STUDYING THE EFFECTIVENESS OF ANIMATION AND GRAPHICS WITH TEXT ON FOURTH, FIFTH AND SIXTH GRADERS

by

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This study evaluates the degree to which computer animation contributes toward learning. With the increasing usability of computers, and everyday usage in life, it is important to know how computers can develop children's interest in discovering the created knowledge through animated simulations in computer-based environments.

This is an "experimental" study with the primary purpose of exploring the effectiveness of animations-with-text compared to graphics-with-text in comprehending scientific knowledge on fourth, fifth and sixth grade students. This study attempts to capture the difference in the amount of information that was learned by a participant by quizzing them on the information presented to them. The subjects were fourth, fifth and sixth grade students visiting the Butterfly Pavilion at the Folsom Children's Zoo Lincoln, Nebraska.

The instructional topic used for both the treatments was the Life Cycle of a Monarch Butterfly. The content of the animation-with-text group was delivered in electronic media in form of animations embedded with text, and the content of the graphics-with-text group was delivered in paper-based format in the form of graphics-with-text. In both groups each student received a pretest and posttest, which identified the differences in recall, inference and comprehension levels of the scientific concept taught through the two different treatments. It was hypothesized that there would be significant

learning gains in the animation-with-text group as compared with the graphics-with-text group.

The results were analyzed using ANOVA. In the animation-with-text group, pre and posttest scores show a statistically significant difference with the mean values of 5.5 and 7.1 respectively.

In the graphic-with-text group pre and post scores show a statistically significant difference with means of 5.1 and 7.1 respectively.

The above implies that there was a significant difference in the measure of pre-treatment knowledge level to post-treatment knowledge level.

The means of posttest of animation-with text as compared to graphics-with-text group posttest scores were 7.1 and 7.1 respectively. Therefore no significant differences in the performance level of the students in two groups were reported.

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CHAPTER I

INTRODUCTION

The success of computer assisted instruction (CAI) has been the subject of continuing examination for over a decade (Fletcher-Flinn & Gravatt, 1995). The use of CAI as delivery media is expanding, but our understanding of how students learn and benefit from such computer-based instruction is disputable. Use of appropriate graphics with text has been demonstrated to be effective in learning. However, computers can make static graphics into dynamic animations. This study explores the potential of combining animations with text in a computer assisted instructional environment.

CONTEXT OF THIS STUDY

With the advancement in educational technology, the delivery of still images has evolved into animation. Animations can be used as a delivery media where learning can be conducted as occurring (1) from technology, (2) with technology, (3) around technology, (4) through technology, and (5) assisted through technology (Goldsworthy, 1999).

Animation refers to computerized simulation of processes using images to form a synthetic motion picture. In the context of learning, Cooper, (1998) points out that the use of the pictorial form of communication leads humans to improved comprehension and retention. Animation appeals to the power of the human visual system (Rieber, 1990). Animation assists learners to visualize a dynamic process, which, otherwise may be difficult to visualize. Animation might thereby reduce the cognitive load (Rieber, 1990). In Kehoe's (1996) review of studies on animation in education, visual aids are found to have a positive effect on learning if certain conditions (“explanative text”, “sensitive tests”, “explanative illustrations”, “inexperienced learners”) are met (Mayes 1989). Lee and Boling, (p. 22, 1999) provide restrictive guidelines for using animations:

- Use animation sparingly (Rieber, 1990; Venezky & Osin, 1991). Small and simple animation may be more effective than large, complex animation (Rivlin, Lewis, & Davies-Copper, 1990).
- Use animation congruent to the learning task (Rieber, 1990, 1994).
- Use animation as a visual analogy or cognitive anchor for the instruction as a visual analogy or cognitive anchor for the instruction of problem solving (Park, 1994; Park & Hopkins, 1993).
- Use animation to stimulate functional behaviors of mechanical or electronic systems and to demonstrate troubleshooting procedures (Park, 1994; Park & Hopkins, 1993).
- Use graphical animation to explicitly represent highly abstract and dynamic concepts in science, including time-dependent process (Park, 1994; Park & Hopkins, 1993; Rieber, 1990, 1994) (Authors call these guidelines restrictive because they attempt to delineate the precise conditions under which animation will be effective and to eliminate other conditions as appropriate for the use of animation).

- Avoid unnecessary or gratuitous animations on the screen so as not to distract (Strauss, 1991).
- Avoid extraneous sounds in the form of background music or unrelated environmental sounds (Clark & Mayer, 2003).

EFFECTS OF COMBINING VISUALS WITH TEXT

Adding printed text, static graphics, charts, maps, dynamic graphics - animations may increase the cost of the instructional material but these elements can make learning an active process (Clark & Mayer, 2003). The psychological evidence in combining “relevant graphics” with the instructional material can lead to learning gains (Clark & Mayer, 2003). Presenting an instructional message in words and pictures engages people in active learning by making mental connections between pictorial and verbal representations. Due to a lack of integration between verbal and pictorial representations as a unified structure, presenting words alone may engage learners in shallow learning (Clark & Mayer, 2003). It should not be implied that by simply placing a graphic may promise any benefits on learning (Peeck, 1987). Studies point to maintaining a balance in the learner’s interaction and the illustration related activities. Too much stimulation can hinder learning (Winn & Holliday, 1982). Providing relevant graphics with text can promote learning. Levin (1981) has identified five different learning functions that graphics can perform with text.

1. Decoration - The purpose of providing decorative images with text is to make the instructional material look motivational and appealing for the readers. There is no

or little relevance of the images, which are prepared in the beginning and at the back with the text description.

2. Representation - “When an image is used to illustrate new ideas and which are used to represent people, tools, things and events they are classified as representational.” Example: children’s book to illustrate poems, fairy tales, and stories.
3. Organization - These images describe the features of an object a step-by-step function, how-to pictures to provide a framework for text. The images provide more information than words associated with each picture.
4. Interpretation - Conveying abstract information through the help of images is classified as interpretational. These images add comprehensibility to difficult or abstract material.
5. Transformation - These images provide learners with a mnemonic aid and help student recall an abstract idea.

It is interesting how different types of images with text have varying functions and help create a “mental model” rather than simply receiving or absorbing knowledge Resnick, (1989); Mayer, (2001); Clark & Mayer, (2003) advocate the use of the following principles in combining pictures and words to the instructional message design:

A. Multimedia Effect: Evidence has supported the benefits of a “multimedia effect” which states that people learn more, deeply from words and pictures than from words alone (Mayer,1989; Mayer & Anderson, 1991, 1992; Mayer & Gallini, 1990). Mayer (1989) ; Mayer & Gallini, (1990) have advocated the following approach under which multimedia presentations have a strong effect on learning:

- Explanation of cause and effect chain.
- Integration of verbal and visual descriptive labels describing the state when students lack domain knowledge
- Transfer test followed by the instruction.

B. Contiguity Principle: Studies have determined the possible benefits of a "contiguity principle". Providing printed words and graphics close to one another on the screen promotes making pictorial and verbal connections and imposes less cognitive load (Mayer, 1989).

C. Coherence principle: that adding extraneous information in the form of:

- Background music and sounds added for motivation and exhaustive textual description can harm learning process in the following ways:
    - i. Distraction – irrelevant material occupies the limited attention and hinders learning.
    - ii. Disruption – superfluous pieces of information come in the way of constructing appropriate links and prevent the learner from making connections.
    - iii. Seduction – unsuitable presented knowledge that is used for organizing the new material.

D. User Interaction: Mayer (2001) also talks about "user interaction" which refers to the control of the pace over the words and pictures that are presented in a multimedia presentation.

COGNITIVE PROCESSES INVOLVED IN LEARNING

Researchers have divided memory processes into stages of acquisition, storage, and retrieval (Bruning, Schraw & Ronning, 1998). The information-processing model of human cognition is integrated into three modes, which is based on the modal model (Cooper, 1998). This model classifies memory into sensory memory, working memory (also known as short-term memory), and long-term memory. Sensory memory deals with incoming stimuli such as sight, sound, smell, taste, and touch. Sensory memory has very short extinguishing time (about half a second for visual information; about three seconds for auditory information). If meaning is not assigned to the incoming information within those extinguishing times, the information is lost forever. Research on the sensory registers suggests:

- A limitation to the amount of information that can be processed at one time.
- Developmental differences in cognition suggest the increase in the size of the sensory registers increases with the age, especially with early elementary age children (Bruning, Schraw & Ronning, 1998). Therefore, information presented should be age appropriate.
- Human memory has a limited capacity for processing information. When the total number of digits to be remembered is ten or more, the task is difficult for most

people (Cooper, 1998). Therefore, strategies like chunking the digits help in better recall (Bruning, Schraw & Ronning, 1998). When large amounts of elements are divided into small sets of groups it is referred to as chunking information. For example - phone numbers are commonly chunked in small sets of numbers, which helps to recall better (Cooper, 1998). Therefore, instructional material should be designed so as they are compatible with human learning processes for effective encoding and retrieval (Clark & Mayer, 2003).

- Learning occurs by active processing in the memory system. New knowledge and skills must be retrieved from long-term memory for transfer to the job (Bruning, Schraw & Ronning, 1998).
- Cognitive load could be reduced if learners have prior knowledge (Mayer, 2001)
- Importance should be placed upon key content which is of extreme relevance (Clark & Mayer, 2003).
- Rehearsal is an efficient way to process information from working memory to long-term memory (Clark & Mayer, 2003).

PURPOSE OF THIS STUDY

Multimedia products in different combinations of text, still images, animation, video and sound, are available. Few research studies identify the principles by which we can combine these media effectively within instructional materials to their full potential for learning (Large & Beheshti, 1995).

The effective use of animation and its positive results on instructional message design is evident by other research (Clark & Mayer, 2003; Mayer & Anderson, 1992; Ford, Chandler & Sweller, 1997) . Animation has shown different effects on cognitive activities through the “Dual-Modality” (Clark & Pavio, 1991), “Contiguity Effect” (Mayer & Sims, 1992), “Element Interactivity Effect” (Ford, Chandler & Sweller, 1997), “Coherence Principle” (Clark & Mayer, 2003) and “Multimedia Effect” (Mayer & Anderson, 1991). Rieber (1990) states that, in , case of children, animations may have an effect under certain conditions such as when dealing with materials that are neither too simple nor too difficult. This relationship between animations and the user’s age needs to be investigated. Mayer (2001) has reported positive results of visually based instruction as a medium for promoting students’ understanding of scientific material for college students. Such evidence is strong on claims for students 19 and above but, so far, relatively very little evidence from studies support claim for fourth, fifth and sixth graders.

SIGNIFICANCE OF STUDY

With the increasing usability of computers, it is also important to know in greater detail how different visual treatments can affect the process of learning on fourth, fifth and sixth grade students. This study assesses the degree to which computer animation contributes toward learning. The results obtained from this research will be helpful for designing instruction for fourth, fifth and sixth grade students so that the processing of the information is simplified. Instructors of grades fourth, fifth and sixth can apply animation technology to develop aids to coursework. Furthermore results of this study can be helpful for graphic designers to develop better and more effective animations by focusing their time and attention upon incorporating features that contribute towards simplifying scientific knowledge and enhancing learning.

STATEMENT OF PROBLEM

The primary purpose of this study is to explore the effectiveness of animations and graphics with text on students' learning. Therefore, the study examined whether the animations-with-text created in Macromedia® Flash™ were effective for fourth, fifth and sixth grade students. These objectives were compared to the graphics-with-text treatment for student learning. The text was designed with the help of a subject matter expert. The National Science Education standards were used as the foundation for the topic selected.

RESEARCH QUESTIONS

RQ1. Does using animation-with-text instruction increase learning?

RQ2. Does using the graphics-with-text instruction increase learning?

RQ3. What is the effectiveness of animations-with-text instruction as compared with graphics-with-text instruction in recall, inference and comprehension levels?

DEFINITIONS

Animation

According to Park & Gittleman (1992), animation can be defined as series of graphics that change over time and/or space.

Graphics

Lih-Juan (1994) describes graphics as the use of images such as pictures, illustrations, diagrams, charts, tables, maps and similar visual representations in conjunction with written prose for the specific purpose of aiding understanding.

