smart	15	so they feel safer
8	the rats are used to going in circles from spinning on the wheel all the time	8	they tend to walk along walls
		7	they have no sense of direction
		6	they get bored
7	they don't have good eyesight	6	they want to stay close to home
6	from being in cage	5	they aren't very smart
4	short attention span	3	rats don't have very good eyesight
4	they feel protected	17	other responses
3	instinct	34	no response
26	other responses		
22	no response		

Table 8: Students' responses to Lesson 21.

Some attributed the tendency to the rats being in the cage all day, or so that they would feel safer. Seven students thought the rats had no sense of direction and five felt the rats weren't very smart. Twenty two students did not respond to the first part of the question, 34 did not respond to the second part of the question.

Lesson Twenty Two

Lesson 22 showed the rats walking past a book titled "B. F. Skinner on Operant Conditioning" (see Appendix J). Students were asked what they thought operant conditioning might be. Table 9 lists student's responses to lesson. About on third of the students inferred from the comic strip series that this was some type of behavioral training or reinforcement. Thirty students used operating or conditioning as a verb. Five students assigned meaning to operant conditioning by tying it in to the storyline of the comic strips they had read.

What do you think Operant Conditioning might be?	
#	Representative samples of student responses
31	A way of reinforcing behavior
18	a method of training
15	related to an operation/surgery/operating
14	related to an experiment/way to do an experiment
9	how to operate something
8	incomplete/forced answer
6	conditioning (verb) something
5	reference from comic strip storyline
4	something to do to get in shape
3	how to take care of a rat
2	no clue
14	other responses
12	no response

Table 9: Students' responses to Lesson 22

Prior to this lesson, the concept of positive reinforcement had been introduced only once before through the comic strip curriculum, and then only indirectly. In terms of science literacy, it was surprising how many students were familiar with the idea of reinforcing behavior.

Assessment: Lessons 18-23

Lesson 23 from the curriculum was an extended activity from the curriculum (see Appendix K). Students were given a set of panels from the cartoon strip used in Lesson 23 which had been cut apart. Students worked in small groups, discussing and organizing the eight panels into what they believed were the correct sequence. As a follow up to this lesson, students were given Assessment 18-23 (see Appendix L) which had them write short responses to three different prompts. Figure 5 shows the prompt and the results from this portion of the assessment.

Responses from the prompt were coded by counting the number of details recalled from the comic strip used in Lesson 23. Fifty percent of the students recalled fewer than 3 details from the sorting activity from Lesson 23. Seven participants did not respond at all. Only 36% were able to recall 4 or more details and only a small number were able to recall more than 5 details.

Respond to the following questions as if you were Newton writing in his diary: Prompt #3: Our first adventure out in the lab on our own

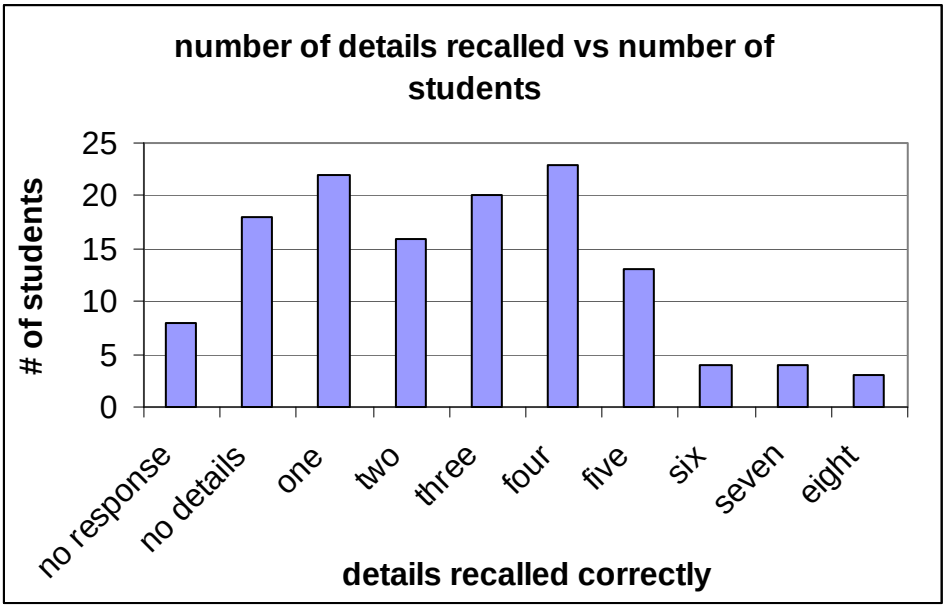


Figure 5: Assessment 18-23, Newton's Diary

Student responses were ranked by two criteria: number of correct details and number of sentences. The graph in Figure 5 shows the number of details students included in their responses. Table 10 contains representative samples of student written responses to the prompt. Spelling and grammatical errors were left intact in these examples.

(X. Y) = Number of details/number of sentences	Representative Samples of student responses to the comic strip from lesson 23. Correctly identified details are in bold type. **Prompt: Our first adventure out in the lab on our own. . .**
0.2	Oh my gosh! The lab is huge! It has soo many things to do like there's this thing that makes letters on the screen. Also there's this instrument that makes Copernicus's nose look huge.
1.1	Copernicus and I **found coffee and drank it**. *They had fun**. (*In this example, student switched from 1st person to 3rd person.)
2.3	. . . was interesting. Copernicus **drank coffee** and went **obnoxious for a few seconds**. All in all it was a good outing
3.4	I think we just explored around. We **went over some books** and then **Copernicus drank some coffee** and got really, **really hiper.** It was so funny! I tried to tell him not to, but he did it anyway.
4.2	We **passed by coffee** and Copernicus **drinks the coffee**. He gets a **caffine rush** and then **is normal again**.
5.3	Our first adventure was very interesting. Of course, **I lead the way.** When **Copernicus drank some of the coffee** after **I told him not to**, **he got very hiper** and **I couldn't understand anything** he said.
8.7	While in the lab I **told Copernicus to stay close**. We **walked by a mug of hot coffee**. Copernicus **asked me what it was** and I replied by **telling him humans usually drink it**. Big mistake! **Copernicus of course, gulps it down** and becomes extremely **hyper**. Luckily for his **fast metabolism**, his sugar **rush was over quickly**.

Table 10: Assessment 18-23, students' written responses to prompt #3

Performance

A second objective of the study was to see if the consistent presentation of the comic strips in the same format made the content accessible to all of the learning style preferences. To compare how each of the learning style preference subgroups were processing and retaining content from the strips, an assessment comprised of 10 multiple choice questions was given at the end of every set of lessons (see Appendix M). The purpose of these assessments was to see if there was a significant disparity between the subgroups with different learning style preferences.

A comparison of the means from each survey shows fluctuations within all subgroups. Interpretation of these differences is problematic and open to interpretation. The graph in Figure 6 shows the results by subgroup for the first assessment.

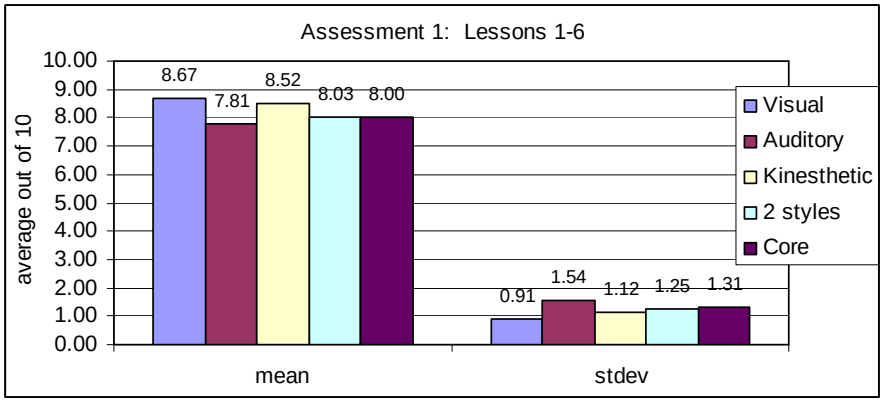


Figure 6: Assessment 1.

The results from assessment 1 showed that the visual and kinesthetic groups performed a half point better than the 2 style, core and auditory group. The auditory group's score was lowest of the 5 groups in this assessment. Auditory scored .40 below the mean for all 5 groups (8.21) and Visual was .41 above the mean for all 5 groups.

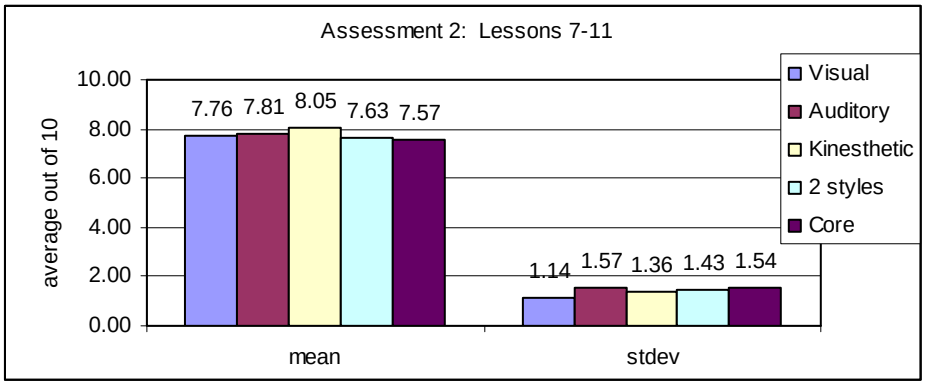


Figure 7: Assessment 1.

Figure 7 shows that in Assessment 2 the auditory subgroup performed on a par with the Visual subgroup. The Kinesthetic subgroup demonstrated a slightly higher score. The mean for

all 5 groups was (7.76) with Kinesthetic highest at .29 points above the mean, visual at the mean 7.76 and the Core group lowest at .19 below the mean for all groups.

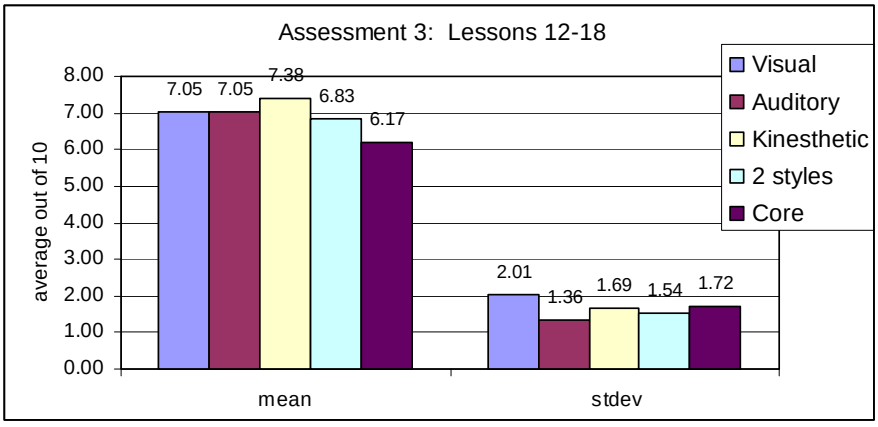


Figure 8: Assessment 1.

Assessment 3 (see Figure 8) indicated that the Visual and Auditory subgroups performed equally well. The Kinesthetic group was .48 points above the mean of (6.90) based on all 5 groups, and the Core group was .73 points below the mean

Phase Two: Presenting Content with Comic Strips

Student performance

Phase two compared the use of a comic strip series to a more traditional approach, which included lecture, note taking and drawings, to introduce a new topic. The two topics introduced with cartoon strips in this phase were **ionic bonds** and **exothermic reactions**. The two experimental groups, Group A and Group B, were used for this portion of the study.

Experiment One: Ionic Bonds

Experiment one used the series of cartoon panels found in Lesson 31 (see Appendix N). The concept of an ionic bond was presented to group A in a lecture format. Students took notes from the whiteboard and textbook and made a drawing illustrating the same exchange of

electrons and ion formation as introduced by comic strip Lesson 31. This control Group A was presented with information that was identical to the content of the comic strip used by the treatment group.

Group B used Lesson 31 “Ionic Bonds” from the comic strip curriculum. Students worked through the comic strip using the format students were trained with in phase one: reading silently, hearing the strip read aloud, students reading the strip aloud, students individually responding to questions.

The day after the concept of ionic bonds was introduced both (Group A: control) and (Group B: treatment), took the same follow up quiz. They responded to the 5 questions found in Table 11.

Q1: What happens when an atom loses an electron?
Q2. What happens to an atom that gains electrons?
Q3: What is the term for a positively or negatively charged atom?
Q4: What is the term for the attraction between ions?
Q5: What is a valence electron?

Table 11: Ionic bond quiz questions

Results from this experiment showed that Control Group A outperformed Treatment Group B by an average of 17% per question. The exception was question four, where the treatment group averaged 22% higher than the control. Group A did better with identifying ions, but Group B performed better on the concept of ionic bonds (see Figure 9). The concept of ionic bonds was the topic presented in the cartoon strip and lecture, making question 4 the focus of analysis.

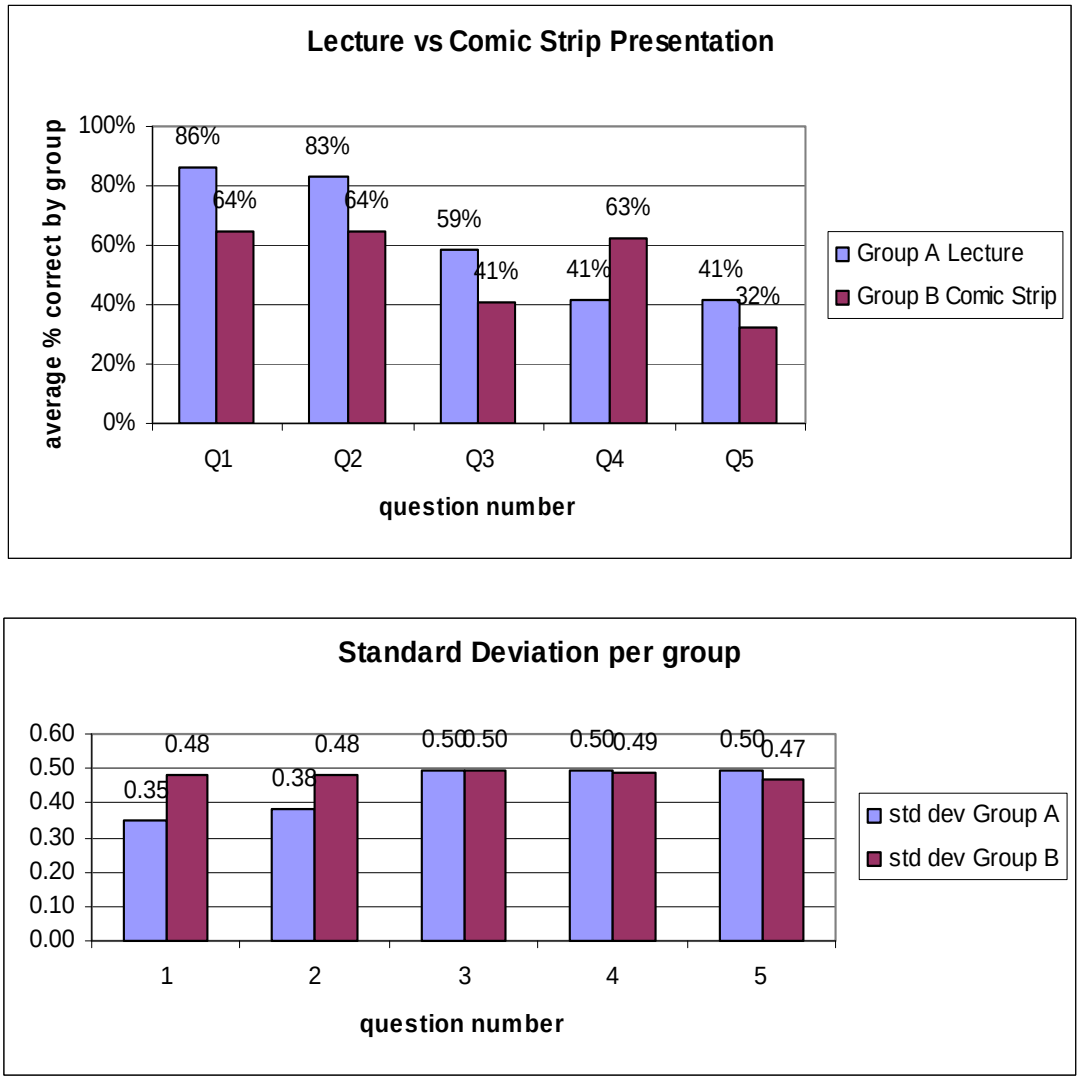


Figure 9: ionic bond quiz results

One month after the initial treatment, the treatment and control groups' scores on the chapter test were compared to the initial quiz. The relationship of the quiz score to the test for the corresponding question was significant (n = .0004).

On the chapter test, Group B (treatment) outperformed Group A (control) on the isolated ionic bond question. The treatment group scored 10% higher on the "ionic bond" question (see Figure 10). This number was significant (n < .01).

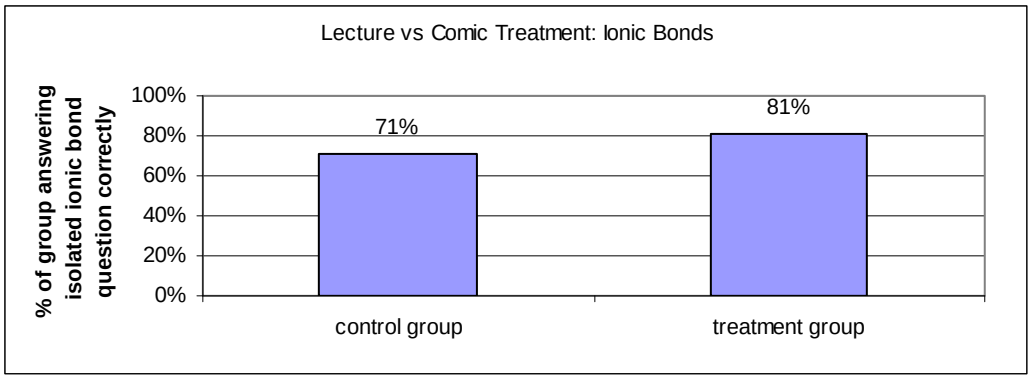


Figure 10: Control vs. Treatment group, Ionic bonds.

Subgroup	Role	% of subgroup correct Ionic Bond Quiz Question	% of subgroup correct Ionic Bond Test Question
Group A	control	41%	71%
Group B	treatment	63%	81%

Table 12: Quiz scores compared with test scores on isolated Ionic bond questions.

The students' quiz scores and test scores on the isolated ionic bond questions are shown in Table 12. Since the relationship between these two sets of scores was significant (n = .0004) the impact of the comic strip on the treatment group is a plausible cause of this relationship.

Experiment Two: Exothermic Reactions

Experiment Two also compared the use of a cartoon strip to the more traditional lecture format to introduce a concept. In this trial, Group B acted as the control group, and Group A as the treatment group. The concept of an exothermic reaction was presented to Group B in a lecture format. Students took notes from the whiteboard and textbook and made a drawing illustrating the "X" in the word "exothermic" with flames coming off of it (see Figure 11). Students were told to think of the "X" as firewood in a campfire.

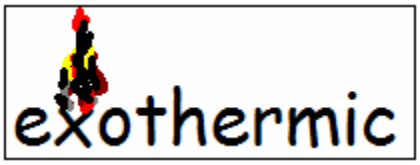


Figure 11: Sample of notes given to control group from Experiment Two.

Group A used Lesson 32 (see Appendix O) from the comic strip curriculum which featured in part the comic strip in Figure 12. Students worked through the set of comic strips using the same format used during phase one of the study.

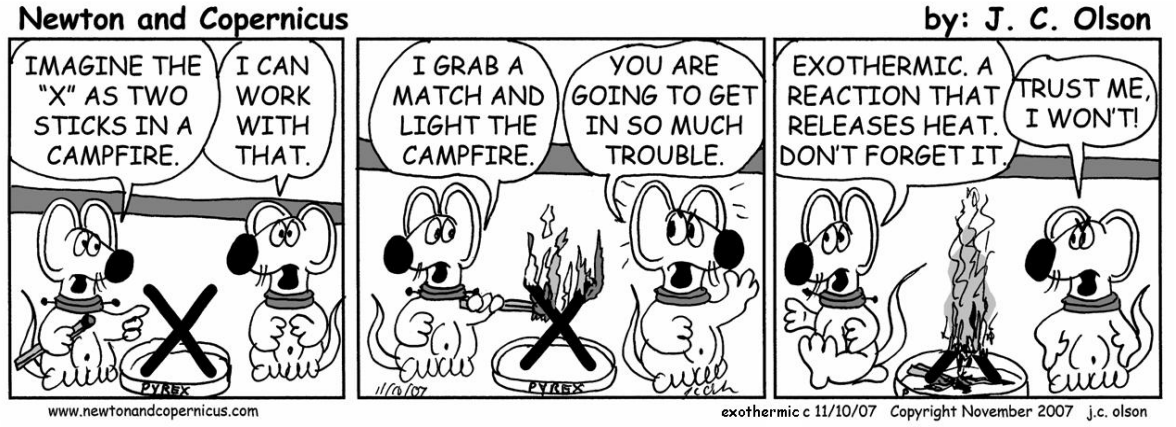


Figure 12: Comic strip from lesson 32.

Two days later, both control and treatment groups took a quiz and responded to the questions found in Table 13.

Q1: What is an exothermic reaction?
Q2: What information did you use to remember this?
Q3: What is an endothermic reaction?
Q4: What type of reaction is burning alcohol?
Q5: What type of reaction occurs between baking soda and vinegar?

Table 13: Quiz questions from lesson 32.

Treatment Group A out performed control Group B on all five questions (see Figure 13). Questions one and question two were related to each other. Question 2 was included specifically to see if the students remembered the burning "X" either from the comic strip (Group A: treatment) or from the lecture notes (Group B: control). Seventy eight percent of group A

answered question 1 correctly and 72% identified the burning “X” from the cartoon strip as the information they used to remember exothermic. Sixty one percent of group B answered question 1 correctly and 23% identified the burning “X” from their notes as the information they used to remember exothermic.

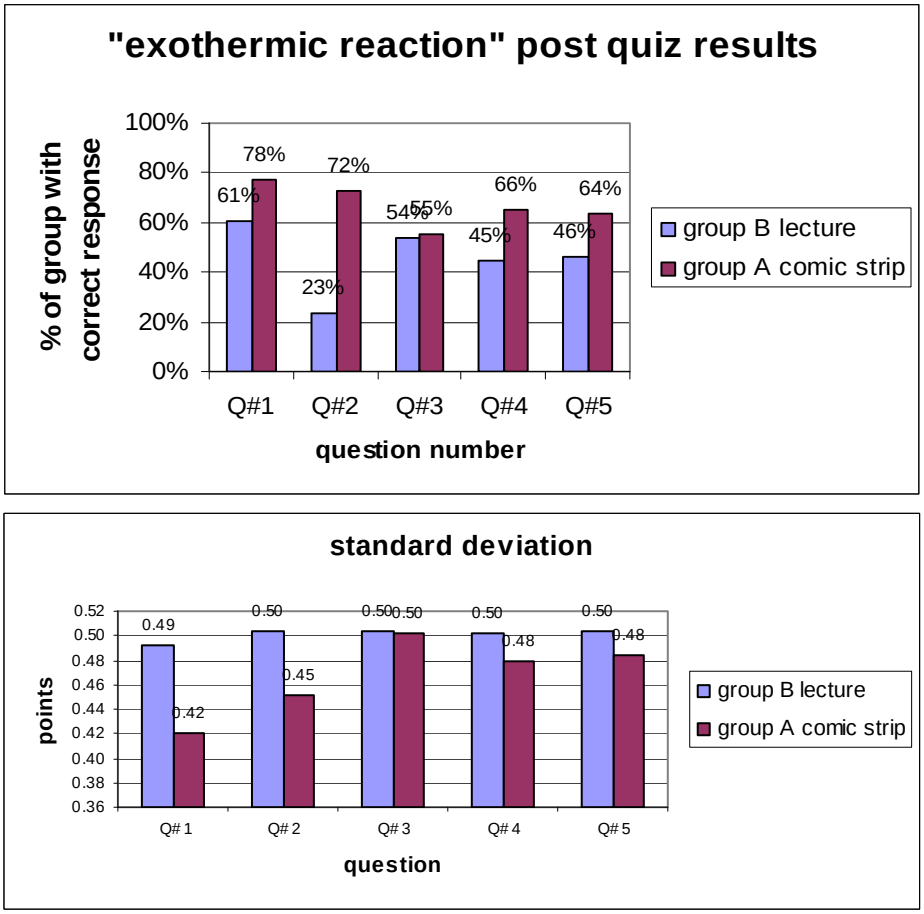


Figure 13: exothermic quiz results

The correlation between student responses on question one and question two was significant (n= 0.03) and indicated a link between a student answering correctly and the image the student used to recall the correct response as shown in Figure 14.

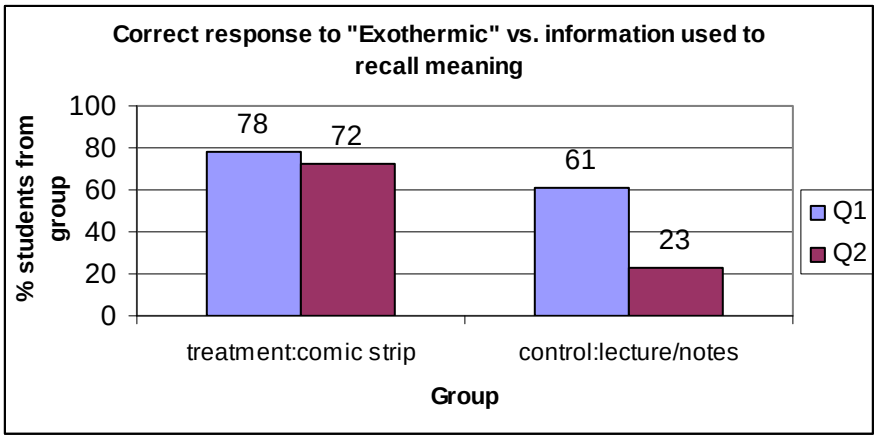


Figure 14: Related responses to exothermic quiz questions 1 and 2.

One month later on the chapter test, the control group had caught up to the treatment group in their performance on the isolated question about exothermic reactions (see Table 14).

Subgroup	Role	% of subgroup correct Exothermic Reaction Quiz Question	% of subgroup correct Exothermic Reaction Test Question
Group A	treatment	78%	83%
Group B	control	61%	83%

Table 14: Exothermic quiz vs. test scores on isolated exothermic questions

Phase Three, Activity One: Student Created Comic Strips

Science Literacy

In phase three, students were given the task of creating a three panel comic strip to illustrate on of the vocabulary/concepts listed in Table 15. Students within their assigned periods chose to work with a partner or to work alone. Those few groups wishing to work as a group of three were expected to create a six panel cartoon strip. Students were given parameters as to size and shape of the comic strip, but were otherwise allowed to approach the project as creatively as

they chose. Students were given the following criteria which they were instructed to incorporate into their comic strips.

Point Value	**Criteria to be included in the comic strip**
3	Concept: The meaning of the concept or vocabulary term was to be clearly stated.
2	Elaboration: The dialogue should elaborate with an example or restatement.
1	Background: The background information clarifies understanding of the concept.
1	Storyline: The storyline flows from frame to frame and makes sense in context.
1	*Character: The dialogue of the rats reflects the characters personalities.
1	*Humor: Students manage to include humor within the context of their strip.
* Character and humor were encouraged but not mandatory. Students were allowed to opt for other characters than the two lab rats, Newton and Copernicus. A score of 7 or higher demonstrated meeting the expected outcome.	
Academic vocabulary topics that students or teams were allowed to choose from:	
chemical change chemical equation chemical property chemical reaction chemistry closed system	conservation of matter matter open system physical change physical property reactants and products

Table 15: Rubric for student created comic strips

Two students were excused from this activity due to a school training session. Of the 139 students participating individually or with a partner, 68% successfully created a comic strip that earned 7 or more points and met or exceeded the expected outcome.

A score of eight was achieved by 51 of the students. Only 7 students scored at or below 4 points. All participants turned in a finished comic strip. The graph in Figure 15 shows the different levels of performance on the comic strip rubric by the students in the main study group.

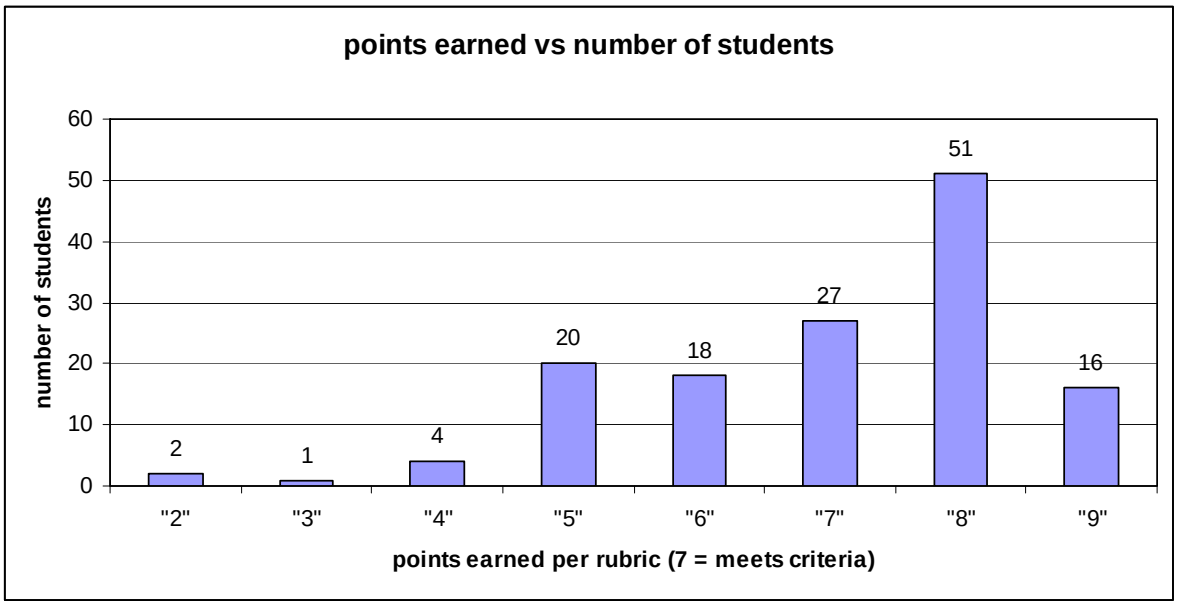
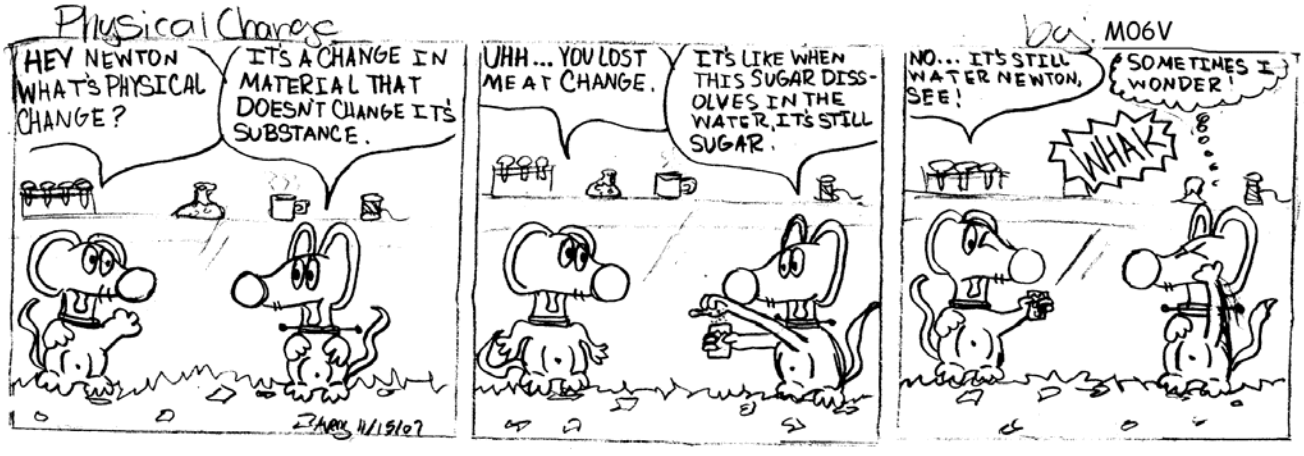


Figure 15: Range of scores on student generated comic strips.

Figure 16 is a representative sample of a student generated comic strip that earned a 9 on the rubric for including all requirements for this assignment. Other student comic strip samples can be found in Appendix P.



Concept 3 Elaboration 2 Background 1 Storyline 1 Character 1 Humor 1 Cumulative 9

Figure 16: Sample of a 9 point comic strip

Performance

Section 1 of the Unit Test included questions on the fifteen vocabulary terms addressed over the course of the chemistry unit. These same words were also the student choices in the comic strip assignment. Vocabulary meanings were developed throughout the regular unit of instruction in addition to the student created comic strip activity. Above and beyond the usual classroom instruction, students were each given an identical set of flashcards for this set of vocabulary terms. The graph in Figure 17 compared student performance on overall vocabulary to performance on each student's comic strip concept from their comic strip.

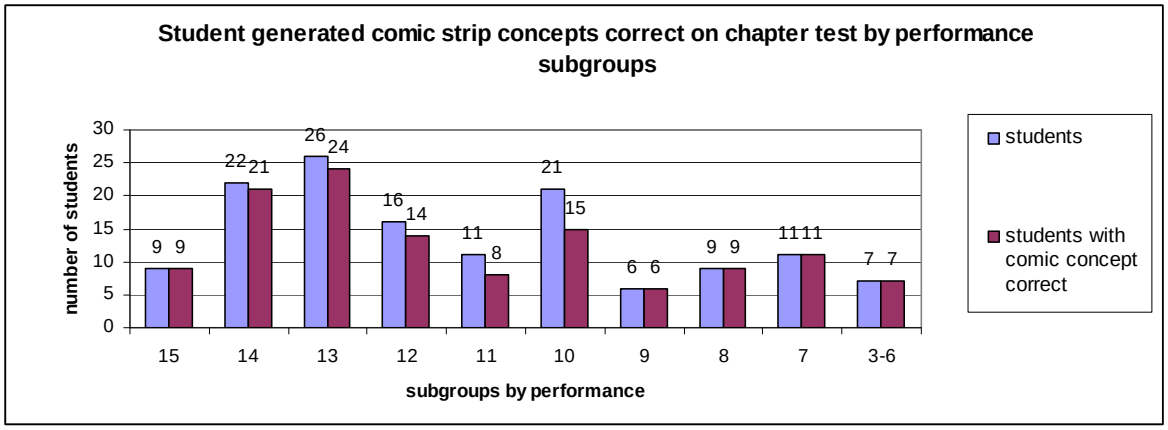


Figure 17: Student's comic strip topic vs. overall quiz performance

Students who recalled and correctly answered the isolated unit test question about their specific comic strip topic were evenly distributed throughout the performance groupings based on test performance. Nine students earned perfect scores on the vocabulary section and consequently got their comic concept correct. Twenty two students scored 14 correct out of 15 on the vocabulary section. Twenty one of those same students correctly answered their comic strip related question. Thirty three students performed poorly overall, with nine or fewer questions right. It was noted that all 33 of those low performing students correctly answered their comic strip topic question. Overall, 81% of the students taking the vocabulary section of the unit

test were able to list what their topic had been, and 88% of the students correctly answered the test question on their comic strip topic.

Phase Three, Activity Two: Student Created Dialogues

Science Literacy

In this second component of phase three, 131 students from the main study group worked with Lesson 33 from the comic strip curriculum. Ten students were absent from school during the time frame of this activity and were excused. Lesson 33 (see Appendix Q) featured a comic strip that told a story entirely with images. Students were then given the task of writing a dialogue for the strip, using a minimum of three academic vocabulary terms from the chemistry unit. Students who incorporated different but appropriate scientific vocabulary were given credit for those responses. Table 16 lists the academic words students were given to chose from.

List of academic vocabulary terms suggested for student dialogues.	
Bunsen burner Lab safety Safety Goggles Flint Reactants	Chemical Change Exothermic reaction Heat Chemical Reaction Products
Students were also given credit for other academic terms they incorporated not listed above.	

Table 16: Suggested academic vocabulary for Lesson 33.

Figure 18 shows the number of students in each subset grouped by the number of academic vocabulary words they used correctly. Forty one students correctly incorporated three academic vocabulary terms in their dialogue. Overall, 62% of the students participating met or exceeded the minimum expectation for this activity. Of the students who did not meet the minimum requirement, 34 students included two academic vocabulary words correctly, 16 used one correctly, and no students created a dialogue without any correctly used academic vocabulary.

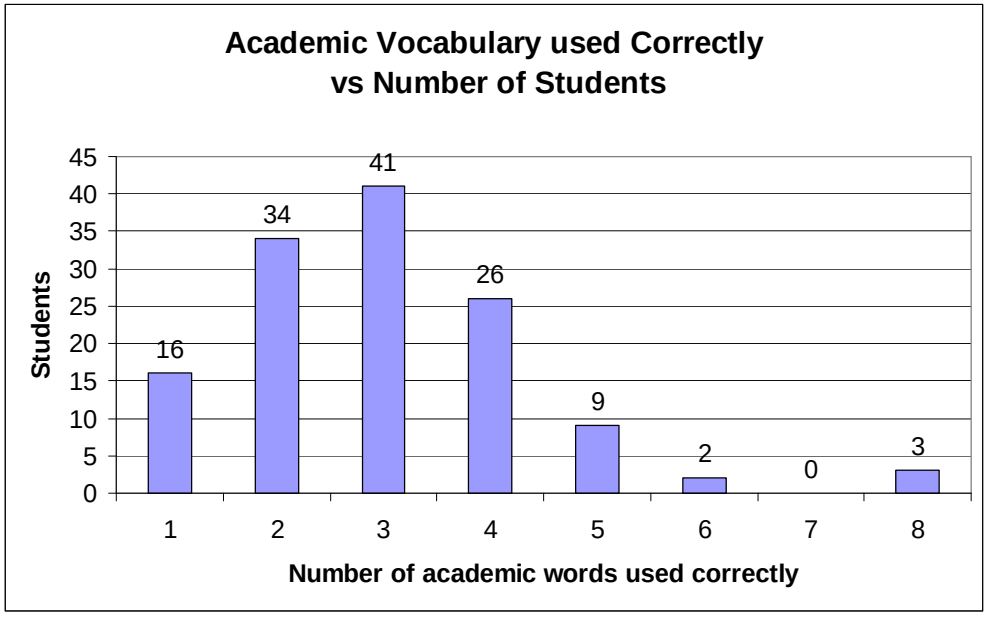


Figure 18: Academic vocabulary used correctly.

Table 17 lists by frequency the misconceptions students had with interpreting the storyline of the comic strip used for this lesson.

Misconceptions samples		
count	misinterpretation, misconception	representative samples
21	flint mistaken for another object	flint; as a burned marshmallow flint; as cork pulled out of flame flint; burning the flint flint; melt this ice flint; take any substance to it, like so… flint; take this off, as in a cap
6	characters mixed up or switched	character mix up panel 4 mice for rats characters reversed
4	misinterpreted Bunsen Burner	Ring stand for Bunsen burner torch for burner lighter for burner candle substituted for burner
8	other misinterpretations	physical change for chemical change *(toasted marshmallow)* product substituted for reactant off prompt, dialog does not match with graphics fire; explosion for combustion

Table 17: Sample misconceptions about cartoon strip

Tables 18 through 21 contain representative samples of student dialogues from Lesson 33. Academic vocabulary words used correctly are marked in bold. Mistakes or misconceptions about the strip are italicized. A brief commentary on each strip is included. Student spelling and grammatical errors were transcribed intact. More examples are listed in Appendix R. Each artifact gives a snapshot of that individual's science literacy skills in context.

Panel 1	Copernicus	what's this?
	Newton	It's a **Bunsen burner**
Panel 2	Copernicus	what does it do?
Panel 3	Newton	Ill show you
Panel 4	Newton	This is how you turn it on
	Copernicus	Wow!
Panel 5	Copernicus	Can we use a marshmallow with it?
	Newton	Yeah lets do it
Panel 6	Newton	This is a **chemical change**
	Copernicus	What?
Student M41S was a male in the core group with a slight kinetic preference. He had a few errors with apostrophes but the dialogue was sound. His use of **chemical change** as his second **academic vocabulary word** showed a bit more depth in his overall understanding of the vocabulary options presented. He did not meet the minimum of three academic vocabulary words..		