Learning

According to Cooper (1998), learning may be defined as the encoding (storage) of knowledge and/or skills into long-term memory in such a way that the knowledge and skills may be recalled and applied at a later time on demand.

Cognitive Load

Cognitive load refers to the total amount of mental activity imposed on working memory at an instant in time (Cooper, 1998).

Multimedia

Multimedia means any presentation that contains both words and pictures (Clark & Mayer, 2003).

Mental models

Mental models are refer to the "mental representations consisting of parts and causal relations among the parts in which a change in the state in one part is related to change in the state of another part" (Mayer & Clark, 2001).

CHAPTER II

LITERATURE REVIEW

WHAT ARE VISUAL REPRESENTATIONS?

Visual representations are maps, charts, diagrams, static graphics, computer animations, hypertext and multimedia that are incorporated into instruction. Visual representations relate to the components of the subject matter (Goodman, 1968). They show a spatial relation and may refer to the concrete objects and real-world relations, or, by analogy, to abstract concepts and conceptual relations (Winn, 1989). Maps are an example of the former, which refers to the real-world relations. The real territory, such as buildings, mountains and lakes, describes them. For useful navigation, they are reduced in scale and correspond to the virtual distances among the features of the territory (Schlichtmann, 1985). Diagrams often illustrate abstract domains of reference (Winn, 1989). Charts represent the procedural steps and exclude physical objects. The joining lines help create a sequence of the steps. Animation refers to a series of computer screens that illustrate movement (Hannafin & Rieber, 1989). Animation provides visual and spatial information. Hypermedia, characterized as "a generic term covering hypertext, multimedia, and related applications, involves the chunking of information into nodes that could be selected dynamically" (Dillon & Gabbard, 1998). Multimedia corresponds to using more than one sense modality (Mayer & Sims, 1994). Multimedia learning occurs when students utilize information presented in two or more modalities – such as visually presented animation and verbally presented narration to construct knowledge (Mayer & Sims, 1994).

Generally people understand the information presented by the visuals better; it is well said "a picture is worth a thousand words.” Understanding occurs when a visual interacts with the psychological process active in the person who receives it (Salomon, 1979). It requires that perceptual and cognitive processes act on the representative elements of visuals and become influenced by them (Winn, 1991).

PREVIOUS RESEARCH ON VISUAL REPRESENTATIONS

Static Graphics

Graphics have played key roles in scientific textbooks for centuries (Brooks, Nolan & Gallagher, 2001). They have been used to stimulate interest in students and increase their involvement for instructional purposes. There has been a considerable amount of research on the process of knowledge acquisition by means of text and graphics (Anglin, Towers, & Levie, 1981; Levie & Lentz, 1982; and Willows & Houghton, 1987). There is a general consent on the beneficial contribution of graphics with the related text information for the readers (Morrison, Ross, & Kemp, 2001). Graphics are a good source of visual communication and can deliver the textual message effectively (Levie & Lentz, 1982). Graphics capture the attention of the learner by arranging the components spatially and they thereby use particular capacities of human visual system for perception of spatial configurations (Schnotz, 1993). Instructional material consists of written texts and graphics such as maps, charts, graphs, diagrams, etc (Schnotz, 1993). The purpose of graphical displays in text is not a mere accessory to texts or to decorate the text and thus appeal the readers. Rather, graphics to illustrate abstract concepts, organize complex sets of information, integrate new knowledge into existing knowledge structures, facilitate retention of information, and foster the process as of thinking and problem solving which are effective aids for learning (Schnotz, 1993). Comprehension of abstract subject matter with the aid of graphics is helpful; graphics explain the spatial relationships described in the text (Peeck, 1987). For example, in a text describing the relationship between the position of the moon relative to earth and sun during a lunar eclipse, an image of these spatial relations would benefit the reader (Morrison, Ross & Kemp, 2001).

Research in various subject areas has shown that graphics can play a beneficial role in instruction, particularly if the emphasis is given on the explanatory role in presentation (Levie & Lentz, 1982; Winn, 1987). Graphics are used to engage learners and are an integral part of many subject areas. Although learners prefer to process instructional materials with illustrations and graphics, they are not aware of the benefits of visualizations and, accordingly pay only little attention to graphics included in texts (Schnotz, 1993).

Comprehension of graphics is a process of constructing meaning, which learners acquire within an active processing framework and the prior experience with the stimuli (Schnotz & Kulhavy, 1994). Task expectations and ability make a difference in how the individuals learn (Schnotz & Kulhavy, 1994). Graphics can serve various functions like depicting data, explaining complex relationships, organizing information, improving memory for facts, and influencing problem solving. These functions are not inherent in graphics, however, but result from the way in which such graphics are processed cognitively (Schnotz & Kulhavy, 1994).

Diagrams and Illustrations

In science instruction, diagrams are often used to present the information (Lowe, 1993). Larkin & Simon (1987) have supported the effect of diagrams on learning with the empirical studies emphasizing the advantages of constructing a mental representation and cognitive processing because of diagrams (Glenberg & Langston, 1992; Winn, Li, & Schill, 1991; Dwyer's, 1970, 1972). An analysis on the effectiveness of different types of illustrations (realistic drawings, simple line drawings, and photographs) concluded that, if the time available is appropriate and sufficient simple line drawings tend to be most effective. If the learning environment is self-paced, then the learner takes more advantage in the realistic pictures.

Animations

There are several instructional opportunities that can be explored with the change in the representation form from static graphics to graphical computer simulations. Animation is one of those components (Rieber, 1990). In several studies involving scientific subject areas, Mayer (2001) has pointed to the importance of animation.

Animation facilitates descriptive and procedural learning (Rieber, 1990; Lih-Juan ChanLin, 2000; Mayer, 2001). Animation is an important component in designing interactive multimedia which creates a visual interest and makes scientific learning more appealing and enjoyable for learners (Lih-Juan ChanLin, 2000). Furthermore, animation is one such component which can be part of computer based instruction and which cannot be combined with any other media (Rieber,1990). Animation adds two unique components as compared to the static graphic – *motion and trajectory* (Klien, 1987).

Animated visuals explain the visual and spatial information when these two components are used effectively. The pace of animations, when controlled by the learners, allows the users to view the motion and replay as many times as desired. This series of actions allows students to explore the different strings of actions (Klein, 1985). Through computer-based instruction, a student constantly creates, manipulates, and interacts within a dynamic conversation of his own creation. S/he constructs mental models (Klein, 1985). Other information delivery media have important similarities and distinctions that may make a difference for the learner. Animations are created symbols which differentiate the real life events but create an opportunity for the learner to interact and move from being a passive information receiver to an active interactor (Klein, 1985)

Animation and simulation features have been used in engineering (Wozny, 1978), physics (diSessa, 1982) and mathematics (Hooper, 1982; Wegman, 1974). These have made effective contribution to instruction by conveying the information through the help of its interactivity and special effects (Hellet, 1999). There are many variables which can affect learning with the aid of animations. Practice and rehearsal is one of them (Bruning, Schraw & Ronning, 1998).

"Wyzt's Playground," a multimedia tool, was created for animation research in fourth grade mathematics. This tool emulates and simulates the real-life scenario of building a playground, and creates an environment that engages the students in active learning (Johnson & Neil-Jones, 1999). This study used interactive videodiscs to discover the nature and proportion of the different learning activities exhibited by group 12-13 year old student to ascertain that the repeated use of disc improved their problem solving skills. The study found that well designed applications could enhance learning (Blissett & Atkins, 1993).

Reports by Hamel & Ryan-Jones (1997) reviewed the use of state of the art graphic and animation for instructional material, and laid a set of guidelines for using interactive graphics:

- Interactive graphics, especially 3-D graphics, views the object in ways that enhance three dimensional interpretations by producing more accurate depth information.
- It directs attention to important parts of the objects.
- It uses interactive graphics, with hints on viewing strategies.
- It presents procedures that enhance visual learning.
- It includes practice of the procedure in the instructional sequence.

Multimedia

Multimedia is an interaction of words and pictures that fosters learning (Mayer, 2001). The delivery of instruction can vary in a broad range. Table 2.1 describes the three views of multimedia (Mayer, 2001).

Table 2.1: Mayer's Three Views of Multimedia

View	Definition	Example
Delivery media	Two or more delivery devices	Computer screen and amplified speakers; projector and lecturer's voice
Presentation modes	Verbal and pictorial representations	On-screen text and animation; Printed text and illustrations
Sensory modalities	Auditory and visual senses	Narration and animation; lecture and slides

Multimedia findings by Mayer (2001):

- Multimedia allows words and pictures to be presented in mixed modalities rather than alone.
- Students perform better on recall tests when presented with dual rather than single mode presentation
- Comprehension and retention are better when words and pictures are presented continuously rather than isolated from one another. The "contiguity principle" states that effectiveness of multimedia instruction increases when words and pictures are presented contiguously, rather than isolated from one another in time or space.
- Excluding extraneous words, pictures, and sounds improves instruction. In accordance with cognitive load theory, to foster the process of organizing and be less taxing on learning, multimedia presentations should present the verbal and non-verbal steps in synchrony without unwanted details in pictures like multiple colors and sounds. These may deviate the learner and increase the cognitive load.
- Design effects are stronger for low-knowledge and low-spatial learners than for high knowledge learners and high–spatial learners.
- The use of animation with narration helps students in better problem solving than does successive presentation.

The following discussion lists some of the features which can serve as guidelines in developing instructional multimedia (Clark & Mayer, 2003).

Graphics for Instruction

Graphics are used when teaching specific lesson content such as facts, concepts, processes, procedures, and principles in computer delivered instruction. Mayer (2001) summarizes the following principles for use of graphics for teaching different content types.

Table 2.2: Graphic Methods for Teaching Content Types

Adapted from Clark & Mayer, 2003.

Content Type	Instructional Method	Example
Fact	• Statements of fact • Pictures of specific forms, screens, or equipment	Illustration of software screen Please refer to Figure 2.1
Concepts	• Definitions • Examples • Non-examples • Analogies	What is a URL? Please refer to Figure 2.2
Process	• Stage tables • Animated diagrams	Plants regenerated from tissue culture Please refer to Figure 2.3
Procedure	• Step-action tables • Demonstrations	How to use a software application Please refer to Figure 2.1
Principle	• Guidelines • Varied context examples	Herbicide intake by leaves Please refer to Figure 2.4

In the first row of Table 2.2, Clark & Mayer (2003) explain about computer delivered training which teaches *fact*. This is represented with pictures of specific forms (screen captures). “A screen capture is a graphic that is a replication of an actual software screen.” Figure 2.1 explains the use of a screen capture for procedure lesson.

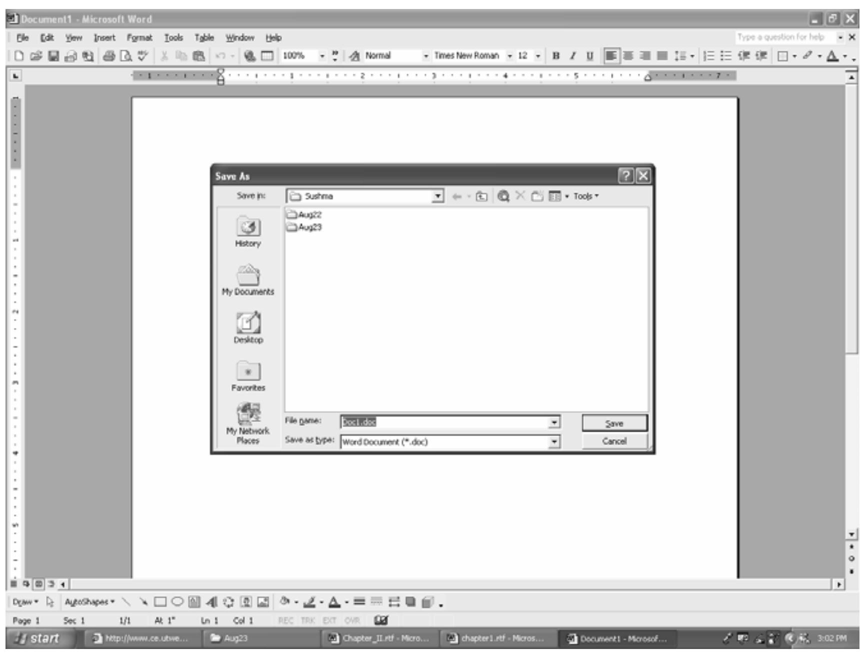


Figure 2.1: Use of a screen capture for procedure lesson.