Table 18: Sample with **two** academic vocabulary words used correctly

Panel 1	Copernicus	What does this object do?
	Newton	This is a **Bunsen burner**. It **heats** up **chemicals.**
Panel 2	Copernicus	Wait, i'm totally confused!
Panel 3	Newton	Fine, i'll show you how it works.
Panel 4	Newton	I'll use this ***marshmellow*** to show you how it heats up things.
	Copernicus	Woah! It's on fire!!
Panel 5	Copernicus	I want a marshmallow.
	Newton	mmm! me too!
Panel 6	Newton	Good idea copernicus
	Copernicus	Thanks!
Student F74S was a female in the core subgroup with a slight kinetic preference. She had a common misconception about the flint, thinking it was a marshmallow being held in the flame, rather than a tool used to light the burner. Interesting how she incorporated junior high speak: "totally confused", into the dialogue. She met the minimum requirement of three academic vocabulary words.		

Table 19: Sample with **three** academic words used correctly and ***1 errors/misinterpretations***.

Panel 1	Copernicus	This is something new. Newton, what is it?
	Newton	This is a **Bunsen burner**! This is **exothermic**, meaning **heat is released**. This equipment heats up things making a **chemical reaction**.
Panel 2	Copernicus	Huh?
Panel 3	Newton	Here I will show you.
Panel 4	Newton	Do you see what I am doing Copernicus? It makes a **chemical reaction**
	Copernicus	Ah! Fire! Get it out, get it out!
Panel 5	Copernicus	Are you thinking what I am thinking?
	Newton	I never actually though I would.
Panel 6	Newton	Wonderful. We are performing **chemical change**.
	Copernicus	I don't know what that means but lets eat.
Student F75V was a female in the visual subgroup with a very strong visual preference. Although the sentence structure is not perfect, the concepts made sense in the manner she used them. Newton's line from panel 5 was actually subtly humorous, as the character Copernicus has "issues' with thinking. She exceeded the minimum requirement of three academic vocabulary words.		

Table 20: Sample with **five** academic vocabulary words used correctly

Panel 1	Copernicus	What is this? What does it do?
	Newton	It's a **Bunsen burner**. It lights up **fire and boils** liquid substances.
Panel 2	Copernicus	Huh? I still dont understand
Panel 3	Newton	You turn this knob it sparks which makes fire. Then put a liquid substance in a **beaker** above and the it boils/bubble to make it hot.
Panel 4	Newton	Almost there, yes! It's a burnt marshellow which makes it a **chemical reaction.**
	Copernicus	Don't get hurt, I don't need to lose a friend
Panel 5	Copernicus	marshmellow
	Newton	marshmellow on a stick.
Panel 6	Newton	You know what I just noticed were not wearing **safety goggles**.
	Copernicus	Oh yeah it's for **lab safety** right?
Student M57K was a male from the kinesthetic subgroup. A few spelling errors but generally student was on prompt and the dialogue flowed logically. The student misinterpreted the flint striker as a marshmallow being held in the flame. Student tied in equipment, chemistry concepts and safety rules in a coherent manner.		

Table 21: Sample with **eight** academic vocabulary words used correctly.

Figure 19 shows student performance on the dialogue writing activity broken down by learning style preference. Kinesthetic and visual learners averaged slightly more than

one half-point higher on this task than the other three subgroups. The same two groups, kinesthetic and visual, had errors or misinterpretations at a rate that was 5% higher than the other three subgroups

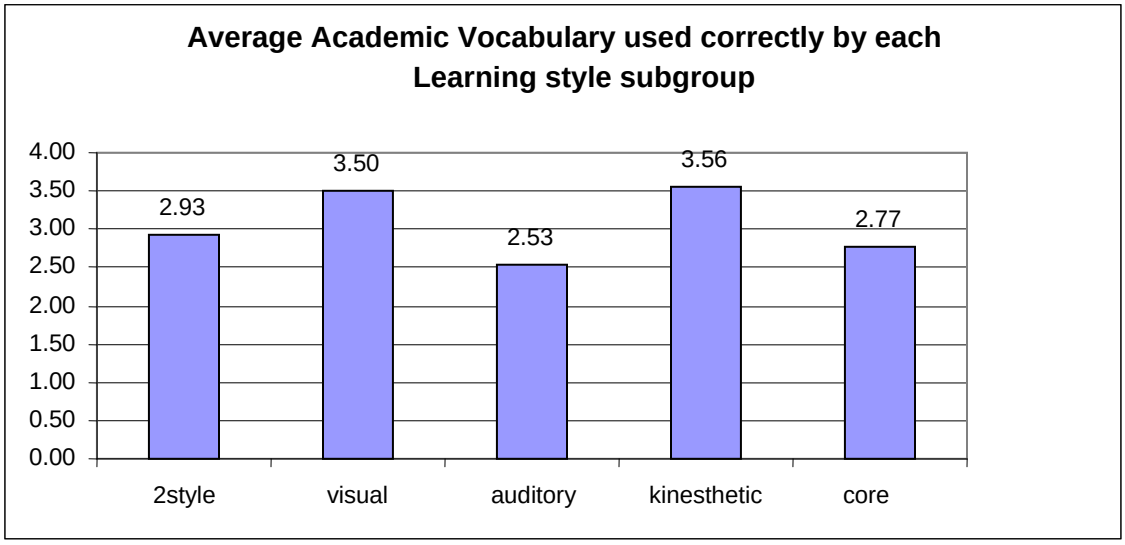


Figure 19: Average Academic Vocabulary used correctly.

Visual and kinesthetic learners used slightly more vocabulary words correctly than the other three subgroups and also had a higher percentage of errors or misconceptions than the other 3 subgroups.

Phase Four: Classroom Discussions, Lesson 34

Science Literacy

Phase four of the study was designed to provide qualitative data demonstrating students science literacy in terms of how readily they would analyze and discuss information related to science or scientific practices included or implied by a comic strip. Using the techniques from phase one, students read a series of six cartoon strips. The classroom conversation covering the

content of the comic strip was tape recorded. The comic strip used involved a feeder rat about to be eaten by a snake (see Appendix S).

Representative samples of student responses as they identified the conflict in the comic strip from lesson 24 are included in Table 22. Students in all four periods were able to identify the conflict and the plot from the series of comic strips.

TOPIC: Identifying the Conflict in the Comic Strip	
Line #	Classroom dialogue
Sample #1	
148	TEACHER: First of all, who can tell me what is going on in this strip? What are they encountering? Yes, F32K
149	F32K: They're uh, trying to help the rat named Lucky get out of the cage, so he doesn't get eaten by a snake?
150	TEACHER: Very good. And then what's the dilemma, obviously, what's the dilemma in this strip?
151	F82V: That he does not get eaten.
152	TEACHER: Louder please.
153	F82V: That the, mouse might get eaten.
Sample #2	
300	Teacher: All right, taking a look at the very first panel on page one of this section, what's the general dilemma, what's going on with this cartoon strip?
301	F27T: Um the rat, he's going to get eaten by the snake.
302	Teacher: He's going to get eaten by the snake. And what's the whole thing about then? M50A?
303	M50A: This guy, Lucky, he's in a cage, and he wants to get out so he doesn't get eaten.
304	Teacher: Okay, and what happens ultimately at the end of the strip?
305	M55K: Um, Newton gets him out?

Table 22: Conflict in comic strip

A new character was introduced in this comic strip from Lesson 34. The classroom discussion led to the origin of the escaped rat's name, "feeder-rat" and to the determination of what a feeder rat was. Students in all four periods identified the purpose of a feeder rat. Table 23 contains excerpts from two periods on this topic.

TOPIC: What is a feeder rat?	
Line #	Classroom dialogue
Sample #1	
195	Teacher: Yeah, what is a feeder rat?
196	Unidentified Male: He gets eaten
197	Teacher: He gets eaten, who gets eaten?
198	Unidentified Male: Lucky, he's supposed to be food.
199	Teacher: Okay what is the purpose of a feeder rat? F10K?
200	F10K: To feed like a snake or another animal.
Sample #2	
346	Teacher: Somebody's lunch. So what kind of a rat is he? When you get into the last panel, what kind of a rat is this? F22C?
347	F22C: He's a feeder rat.
348	Teacher: A feeder rat. What is a feeder rat? Is there really such a thing? M23T?
349	M23T: Yes, um, it's food for the snake.
350	Teacher: It's food for the snake. Does anyone have a snake. F22C, do you have one.
351	F22C: My brother has one.
352	Teacher: What do you have to feed it?
353	F22C: Rats. But we don't feed it live rats, we feeds it dead ones.
354	Teacher: He'll eat the dead ones?
355	F22C: Yeah, cause my mom can't do rats.
480	Teacher: So, where did he hear the name, Pheederat? Where did he get his name? F64K?
481	F64K: From the scientists.
482	Teacher: Yeah, he probably heard them talking about him, so he thought that was his name. "Were you meant to be part of some experiment?" "I think I was meant to be somebody's lunch." Okay, so what's the main difference between Lucky and the other rats? If he's a feeder rat, what's the difference? F09K?
483	F09K: That he was going to get eaten.
484	Teacher: He was going to get eaten. So what's his purpose in life? F65V
485	F65V: Um, they're grown to be eaten. And uh, Copernicus and Newton are lab ones.

Table 23: What is a feeder-rat?

Two of the vocabulary terms introduced in this lesson were carnivorous and constrictor, both in reference to the snake presented in Lesson 34. Classroom discussions were led in a direction to elicit student responses as to the meaning of each of the terms (see Table 24). Since these were not concepts covered in the 8th grade curriculum, students used prior scientific knowledge when they responded to these vocabulary terms.

TOPIC: Meaning of carnivorous and constrictor?	
Line #	Classroom dialogue
Sample #1	
320	Okay, in the last panel, he's asking him about the weather and what kind of a snake it is, and what kind of a snake does Lucky say it appears to be? M34T
321	M34T: a carnivorous constrictor.
322	Teacher: What is a carnivorous constrictor? What does carnivore mean? Does anybody know?
323	M34T: meat eater?
324	Teacher: Meat eater. What is a constrictor, what does a constrictor do? M55K
325	M55K: It squeezes its prey.
326	Teacher: Yeah, it wraps around and squeezes, and what does that do?
327	M55K: It suffocates it.
Sample #2	
446	M36T: um… "So, what kind of snake is that?"
447	Teacher: Very good, yeah. It's not going to keep him calm.(garbled by coughing) And what's Lucky's answer? What does he call it? M22K
448	Several background voices: a carnivore,
449	M22K: A carnivorous constrictor.
450	Teacher: Okay, those are two big words. What does carnivorous mean? M02C
451	M02C: Um, it eats meat.
452	Teacher: Yeah, it's a carnivore, it eats meat, and what's a constrictor, what kind of snake is a constrictor? F67K
453	F67K: Um.. A constrictor is like a snake that uses its body to like squeeze, um the life out of an animal that it's about to eat.
Sample #3	
67	TEACHER: Then he asks him, "what kind of a snake is that?" What is his response?
68	M42C: A carnivorous constrictor,
69	TEACHER: A carnivorous constrictor. What's carnivorous mean? Does anyone remember what that means? Yes, F49C?
70	F49C: A person that eats meat.
71	TEACHER: A person that eats meat or a meat eater is a carnivore. So a carnivorous constrictor, what does that mean? F12C?
72	F12C: A rat eater

Table 24: Transcript of conversation about carnivorous snakes

The conversations in Table 25 addressed the value of a feeder rat, comparing it to what would be considered a pet quality rat and a laboratory rat. Student responses gave some indication of their understanding of the differences between the types of rats used in science and those kept as pets or used for feeding snakes.

TOPIC: Value of different lines of rats.	
Line #	Classroom dialogue
Sample #1	
205	Teacher: One rat you're going to keep and one rat you're going to feed to another animal. What do you suppose the difference is between the rats? F78T
206	F78T: Their size.
207	Teacher: Their size would be one thing. F20C?
208	F20C: One lives longer.
209	Teacher: One lives longer. Probably, what else? F10K
214	F82V: Is it maybe, maybe they take the weaker, or maybe the ones that are kind of sick or something?
215	Teacher: Yes. It's the quality of the rat's genes and the quality of the rat's health and stuff like that. They have a certain pool of rats they use for feeder rats, and they have another pool of fancy rats they sell as pets. It's kind of a strange thing to think of, that people can buy a rat in one cage to feed a snake and another one to keep as a pet. F39T?
218	F55C: How would they know about the genes and stuff like that?
219	Teacher: Well, because you know they've mapped the genes of humans and of rats, and they can actually keep track of that. In fact there are mice that have human genes implanted so that the mice respond to drugs better, the way humans would. So there's a lot of manipulation that goes along, but a lab rat is an expensive animal because it is raised because the strain is perfect and they know all of its genetic behavior and the next generation will be predictable …
Sample #2	
364	…what do you suppose is the difference between a feeder rat, and a rat you buy in a pet store for a pet? What's the difference between them? M50A
365	M50A: Well, they're, they're … like a rat that you buy in the store to eat, their like, boring, they just happen, and then they make, they make rats have babies so they can give them to snakes.
366	Teacher: Okay, so one of them is raised specifically to feed,
367	M50A: yeah,

Table 25: Comparative values of lines of rats

Beyond addressing the concepts presented in the comic strip from Lesson 34, each of the classrooms developed questions about different aspects of the comic strip. These unpredictable discussions provided insight into the thoughts of the students and demonstrated that students were practicing science literacy by thinking and discussing. Sample #1 in Table 26 illustrates a student's curiosity about the ability of a snake to swallow prey larger than its head. Sample #2 illustrates a discussion that compared humans eating meat to snakes eating rats.

TOPIC: Student driven discussions	
Line #	Classroom dialogue
Sample #1	
369	M44A: I have a question about the snakes.
370	Teacher: Yes
371	M44A: I know they can unhinge their jaw and swallow a huge food, but how can they swallow the stuff that's so big without dying? Wouldn't it crush their organs?
372	Teacher: No, because everything about them is designed to be flexible and expandable…
373	M44A: Oh, so there organs are spread out?
374	Teacher: Yeah
375	M44A: Okay
376	Teacher: Their whole rib cage can spread out
377	M44A: So where their heart is
378	Teacher: Yes, I think it's along their back.
379	M44A: Oh, snakes have a rib cage?
380	Background voice: Their whole body is a ribcage.
Sample #2	
494	…what's the difference between feeding a snake a rat and us eating hamburger? Think about it before you respond. F64K?
495	F64K: We cook our food and it doesn't really matter about the cow? like,.. (good natured laugher)
496	Teacher: Okay, why doesn't it matter about the cow?
497	M22K: That's soooo nice… (mixture of reactions and comments)
498	Teacher: Excuse me, I want her to be able to explain what's she's saying..
499	F64K: ‘Cause it can be like any cow as long as it's healthy and it has enough meat, but like with the rats, (she laughs at herself) 'cause they don't keep cows as pets, kind of.
500	Teacher: People don't keep cows as pets?
501	Multiple responses: "yes they do," garbled responses, students citing examples..
504	… Okay, so cows don't matter. F07T?
505	F07T: (garbled)
506	Teacher: Okay, say it again please
507	F07T: It's kind of like, we're using cow meat
508	Teacher: Or chicken or pork, yeah. What's the specific reason cattle and pork are raised? M05C
509	M05C: To be eaten? And have babies so that we can have more meat.
510	Teacher: Yes, we keep the line going. So what's the specific reason feeder rats are raised? F09K
511	F09K: To be eaten by snakes.

Table 26: Sample discussions from lesson 34

Student's Perceived Benefits and Drawbacks of Study

End of study exit survey: Likert-Scale

To aid in investigating research question #3, an exit survey was given to all participants. The survey consisted of 16 Likert-Scaled questions with a ranking of 1-5 and five open ended questions. The averaged responses by subgroup for each question can be found in Table 27.

	Likert-Scale Exit Survey Results	Learning Style Subgroup				
Q#	Question	VIS	AUD	KIN	2 ST	COR
1	Reading the dialogue silently to myself helped me understand the comic strips.	**4.1**	3.8	3.5	3.8	3.6
2	Hearing the dialogue read out loud helped me understand the comic strips.	3.6	3.5	**3.9**	3.8	3.8
3	I benefited from sharing my ideas out loud.	**2.7**	3.4	3.3	3.4	3.3
4	I benefited from hearing other peoples ideas out loud.	3.4	**4.0**	3.8	3.6	3.9
5	The comic strips made it easier to think about and talk about science.	3.9	3.9	3.8	**4.3**	3.8
6	I put in my best effort when answering the questions from the warm ups.	4.2	4.0	3.9	3.8	**4.3**
7	The comic strip made it easier for me to understand issues in science.	**3.9**	3.6	3.8	**3.9**	3.7
8	The words and pictures made the topics easy to understand	4.2	4.2	**4.6**	4.3	4.3
9	I liked hearing the dialogue read out loud before trying to answer the questions.	3.1	**4.0**	3.4	3.7	3.8
10	I am more aware of the issues involved with animal testing.	3.7	3.9	**4.0**	3.9	3.8
11	I am more aware of different jobs in the field of science.	**3.5**	2.8	**3.5**	3.1	3.4
12	I enjoyed working with the comic strips.	3.8	3.8	**4.4**	3.9	4.2
13	I think working with the comic strips was a good use of time.	3.7	3.8	**4.4**	4.0	4.0
14	Drawing and writing my own comic strip was beneficial.	3.3	3.6	3.7	**3.8**	3.7
15	Using the comic strips was a good way to get focused at the start of class.	3.7	3.8	**4.2**	4.0	3.9
16	I used the pictures as well as the words to help me understand what was happening.	**4.5**	4.0	**4.5**	4.4	4.3

Table 27: Survey results by subgroups

Visual Learners

The visual learner subgroup ranked question number 1 (reading dialog silently helped understanding) slightly higher than the other subgroups (see Figure 20). Visual matched with kinesthetic on questions 11 and 16. In contrast, the visual learners ranked question number three (I benefited from sharing my ideas out loud) at 2.7, the lowest of any response from the survey.

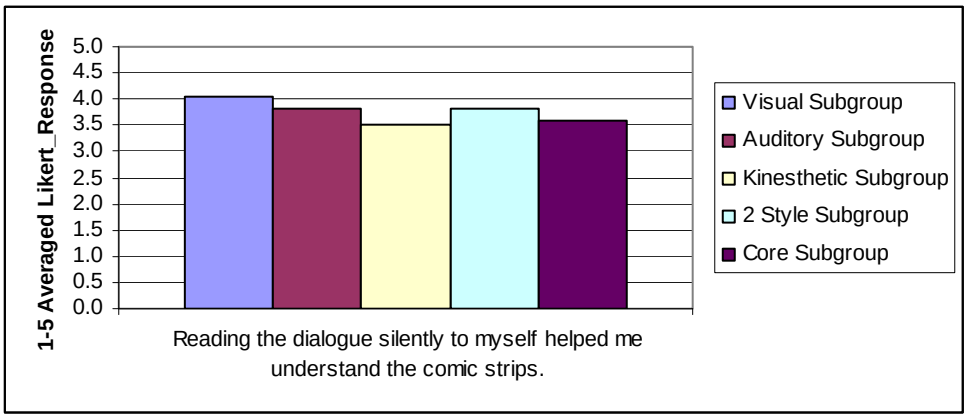


Figure 20: Reading dialog silently

Auditory Learners

Auditory learners ranked questions 3, 4 and 9 slightly higher than the other subgroups. These three questions addressed hearing or listening to material or ideas out loud. The difference between the rankings of auditory and visual learners on question nine was one point (see Figure 21). Visual learners ranked this response two points lower than the auditory group.

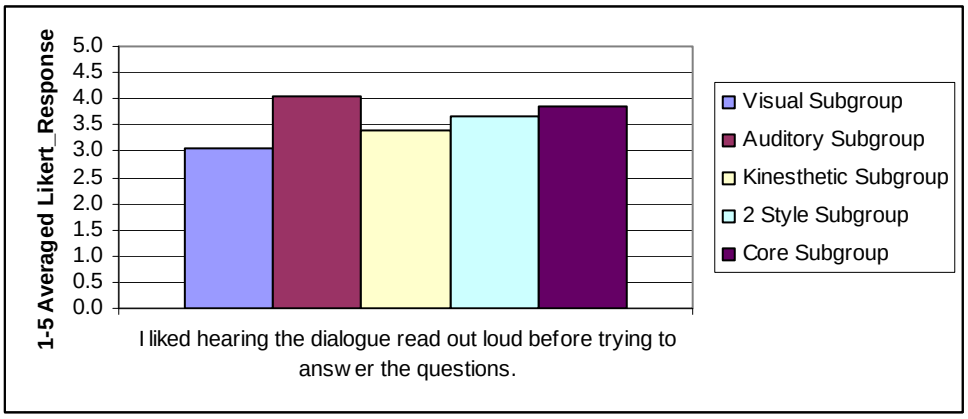


Figure 21: Hearing dialogue read aloud

Kinesthetic Learners

Kinesthetic learners ranked questions 8, 12, 13 and 15 higher than the other four subgroups on the exit survey. Questions 13 and 15 addressed the students' perceptions of the value of using the comic strips. Kinesthetic learners (see Figure 22) ranked the comic strip curriculum as a good us of time 4/10 of a point higher than the core and 2 style group and 6/10 of a point higher than the auditory subgroup.