The second row of table 2.1 talks about *concept* which is another content type. Figure 2.2 explains the example of how the image is utilized to display the presence of a URL when the mouse is taken over the web link.

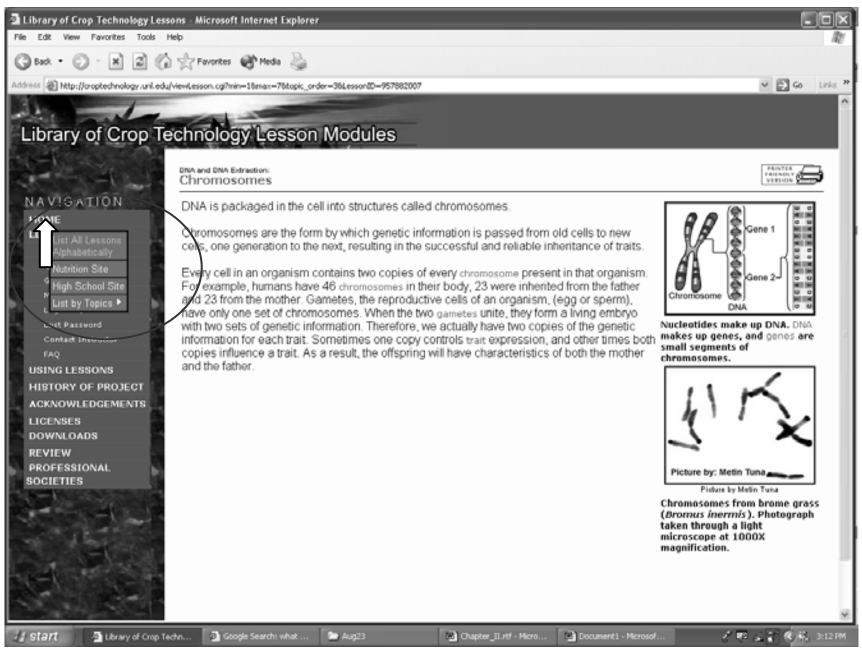


Figure 2.2: Use of mouse over to illustrate the URL. (With permission of Deana Namuth.).

The third content type is *process*. Process information is effectively visualized with animations. Figure 2.3 is an image that illustrates how plants are regenerated from tissue culture.

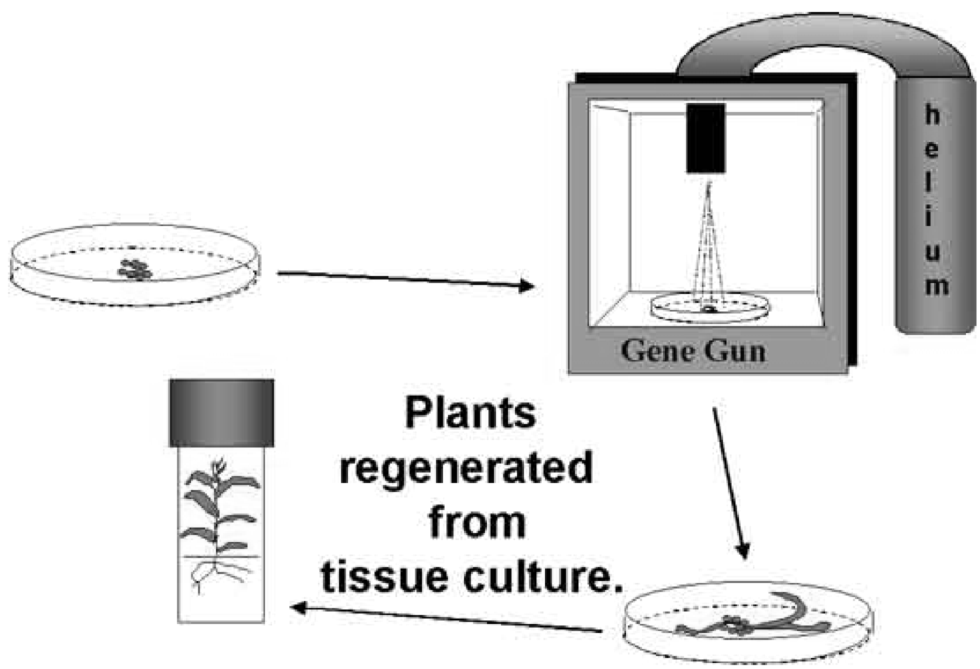


Figure 2.3: Screen capture of animation illustrating regeneration of plants from tissue culture. (With permission of Deana Namuth.).

Procedures are explained appropriately by demonstrating step action tables and demonstrations. Figure 2.1 explains how to use a software application to save a document in Microsoft Word™.

Principles are contents that explain the guidelines and context examples of information. Figure 2.4 explains the principle of herbicide intake by leaf. It is a screen capture from an animation of herbicide intake by a leaf.

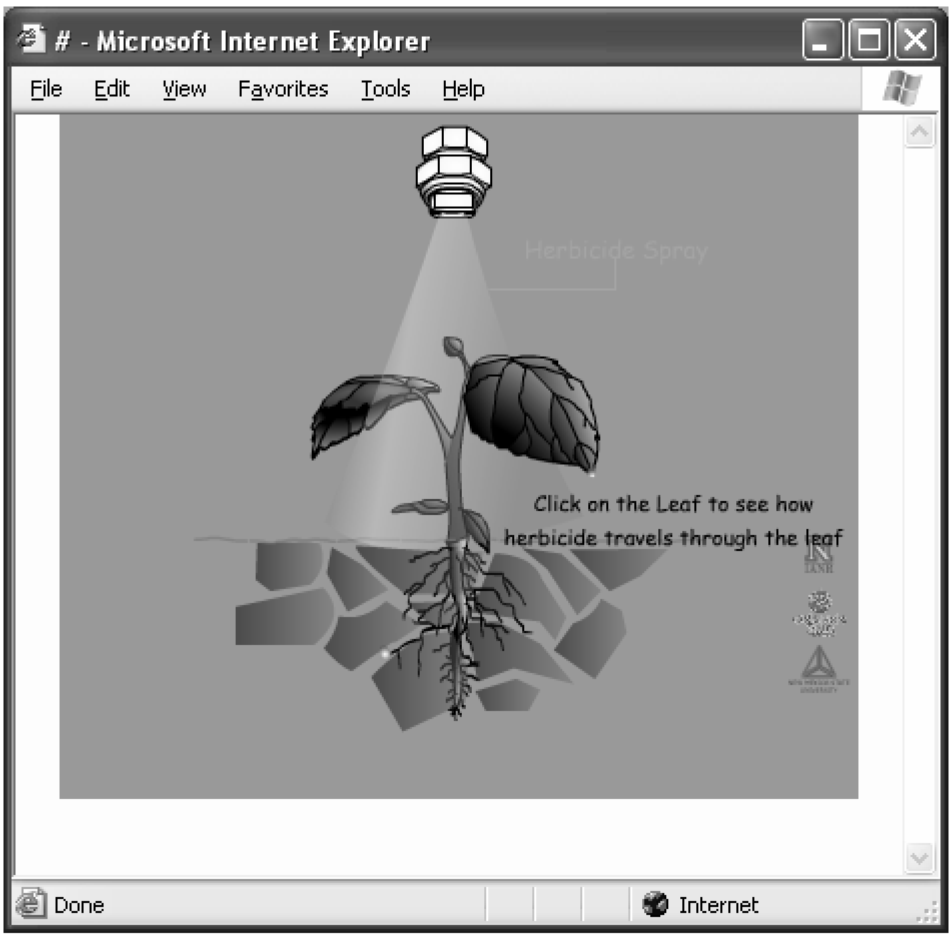


Figure 2.4: Principle of herbicide intake by leaf (With permission of Deana Namuth.).

Graphics as topic organizers

Graphics can act as topic organizers by organizing topics in a lesson and by showing relationships among topics in a lesson. In Figure 2.5 shown below, the topics are mapped to the left-hand menu. Changes in the topic on the right hand side can be seen when the mouse is clicked over each of the graphical buttons on the left hand menu.

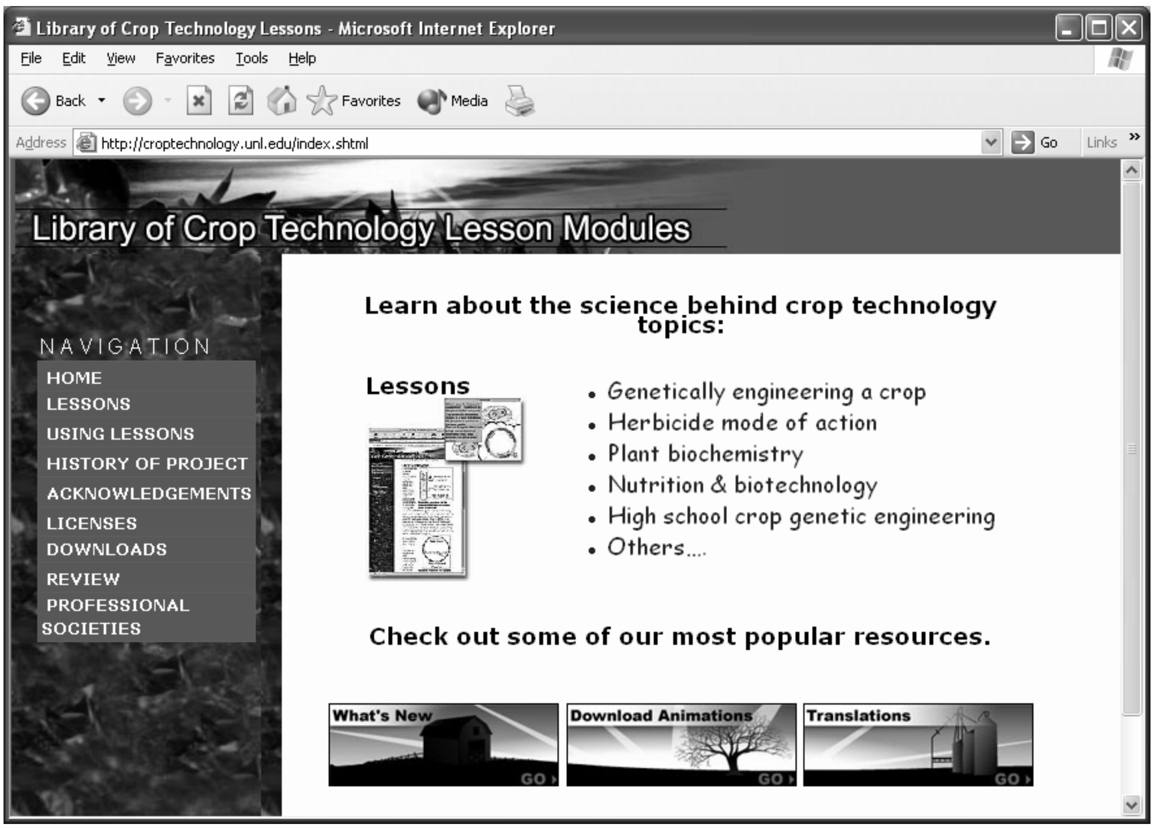


Figure 2.5: Graphics as topic organizers. (With permission of Deana Namuth.).

Graphics to show relationships

Dynamic and static graphics can be helpful in constructing invisible phenomenon visible and show relationships. Imagine a lesson to teach how a chlorophyll molecule captures light energy and excites an electron to begin photosynthesis. Figure 2.6 is a screen capture of an animation that shows the relationships among the interacting entities.