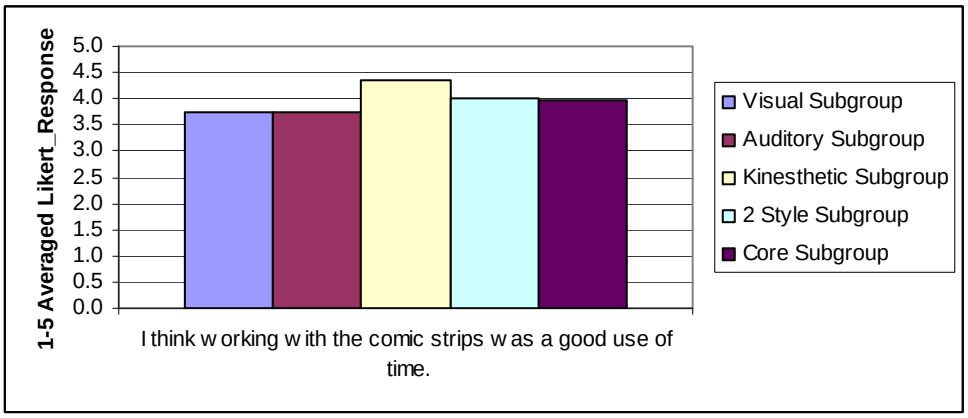


Figure 22: Good use of time

Kinesthetic and core subgroup ranked question 8 (enjoyed working with the comics) highest of the 5 subgroups (see Figure 23). The core subgroup ranked enjoying working with the comic strips second after the kinesthetic learners.

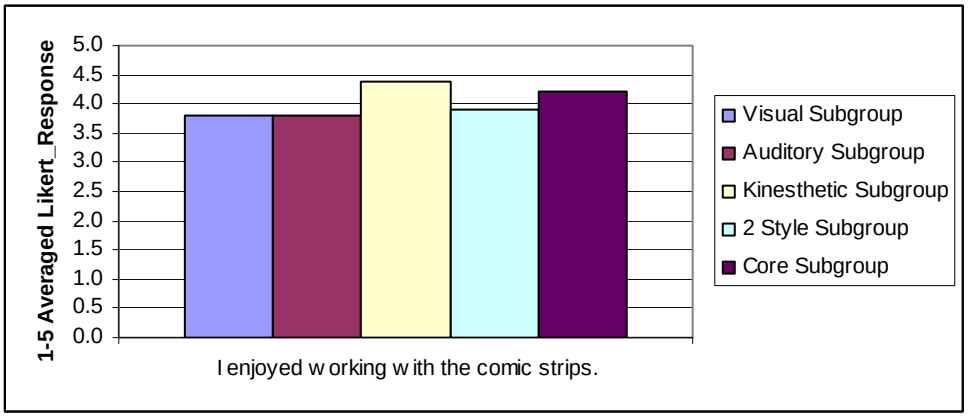


Figure 23: Enjoyed working with comic strips

Two Style Subgroup

The two style subgroup, those students who demonstrated an equal preference for two or three learning styles, ranked questions 5 (easier to talk about science) higher that any other group, but otherwise were always ranked near the middle average (see Figure 24).

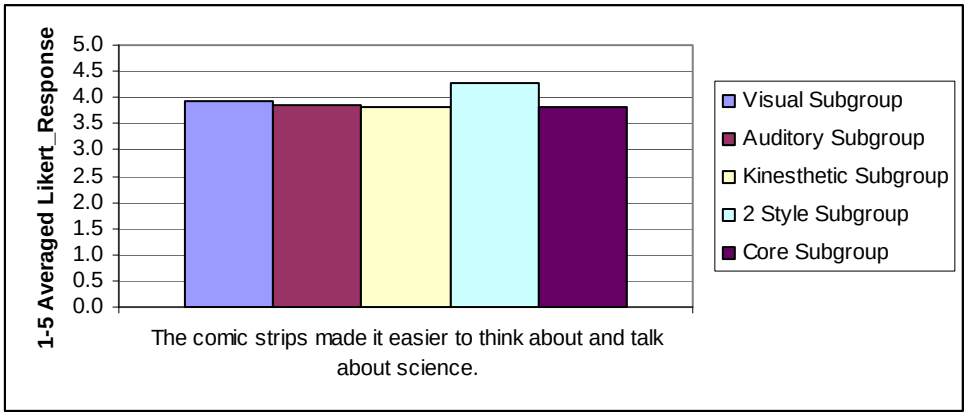


Figure 24: Easier to think and talk about science

Core Subgroup

Figure 25 shows the only question where the core group ranked highest. The core group ranked highest on question number 6, which asked about best effort. Otherwise, the core group comprised of students with only slight preferences for one learning style or who had unreliable data from their learning assessments style usually ranked in the middle average range.

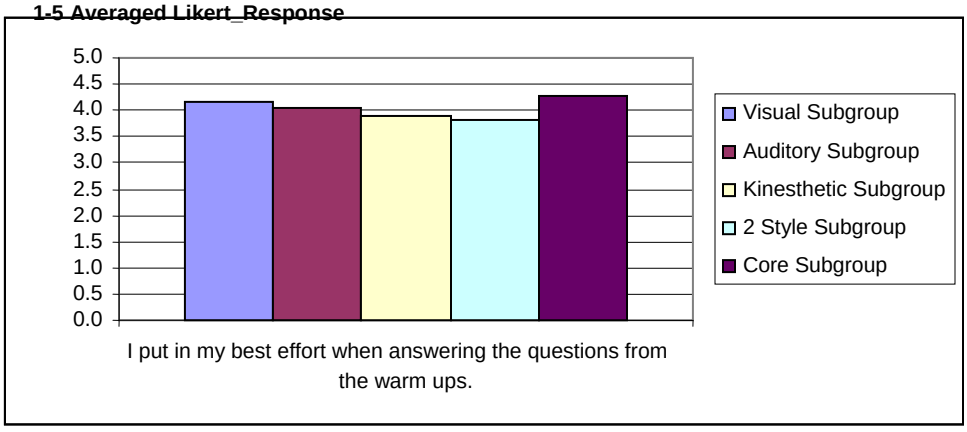


Figure 25: Best effort when answering questions

The remaining questions 2, 7 and 10 demonstrated little variation in student responses. Overall, the student responses to the exit survey did not flag any one specific subgroup.

End of study exit survey: Free Response

To get a feel for what the students perceived as the benefits of the comic strip curriculum, a series of 5 free response questions were included in the exit survey.

Question number 18 on the exit survey specifically asked students to identify something they liked about the comic strip curriculum (see Table 28). 41 of the students responding either found the activities fun or the comic strips funny. Thirty five students felt that the comic strips helped them understand the concepts better or helped them to learn. Fourteen students in the group enjoyed the act of reading the comic strips.

#18: Something I liked about using the comic strips was….	
Count	response type
41	It made science more fun
	it put humor in boring science
	It was a fun way to learn about science
	It humored me and helped me understand the lesson better.
19	helped me learn about science
	I*t taught me extra science issues or words because it explained them in the comic strip*
	learning science in a new way
16	they help me understand better
14	reading the comics
9	I liked looking at the pictures
9	they are a good warm up
8	no response/data
7	other responses
6	storyline, finding out what happens next
4	it was easy
4	work with a partner
4	interesting comments
	I got to see what was going on . . . I'm not an automatic learner.
	The interesting story line because it almost made me want to do the assignment.
	How smart Newton is and how naïve Copernicus is. It helps me understand their characters better.
	It was a creative way of learning

Table 28: Things students liked about the comic strips

Of the fourteen that listed reading the strips, 3 were from the visual subgroup, 4 from the auditory subgroup, 1 from the kinesthetic subgroup, 4 from the two style subgroup, and 2 from the core group. Some unique representative samples are included in Table 28.

Students were also asked to identify what they did not like about using the comic strips. The first 23 lessons of the curriculum were designed with a comic strip or strips, followed by a set of questions for the students to respond to. Each lesson averaged 3-5 questions. Some questions were very content specific and others were more open ended. In terms of what the students did not like, 58 of the students responded that they did not like answering the questions (see Table 29). Eight visual, 10 auditory, 7 kinesthetic, 15 two style and 18 core subgroup members learners did not like the questions. The students' reasoning behind the dislike of the questions was fairly evenly divided. Students listed writing down the answers, too many questions to respond to, answering the questions was unnecessary since the comic strip had already been discussed.

#19: something I didn't like about using the comic strips was…	
Count	response type
58	writing out the answers to the questions
18	other responses *I'm sorry, just didn't like them at all. Kind of pointless.* *You used rats* *I didn't like the talking animals* *I didn't like was what they did to Newton*
17	I liked everything
10	no response/no data
9	it was boring
8	it wasn't in color
8	it was confusing sometimes
7	doing a lot of them, not in order
4	would like to do more frequently
2	reading the comics out loud

Table 29: Representative samples of student responses to dislikes of the comic strips

Eighteen students had fairly unique responses. A few are shown as representative samples in Table 29. Seventeen students did not have anything to complain about. Interesting

aspects that students found negative included the lack of color, the pacing (too often or not often enough) and 8 students stated specifically that the comics were confusing at times.

Question 21 from the exit survey (see Table 30) asked students to respond to the prompt: Did the comic strips keep your interest? Please explain why or why not?

21: Did the comic strips keep your interest? Please explain why or why not.		
Response	Count	Generic representative sample/representative samples
No	10	Comics strips were boring/not entertaining • *no, because there were too many questions* • *No, I think its boring needs to be more fun* • *No. it got boring and confusing. I don't learn anything.* • *no, cause it wasn't really entertaining*
Yes and No	12	Kind of, because sometimes it got boring and other times it didn't • *Yes for the most part I stayed interested in them but sometimes I got sick of them because we did them so often* • *Kind of, I didn't really like them but some were okay* • *For the most part, they got kind of boring sometimes*
Yes	110	Yes responses by subcategory/representative samples
	26	Storyline: I wanted to know what would happen next • *Yes, this comic strip did because it had talking animals and put topics in interesting ways* • *Yes, because they are like a TV show, where you want to see the next episode* • *Yes because they were fun and interesting to read, and kept me interested because it didn't come out of a text book, and the comics made learning more fun*
	25	The comic strips were fun/funny/entertaining
	19	Other responses • *YES: In each strip, both rats were learning or experiencing something new.* • *yes, because I got to actually see the settings and what the expressions look like on the rats faces* • *yes. Two rats talking about science*
	15	The characters and dialog were interesting
	13	It's an easy way to learn
	5	They are fun to read
	4	The cartoons and drawings.
	3	Helped me understand the lesson better.
No Data	9	No response/no data

Table 30: Did the comic strip format keep your interest?

Out of 141 participants, 110 stated that the comic strips kept their interest. Representative samples addressed research question #3: student perceptions of benefits and drawbacks of the comic strip curriculum.

Of the 141 students in the study, 26 cited the storyline as the reason the comics kept their interest, (anticipating what would happen next). Twenty five students responded that the comics were fun, or funny, and 15 cited the characters and dialog. Twenty two students found the strips to be boring or not entertaining. Ten of those students stated that the comic strips did not keep their interest, and 12 students found the comics to be interesting sometimes and boring at other times. Nine students did not respond or were absent during the exit survey.

After analyzing question #17, it was determined that it did not directly address a specific research question. The anecdotal information was of interest so it was included in the appendices (see Appendix T). Question #20 also did not address a specific study question and was not included in the study.

Student perceptions: Field notes

Table 30 contains representative samples of student comments recorded in a field note log during the study. These artifacts are of particular interest, as they were statements made directly to the teacher by students as they interacted with the curriculum. While not exhaustive, these comments gave some indication of the perceptions of individual students. Comments were usually spoken in passing from student to teacher and written down on a clipboard or typed directly into the field notes (see Appendix U). Most of the comments from the field notes came from students in the core subgroup. Students were identified in the field notes and discussion transcripts by an alphanumeric label (M17K). In this example, the student is identified by gender (M)ale, a randomly assigned number (17) and learning style preference (K)inesthetic.

Positive student comments from Field Notes	Negative student comments from Field Notes
F12C: "are we going to get to read the whole thing?" Student M41C asked if we were going to do this all year. My response was, "probably just the first semester." He said "he liked doing them and wanted to see how it turns out." M15C "Mr. Olson, I really like the cartoon strips." Student M28T commented, "I don't remember reading this one before." *He had read the series in one of the books and online*. I pointed out that this one was specifically written for this lesson. F82V great insight on inference, although she jumbled with her thoughts out loud, her basic idea was "making best explanation based on the information available.' She then correctly inferred what was occurring. "His head was being filled with images." [from Lesson #6]	Unidentified male: "this was not a fun experiment!" Context: Class was working at the lab tables on a comic strip warm up, not doing a lab. The comment could be equated with not getting to do a lab, or with the quality of the activity. F08C complained. "I don't like the rats". *Why not?* "Rats are creepy."

Table 30: Comments from field notes

Student perceptions: Focus group

At the end of the study, a small focus group was invited to come in at lunchtime to participate in an informal discussion about the comic strip curriculum. The members of the focus had all read the comic strip beyond the classroom assignments online at the Newton and Copernicus website. Students were first asked what their motivation was to go to the website to read beyond the requirements of the warm up activities (see Table 31). A common theme among the students' responses was that they found the comic strip funny. Others noted that it was interesting, a new experience, something they haven't seen before. F15T, a female student in the

two style subgroup, commented that she liked it because one could learn a little science while reading it.

What made you decide to go to the web site in the first place to read more?	
Line #	Classroom dialogue
2 - Teacher: The first question is, and you can just speak out, or you can raise your hand, what made you decide to go to the web site in the first place, to read more and more. Yes?	
3 - M13C: um, because you kind of showed us Newton and Copernicus and I thought it was funny and kind of cool.	
4 - Teacher: yes, M28T?	
5 - M28T: I agree with what he said.	
6 - Teacher: - and what did he say?	
7 - M28T: -He said that um you kind of like showed us the web site and it was like funny and cool.	
8 - Teacher: - okay, anybody else? M13C, I mean M12C	
9 - M12C: it's funny and people that are stupid are funny, and people that are smart that try to show people that are stupid smart things is funny.	
10 - Teacher: - Okay, yes?	
11 - F02K: It was interesting	
12 - Teacher: you found it interesting, okay, yes?	
13 - F56T: I thought it was funny, and cool	
14 - Teacher: M06V?	
15 - M06V: - It was a new experience I haven't seen before, that was science, and the rats and usually, I usually see stuff, that's usually like boring.	
16 - Teacher: -Okay, how many of,… oh, go ahead	
17 - F15T -It was funny, and you also got to learn a little bit about science while reading it.	

Table 31

When asked about the things that they liked about the strip, the most common response was the fact that the rat Copernicus wasn't very smart. Students like the interaction of the two characters, one knowledgeable and the other ignorant. Student (M12C) a male student in the core study group, liked having more than one character talking about things, and having a comic relief character. Student (F15T) a female in the two style subgroup, liked how Newton had to explain things to Copernicus, and that Copernicus didn't always get what he was talking about. Table 32 contains representative samples of student responses from the small focus group.

Tell me a little bit about the things about the strip that you like….	
Line #	Classroom dialogue
20 - The first question was about what made you go there (to the site) first, okay, tell me a little bit about the things about the strip that you like, you know the characters, or whatever. 21 - F15T: oh, I like how Copernicus wasn't that smart, and he always try to explain to him stuff about science, and Copernicus doesn't always understand. 22 - Teacher: - Okay. M06V 23 - M06V :- I like um how there rats and they're small and they adapt and use things that we use like I like how they use like coffee cups and stuff. 24 - Teacher: Oh, okay, 25 - M13C: -I like how Newton is all smart, and how Copernicus is all dumb, and it's kind of equaled out. 26 - Teacher: -Equaled out 27 - F56T: - I like Copernicus' personality. 28 - Teacher: -What's his personality like? How would you describe it? 29 - F56T: - Dumb, and funny. 30 - Teacher: - M28T? 31 - M28T: - Yeah, because Newton supplies like all the information in it, but Copernicus makes it funny cause like his lack of knowledge about stuff, so like his curiosity. 32 - Teacher: - Cool, yes 33 - M12C : I like how instead of having just one person talking about things, that are sort of like ahhn, it's fun to have a comic relief guy to like make things funny, and make mistakes and have the smart guy fix 'em.	

Table 32

Further responses from this small focus group are recorded in the focus group transcript which can be found in Appendix V.

Chapter V

Discussion

Overview of the Study

This study was conducted to determine if using a daily comic strip as a warm up in my science classes would promote science literacy. The comic strips were a format for students to write, think, and talk about science and science issues. The study also looked to see if the comic strip format had any impact on student achievement. Students' perceptions of the value of using a comic strip as part of their daily instruction were also investigated.

The results for this study were obtained through a series of lesson plans featuring a comic strip about two lab rats and their experiences as the test subjects of an experiment. Students' written responses were the primary sources of data for analysis. Students also created a comic strip, which provided additional information and insight into their literacy skills and learning. An audiotape of four classroom discussions was transcribed and analyzed (see Appendix W), and students participated in an exit survey. Audiotape of an interview with a small focus group provided additional data. Study participants also responded to an exit survey.

Summary of Findings

Student artifacts, data coding and representative samples demonstrated that the comic strip curriculum did provide a forum to promote science literacy. Students were thinking, talking and writing about science and science issues. Students' written responses also revealed a curious mix of misconceptions and naïve thinking in terms of science literacy, providing insight into the thought processes of 8th graders and their general knowledge of science and science issues.

Student created dialogue and cartoon strips provided representative samples of students writing. Artifacts demonstrated students applying academic vocabulary correctly in context and demonstrating a wide range of science literacy within the population of the study.

The experimental treatment used in the study provided quantitative data which demonstrated that selected cartoon strips and the images within those cartoon strips had a measurable effect on student retention of very specific concepts.

The student generated comic strips provided qualitative samples of their literacy and science literacy skills when working with academic vocabulary. A strong relationship between creating a comic strip and learning a specific concept was indicated but could not be quantified.

Students with different learning styles appeared to have slight preferences for different aspects of the study, but no one learning style seemed to be favored or hindered overall.

Student feedback provided insight into the students' perceived value of working with comic strips in the classroom.

Conclusions

This study investigated three different research questions. The major focus of the study was to analyze the data that addressed research question number one: does the use of a science themed comic strip promote science literacy by providing students a forum to think, talk and write about science and science issues? Representative samples, transcripts of discussions, student projects and coded responses to lessons questions provided a substantial sample of artifacts which demonstrated through example that students were thinking, conversing and writing about science and science issues; therefore, students were practicing and engaging in science literacy activities.

Sixty eight percent of students met or exceeded the expected standard when creating a comic strip demonstrating an academic vocabulary concept. Sixty two percent of the students were able to create a meaningful dialog using three or more academic vocabulary terms correctly. Those numbers demonstrated that a majority of the students met the science literacy objectives set for these activities. It should be noted that since the data used in this study is mainly qualitative and was not measured against any other instructional formats, no claims can be made that the comic strips were more or less effective than other methodologies.

The experimental treatment portion of the study addressed research question number two: do comic strips presenting grade level content improve student performance? Two different activities were used in the experimental phase.

During the first treatment, one group was introduced to the concept of ionic bonds through a comic strip (treatment) and the other group through lecture, notes and drawings (control). The results of that study demonstrated that Group B (treatment) scored 22% higher than Group A (control) on the ionic bond question from the follow up quiz and 10% higher on the ionic bond question on the chapter test. The correlation of the quiz score to the test score for the isolated ionic bond question was significant ($n = < .05$). The treatment group scored 10% higher on the “ionic bond” question on the chapter test than the control group. That number was also significant ($n < .05$). It can be concluded from the scores that the presentation of the ionic bond concept with the cartoon did improve performance, but this only applies to the isolated ionic bond questions.

In the second experiment, the grouping for control and treatment were reversed. Of interest was the data from the quiz results from the day after the treatment. Group A (treatment) outperformed Group B (control) on all quiz questions. The first quiz question asked students to

identify what an exothermic reaction was. The second question asked students to identify what information they used to recall their answer. Seventy eight percent of Group A answered question one correctly and 72% of Group A identified the picture of the burning "X" from the cartoon strip as the image they used to remember the meaning of exothermic. Sixty one percent of Group B answered question one correctly and 23% of Group B identified the picture of the burning "X" from their notes as the image they used to remember the meaning of exothermic. The correlation between student responses on question one and question two was significant (n = 0.03). There was an implied link between a student from Group A answering the quiz questions correctly and the image that student recalled from the exothermic reaction comic strip from Lesson 32. The image that the students in the treatment group cited as the one they used to recall the correct response to the related question is shown in Figure 26.