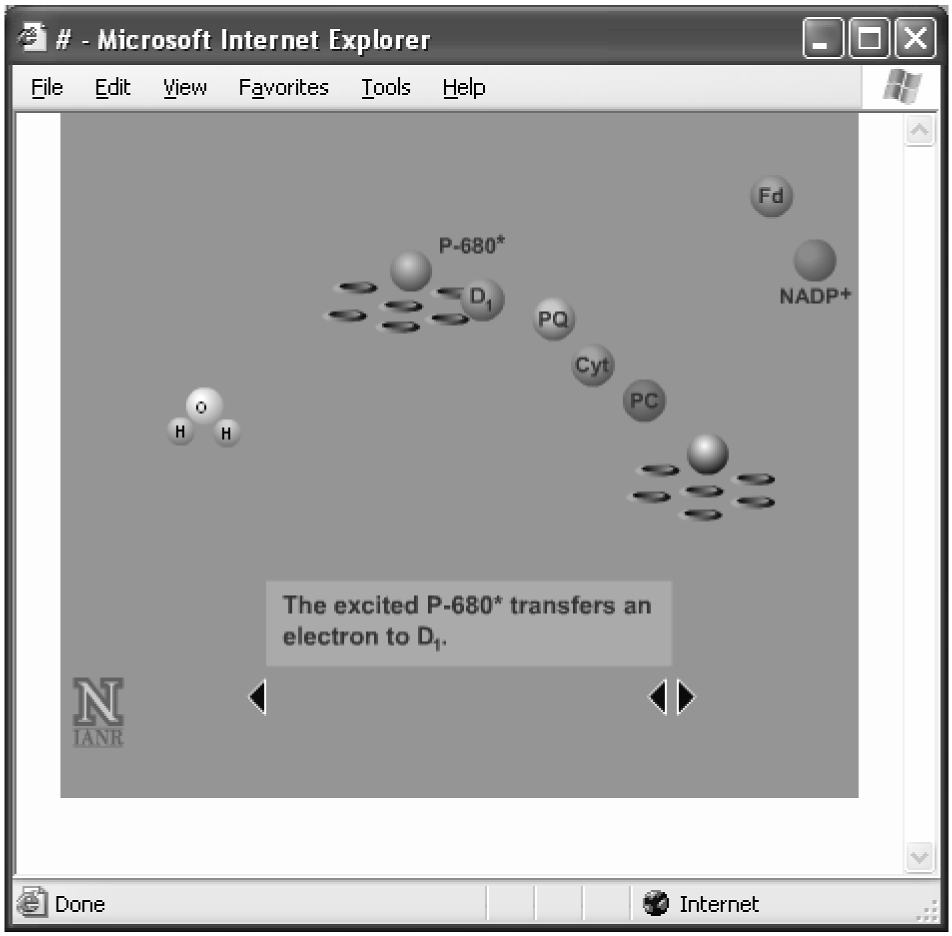


Figure 2.6: Animation of chlorophyll molecule capturing light energy. (With permission of Deana Namuth.).

Graphics as lesson interfaces

Figure 2.7 shows an example of graphical interface that is used as a backdrop to present lessons to create a guided discovery approach in a high school crop technology course.

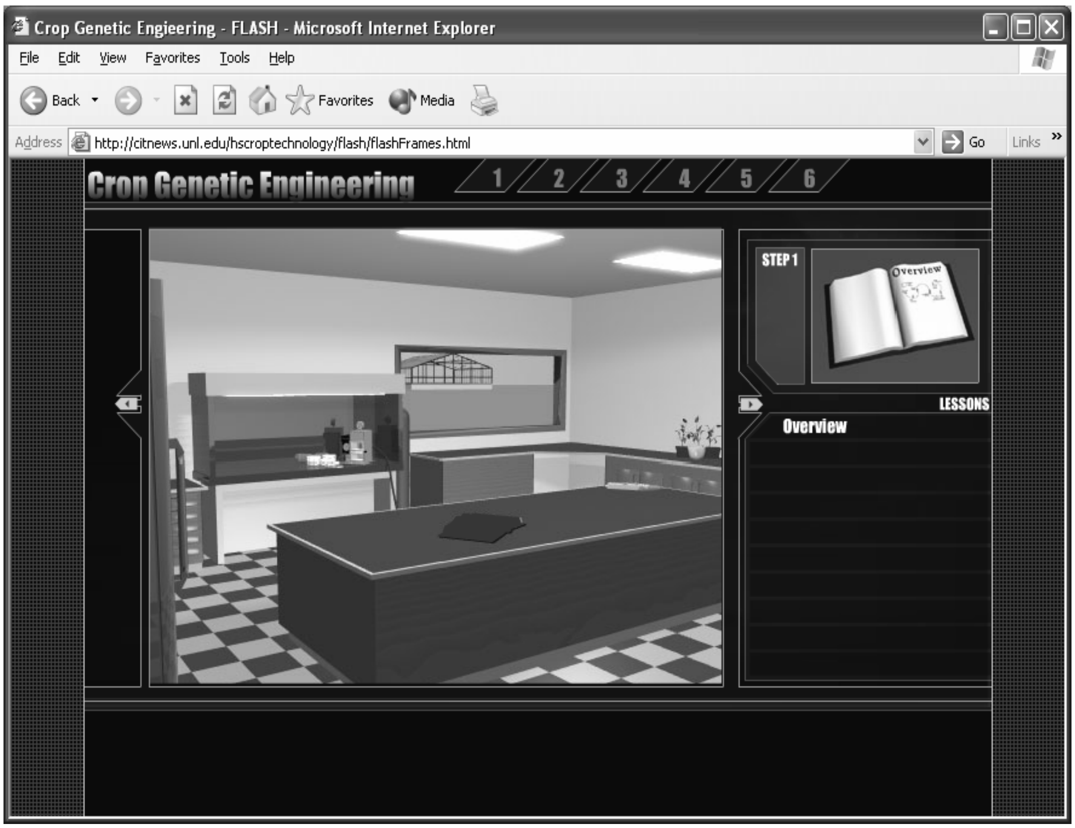


Figure 2.7: Animated graphical interface. (With permission of Deana Namuth.).

EFFECT OF VISUAL REPRESENTATION ON HUMAN COGNITIVE SYSTEM

There is substantial confirmation that creating visual spatial structures improves people's ability to recall and understand (Bellezza, 1983, 1986: Decker & Wheatley, 1982; Clark & Pavio, 1991; Mayer 2001). Bellezza (1986) concluded that subjects recalled more words when they were presented with visual presentation because the visuals were encoded as intact images in memory and were retrieved intact in response to cue words. The visuals were helpful in organizing the information in the brain and cues served a connection between stored information and thus retrieved it effectively (Kulhavy, Lee & Caterino, 1985). It is expected that creating structural arrangements improves recall and comprehension of information in visuals by helping students organize the information (Winn, Li & Schill, 1991). When the information is visually presented, it is encoded as it is presented. Meaning is then assigned to it, and it is connected with previous information already in store (Hirtle & Jonides, 1985). Careful spatial construction makes it easier for people to organize the visual representation meaningfully (Winn, Li & Schill 1991).

Many questions regarding the interaction between a visual representation and the human cognitive system relate to time. Background knowledge and presentation of the information and graphics can be associated with the construction of a mental model in the human brain (cf. Pinker, 1990). It can be helpful in reducing cognitive load (Bruning, Schraw & Ronning, 1998). Dual coding makes it simpler to recall and understand the information. Dual coding theory (Pavio, 1986) provides theoretical support for the use of visuals. According to this theory, words and visuals stimulate autonomously and encode the information separately in long term memory. If one code is lost, the other code can be helpful in retrieving the information. We took an example of how a pump works to create a mental representation to explain the relationship between visual aid and knowledge construction (Mayer & Sims, 1994).

> *"Bicycle tire pumps vary in the number and location of valves they have in the way air enters the cylinder. Some simple bicycle tire pumps have the inlet valve on the piston and the outlet at the closed end of the cylinder. A bicycle tire pump has a piston that moves up and down. Air enters the pump near a point where the connecting rod passes through the cylinder. As the rod is pulled out, air passes through the piston and fills the areas between the piston and the outlet valve. As the rod is pushed in, the inlet valve closes and the piston forces air through the outlet valve.*

The movement of the handle, piston, an inlet valve and a cylinder creates a cause and effect which is self explanatory with the aid of animations and text as compared with static graphics and text. The animations with text create a cross referential connection between verbal and visual codes. Studies also point towards the meaningful learning rather than just rote learning (Mayer & Sims, 1994) which can be measured by retention and recall tests.

The use of animation and interactive features of computer-based instruction can enhance learning and support human cognitive load (Hamel & Ryan-Jones, 1997). A study by Rene (2000) has predicted that cognitive load is a major factor in instructional design of computer-based instruction. Cooper (1998) defines cognitive load as the total amount of mental activity imposed on working memory at an instant in time. “Cognitive load theory” consists of intrinsic cognitive load and extraneous cognitive load. “Intrinsic cognitive load” is due to the inherent nature of some to-be-learned content. This nature of the difficulty cannot be simplified with the aid of instructional design. For example, content high in element interactivity remains high in element interactivity in spite of its presentation (Cooper, 1998). “Extraneous cognitive load” can be reduced by the instructional material. For example, concepts such as “continental drift” will be more effective if appropriate use of visuals is made rather than just text presentation. By changing the instructional materials presented to students, the level of extraneous cognitive load may be modified (Cooper, 1998).

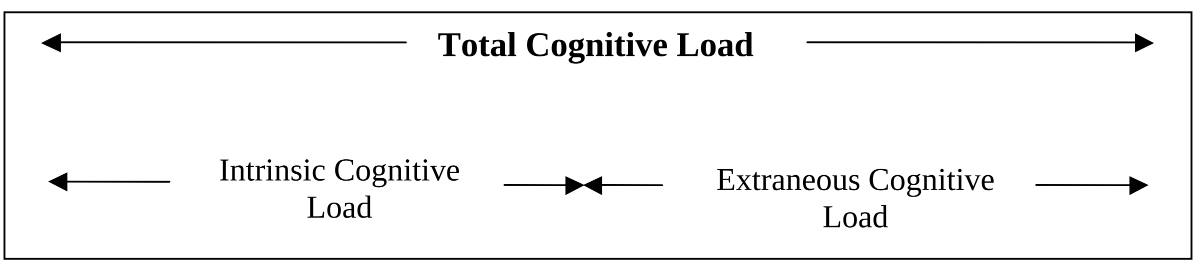


Figure 2.8: Intrinsic and extraneous cognitive load (Adapted from Cooper, 1998)

Cognitive load theory focuses on the role of working memory in learning new information. According to Cooper (1998), cognitive load theory consists of the following theories:

1. Working memory is limited in size and can store limited amounts of information.

2. Long term memory is unlimited, and the information which is filtered by the sensory memory and working memory is stored in long term memory.
3. Learning occurs when the new information is actively attended to by the learner and is encoded and comprehended in long term memory.
4. For effective learning, it is assumed that the information presented should not surpass the capacity of working memory.

Baddely (1986) describes working memory in term of the Visuo–spatial sketchpad and the phonological loop. The former helps to hold visual–spatial information. The latter holds information dealing with verbal material. Visually processed information has extraordinary capabilities of remembering the information. As cited by Bruning, Schraw & Ronning (1998, p 61)

> *"A study by Standing, Conezio, and Haber, 1970 showed subjects 2,500 slides for ten seconds each and found out the effect of remembering visual information. Recognition, estimated from a test on a subset of these slides, was over 90 percent. In another study by Standing (1973), participants viewed an even larger number of pictures -10,000 - over a five-day period. From the test performance, standing estimated subjects' memory at 6,600 pictures, remembered in at least enough detail to distinguish these pictures from the ones they had not seen before. Given evidence such as this, there is little doubt that pictorial information can be represented in our memories quite well. Most*

of us can easily conjure up images of a book, a soaring bird, a train wreck, or a walk in the woods."

According to the dual coding theory (Paivio, 1971), the information that is presented verbally and visually is expected to integrate within the learner’s working memory. It builds referential connections (Mayer, Sims, 1994). When both visual and verbal modalities are used to process the information, the encoding simplifies and results in better retrieval. If the information is actively processed by the learner at that moment it is passed on to the long term memory. If the information is so passively attended it is lost forever. The diagram below shows how visual and verbal presentation uses different modalities and if actively processed then it is passed on to the long term memory.