Figure 26: Recalled image from exothermic comic strip (n=.03)

Students from both the treatment and control groups performed equally well on the chapter test question related to the concept of exothermic reaction, so no claim can be made about the longer term advantage the comic strip offered to the treatment group.

Data from the vocabulary section of the chapter test confirmed that eighty nine percent of the students correctly answered the unit test question related to their comic strip concept. The mean score on the vocabulary test for all students was 11.9 points out of 15. The mean percentage score on the vocabulary test was 67 percent. There was no discernable way to

statistically analyze these two sets of data, so there was no claim made that these numbers are significant.

Averaged cumulative scores from the three curriculum assessments (10 points per assessment) found visual and auditory learners matched at 7.3 points, with kinesthetic learners scoring highest at 7.6 points and the core subgroup one point lower at 6.6 averaged points. There were no significant differences between the scores of the five subgroups and no clear meaning of what the results implied.

The third research question asked: what do students with different learning styles perceive as the benefits of the cartoon strip curriculum? What are the drawbacks? Learning style preference did not seem to be a factor in student performance related directly to the comic strip curriculum. There is no quantitative evidence from the analysis in the findings to support any claims of benefit or hindrance for any particular learning style preference. Averaged cumulative scores from the Likert-scale survey (based on a 1-5 ranking) for visual and auditory learners were evenly matched at 3.7. The other three subgroups were evenly matched at a cumulative averaged score of 3.9. Overall, students from all subgroups cited common aspects that they liked (funny, characters, different, interesting storyline) and things that they did not like (questions, boring, confusing) about using the comic strips. On the surface, feedback from the student responses suggested that the comic strips appealed to all of the subgroups, but there were no hard numbers to support any claims.

Implications

One implication from the study is that the comic strips do seem to have an appeal, not only across learning style preferences but also for students who might otherwise not be engaged in science. Months after the end of the study, there were students on the team who continued to

struggle with completing homework or passing tests who would ask to read one of the copies of the comic strip book for independent reading. The students seemed to have developed an affinity for the characters and looked forward to the continuing story. Making this sort of reading material available for resistant readers might help them develop an interest in reading.

The daily comic strip was a practical tool to get students on task at the start of the period. The multi-modal design of the curriculum appealed to a wider range of students with varied learning styles. Students with poor reading skills could still get information out of the comic strip and participate. The use of comic strips, especially student created comic strips could prove to be excellent tools for identifying misconceptions, for constructivist teaching and for promoting conceptual change.

In terms of student performance, comic strips could prove valuable in identifying concepts for re-teaching, as a creative alternative standards assessment tool, for introducing abstract concepts or for modeling step by step processes that are difficult for students to visualize.

Results from the treatment portion of the study indicate that the images in the comic strip can make a lasting impression on the reader and may therefore have value in presenting abstract concepts that are difficult for students to visualize. Twenty six students cited on the exit survey the picture of the rat lighting the “X” on fire as the image they remembered most from the comic strips (see Appendix T).

Recommendations

The use of comic strips in my classroom did appear to generate some interesting responses and quality work from my students, and I did notice that the first semester of the year when the study took place I found the students more often on task and involved with their warm

ups than the second half of the year when the routine returned to normal. Therefore I would recommend continuing the use of the comics as a warm up in a less structured form.

The curriculum may have been better received and more engaging if the comic strip had used a series of think about questions, and perhaps only one open ended response question. In that way, students could have focused more on reading, thinking and discussing, without feeling pressured to start answering the questions.

Many students cited in the survey that they found the comic strip preferable to working out of the textbook, and several students perceived that the comics made learning science fun. Using comic strips or other unique formats to improve science literacy skills would be beneficial for teachers and students.

Limitations

One limitation of this study was that the students knew their teacher was also the creator of the comic strips. Although students in the focus group stated that they would have read the comic strips with the same level of interest, there had to be some influence on students' honesty and some unspoken pressure on their willingness to participate since they knew the comic strips were their teacher's creations.

Although the qualitative data was enlightening in its ability to give snapshots of student performance, the quantitative data seemed rather limited in its scope and validity. The quantitative data focused on isolated questions within a test, not an entire test. Therefore its overall effectiveness is problematic. The two subgroups used in the performance treatment were balanced strictly by class size and may not have been balanced in ability.

The Likert-Scale data, while providing interesting anecdotal feedback, did not provide any definitive information about the limitations the comic strips might have for addressing different learning style preferences.

Future Questions or Studies

I would like to revise the curriculum and make it available to other science teachers at the school, especially the team that has the ELL and Special Education Inclusion students to see if the comic strips help with their visual literacy and engagement.

In my own classroom I will be using a revised format of the curriculum on a regular basis, and will be incorporating more student created comic strips and dialogue activities, which I found to be the most interesting artifacts of the study.

Questions for possible future research are found in Table 32.

Possible future research questions using the comic strip format
1: Can student generated comic strips help identify students' preconceptions? 2: Can student generated comic strips help identify students misconceptions in science? 3: Are comic strips a viable alternate assessment tool? 4: What aspects of a comic strip motivate resistant readers?

Table 32: Future research questions

Recognition

This culmination of this action research would not have been possible without the ongoing support and inspiration from Dr. Michael Rivas who has graciously mentored me through the entire process. A special word of thanks to Dr. Norman Herr, whose classes have taught me a great deal about the value of structure and organization, to Dr. Brian Foley, who has opened my mind to new ways of practicing my craft and understanding my students, and to Dr. Ken Berry, who has helped me appreciate the value of knowing what the driving forces behind education are and where they came from.

I must offer my deepest appreciation and heartfelt thanks to my dear wife, Sharon, who has been my strength and my champion through this entire process, and to my daughter Katie and my son Andy for their support and assistance with editing.

A word of thanks is also due to my colleagues in Science Cohort #2. Their encouragement, support and peer editing skills were instrumental in the crafting of this final document.

A special word of thanks goes out to Mrs. Rhondi Durand, my site administrator, for allowing me to leave every staff, leadership and department meeting early for the last two years, so I could make it to classes on time.

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Appendix A

Informed Consent Letter

Mr. John C. Olson
Arroyo Seco Junior High
Team Discovery/8th Grade Science
September 10, 2007

Dear Team Voaygers Parents:

This year I will be conducting a classroom research project (action research) as a part of my Masters Degree program at California State University, Northridge. The bulk of the research will occur during the first semester of the 2007-2008 school year.

THE STUDY

Over the summer of 2007, I worked with my CSUN advisor to develop a curriculum for use in my classroom to augment student learning and support science literacy. The project is a series of daily warm ups and extended activities using a science themed comic strip about two lab rats. The objectives of the warm up activities are: to engage students in thinking and talking about science issues and science ethics, and to support and clarify the 8th Grade California Science Standards. The purpose of this research study is to evaluate the curriculum. This study will support the regular curriculum, not replace it.

ADVANTAGES OF STUDY:

The students will be exposed to research methods while learning about science. Students may see some improvement in grades or performance. Students will have increased opportunities to discuss and debate scientific issues. The nature of the warm ups will focus students' attention when they come to class, resulting in increased time on task. Through this study, students may acquire a better understanding of their own learning style preferences, and a better understanding of the content presented in the classroom.

CONFIDENTIALITY OF DATA FROM STUDY

The names of students participating in the study will not be included or revealed in any part of the research findings. All student tests scores, written and oral responses, and survey responses will be identified with a study number, not by student name. All data and materials related to the study will be kept secure by the classroom teacher. No names will appear in any of the study documentation.

EXTENDED RESEARCH:

Some small group activities in the study may be audio or video taped. Your child may be invited to participate in one of these groups. Some students may be invited to participate in more in-depth interviews, either working with the curriculum or responding to the curriculum. No video or audio tapes will be made public. Only transcripts and commentary will be included in the study document. Tapes will be kept secure for 3 years then erased.

Appendix A

INFORMED CONSENT FORM FOR ACTION RESEARCH PARTICIPATION

Name of Student

STUDENT DATA (parent please initial one in this section)

_____ Mr. Olson has my permission to use relevant test scores, student's written words, class work, survey results and other relevant study data, with the understanding that the above named student will not be identified by name or otherwise be identifiable in the study document or any related documents.

_____ Mr. Olson MAY NOT USE any student data for the above named student (student's data will not be included in this study)

EXTENDED RESEARCH (parent/guardian please initial one in this section)

_____ The above named student may be video taped in a small group activity or interview setting related directly to this study. Mr. Olson has my permission to use all or portions of transcripts of audio or video tape collected in the study with the condition that the above named student will not be identified by name or be otherwise identifiable in the study document or any related documents.

_____ The above named student MAY NOT BE VIDEO TAPED OR AUDIO TAPED. (student will not be included in this portion of the study)

Participation in this study is voluntary and involves no unusual risks to your child. You may rescind your permission at any time with no negative consequences. Your child can refuse to participate or withdraw from the project at any time with no negative consequences.

Student Signature (participant) date

Parent signature (parent or guardian of participant date

CONTACT INFORMATION

Please contact Mr. Olson if you have any questions regarding this study.
Phone: 661-296-0991 (ext. 301) EMAIL: jolson@hartdistrict.org

Mrs. Durand, ASJH Principle, is aware of this study and will be kept apprised of its progress.

Appendix B

Learning Style Assessment #1: ulc.arizona.edu

*This Learning Style Assessment was developed by Reed Mencke Ph.D. and Stacey Hartman M.A. to assist college students in the development of effective study strategies.

To better understand your preferences as a learner, take a few minutes to answer the following questions.

Please read the questions carefully and place a check on the appropriate bubble after each statement. When you are finished and satisfied with your responses, you will take the assessment on line and write down your scores.

1. I follow written directions better than oral directions.
   Often Sometimes Seldom

2. I understand things I hear better than things I read.
   Often Sometimes Seldom

3. I enjoy classroom activities where I can participate over listening to a lecture.
   Often Sometimes Seldom

4. My notes have lots of pictures, arrows, or other symbols in them.
   Often Sometimes Seldom

5. I learn to spell better by reading a word out loud than by writing it on a paper.
   Often Sometimes Seldom

6. I understand and follow directions on maps.
   Often Sometimes Seldom

7. I enjoy working with my hands.
   Often Sometimes Seldom

8. Before beginning an unfamiliar task, I prefer to see someone else do it first.
   Often Sometimes Seldom

9. I often need verbal explanations of graphs, charts and diagrams to understand them.
   Often Sometimes Seldom

10. I can "picture" the right answer in my notes while taking a test.
    Often Sometimes Seldom

11. I prefer that the professor write the information on the board during lecture.
    Often Sometimes Seldom

12. I think better when I have the freedom to move around.
    Often Sometimes Seldom

13. Before beginning an unfamiliar task, I would prefer to have someone tell me the correct procedure.
    Often Sometimes Seldom

14. I remember material better when I summarize it out loud.
    Often Sometimes Seldom

Appendix B

15. I make pictorial representations of ideas, like graphs and charts, to help me better understand concepts.
Often Sometimes Seldom

16. It is difficult for me to study in a noisy area.
Often Sometimes Seldom

17. When I can't think of a specific word, I use my hands a lot.
Often Sometimes Seldom

18. The best way for me to remember something is to picture it in my head.
Often Sometimes Seldom

19. I prefer to listen to a speech than read about some material.
Often Sometimes Seldom

20. When learning something, I often ignore the directions and just start doing it.
Often Sometimes Seldom

21. If I sat near a window in a classroom, I would probably be distracted by it.
Often Sometimes Seldom

22. I often tap my foot or pencil when thinking.
Often Sometimes Seldom

23. I follow oral directions better than written ones.
Often Sometimes Seldom

24. I have a good sense of direction.
Often Sometimes Seldom

25. I prefer to engage in some activity, like snacking, while studying.
Often Sometimes Seldom

26. I can remember more about a subject through listening to a lecture than reading a text.
Often Sometimes Seldom

27. I get restless when I am required to sit still for an extended period of time.
Often Sometimes Seldom

Learning Styles Assessment: Results

Your score in Visual is: _____

Your score in Auditive is: _____

Your score in Kinestetic is: _____

Appendix C

Learning Style Assessment #2: Marcia L. Conner

What's Your Learning Style?

By Marcia L. Conner

Learning style refers to the ways you prefer to approach new information. Each of us learns and processes information in our own special style, although we share some learning patterns, preferences, and approaches. Knowing your own style also can help you to realize that other people may approach the same situation in a different way from your own.

Take a few minutes to complete the following questionnaire to assess your preferred learning style. Begin by reading the words in the left-hand column. Of the three responses to the right, circle the one that best characterizes you, answering as honestly as possible with the description that applies to you right now. Count the number of circled items and write your total at the bottom of each column. The questions you prefer provide insight into how you learn.

1. When I try to concentrate...	I grow distracted by clutter or movement, and I notice things around me other people don't notice.	I get distracted by sounds, and I attempt to control the amount and type of noise around me.	I become distracted by commotion, and I tend to retreat inside myself.
2. When I visualize...	I see vivid, detailed pictures in my thoughts.	I think in voices and sounds.	I see images in my thoughts that involve movement.
3. When I talk with others...	I find it difficult to listen for very long.	I enjoy listening, or I get impatient to talk myself.	I gesture and communicate with my hands.
4. When I contact people...	I prefer face-to-face meetings.	I prefer speaking by telephone for serious conversations.	I prefer to interact while walking or participating in some activity.
5. When I see an acquaintance...	I forget names but remember faces, and I tend to replay where we met for the first time.	I know people's names and I can usually quote what we discussed.	I remember what we did together and I may almost "feel" our time together.
6. When I relax...	I watch TV, see a play, visit an exhibit, or go to a movie.	I listen to the radio, play music, read, or talk with a friend.	I play sports, make crafts, or build something with my hands.
7. When I read...	I like descriptive examples and I may pause to imagine the scene.	I enjoy the narrative most and I can almost "hear" the characters talk.	I prefer action-oriented stories, but I do not often read for pleasure.
8. When I spell...	I envision the word in my mind or imagine what the word looks like when written.	I sound out the word, sometimes aloud, and tend to recall rules about letter order.	I get a feel for the word by writing it out or pretending to type it.
9. When I do something new...	I seek out demonstrations, pictures, or diagrams.	I want verbal and written instructions, and to talk it over with someone else.	I jump right in to try it, keep trying, and try different approaches.

Appendix D

Learning Style Assessment #3: Middlesex Community Technical College

Often (3)	Sometimes (2)	Seldom/Never (1)

Visual Modality
_____ I remember information better if I write it down.
_____ Looking at the person helps keep me focused.
_____ I need a quiet place to get my work done.
_____ When I take a test, I can see the textbook page in my head.
_____ I need to write down directions, not just take them verbally.
_____ Music or background noise distracts my attention from the task at hand.
_____ I don't always get the meaning of a joke.
_____ I doodle and draw pictures on the margins of my notebook pages.
_____ I have trouble following lectures.
_____ I react very strongly to colors.

_____ **Total**

Auditory Modality
_____ My papers and notebooks always seem messy.
_____ When I read, I need to use my index finger to track my place on the line.
_____ I do not follow written directions well.
_____ If I hear something, I will remember it.
_____ Writing has always been difficult for me.
_____ I often misread words from the text, i.e. "them" for "then").
_____ I would rather listen and learn than read and learn.
_____ I'm not very good at interpreting an individual's body language.
_____ Pages with small print or poor quality copies are difficult for me to read.
_____ My eyes tire quickly, even though my vision check-up is always fine.

_____ **Total**

Kinesthetic/Tactile Modality
_____ I start a project before reading the directions.
_____ I hate to sit at a desk for long periods of time.
_____ I prefer first to see something done and then to do it myself.
_____ I use the trial and error approach to problem-solving.
_____ I like to read my textbook while riding an exercise bike.
_____ I take frequent study breaks.
_____ I have a difficult time giving step-by-step instructions.
_____ I enjoy sports and do well at several different types of sports.
_____ I use my hands when describing things.
_____ I have to rewrite or type my class notes to reinforce the material.
_____ **Total**

Total the score for each section. A score of 21 points or more in a modality indicates a strength in that area. The highest of the 3 scores indicates the most efficient method of information intake.

Appendix E

Lesson 1

Name: Date: Period/Class:

Newton and Copernicus: Lesson #1

Rules to Read by: (Student Reference Sheet)

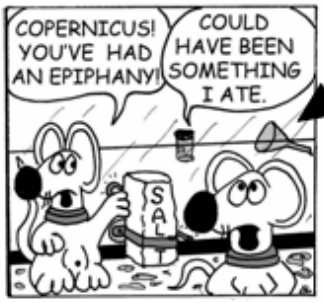
Newton and Copernicus is a comic strip designed to help you (the student) understand some basic scientific concepts, as well as to get you thinking about science, science ethics, and the role of science in our society. The information on this page will help you get the most out of your reading. Take a few minutes to become familiar with these **Rules to Read by**.

Speech bubbles

-When a speech bubble has a tail that points to a character, that character is speaking.
-In Newton and Copernicus, the rats talk to one another in CAPITAL letters.

Speech Lines

-When a speech line is used, (the text has no bubble) the character speaking is outside of the panel (box).
-In this collection, the humans speak to one another in lowercase letters.



Background Information

-The funnel, the jar, the salt lick, even the lines indicating glass, are referred to as background information. Understanding the storyline often depends on observing the background information.

Thought Bubble

Cloud-like bubbles with a chain of circles indicates when a character is thinking.

Appendix F

Lesson 2

Name: Date: Period/Class:

Newton and Copernicus: Lesson #2

1: What do you think Dave's job is? What about the person asking for "a couple of" rats?

2: From your observations, what do you predict is going to happen to the rats?

3: One rat is going to be the "test subject", the other one the "control". Which rat will probably be the experimental (manipulated) rat?

4: What does the term, "live biological specimens" mean?

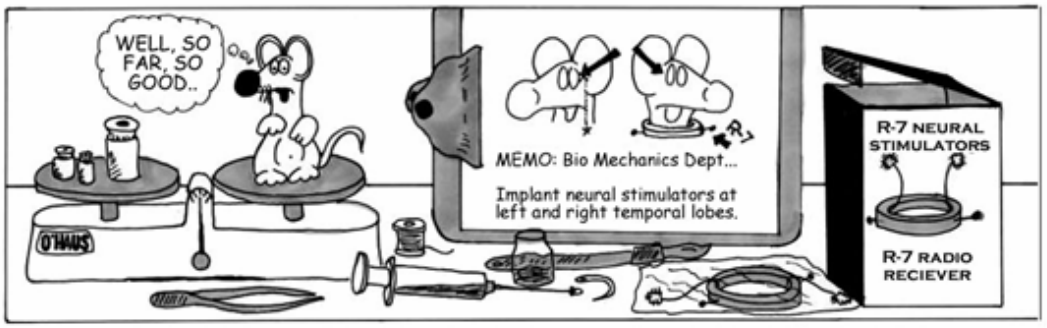
5a: Positives of animal testing	5b: Negatives of animal testing

Appendix G

Lesson 5

Name: Date: Period/Class:

Newton and Copernicus: Lesson #5



1: What is the instrument Newton is sitting on used for? What other pieces of scientific equipment do you recognize (background information)?

2: What do the clipboard instructions and the equipment on the table indicate will happen next?

3: What evidence tells you that Newton is **thinking**, not **talking**?

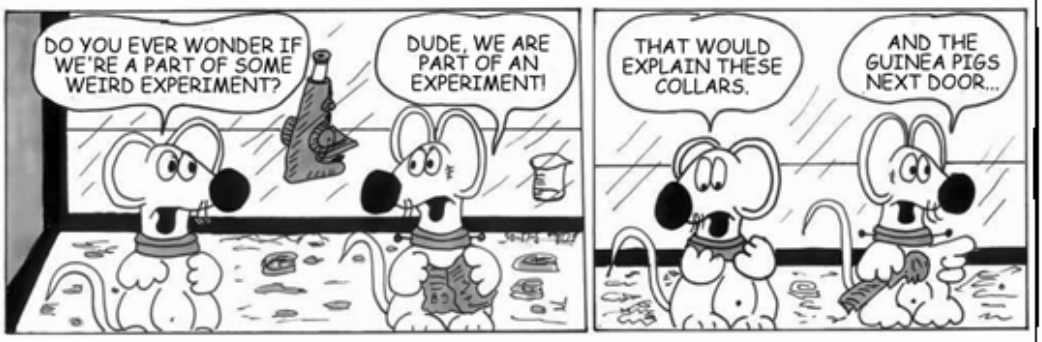
4: Why would Newton think to himself, "well, so far, so good," when all the background information indicates that something unpleasant is going to happen to him?