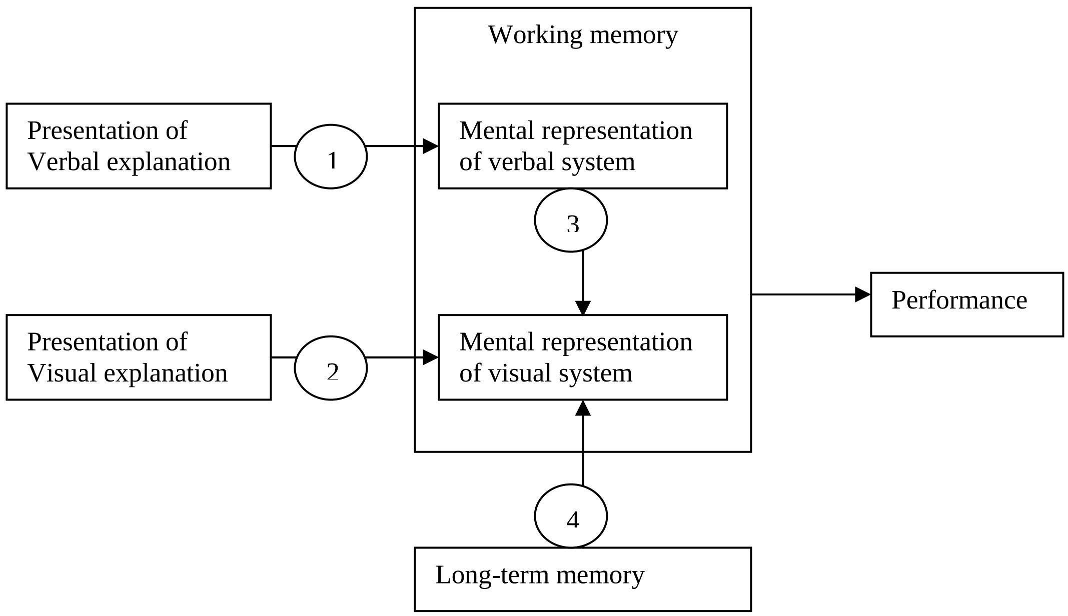


Figure 2.9: A dual code model of multimedia learning. The number 1 refers to building verbal representation connections; 2 refers to building visual representational connections; 3 refers to building referential connections; 4 refers to retrieval from long-term memory. Adapted from Mayer & Sims, 1994.

According to Cooper (1998), the application of cognitive load theory to instructional design rests upon the following:

1. Instructional materials presented to the learners may not include unnecessary information thereby increasing the cognitive load.
2. Extraneous load may be reduced by the instructional material.
3. Content areas that are most likely to demonstrate beneficial results from improved instructional design are those that deal with “complex” information where the elements of to-be-learned information interact with one another.

MAYER’S PRINCIPLES

The “Multimedia Principle” and “Contiguity Principle” are described briefly below. Mayer (2001) offers a scientific approach to the development of design principles. He has supported his principles with research aimed at understanding how people learn from words and pictures. The findings of the research support two design principles.

The Multimedia Principle

According to the multimedia principle (Mayer, 2001), students learn better from words and pictures than from words alone. Learners build picture-based and word-based representations in their minds; they build systematic connections with them. If words alone are presented, students make a verbal mental model. Due to the absence of pictures, they are less likely to make a visual mental model, and an association between the visual and verbal mental models is deficient.

Contiguity Principle

Students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen. The results supporting this principle are coherent with three assumptions underlying the cognitive theory of multimedia learning – dual channel, limited capacity and active processing. Mayer supports that, when presenting coupled text and images, the text should be embedded within the images. This reduces the cognitive workload of the learner, as s/he does not have to search visually for the image with corresponding text. The learners are more likely to be able to hold the information in working memory and to make better connections.

RESEARCH ON DUAL MODALITY

In a study by Ford, Chandler & Sweller (1997), which reviewed and hypothesized dual-mode presentation format outperform single modality format. Subjects were shown a variety of electrical engineering instructional material in three experiments incorporating visual diagrams or tables. In this experiment, thirty first year trade apprentices from a Sydney Company participated in the experiments using introductory electrical engineering material. The participants were divided into following three groups:

i. Instructions consisted of diagram with textual explanations of each step.

ii. An audio-visual format provided the same diagrams, but textual statements were presented in auditory form by the means of tape recorder.

iii. An integrated instruction contained the identical textual information as visual only format but the textual statements were physically integrated at appropriate locations on the diagram.

It was predicted was that audio-visual format and integrated format would outperform the visual only instruction. The reason was that the visual only instructional format apprentices would require "more cognitive resources to mentally integrate text and diagram, thus leaving relatively fewer mental resources available for learning and understanding." In the dual modalities, such as audio-visual format and an integrated format, learners mentally integrated instructional material in working memory. The results suggested that mental processing may be easier if audio-visual instruction is used instead of text information. This kind of instructional format reduces the load on limited working memory and thus results in superior performance. Because of the split attention effect, high element interactivity material combined with a high extraneous cognitive load would require more cognitive resources for learning and understanding and thus inhibiting learning.

In another similar study, Mousavi, Low & Sweller (1995) support the notion that working memory may be used effectively if the presented material is in a mixed rather then a unitary mode. It is suggested that there are multiple working memory channels with separate auditory and visual processing rather than a unitary channel. In this study three experiments were conducted comparing three presented modes:

1. Simultaneous group – studies worked examples with diagrams,
2. Visual-visual group-which diagram and statements were presented visually.
3. Visual-auditory group in which diagram were presented visually while listening to the audiotape.

It was predicted that the visual-auditory group would perform better than the other two groups “because of an expansion of effective working memory capacity.” Results were consistent with the hypothesis “that the use of dual sensory modes reduces the cognitive processing load by expanding working memory capacity. A mixed auditory and visual mode of presenting information was more effective than a single visual mode.”

RESEARCH IN COMPUTER BASED INSTRUCTION

Using computers to deliver instruction is common. This one-on-one interaction can provide immediate feedback. It also utilizes the components of “multimedia principle." Hypermedia instruction "involves classes using computer-based interactive videodisc, computer simulators, or interactive multimedia as instructional tools to teach students" (Liao, 1998).

Liao (1998) synthesized existing research comparing the effects of hypermedia versus traditional instruction on students' achievement. Hypermedia instruction was defined as an instruction, which "involves classes using computer-based interactive videodisc, computer simulators, or interactive multimedia as instructional tools to teach students. Traditional instruction was defined as instruction, which "involves classes or labs using conventional lecture/demonstration instructional methods to teach students." Thirty-five studies were located from three sources, and their quantitative data were transformed into Effect Sizes (ES). The overall grand mean of the study-weighted ES for all 35 studies was 0.48. The results suggested that hypermedia instruction is more effective when compared to the effect of traditional instruction.

Dillon & Gabbard conducted an extensive meta-analysis of experimental studies, which assessed the benefits of hypermedia in education. Hypermedia here is defined as "a generic term covering hypertext, multimedia, and related applications involving the chunking of information into nodes that could be selected dynamically." Specifically, the review categorizes this research into three themes: studies of learner comprehension compared across hypermedia and other media, effects on learning outcome offered by increased learner control in hypermedia environments, and the individual differences that exist in learner response to hypermedia. The review concentrated on the research findings published between 1990 and 1996. It concluded that to date, the benefits of hypermedia in education are limited to learning tasks conditional on repeated utilization and searching of information, and are differentially distributed across learners depending on their ability and preferred learning style. These were the three broad conclusions, which were suggested:

1. "*Hypermedia presents the most benefit for searching through lengthy or multiple information resources and where data manipulation and comparison are necessary. Outside of this context exiting media are better than or as effective as the new technology.*
2. *Increased learner control over access is differentially useful to learners according to their abilities. Lower ability students have greatest difficulty with hypermedia.*
3. *The interaction of learner style in the use of various hypermedia features offers perhaps the basis of an explanation for generally confusing results in the literature comparing hypermedia and non-hypermedia learning environments. Specifically, passive learners may be more influenced by cuing of relevant information, and the combination of learner ability and willingness to explore may determine how well learners can exploit this technology."*

CHAPTER III

METHOD

GENERAL OVERVIEW

This study assessed the degree to which computer animation contributes towards learning in fourth, fifth and sixth graders in one controlled setting. Subjects were divided into two groups: (i) animation-with-text and (ii) graphics-with-text. Two instruction sets were created for the appropriate group. The animation-with-text instruction set was created in Macromedia® Flash® and the graphics-with-text instruction set was created in Microsoft® Word®. Both instruction sets were created by the investigator under the supervision and review of committee members Drs. Brooks and Heng-Moss.

The animation-with-text group received computer-based instruction with text embedded within the animation. This group viewed the animations on Macintosh® iBook® laptop computers that were pre-loaded in the local hard-drives. The graphics-with-text group received the instruction set in the form of a printed document. Both groups' instruction sets had the same text content. The topic of the instruction was *fundamentals of the life cycle of a monarch butterfly*.

The total time estimated to view the instruction and complete the pretest and posttest was 20 minutes per student. Data for the study was collected on September 1st and September 2nd, 2002. Seven volunteers helped collect the data. Instruments for the data collection were the paper-based instructions, computer based instructions, pretests and posttests.

Subjects in this study were fourth, fifth and sixth grade students who were visiting the Butterfly Pavilion at the Folsom Childrens' Zoo, Lincoln, Nebraska. The children and accompanying adults were introduced to the study and invited to participate. Those interested in participating were requested to sign a consent form that had been reviewed by the UNL IRB. Participation in the study was voluntary and was not restricted to any one gender or ethnic group. As a motivation to participate in the study, the participants were rewarded with a free Folsom Childrens' Zoo train ride ticket that were given to them after they finished the study.

Equipment was set up outside the Butterfly Pavilion. The Butterfly Pavilion is a *one way* covered area where the visitors enter from one side and exit from the other. The pretest, study introduction and the instruction set arrangements were made at the entrance to the pavilion. The posttest and the ticket reward were at the pavilion's exit.

Subjects were first introduced to the study and, with the consent of accompanying adults, were allowed to participate in the study. A pretest was administered prior to any visual treatment assignment to the subject. Students were then randomly assigned to a treatment group. They were then allowed to tour the Butterfly Pavilion. When the subject reached the exit, s/he was given a posttest. These data collected in the test were assessed to determine the effectiveness of the instruction.

HYPOTHEISES

- Student's knowledge on the life science content will increase through both instruction sets.
- The students in the group using animation-with-text instruction will show improved performance over group using graphics-with-text instruction.

VARIABLES AND MEASURES

The independent variable studied here is the visual representation which has two levels *animation* and *graphics*.

A second independent variable is the subject's *prior knowledge*. Prior knowledge is the old knowledge that is already stored in the mind and has been acquired by a subject over time. Prior knowledge was measured using the pretest. The pretest contained questions addressing prior knowledge about the life cycle of a monarch butterfly, differences between male and female butterflies, the definition of metamorphosis, and the different stages of metamorphosis.

The dependent variable is *newly acquired conceptual understanding* of the presented information. This may be defined as the degree to which a student understands the concept. Understanding was determined by the posttest designed to cover each objective in this study. Posttests required students to choose from multiple-choice questions, write two line explanation answers, number each stage of the life cycle, and fill in the blank. The instrument compared the effectiveness of animations-with-text and graphics-with-text on learning by measuring the differences in recall, inference, and comprehension levels of the scientific concept taught through the two different visual treatments to the two groups. Therefore, posttest scores was a dependent variable.

POPULATION & SAMPLE

The population for this sample was fourth, fifth and sixth grade students visiting Butterfly Pavilion at the Folsom Childrens' Zoo, Lincoln. The subjects were introduced to the study. The population was restricted to a sample of 60 students. Both groups had equal numbers of participants, 30 for each group. The samples included students 9 through 11 years old. The demographic information is summarized in Table 3.1. In Group A - (animation-with-text group) there were 12 students from 4^{th} grade, 11 students from 5^{th} grade and 6 students from 6^{th} grade; details on age and grade was not reported by one subject. In Group B - (graphics-with-text group) there were 18 students from 4^{th} grade, 9 students from 5^{th} grade and 3 students from 6^{th} grade. The age group and grade distribution of subjects who participated in the study are shown in Figures 3.1, 3.2 and 3.3.