5: What does Newton's situation make you think about? How does it make you feel?

Appendix H

Lesson 16

Newton and Copernicus: Lesson #16



1: Why would Copernicus wonder if they are part of "some weird" experiment?

2: How does Newton **know** that they are part of an experiment? (dude, we are part of an experiment)

3: What does Copernicus mean by "that would explain these collars"?

4: What other information (conversation and background) supports Newton's theory that they are part of an experiment?

5: Background information: Newton is holding a scrap of paper. From the way he is holding it, what do you think the paper is foreshadowing? (Think about previous strips)

Appendix I

Lesson 20

Name: Date: Period/Class:

Newton and Copernicus: Lesson #21

1: What happens when Copernicus leads the way? Why are there four rats and two cages in panel two?

2: What natural behavior of rats might have caused this to happen? Why might rats have a tendency to do this?

3: What two things does Copernicus say to try and impress Newton? Is he right?

4: What does Copernicus say that sets up the gag in the last panel? What is the "gag"?

5: Why is Copernicus disappointed? What do you think he was expecting?

Appendix J

Lesson 22

Name: Date: Period/Class:

Newton and Copernicus: Lesson #22

1: What background information shows you that Newton is leading them away from the cage?

_____

_____

2: Who is the author and what is the title of the book Copernicus is walking across in panel two?

_____

_____

3: What do you thinking operant conditioning might be?

_____

_____

4: From the context of what Newton and Copernicus say to one another in panels two and three, what do you think happened in that "little maze incident"?

_____

_____

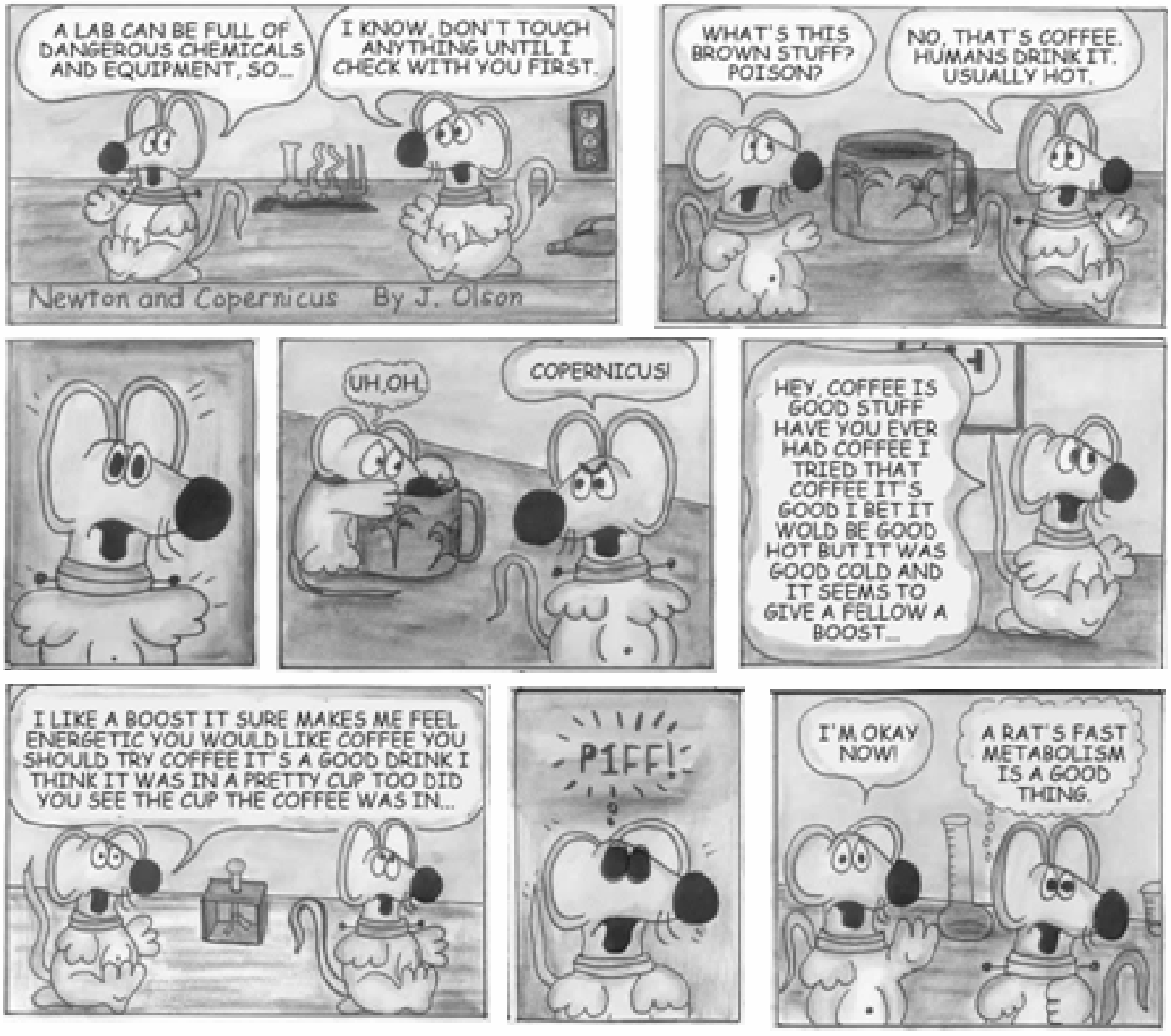
5: Would finding a piece of cheese at the end of a maze be a positive reinforcement or a negative reinforcement for a rat?

_____

_____

Appendix K

Comic Strip from Lesson 23



Appendix L

Title

Name: Date: Period/Class:

Newton's Diary: lessons 18-23

Respond to the following questions as if you were Newton writing in his diary about each of the adventures below.

(you may use the back if you need more room)

1: How we got out of our cage…

2: Copernicus takes a shot a leading the way…

2: Our first adventure out in the lab on our own…

Appendix M

Sample of Unit Assessment: Assessment 1-6

Newton and Copernicus: Assessment (1-6)

1: In a comic strip, this shows that a character is talking.

(a) speech bubble (b) thought bubble
(c) Uppercase (d) Lowercase

2: In a comic strip, this shows that a character is thinking.

(a) speech bubble (b) thought bubble
(c) Uppercase (d) Lowercase

3: Information that comes from the picture, not the dialog of a comic strip.

(a) text (b) panel
(c) graphics (d) background information

4: What would the label on a shipment of animals used in testing say?

(a) organic material (b) handle with care
(c) live biological specimens (d) laboratory supplies

5: People agree that animal testing

(a) is okay (b) is not okay
(c) depends on what is done (d) is a complicated issue

6: The characters, Newton and Copernicus, are two

(a) technicians (b) famous scientists
(c) lab rats (d) mice

7: Talking animals could best be described as…

(a) science fiction (b) fantasy
(c) non-fiction (d) science fact

8: Neural stimulators

(a) are science fiction (b) send signals to nerve endings
(c) are not currently in use (d) have been around for hundreds of years

9: A synonym for naive would be

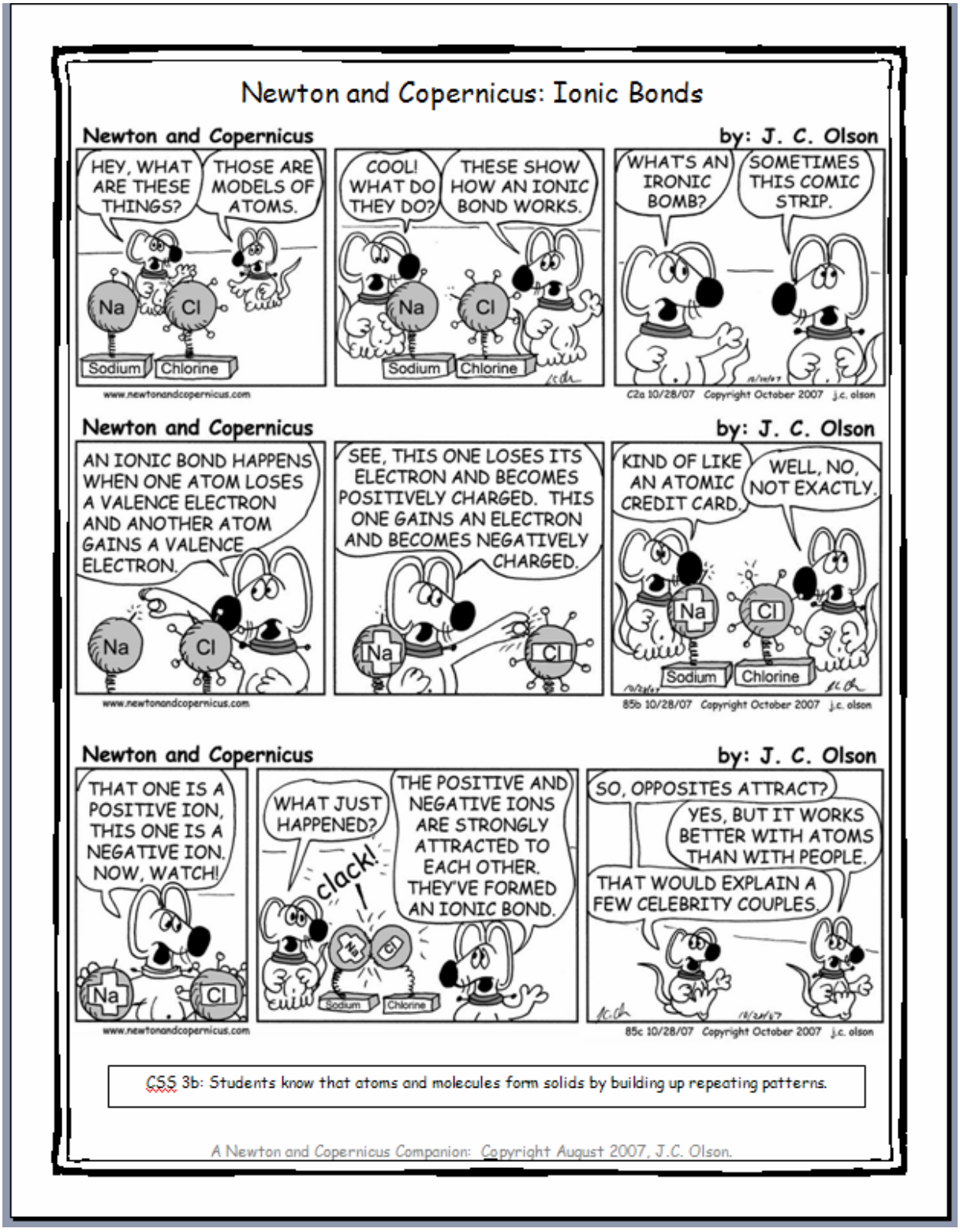
(a) innocent (b) angry
(c) young (d) European

10: Assigning human traits to animals or objects is a literary device called

(a) humanism (b) metaphor
(c) simile (d) personification

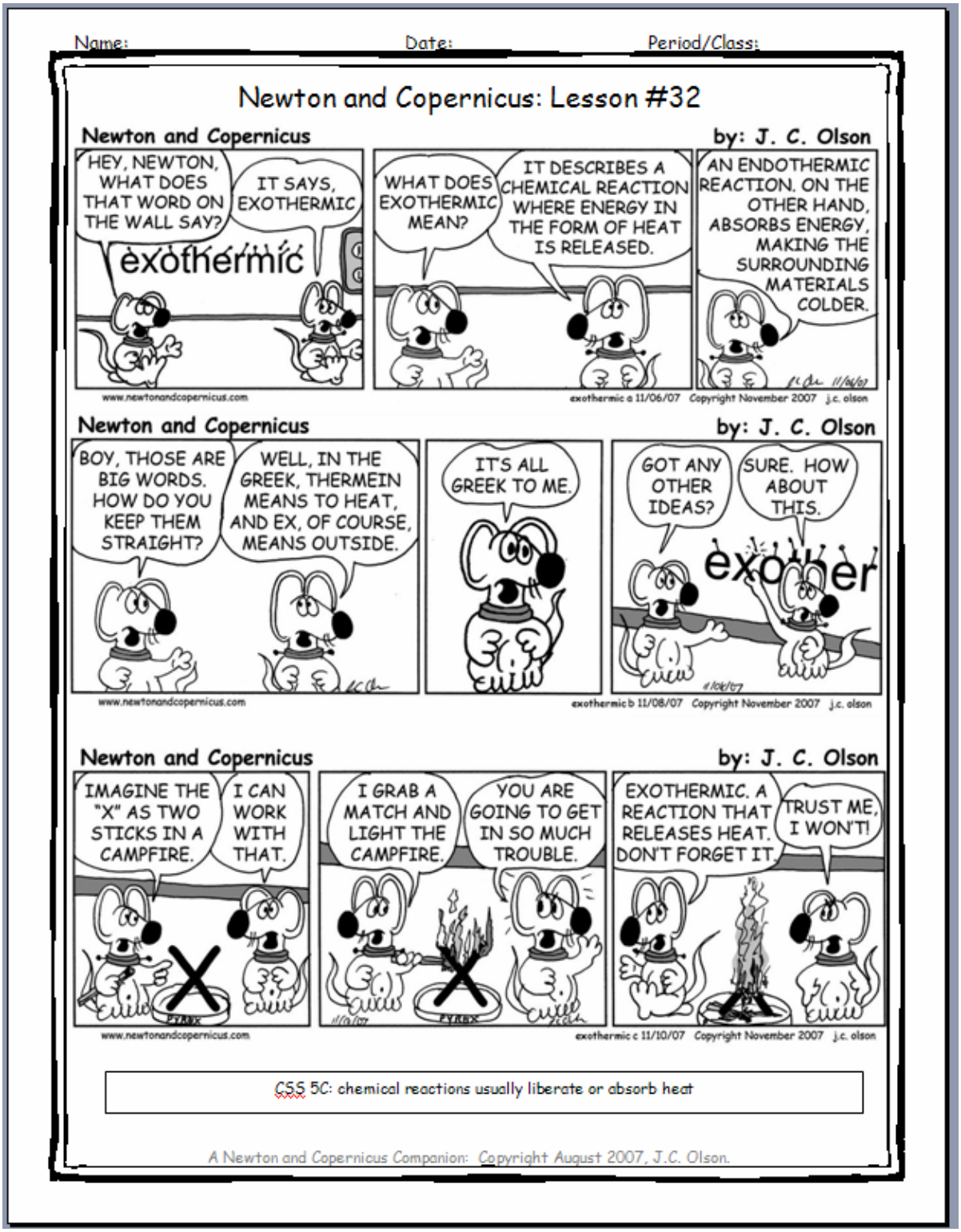
Appendix N

Title



Appendix O

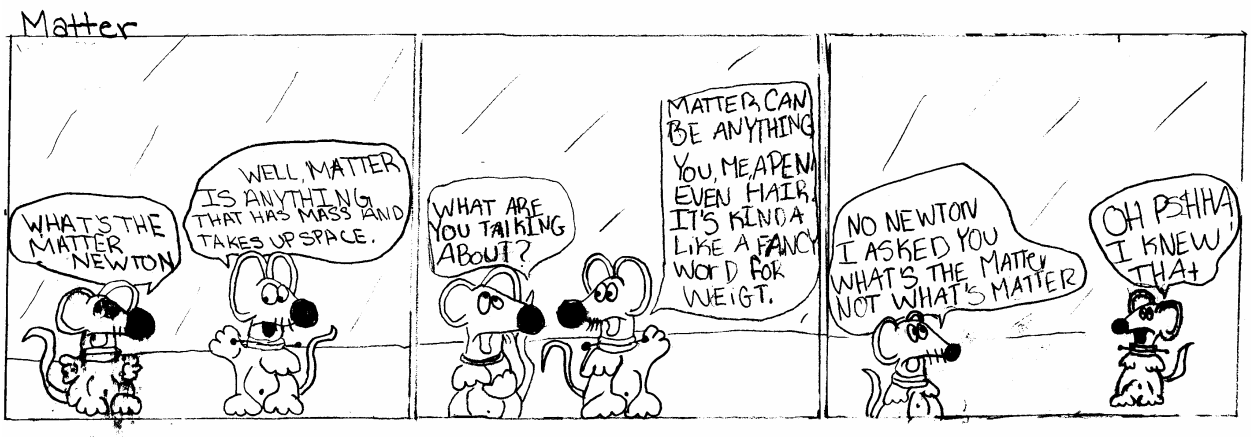
Title



Appendix P

Samples of student created comic strips

Concept 3 Elaboration 0 Background 0 Storyline 1 Character 1 Humor 1 Cumulative **6**

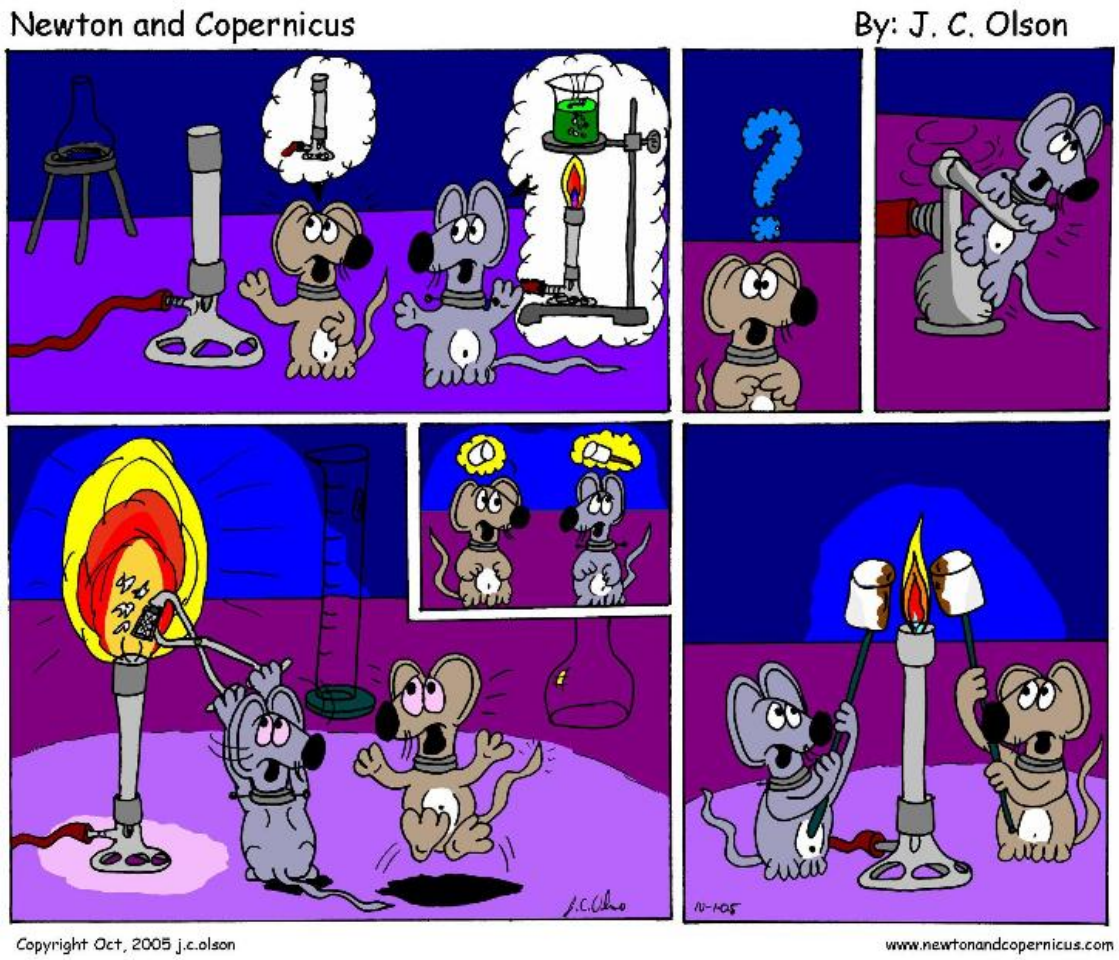


Concept 3 Elaboration 2 Background 0 Storyline 1 Character 1 Humor 1 Cumulative **8**

Concept 3 Elaboration 0 Background 0 Storyline 1 Character 1 Humor 0 Cumulative **5**

Appendix Q

Comic strip from Lesson 33 for students' dialogue activity



Appendix R

Sample student dialogues from Lesson 33

Panel 1	Copernicus	What is that?
	Newton	Well, that is the **bunson burner**
Panel 2	Copernicus	How does it work?
Panel 3	Newton	Now lets see… I you give it a little push
Panel 4	Newton	It makes a spark.
	Copernicus	Oh I see
Panel 5	Copernicus	How bout smores.
	Newton	I dont see why not
Panel 6	Newton	This works very well
	Copernicus	Mhm… sure smells good
Student F05S was a female in the SLP/ID group, with a slight kinetic preference. She included one **academic vocabulary word** (AVW) correctly. Her dialog made sense in the context, and the reference to a spark fit the storyline. She had two contraction errors. She did not meet the minimum standard of 3 academic vocabulary terms.		