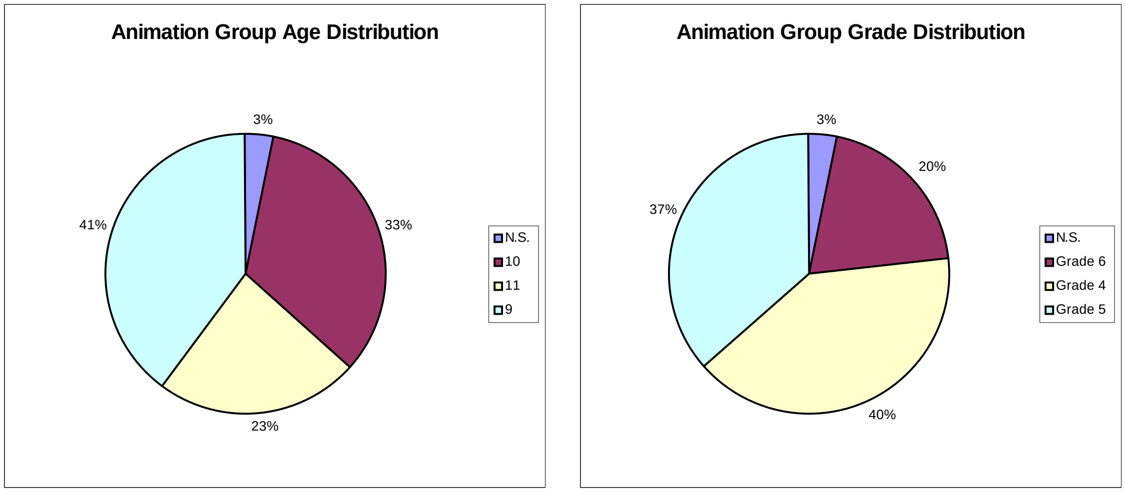


Figure 3.1: Participant population distribution

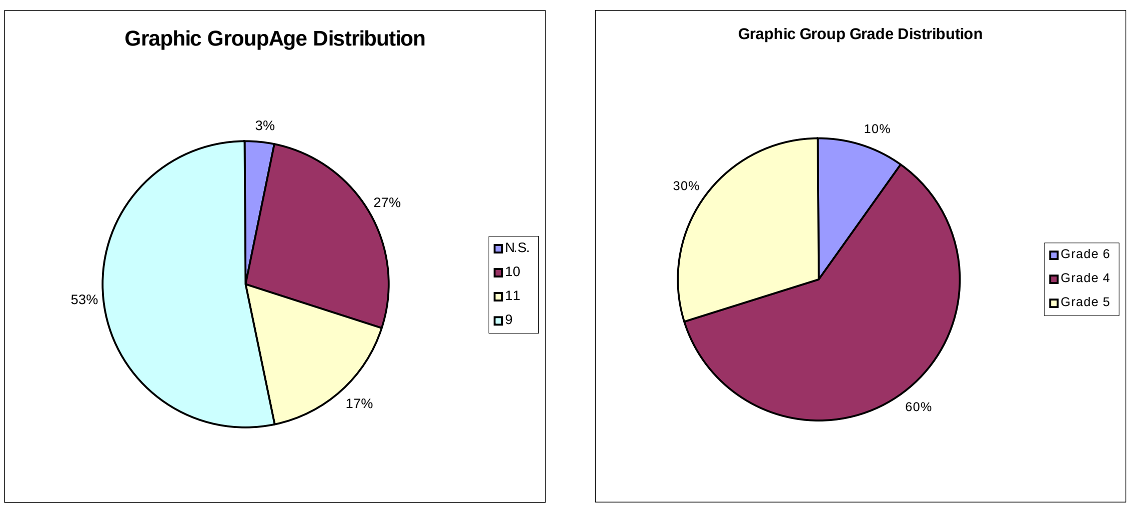
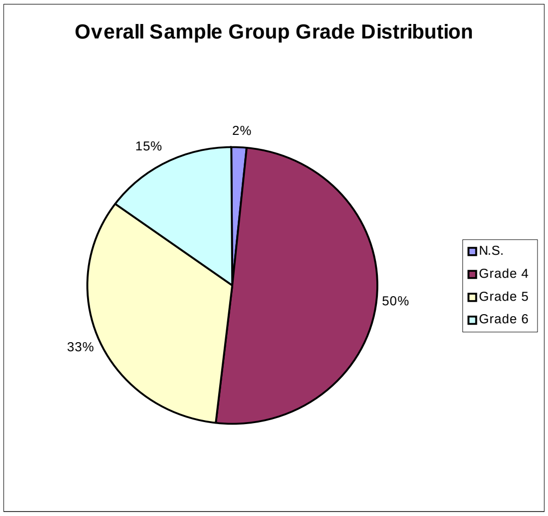


Figure 3.2: Participant population distribution



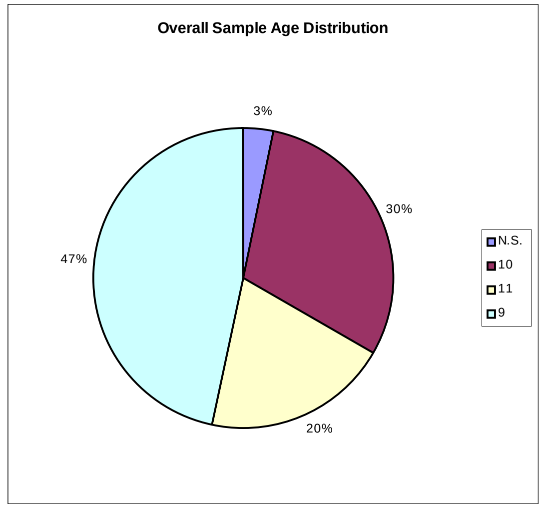


Figure 3.3: Participant population distribution

Table 3.1: Participants Demographics

	Treatment (N = 30) Animation-with-text*	**Control (n = 30) Graphics with text**
Number of 4th grade students	12	18
Number of 5th grade students	11	9
Number of 6th grade students	6	3

* One student in the animation with text group did not report the class grade

TREATMENT

The animation-with-text and graphics-with-text groups experienced two different visual treatments (Table 3.2).

Table 3.2: Treatment Groups

Animation	**Graphics**
Instruction set consisted of computer animation that had embedded text	Instruction set consisted of paper based document that had text and accompanying graphics

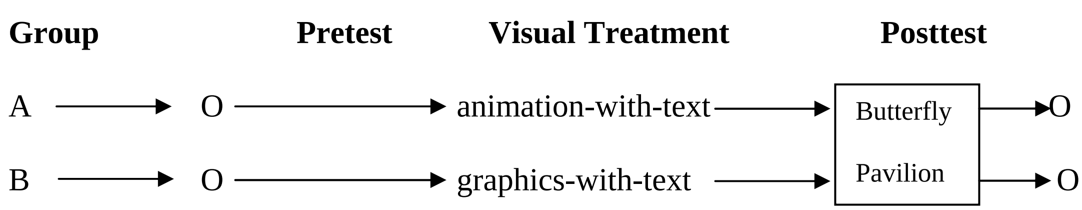


Figure 3.4: The Experiment

Figure 3.4 shows the process of the experimental study. The animation subjects were given the pretest followed by providing instruction about the complete life cycle of the monarch butterfly using computerized animation. This instruction set contained animated graphics along with the embedded text. After undergoing the visual treatment the subjects entered the Butterfly Pavilion. When they exited the pavilion, they were given the posttest. The graphic subjects were given the pretest followed by providing instruction about the complete life cycle of monarch butterfly using a paper-based instruction. This set contained graphics along with the accompanying text. After undergoing the visual treatment, the subjects entered the Butterfly Pavilion. When they exited the pavilion, they were given the posttest.

LIMITATIONS

1. The experiment included questions to the fourth, fifth and sixth grade students visiting Lincoln Childrens' Folsom Zoo at Nebraska.
2. The selection of the population depends on the availability of the population. Therefore, the generalizability of the findings will be limited to the characteristics of the subjects and the experiences of the subjects.
3. The sample size was N = 30 for each group, which limits the statistical power of the experiment.
4. This instrument did not take into consideration the socio-economic status, pre-exposure to computer environment or usability of computers, or experience in learning from animation and graphics.
5. This study was intended to be an equal-time experiment, with two types of experimental groups spending equal amounts of time on each visual treatment, approximately 15-20 minutes. It is impossible for absolute equality to prevail, given the complexity of visual treatment procedures and differences among the students.

EXPERIMENTAL SITE DESCRIPTION

Every summer, Folsom Childrens’ Zoo Lincoln organizes a Butterfly Pavilion where one can enter into a free flight aviary containing hundreds of live butterflies native to North America. One can see monarchs, painted ladies, red admirals, queens, and swallowtails, just to name a few. Because it focuses on invertebrates, the Butterfly Pavilion is a new concept for the Zoo. Apart from the live butterflies all around inside the pavilion, there is an area in the pavilion that has live displays of the stages of butterfly formation starting from an egg to a fully matured butterfly.

TOOLS AND TECHNOLOGIES USED

Drawing Tablet

A drawing tablet is a computer input device that allows the user with an alternate method of computer input. The tablet is generally accompanied with a drawing stylus. A user may take notes or draw sketches; the digital data is transferred directly onto user's computer. The tablet offers the power one needs to create the graphics with the control and assemble the pages. With the improvement in technology, tablets are available that are pressure sensitive and allow users to use the drawing stylus on the tablet similar to a brush on a canvas. One may draw and sketch with the same control and expression as a real paintbrush. These different levels of pressure-sensitivity work in coherence with various multimedia and image editing software such as Flash®, Photoshop®, Painter® and

Fireworks®. The availability of such a device increases the speed of work and productivity. Figure 3.5 shows a drawing tablet.

Figure 3.5: Drawing tablet

Macromedia® Flash®

Macromedia® Flash® is the professional standard software for producing high-impact web experiences. It is helpful in creating animated logos, web site navigation controls, long-form animations, entire web sites, or web applications. Flash® provides enhanced capabilities for creating artwork, streamlining the workflow, and creating interactivity. It also includes greatly expanded capabilities for creating actions with Action Script. Flash® movies are graphics and animations for web sites. They consist primarily of vector graphics, but they can also contain imported bitmap graphics and sounds. Flash® movies can incorporate interactivity to permit input from viewers, and one can create nonlinear movies that can interact with users. Web designers use Flash® to create navigation controls, animated logos, and long-form animations with synchronized sound. Flash® movies are compact, vector graphics, so they download rapidly and scale to the viewer's screen size.

The Flash Player® is a small application that resides on a local computer, where it plays back movies in browsers or as stand alone applications. Viewing Flash® movies on the Flash® Player is similar to viewing a videotape on a VCR. As one works in Flash®, one can create a movie by drawing or importing artwork, arranging it on the *Stage*, and animating it with the *Timeline*. One can make the movie interactive by using actions to make the movie respond to events in specified ways. When the movie is complete, the movie can be exported as a Flash Player® movie to be viewed in the Flash Player®, or as a Flash® stand-alone projector to be viewed with a self-contained Flash Player® included within the movie itself. One can play a Flash movie in the following ways:

- In Internet browsers, such as Netscape Navigator® and Microsoft® Internet Explorer®, those are equipped with the Flash Player®.
- With the Flash ActiveX® control in Microsoft® Office®, Microsoft® Internet Explorer® for Windows®, and other ActiveX® host environments.
- In the Flash Player®, a stand alone application similar in operation to the Flash Player® plug-in
- As a stand–alone projector, a movie file that can be played without the Flash Player® software

Flash® provides a variety of methods for creating original artwork and importing artwork from other applications. One can create objects with the drawing and painting tools, and modify the attributes of existing objects. One can also import vector and bitmap graphics from other applications and modify the imported graphics in Flash®. Using Flash®, one can animate objects to make them appear to move across the Stage and/or change their shape, size, color, opacity, rotation, and other properties. One can create a frame-by-frame animation, in which one can create a separate image for each frame. One can create *tweened* animation, in which one can create the first and last frame and direct Flash® to create the frames in between. One can create animation by changing the content of successive frames. One can make an object move across the Stage, increase or decrease its size, rotate, change, color, fade in or out, or change shape. Changes can occur independently of, or in concert with, other changes.

There are two methods for creating an animation sequence in Flash®: frame-by-frame animation and tweened animation. Flash® allows creating interactive movies, in which the audience can use the keyboard or the mouse to jump to different parts of a movie, move objects, enter information in forms, and perform many other operations. One can create interactive movies by setting up actions using ActionScript (Macromedia, 2000).

INSTRUCTIONAL MATERIAL DEVELOPMENT PROCESS

Selection of the Topic

The first step involved in creating the experiment tools for this study was selection of the topic. In order to comply with the standards of content material for the subjects' age group, the content material for visual treatment was based on a life science topic confirmed by the National Science Standard guidelines, National Research Council, Washington, D.C. The guideline provides children with the opportunity to learn age-appropriate concepts and skills and to acquire scientific attitudes and habits of mind.

According to the content standard for the activities of grade fourth students should be able to develop and understand:

- The characteristics of organisms
- Life cycles of organisms
- Organisms and environment

Table 3.3, Table 3.4 and Table 3.5 list the fundamental concepts and principles that underlie this standard include

Table 3.3: The Characteristics of Organisms (Source, National Science Education Standards.)

The Characteristics of Organisms

- Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light. Organisms can survive only in an environment in which their needs can be met. The world has many different environments, and distinct environments support the life of different types of organisms.
- Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking.
- The behavior of individual organisms is influenced by internal cues (such as hunger) and by external cues (such as a change in the environment). Humans and other organisms have senses that help them detect internal and external cues.

Table 3.4: Life Cycles of Organisms (Source, National Science Education Standards.)

Life Cycles of Organisms
• Plants and animals have life cycles that include being born, developing into adults, reproducing, and eventually dying. The details of this life cycle are different for different organisms. • Plants and animals closely resemble their parents. • Many characteristics of an organism are inherited from the parents of the organism, but other characteristics results from an individual's interactions with the environment. Inherited characteristics include the color of flowers and the number of limbs of an animal. Other features, such as the ability to ride a bicycle, are learned through interactions with the environment and cannot be passed on to the next generation.

Table 3.5: Organisms and their environment (Source, National Science Education Standards).

Organisms and their environment • All animals depend on plants. Some animals eat plants for food. Other animals that eat plants. • An organism's patterns of behavior are related to the nature of that organism's environment, including the kinds and numbers of other organisms present, the availability of food and resources, and the physical characteristics of the environment. When the environment changes, some plants and animals survive and reproduce and others die or move to new locations. • All organism cause changes in the environment where they live. Some of these changes are determined to the organisms or other organisms, whereas others are beneficial. • Humans depend on their natural and constructed environments. Humans change environments in ways that can be either beneficial or detrimental for themselves and other organisms.

Based on the guidelines mentioned in Tables 3.4 and Table 3.6, and discussions with Drs. Brooks and Heng-Moss it was decided to select the topic of the life cycle of a monarch butterfly. Research on the latest audio and visual material related to the life cycle of a monarch butterfly was conducted.

The next step was to collect the information related to the selected topic. While the subject matter was being collected, various media types of instructional sets were reviewed. These included books, magazines, CD's, educational video games and videos. Reviewing the different media types was done in order to determine the approach that had been taken by other instruction providers in the field of the life cycle of monarch butterflies. It also helped in understanding how effectively other illustrators and graphic designers are designing and conveying the instructional message. Once the instructional materials were collected, the specifics of the exact content that needed to be conveyed to the students was determined. Table 3.6 shows the specifics of the content for the instruction set. Table 3.7 shows the objectives of the instruction set.

Table 3.6: Content Specifics and objectives for the instruction set

Topic

"The life cycle of a monarch butterfly" - The content involves the discussion regarding how the monarch butterfly evolves and changes its form and shape from one stage to the other. It introduces the students about the concept of *Metamorphosis*.

The students were introduced to the following concepts, attitudes and skills:

Concepts

- The different stages of the monarch butterfly's life cycle are egg, larva, pupa (chrysalis), and adult.
- Eggs are laid on milkweed plants by the monarch butterfly. They have an estimated time period to hatch and form caterpillar.
- A caterpillar first eats its own egg shell later it needs food, air, and space to survive and grow. A caterpillar molts five times during its the larva stage.
- The caterpillar hangs in a *J* shape and forms a chrysalis. It forms a green shell and very soon the shell darkens.
- Inside the chrysalis the caterpillar's tissues are broken down and reassembled into a butterfly.
- After the darkening of casing a butterfly emerges from the chrysalis.
- The butterfly emerges and expands its wings.
- A butterfly is then ready to fly.
- Comparing male and female butterflies
- Relating the modification in the butterfly's growth with other insects.

Table 3.7: Objectives of the instruction set

Objectives
It is anticipated that the following will be observed among the students after understanding the information material. • An interest in studying insects. • Understanding of the needs of insects. It is also anticipated that following skills will be developed among the students after understanding the information material. • Viewing the growth and change in every stage of the monarch butterfly. • Observing change in appearance and size over time. • Comparing the female and male butterfly. • Relating change with other insects

Storyboarding

Once the content specifics and the instruction objectives were finalized, the next step was to develop a storyboard. The process of *Storyboarding* may be defined as a creative way to accomplish the most important step between scripting and production. It involves pre-visualization and planning of the project that needs to be explored. Storyboarding helps one create the visuals that are needed in order to give ideas a descriptive form. This storyboard acts as a communication tool between the researcher and the content specialist. Figures 3.6, 3.7 and 3.8 are some of the storyboard sketches that were developed.

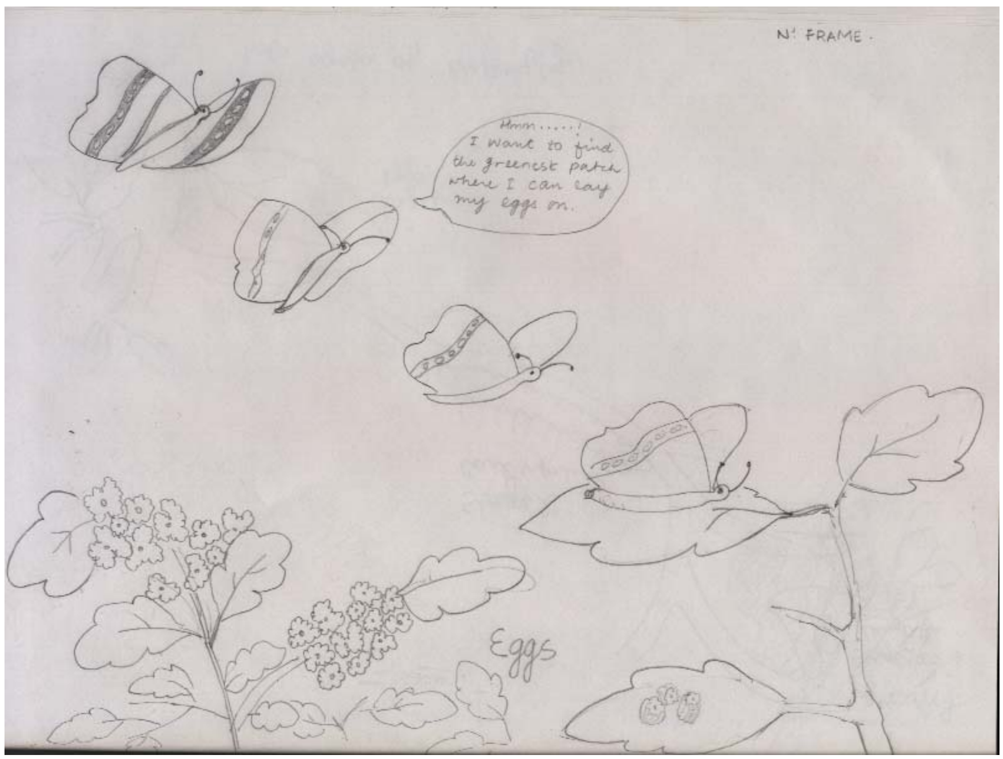


Figure 3.6: Storyboard Sketch (Finding a place to lay eggs)

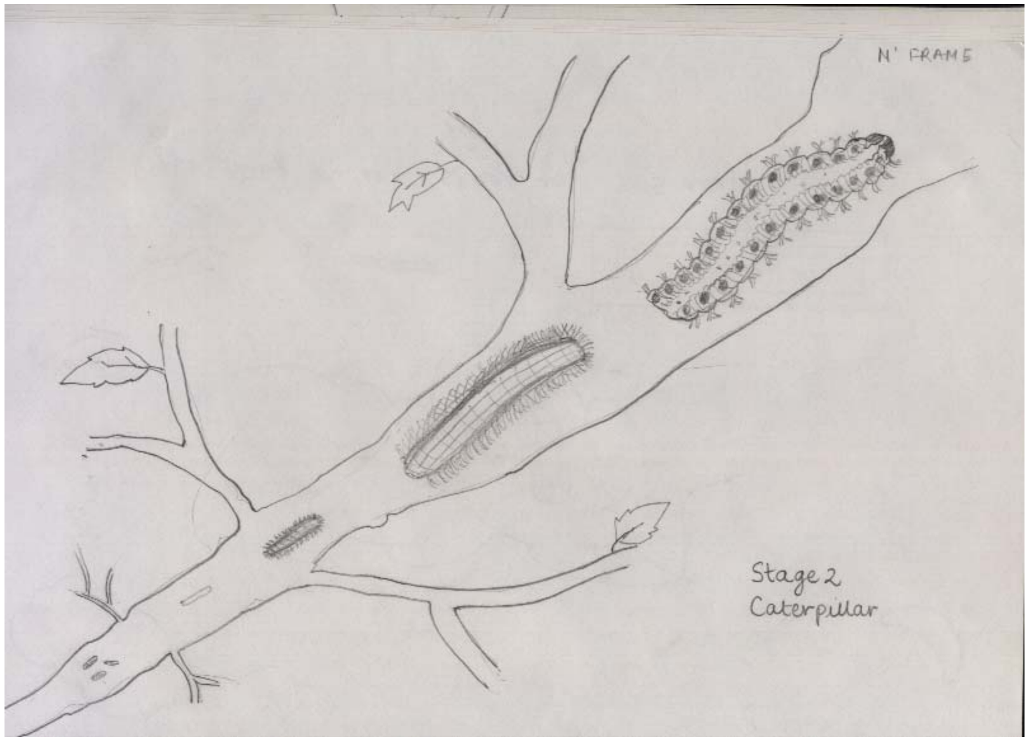


Figure 3.7: Storyboard Sketch (Metamorphosis)

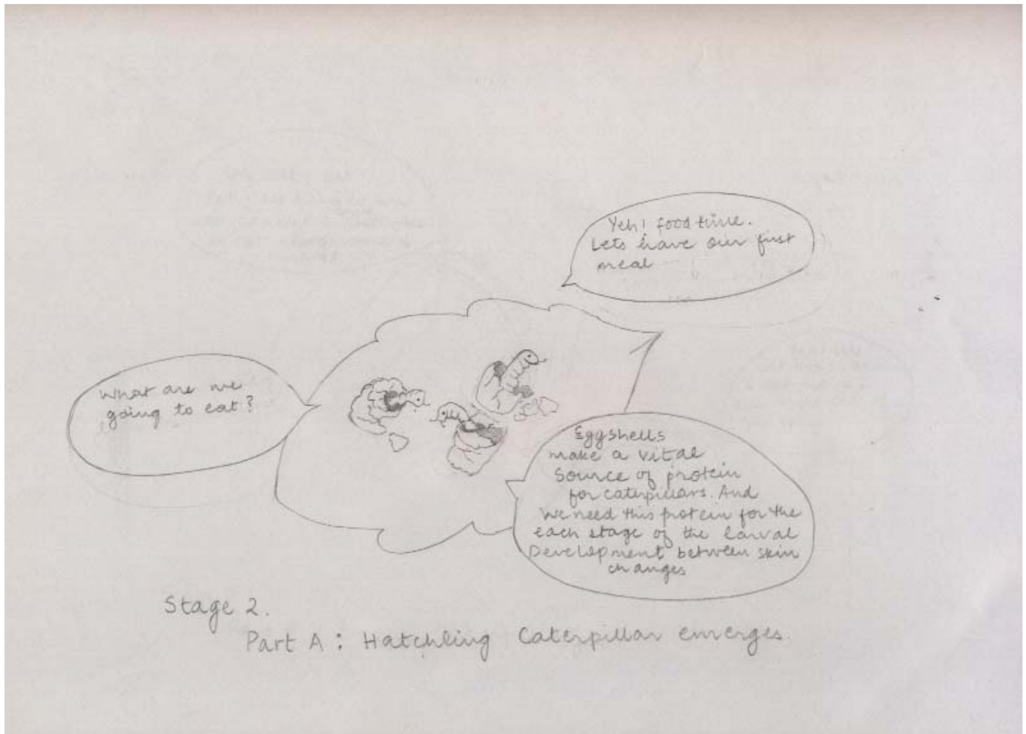


Figure 3.8: Storyboard Sketch (Eggs Hatching)