Panel 1	Copernicus	What is this?
	Newton	**A bunson burner.** It has an **exothermic way** and **burns chemicals** to get a **chemical change**.
Panel 2	Copernicus	Wait, what?
Panel 3	Newton	here i'll show you. Pull this lever.
Panel 4	Newton	***take this off and…***
	Copernicus	AHHH!
Panel 5	Copernicus	don't you think marshmallows are yummy?
	Newton	why yes. we should roast some!
Panel 6	Newton	Now Copernicus, don't make your marshmellow catch on fire
	Copernicus	I know how to make marshmellows!
Student F02K was a female in the kinesthetic subgroup. She managed to include **four AVW** in Newton's first response. (exothermic way is not quite correct). She misinterpreted ***the flint for a cover*** that when removed allowed the flame to start. She exceeded the minimum requirement.		

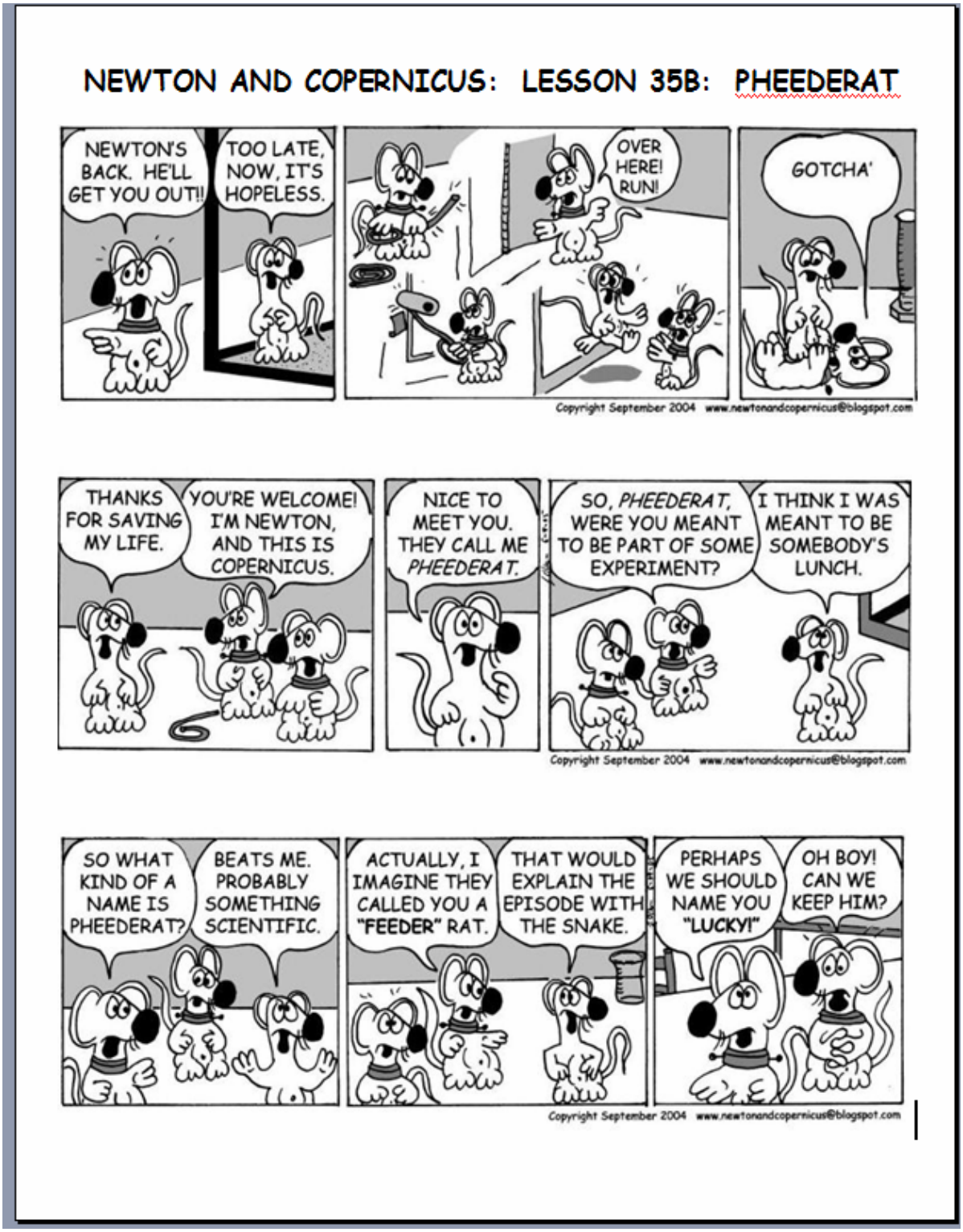
Panel 1	Copernicus	Hey Newtun wat is this
	Newton	A **bunsin berner** it **heats** things up using an **exothermic reactin**
Panel 2	Copernicus	I don't get it
Panel 3	Newton	Watch
Panel 4	Newton	I'll use this **flint** to turn it on
	Copernicus	That not safe
Panel 5	Copernicus	Let cook some marshmallows
	Newton	I was thinken the same thing
Panel 6	Newton	Thes are gonna be good
	Copernicus	I knew it
Student M24S was a male in the SLP/ID. He showed a matched preference for auditory and kinesthetic, but his data was not completely dependable as his tendency for testing is to fill in bubbles at random. He was approximately 4 years below grade level in reading, but he was very verbal and intelligent. He generally lacked motivation to complete any work that involved writing or reading, and has multiple spelling errors. The accuracy of his dialog was therefore surprisingly sophisticated. It underscored his adaptation to listening and remembering what he heard in class. He exceeded the minimum requirement.		

Appendix S

Lesson 35 A

Appendix S

Lesson 35 B



Appendix T

Question 17

Anecdotal Data not directly related to a specific research question.

To get a feel for what the students perceived as the benefits of the comic strip curriculum, a series of 5 free response questions were included in the exit survey. The first of these questions asked the students to recall a specific image from the comic strips they had read. The most common image recalled with 26 responses was the image of the rat Newton lighting the X on fire from the exothermic lesson. Other highly remembered images were the image of the feeder rat and the snake from the last activity of the study. Seven students recalled the very first image from the first comic strip, two rats being selected from a box of biological specimens. One even recalled the label on the box, “live biological specimens.”

#17: Describe an image from the comic strips that you clearly remember.	
Count	response type
26	exothermic reaction
20	saving the feeder rat
18	escaping from their cage
17	Neural stimulation experience
13	Copernicus drinking coffee
7	biological specimens
6	absent no data
6	Toasting marshmallows (dialogue activity)
4	counting
2	topic of student generated comic

Table X: free response to survey question #17

Appendix U

Field Notes

Initial observations: Lessons 1 and 2 8/27/07

Period A:

Most students in period A engaged, interest high, likely because of difference of materials. We covered the different types of information to look for in the strips, dialog, upper and lowercase type and their meaning, and the importance of background information and

Period B:

Students quickly engaged (SB1) **"are we going to get to read the whole thing?"**

1 student hesitant to find a partner to pair share with

Students seem genuinely engaged, however, **Initial observations: Lessons 1 and 2**only a few reticent volunteers to read roles in front of class.

Period D:

Students read well, interacted appropriately

All involved writing out their responses

1 asked for clarification on a question

Period E:

More willing volunteers to read aloud, group work (pair share and reading parts) less focused overall.

Period F:

Students allowed to pick group to work with. Most students on task, a few acting out or overacting with the reading aloud.

GENERAL;

With all but period A, we followed the prompt to circle, then square the answers they felt they could respond to. With all students we discussed the different possible persons that could be involved with taking the rats out and what they would be used for. We also discussed the pros and cons of animal testing and students shared their viewpoints

This time gap between 8/27 and 9/10 was to allow permission forms to go out and be collected.

9/10/07 Lesson 4

Period A:

Students worked in small groups on lesson 4. Students were to sort the 6 panels into logical order. Most groups were able to order the panels correctly. Those that had them out of order most often switched panels 4 and 5.

Period B

Students in general worked together to order cartoons. Only one table group failed to get the panels in order the first time. There was some confusion among the written response as to which rat had been taken out first and which rat had been left behind. The background information in panels 3 and 4 is complex, each being a 180 degree change of viewpoint. Students used the "a short time later" and "much, much later" background information correctly.

Period D

Specific instructions given: put panels in order, check background carefully, be able to identify each rat in each panel: Only table 3 missed the order on the first round. Table 8 group was confused about which rat was which. Table 1 understood that the background information in panels 3 and 4 showed opposite sides of the cage.

Period E:

All eight groups correct ordered the six panels the first time around.

Group 3 had good observations on the background information of panels 3 an 4.

One student at table 4 commented that "this was not a fun experiment" because we were working at the lab tables on a warm up, not doing a lab.

Table 7, one student was overheard commenting "this one that says much, much later, and the one that says a little bit later won't be first!" Good use of context clues.

Period F:

Appendix U

Field Notes

Table 1 missed identifying Copernicus with the "be brave, Copernicus" clue in text
Table 2 used the "be brave, Copernicus" clue in text to identify Copernicus.
Table 6 missed the collar in the background information to put the last two panels together and to identify Copernicus as the same rat in both panels.

September 17, 2005

Lesson #7 Newton returns

A Period: Most students on task quickly. A few table groups worked together to solve problem.

B Period: This group was very quiet and focused on the work from the minute they received the assignment. Good dialog and correct responses to the order and reasons for the order of the task.

D Period: Group quietly worked. Noticed 2 boys (D281107 &D281107) working actively together discussing the choices, one girl (D51107) reading the choices aloud to help her understand. Most students agreed on the correct order of comments.

E: Most students worked independently on this one.

F Period: One boy, (F281107) said to neighbor, "Hey isn't 'Hey Newton you're back!' the first one?" Many student groups talking the lines out loud to solve. Student (F291107) asked if we were going to do this all year. My response was, probably just the first semester. He said he liked doing them and wanted to see how it turns out.

Lessons 8 and 9 September 18, 2007

Period B: Students read together after teacher read. Even 1 reticent student reader was overheard reading this period. Students had good discussion of questions and answers.

Period D: (Picked up at door as they came in, seemed to work) Students reading together. 2 girls chatting, off task. Students are growing quieter, many have started writing. One boy asked if "we are allowed to start answering." Other comments "Do you get number 3," "because he is looking right at him."
Period E: (Warm up picked up at door, seemed to work well, but a few missed it. Will need to be trained to look for it.). Good responses, called on some students cold, they had the right information. I heard most of the students reading aloud. Reading it aloud myself first seems to better give students the idea of inflection and pacing of the conversation.
Period F: Quietly started reading as directed. Students read through, not as loud as other classes, but most students attempted to read aloud. Most seem willing and anxious to start answering questions. Marked a pattern of dots on seating chart to track who responded.
Period A: Really good conversation about the questions. Students who have not contributed before were raising their hands and answering questions.
Thursday, September 20, 2007
D: Students read lesson #10 silently after test and circled answers they felt they could answer. Then teacher read text, then 2 pairs of students read text. Noticed that D14G misread a few words, as did D22G. Students all engaged in writing answers to 3 questions. WHAT IS HAPPENING IN THE LAST PANEL? D3G **great insight on inference**, although she jumbled with her thoughts out loud, her basic idea was 'making best explanation based on the information available.' She then correctly inferred what was occurring. "His head was being filled with images."

E: No time for discussion (end of period after test)

Appendix U

Field Notes

F: Short but quality discussion about the first few questions. I read aloud with a student (F23B), who did a great job reading Newton's thoughts.

A: Told class we would do our warm up as a warm down. 1 student, (A23G) groaned. *"I don't like the rats.* ***Why not?*** *Rats are creepy."* Same student complains about most things, and says she does not like science.

B: No time for the activity, add to tomorrow.

9/21/2007

E: Groups worked quietly and efficiently for 10 minutes. Most groups identified pictures with discipline correctly.

F: (F34B) not on task until directed. "Wait, what's the area of a circle?" Some students went ahead and did it on their own, rather than group work. Most groups correctly identified categories. An alternative might be to not give the description, but just the discipline, Physics, Chemistry, etc.

A: Class was not very focused, some groups dialoged better than others.

B: Students worked quietly and efficiently, discussing answers and sharing information.

D: Students worked in groups. Some complaints about having to write both the discipline and the description. 1 boy, (VOGLD) "Mr. Olson, I really like the cartoon strips."

October 2, 2007

Read 3 strips, lessons 19+20 as a sequence. Students answering questions.

D. Had two students act out point of view between panels 1 and two. Students had some strong insights into the whys and possibilities of the questions for these two lessons.
E. Students quietly reading after teacher and 3 sets of students read through the series twice. 1 student w/head down on table called on him. Principal observed part of lesson. Took a copy of lesson #19.
F. Good responses: Good ideas.
A: Noisy, but some good answers.
B: Same

October 8th, 2007

After evaluating the extended lesson again, it does not appear to be a valuable portion of the project. Some students willing take it on, but others struggle or wait for neighbors to help them. Students seem to be more engaged with the reading and questions, but the extended lessons where they (student teams) sort cut up strips do not seem to be engaging enough to justify the amount of time they require.

Down the line, I will attempt having them do a cartoon to explain a concept or vocabulary term instead of the sorting activity.

October 10, 2007

Today's warm up students reread 7-17, then took assessments 7-12 and 13-17. I think these will prove valuable comparing laterally the learning preference group scores, and also, looking at individual questions to see what types of materials students retain, and which type of questions elude them.

Appendix U

Field Notes

October 30, 2007

B period: Students read through 3 strips on **ionic bonds**, then answered the questions about the cartoon strip based on ionic bonding. We then went over the vocabulary from the previous evening and worked on the regular classroom assignment.

D Period: Students did a **different warm up** which featured a 2 panel cartoon from the textbook. We then discussed the same concepts as found in the cartoon strip, with drawings on the board. Students were not as engage with the notes and drawings on the board as the class was with the cartoon strip.

E: .Similar to D. The class was quieter than period B with the cartoon strip, but it seemed to be pretty much rote copying of the notes from the text. One of the purposes of the series is to get the students to read and think about science. The students worked, but were not as involved with the notes or the information as the students using the strip.

G. Second experimental group. Students read quietly and responded to questions quietly. Students were very adept at correctly reading aloud the text after hearing it from the teacher. Student F29 commented, "I don't remember reading this one before." He has read the series in one of the books and online. I pointed out that this one was specifically written for this lesson.

A: Students took several minutes to settle in and get to work. Once everyone had their work out and started the warm up, students were on task. The notes and discussion over the same concepts as in the strip did not hold the attention of the students as well as the strip. This was also the end of the day with my most social and immature class.

Periods B, D, E, and F and A will be given a short assessment tomorrow in which they will respond to the content that was presented in the cartoon strip or covered in class.

November 6, 2007
Period B: Presented the concepts of **exothermic and endothermic** using drawings on the board showing the direction of energy flowing into or out of the system. Presented the same content and concepts as the cartoon strips, but in a lecture type format.

Period D: Students interacted with the cartoon strips (lesson #32). Students were more attuned to the lesson than period B. Only 17 students present due to assembly. They understood the sequence of the storyline and how it would help Copernicus (and them) remember the difference between exothermic and endothermic.

Period E: This group was poorly focused and did not interact the way they have in the past with the cartoon strip. Not having the strip nearly daily may account for part of this. Most did get the connection between the burning X and the exothermic reaction.

Period F: Students focused on notes on exothermic, endothermic (same content as N+C). Students were also the most focused and successful in the lab activity on endothermic reactions.

Period A: Not many students actually involved in the discussion, group a little antsy this afternoon. Students got most of the ideas, but didn't think Copernicus would remember the demonstration.

Appendix U

Field Notes

November 14, 2007.

Students in all classes chose partners and topics and began writing dialog. Very few students off task, interest in project appears to be high.

November 15, 2007

Groups worked today in class finishing projects. Students were highly engaged in this activity. Students showed high interest in seeing their projects scanned. I was able to sit at my desk, (something I don't usually do) for most of the period scanning while students observed the process. 2 students were out for this activity and did not participate.

November 16, 2007. The last of the projects were turned in. No individual or group failed to turn in a project. Only one student (D10) needed class time to finish.

November 19th: Cartoon Strip project follow up questions.

December 4th. 5 periods, read through 6 strip lesson on Pheederat, then audio taped discussion of what was going on in 4 classes, and discussion of use of rats as food for snakes. See transcripts.

December 14th. Students were given a cartoon that was completely graphic. They were asked to individually write a dialog for the rats that went along with the story. Students were given this list of academic vocabulary and asked to incorporate some of the terms correctly in their dialog.
Academic Vocabulary: Bunsen burner, exothermic, chemical reaction, reactants, products, lab safety, goggles, chemical change.

December 14th, lunch. Out of curiosity, I interviewed a subgroup of students who had either independently read the strip on line or in one of the class set books. Talked about what was their motivation to read beyond what was assigned.

December 18th. Students took benchmark test today. There may be some questions from the benchmark that will align with some of the vocabulary strips and the exothermic series. I will use these questions to compare with the quizzes and chapter 6 test.

December 19th: Gave exit survey today.

Appendix V

Transcript of Focus Group

Coding -line # - comment

- 1 - Focus group of students who went to the web site to read beyond the classroom assignments.
-
read more - 2 - Teacher: The first question is, and you can just speak out, or you can raise your hand, what made you decide to go to the web site in the first place, to read more and more. Yes?
read more - 3 - M13C: um, because you kind of showed us Newton and Copernicus and I thought it was funny and kind of cool.
read more - 4 - Teacher: yes, M28T?
read more - 5 - M28T: I agree with what he said.
read more - 6 - Teacher: - and what did he say?
read more - 7 - M28T: -He said that um you kinda like showed us the web site and it was like funny and cool.
read more - 8 - Teacher: - okay, anybody else? M13C, I mean M12C
read more - 9 - M12C: it's funny and people that are stupid are funny, and people that are smart that try to show people that they're stupid, smart things is funny.
read more - 10 - Teacher: - Okay, yes?
read more - 11 - F02K: It was interesting
read more - 12 - Teacher: you found it interesting, okay, yes?
read more - 13 - F56T: I thought it was funny, and cool
read more - 14 - Teacher: M06V?
read more - 15 - M06V: - It was a new experience I haven't seen before, that was science, and the rats and usually, I usually see stuff, that's usually like boring.
read more - 16 - Teacher: -Okay, how many of,… oh, go ahead
read more - 17 - F15T -It was funny, and you also got to learn a little bit about science while reading it.
- 18 - Teacher: Cool, and uh, how many of you read anime'? (pause) So, somebody made a comment to me, I don't remember who it was, that cartoon strips usually don't have a storyline, but anime' does, and this one is an ongoing story, is that part of the reason anybody went to the site?
- 19 - M28T: Kind of
like - 20 - Teacher: Kind of, not really though, okay, The first question was about what made you go there (to the site) first, okay, tell me a little bit about the things about the strip that you like, you know the characters, or whatever.
like - 21 - F15T: oh, I like how Copernicus doesn't that smart, and he always try to explain to him stuff about science, and Copernicus doesn't always understand.
like - 22 - Teacher: - Okay. M06V
like - 23 - M06V :- I like um how there rats and they're small and they adapt and use things that we use like I like how they use like coffee cups and stuff.
like - 24 - Teacher: Oh, okay,
like - 25 - M13C: -I like how Newton is all smart, and how Copernicus is all dumb, and it's kind of equaled out.
like - 26 - Teacher: -Equaled out
like - 27 - F56T: - I like Copernicus' personality.
like - 28 - Teacher: -What's his personality like? How would you describe it?
like - 29 - F56T: - Dumb, and funny.
like - 30 - Teacher: - M28T?
like - 31 - M28T: - Yeah, because Newton supplies like all the information in it, but Copernicus makes it funny cause like his lack of knowledge about stuff, so like his curiosity.
like - 32 - Teacher: - Cool, yes
like - 33 - M12C : I like how instead of having just one person talking about things, that are sort of like ahhn, it's fun to have a comic relief guy to like make things funny, and make mistakes and have the smart guy fix 'em.
like - 34 - Teacher: - Okay. All right, now let me go around to each of you, uh starting with M13C, how far have you read would you guess, and what part of what you read did you find the most interesting, or what was your favorite part?

Appendix V

Transcript of Focus Group

far - 35 - M13C: - I read maybe about 5 to 10 weeks ahead, and my favorite part was when they found the little mouse guy, and he was all quiet, and then he like talks all smart like Newton and they're all surprised.
far - 36 - Teacher: - Six right? Six of ten?
far - 37 - M13C : - Yeah
far - 38 - Teacher: -Okay, Miss F15T
far - 39 - F15T : I got to like week 25 or so, and my favorite part was when Copernicus gets stuck in the beaker, and Newton gets him out by tossing marshmallows in, and Copernicus eats them.
far - 40 - Teacher: -Okay, what was he supposed to do?
far - 41 - F15T: - Pile them up so he can get out.
far - 42 - Teacher: - Okay, do you remember what the science was that Newton talked about?
far - 43 - F15T: - ummm
far - 44 - Teacher: - to get him out with marshmallows I mean.
far - 45 - F15T: - something, I don't remember
far - 46 - Teacher: - Okay, it had to do with volume, decreasing the volume of the thing. Okay, M28T
far - 47 - M28T: - Um, I got to week 64 which is after they escaped from the lab, and they're trying to escape from the campus. After they let um Six of Ten go. And my favorite part would be the escape part, like, where they use the wire to like ride down onto the grass.
far - 48 - Teacher: - Oh, Okay, you ready M06V?
far - 49 - M06V: - Yes
far - 50 - Teacher: -Go ahead
far - 51 - M06V: - Um, I think I read up to like week 20 or something, I got to, my favorite part was when, um, Copernicus finds that apple, and says, I claim this apple in the name of Copernicus. And then he falls into the trash can.
far - 52 - Teacher: - Okay, and then how did they get him out?
far - 53 - M06V: - With the crane thing.
far - 54 - Teacher: -The robot?
far - 55 - M06V: - Yeah, the robot arm.
far - 56 - Teacher: - cool,
far - 57 - F56T: - I don't remember where I got, but I think it was like twenty, somewhere around twenty, and my favorite part is like up where they're riding on that, going down the ramp thingy, and
far - 58 - Teacher: - Oh, I know what you mean, with Six, and they're accelerating down the ramp. Do you remember what kind of science that was about?
far - 59 - F56T: - Um, hun uh.
far - 60 - Teacher: - M28T?
far - 61 - M28T: - Was it gravity?
far - 62 - Teacher: - Gravity.
far - 63 - F02K: - I read like five weeks ahead and my favorite part was when Copernicus drinks a lot of coffee and goes crazy.
far - 64 - Teacher: - Oh, when he gets into the caffeine. Okay, very cool. So, if I hadn't written it, would that have made a difference? I'm just curious what you would think?
differenc - 65 - M28T: - No, it wouldn't of made a difference.
characters - 66 - Teacher: - It wouldn't of, cause you liked the characters? So there are several characters. Which of the characters do you most identify with? Which one do you have the most empathy for? Let's start around again. M12C?
characters - 67 - M13C: - M13C
characters - 68 - Teacher: -M13C, I'm sorry, M13C
characters - 69 - M13C: - I like the little mouse dude, six.
characters - 70 - Teacher: - Why do you identify with him?
characters - 71 - M13C: - 'Cause he's like really smart, but like not as smart as Newton, he's just average smart.
characters - 72 - Teacher: - Okay F15T, who do you identify with

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Transcript of Focus Group

characters - 73 - F15T: - um, probably Copernicus, cause he's smart but he makes things funny. I mean he's stupid but he makes things funny.
characters - 74 - Teacher: - Okay. Um, M06V
characters - 75 - M06V: - I can't remember his name, but the Guinea Pig.
characters - 76 - Teacher: - Oh, Mr. Squeaks.
characters - 77 - M06V: - Yes, because he's well-mannered.
characters - 78 - Teacher: -Well-mannered, cool. M28T?
characters - 79 - M28T: - um, Copernicus, because a lot of the times he makes things funny, but he doesn't try to make things funny. He's trying to be serious but he makes it sound funny.
characters - 80 - Teacher: - Is that something you're like?
characters - 81 - M28T: - Sometimes.
characters - 82 - Teacher: - Um, F02K?
characters - 83 - F02K: - I like Pheederat.
characters - 84 - Teacher: - Pheederat? Why do you like Pheederat?
characters - 85 - F02K: - Because he doesn't know how to pronounce, what his name means, he's kind of like Copernicus.
characters - 86 - Teacher: - Okay.
characters - 87 - F56T: - I like Copernicus because he's small, he's not that smart and he's still funny, yeah.
characters - 88 - Teacher: - Okay, M12C.
characters - 89 - M12C: - I think I relate to Newton, because he's like, he's a smart guy, and he uses it most of the time, but sometimes like, once in a while, he doesn't.
characters - 90 - Teacher: - Okay
characters - 91 - M12C: - When he realized he could read, he didn't realize it until after he read.
storyline - 92 - Teacher: - Oh, okay. Um, the last one I have to ask you is, what would it be like if Copernicus had been given the neural stimulation and Newton was the one that was left as the control. How do you think their personalities would have changed the way the strip works? Yes?
storyline - 93 - Conner: - I think Copernicus would have been smart, but wouldn't have been funny and stupid in the same way, Newton would have just been Newton, but not really smart.
storyline - 94 - Teacher: - Okay. Yes, M28T?
storyline - 95 - M28T: - I actually think that it would be less funny, because Newton would still have like his same manners and stuff, so he wouldn't really be, he wouldn't do things like Copernicus would do and make them funny. He would just like, he would just ask questions but he wouldn't make anything sound funny, and Copernicus, since he would become smart, he wouldn't have that much curiosity any more, and there wouldn't be that much humor.
storyline - 96 - Teacher: - M12C
storyline - 97 - M12C: - I think that it wouldn't do very well because Newton would just sort of just be there, not really doing anything, and Copernicus would just be, it would just be like Copernicus would be traveling by himself with the occasional question or comment from Newton.
storyline - 98 - Teacher: - Okay.
storyline - 99 - F15T: - I think that Copernicus would be kind of mean and like bragging about it a lot, and he doesn't have like the philosophy that Newton has, about Newton being smarter than Copernicus.
storyline - 100 - Teacher: - Oh, Okay. Interesting. Just one more question. What human like personality traits do you admire in Newton and Copernicus. Yes?
storyline - 101 - M13C: - The one I like the most in Copernicus is how he makes like everything funny, and the one I like the most about Newton is that he's like a super genius.
storyline - 102 - Teacher: - Super genius. Okay, yes?
storyline - 103 - M12C: - I think my favorite thing about Copernicus is he kind of like stupider than the average rat, so I like that he's too curious and he's too stupid.
storyline - 104 - Teacher: - M06V
storyline - 105 - M06V: - The quality I like most about in Copernicus is that he's like naïve, kind of, and I like how Newton is kind of modest.
storyline - 106 - Teacher: - modest and naïve. Good. Anyone else? Cool. Well thank you very much.

Appendix W

Sample Transcript of Classroom Interview: Period 6

- - - New Discussion: Period 6
- F - 423 - Teacher: Okay, who can tell me in the first strip, what's the set up, what's going to be happening in the strip because of what's going on in the first panel. Yes, the gentleman over here, M02C.
- F - 424 - M02C: Um, With, What was the question, you said, what was…
set - F - 425 - Teacher: What's the, what's the first strip show you that's going to be going on?
set - F - 426 - M02C: What's going to be going on is, they're going to save this dude from a snake.
set - F - 427 - Teacher: Thank you, they're going to save this dude from a snake. Okay, and take a look at the third panel. How do you explain the expression on Copernicus's face, what does he suddenly realize? F09K?
set - F - 428 - F09K: That the snake is going to eat him?
- F - 429 - Teacher: Yea, he realizes there is a snake in there that is going to eat the rat. Okay, and then Newton offers, is there something we can do to help? And he asks, can you get me out of here, and then somebody read in a Newtonish type voice, of what Newton says in the second panel. M28T?
- F - 430 - M28T: Yes, I believe I can figure out a way to release you. (student alters voice)
- F - 431 - Teacher: Okay, so what would be a simpler way to say that instead of the way Newton says it? F35V?
- F - 432 - F35V: I can get you out.
- F - 433 - Teacher: I can get you out, okay, so, and then, so why does, there are two reasons then that Lucky says "now maybe" really loud. What are they? F33K
- F - 434 - F33K: The snakes about to eat him…
- F - 435 - Teacher: The snakes about to eat him, and what's the other one? F09K?
- F - 436 - F09K: because he's scared?
- F - 437 - Teacher: He's scared? Okay, what else? M28T?
- F - 438 - M28T: Like Newton is giving a big explanation about, of something simple, so he just wants him to hurry up.
- F - 439 - Teacher: Okay, very good, he wants him to hurry up. His giving him a big explanation about something that would be really simple. Okay, so Newton takes off, and obviously, where do you think he's going? M40A?
- F - 440 - M40A: To get a paper clip?
- F - 441 - Teacher: To get a paper clip, or something to open the door with. Copernicus, why does he start out with "some nice weather?" Why would say that? First of all, they're indoors so it doesn't matter, but why would he say that?
- F - 442 - M22K: It's a good topic of small talk, and it would keep him preoccupied.
- F - 443 - Teacher: Excellent, it's a good topic for small talk, and what's the second reason?
- F - 444 - M22K: And to keep him preoccupied.
- F - 445 - Teacher: To keep him preoccupied. Very good, and good vocabulary too. Oh yeah, what does Lucky say. "Yeah, great evening to get eaten." And then, what's the next dumb question that Copernicus asks, that probably shouldn't have been asked? M36T?
carnivorous - F - 446 - M36T: um… "So, what kind of snake is that?"
carnivorous - F - 447 - Teacher: Very good, yeah. It's not going to keep him calm.(garbled by coffing) And what's Lucky's answer? What does he call it? M22K
carnivorous - F - 448 - Several background voices: a carnivore,
carnivorous - F - 449 - M22K: A carnivorous constrictor.
carnivorous - F - 450 - Teacher: Okay, those are two big words. What does carnivorous mean? M02C
carnivorous - F - 451 - M02C: Um, it eats meat.
carnivorous - F - 452 - Teacher: Yeah, it's a carnivore, it eats meat, and what's a constrictor, what kind of snake is a constrictor? F67K
carnivorous - F - 453 - F67K: Um.. A constrictor is like a snake that uses its body to like squeeze, um the life out of an animal that it's about to eat.
- F - 454 - Teacher: Yeah, it squeezes life out of it. What it does, is it wraps around and crushes it so it can't breathe, and it suffocates it. It's a rather unpleasant experience, I imagine. Okay, so he says, "Sorry, I'm not very good at this." And they agree on that one point. On the back. Why do you suppose Lucky says "too late now, it's hopeless?" M06V
- F - 455 - M06V: because Newton has been gone for so long?

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Sample Transcript of Classroom Interview: Period 6

- F - 456 - Teacher: Okay, why else, he's been gone a long time. What does he know about Newton?
- F - 457 - M05C: That he's stupid?
- F - 458 - Teacher: M05C?
- F - 459 - M05C: That he's not very smart.
- F - 460 - Teacher: How does he know that?
- F - 461 - M05C: Because of how he's just is going, oh, how he talked the small talk?
- F - 462 - Teacher: Okay, that's Copernicus, I'm talking about Newton, the one that left.
- F - 463 - M05C: Oh.
- F - 464 - Teacher: F09K?
- F - 465 - F09K: Because he takes a long time to explain things, when he can just do it. Like he might explain how he's opening it.
- F - 466 - Teacher: Okay, he might explain how he's opening it. Also, what does he assume about Newton and Copernicus that there similar to him. M36T?
- F - 467 - M36T: What were you saying (garbled: asked for clarification)
- F - 468 - Teacher: Oh.. what would Lucky assume about Newton and Copernicus as far as what they must be like compared to him?
- F - 469 - M36T: Well, after what Copernicus had been trying to keep Lucky calm, that he can't really depend on Newton to do anything.
- F - 470 - Teacher: Yes, he was probably worried that if this guy is keeping me calm, we're in big trouble. What else? M22K
- F - 471 - M22K: He thinks that if he can't get out of the cage, then they won't be able to.
- F - 472 - Teacher: He must just assume they're a couple more rats, he doesn't have any idea of what? F64K?
- F - 473 - F64K: That Newton has gone through the smart, brain, laser thing…
- F - 474 - Teacher: The smart, brain, laser thing, which is called the what? M28T?
- F - 475 - M28T: Neural stimulation.
- F - 476 - Teacher: Neural stimulation. Thank you. Okay, 5th panel, "Thanks for saving my life", "You're welcome", They introduce each other, "They call me Pheederat." Why does he spell his name that way? Why is his name spelled that way? M06V?
- F - 477 - M06V: So it sounds and looks like a name?
- F - 478 - Teacher: So it sounds and looks like a name. How would he, why is it spelled phonetically, do you think? Why did the author choose to spell this phonetically? (laughter at inside joke) instead of correctly? Yes, M31T?
- F - 479 - M31T: Cause he's not smart.

feed - F - 480 - Teacher: He's not smart and he doesn't know how to spell things, right? So, where did he hear the name, Pheederat? Where did he get his name? F64K?

feed - F - 481 - F64K: From the scientists.

feed - F - 482 - Teacher: Yeah, he probably heard them talking about him, so he thought that was his name. "Were you meant to be part of some experiment?" "I think I was meant to be somebody's lunch." Okay, so what's the main difference between Lucky and the other rats? If he's a feeder rat, what's the difference? F09K?

feed - F - 483 - F09K: That he was going to get eaten.

feed - F - 484 - Teacher: He was going to get eaten. So what's his purpose in life? F65V

feed - F - 485 - F65V: Um, they're grown to be eaten. And uh, Copernicus and Newton are lab ones.

- F - 486 - Teacher: Okay, very good, Copernicus and Newton are lab rats and they're probably a little more valuable. M22K, I think I could ask you this question, When Newton gets the infrared thing put on his collar, and Copernicus compares him to a TV clicker, how much, do you remember, is he probably worth?
- F - 487 - M22K: What?

value - F - 488 - Teacher: Anyway, Newton's worth about $10,000 with the hardware and stuff he's got on him. So he's a valuable rat. What do you suppose a feeder rat costs? Yes, M54K.

value - F - 489 - M54K: A couple dollars.

value - F - 490 - Teacher: A couple of dollars. Most of the kids who have snakes earlier today said it's about a dollar, or a dollar and a quarter for a feeder rat. Okay, so what do you suppose the difference is if you go to a pet

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Sample Transcript of Classroom Interview: Period 6

store and you buy a fancy rat as a pet or a feeder rat to feed to a snake, what do you suppose the difference is in those two lines of rats? F35V?
value - F - 491 - F35V: Um, the size and like the build of the rats.
value - F - 492 - Teacher: Okay, the size and like the build, and the build would depend on what?
value - F - 493 - F35V: Like cause I know because we had a couple of rats and the feeder rats are really scrawny, and then the, like the pet rats, the expensive ones, are a little more muscular.
discussion - F - 494 - Teacher: Okay, so, genetically, they're better off rats. Feeder rats become feeder rats because they're not good enough to become pets, and some feeder rats are just raised as feeder rats. Which brings up the whole question this strip is actually about, this series, is,what's the difference between feeding a snake a rat and us eating hamburger? Think about it before you respond. F64K?
discussion - F - 495 - F64K: We cook our food and it doesn't really matter about the cow? like …? (good natured laugher)
discussion - F - 496 - Teacher: Okay, why doesn't it matter about the cow?
discussion - F - 497 - M22K: That's,.. so nice… (mixture of reactions and comments)
discussion - F - 498 - Teacher: Excuse me, I want her to be able to explain what's she's saying..
discussion - F - 499 - F64K: Cause it can be like any cow as long as it's healthy and it has enough meat, but like with the rats, (she laughs at herself) 'cause they don't keep cows as pets, kind of.
discussion - F - 500 - Teacher: People don't keep cows as pets?
discussion - F - 501 - Multiple responses: "yes they do," garbled responses, students citing examples..
discussion - F - 502 - Teacher: Excuse me, I need the hands, or otherwise it will get so garbled I can't hear what you are saying. Okay, F53A.
discussion - F - 503 - F53A: I have a question. Um, in panel three, why is Lucky on top of Newton?
discussion - F - 504 - Teacher: He jumped out of the cage and landed on him. Okay, so cows don't matter. F07T?
discussion - F - 505 - F07T: (garbled)
discussion - F - 506 - Teacher: Okay, say it again please
discussion - F - 507 - F07T: It's kind of like, we're using cow meat
discussion - F - 508 - Teacher: Or chicken or pork, yeah. What's the specific reason cattle and pork are raised? M05C
discussion - F - 509 - M05C: To be eaten? And have babies so that we can have more meat.
discussion - F - 510 - Teacher: Yes, we keep the line going. So, what's the specific reason feeder rats are raised? F09K
discussion - F - 511 - F09K: To be eaten by snakes.
discussion - F - 512 - Teacher: To be eaten by snakes. So I guess the question is, somebody said you can buy frozen dead rats and feed those to your snakes, but some snakes will only respond to a living rat. So, is it cruel to feed a live rat to a snake?
discussion - F - 513 - Choral response: Multiple, yes!
discussion - F - 514 - M28T: "No, it's part of nature!"
discussion - F - 515 - Teacher: Explain that M28T.
discussion - F - 516 - M28T: If, like, in nature, without humans interrupting, like if a snake would see a rat, it would go and eat it.
discussion - F - 517 - Teacher: Okay, so how about a snake that's in a cage and its captive and you put a rat that's never been around a snake in a cage, is that fair to the rat?
discussion - F - 518 - F65V: No, it's going to die eventually.
discussion - F - 519 - Teacher: It's going to die eventually. Okay, M06V?
discussion - F - 520 - M06V: What lives must die.
discussion - F - 521 - Teacher: What lives must die. I like that, good philosophy. F64K?
discussion - F - 522 - F64K: If we didn't have snakes rats would overpopulate, and like, like,
discussion - F - 523 - M05C: bring diseases.. (choral reaction)
discussion - F - 524 - Teacher: Excuse me. Excuse me. If we didn't have snakes, rats would over populate, and what?
discussion - F - 525 - F64K: Rat's would overpopulate, since they like have babies all the time,

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discussion - F - 526 - M02C: nooooo
discussion - F - 527 - Unidentified male: Yeah they do.
discussion - F - 528 - Teacher: And that's a good point. How often do rats reproduce?
discussion - F - 529 - M02C: a lot
discussion - F - 530 - F64K: like every month.
discussion - F - 531 - Teacher: A lot. And why do animals like rats reproduce a lot?
discussion - F - 532 - F64K: cause, so they can be eaten.
discussion - F - 533 - Teacher: So they can be eaten. They're roll in nature is, they're in the middle of the food chain. They eat plants, and grass and bugs, and then they're food for the larger carnivores. So, in nature their part, so in nature it doesn't seem cruel that anything eats anything else, it's just the way nature is. So, but when we look at it in labs you know, it's different. So, one rat in the pet store is worth a dollar, his life is worth a dollar, this [rat's] life is worth nineteen dollars, this guy gets fed, this guy we spend another two hundred dollars feeding him. Do you see any kind of irony in that? Or is that normal? Okay, any other comments? M28T?
discussion - F - 534 - M28T: Um, so aren't like humans at the top of the food chain?
discussion - F - 535 - Teacher: Yes, so long as we have weapons and we don't have to live in nature. What would happen to most human beings if they were out in the jungle without any weapons?
discussion - F - 536 - M02C: They'd get killed by lions.
discussion - F - 537 - Teacher: They'd become prey. Most of them would probably die of starvation and then become decomposed by decomposers. M36T?
discussion - F - 538 - M36T: Wait, do you know if feeder rats are like the rejects of all the rats, so that's why they're purposefully chosen to be fed, because they don't fit in?
discussion - F - 539 - Teacher: I think that's probably part of it, and also, there's a certain quality, like lab rats are actually very expensive, because they've been genetically bred for years and they've got pure strains so predict how generation after generation is going to react and respond, but a feeder rat's probably have all kinds of mixed up genes, and so it's really not dependable, and so it doesn't have value, and people who have pet rats have the fancy ones with the pretty colors and the thick coats, not like as F35V said, the real scrawny ones, so the scrawny ones are used as food, so it's probably the rejects, yeah. What does our society do with "reject" people?
discussion - F - 540 - M31T: Throw them in jail (kill 'em) other off mark responses "you are so mean"
discussion - F - 541 - Teacher: We make accommodations for them, we help them, we design ways for them to get around. We don't have reject people. People are different from rats in that way. M28T?
- F - 542 - M28T: F09K wants to know where cheese comes from.
- F - 543 - Choral response: milk, cows, etc.
- F - 544 - Teacher: It comes from the cheese plant, which is called grass.
- F - 545 - End of Session.