Flash® Animation Development

The outcome of the storyboarding process was an improvised form of content in form of sketches. These paper sketches subsequently were animated. The animations were designed and created using Macromedia® Flash®. A drawing tablet was used to design the animations. It took an approximately 300 hours to finish the animation and bring it to the finished version. There were periodic reviews of the animation by the thesis advisor and content specialist. After each review, the changes that were recommended were made until the final version was ready. The edited animation was published on the web, and CD's were made for use during the experiment. Figures 3.9, 3.10, and 3.11 are some of the screen shots of the final Flash® animation

Figure 3.9: Screen capture of Flash® animation (Finding a place to lay eggs)

Figure 3.10: Screen capture of Flash® animation (Metamorphosis)

Figure 3.11: Screen capture of Flash® animation (Eggs Hatching)

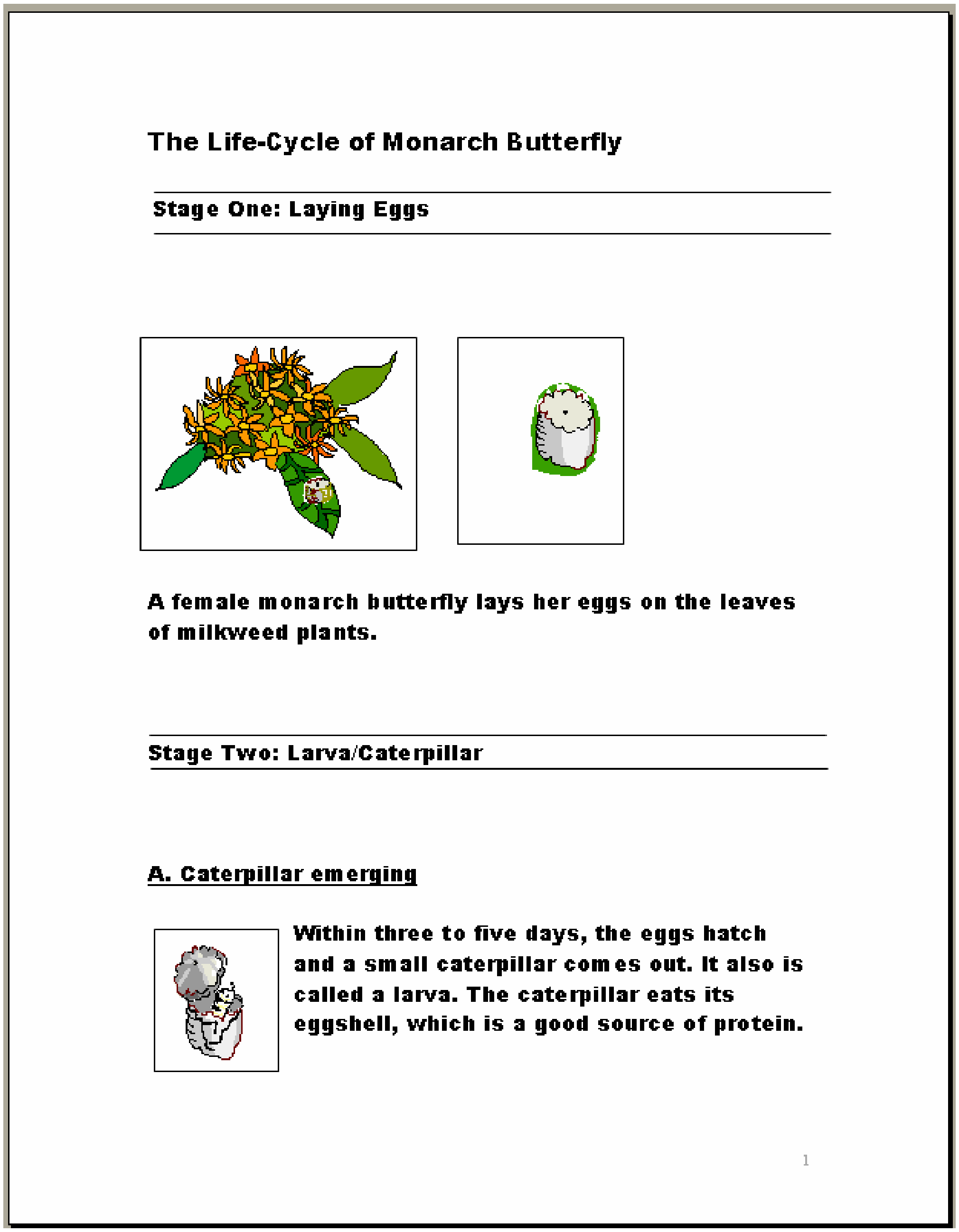
The animation had a control bar at the lower end of the screen that was always present. There were buttons on this control bar that allow a user to go back and forward in the animation, giving them full control of the pace of the animation. The animation was embedded with graphics and text that were relevant to the content text. A total of twenty-nine animation slides were created to cover all the objectives mentioned in Table 3.7. Table 3.8 describes the categories, content topics and anticipated time that a student could spend on the content.

Table 3.8: Important content topics and anticipated time

Topic Shown	Anticipated Time
Life cycle of Monarch butterfly • Stage 1 –Egg • Stage 2 – Larva/Caterpillar • Stage 3 – Pupa • Stage 4 – Butterfly	 2 minutes 1 minute 3 minutes 2 minutes
Difference between male and female butterfly • Difference in the shape and pattern of wings	 1 ½ minutes
Metamorphosis • What is metamorphosis • Types of metamorphosis: • No metamorphosis • Incomplete metamorphosis • Complete metamorphosis	 2 minutes 1 1/2 minutes 1 1/2 minutes 1 1/2 minutes

Graphics-with-Text Instruction Set Development

For the paper-based graphic illustration, graphics were exported from the Flash® animation so that they could be used in the paper-based instruction set. These Flash® exported graphics were then pasted into Microsoft word and the text and these graphics were formatted to ensure readability and conform to the formatting recommendations for the fourth, fifth and sixth grade student's age. Similar to the process of animation development, paper-based instruction was developed under periodic review by the thesis advisor and content specialist. After each review, the changes that were recommended were made until the final version of the paper based instruction was ready. The final version of the paper based instruction had three pages of printed text and graphics. Analogous to the animated counterpart, the paper-based instruction was also divided into three categories, and the anticipated instruction time was same as in Table 3.8 above. Once the final version of paper based instruction was prepared, paper copies were created. The development time of the paper based instruction was considerably reduced to a total of 25 hours since the graphics that were created for the animations were reused for this medium. Figures 3.12, 3.13, and 3.14 are image scans of the final paper-based instruction.



The Life-Cycle of Monarch Butterfly

Stage One: Laying Eggs

A female monarch butterfly lays her eggs on the leaves of milkweed plants.

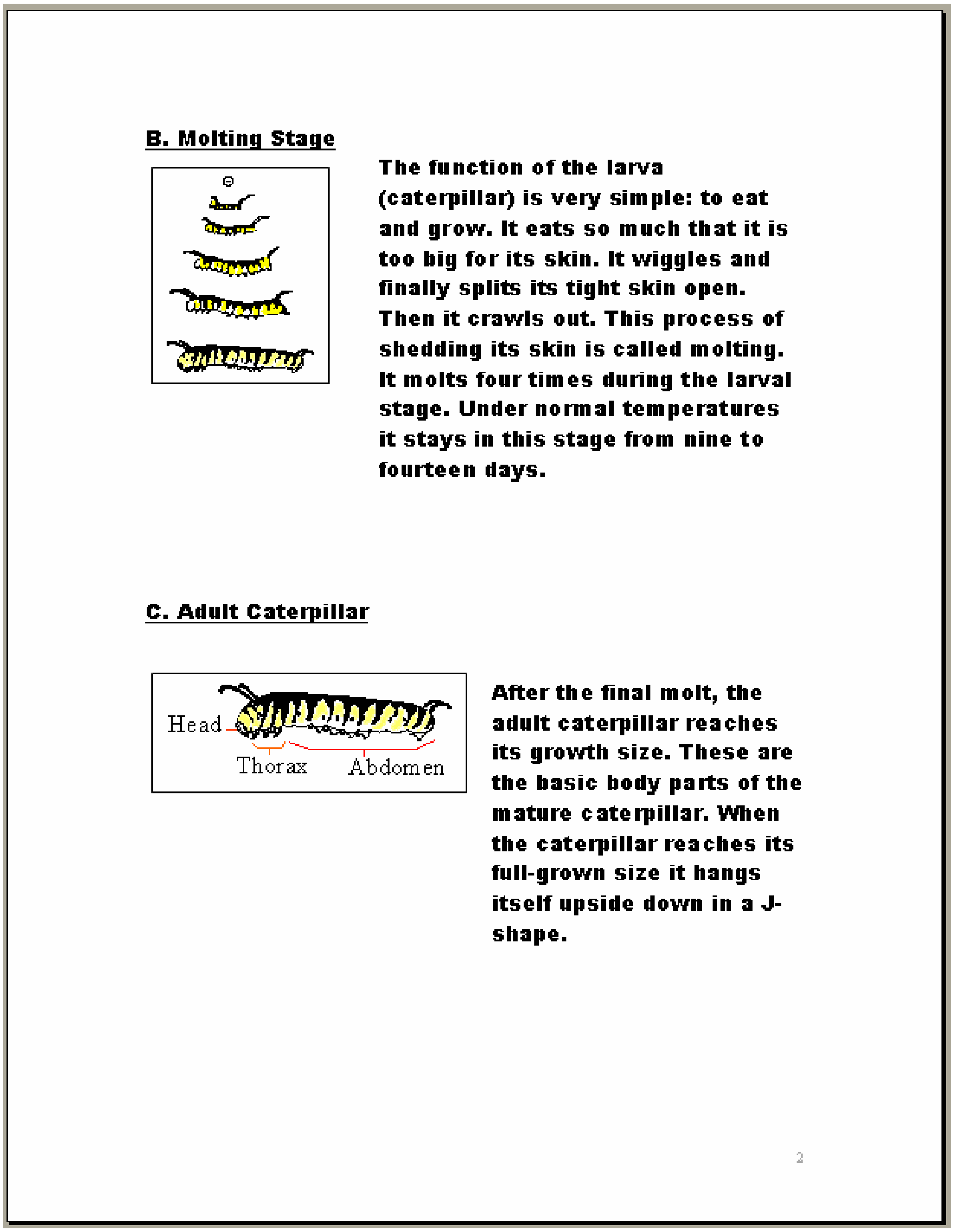
Stage Two: Larva/Caterpillar

A. Caterpillar emerging

Within three to five days, the eggs hatch and a small caterpillar comes out. It also is called a larva. The caterpillar eats its eggshell, which is a good source of protein.

1

Figure 3.12: Image scan of paper based instruction (Page 1)



B. Molting Stage

The function of the larva (caterpillar) is very simple: to eat and grow. It eats so much that it is too big for its skin. It wiggles and finally splits its tight skin open. Then it crawls out. This process of shedding its skin is called molting. It molts four times during the larval stage. Under normal temperatures it stays in this stage from nine to fourteen days.

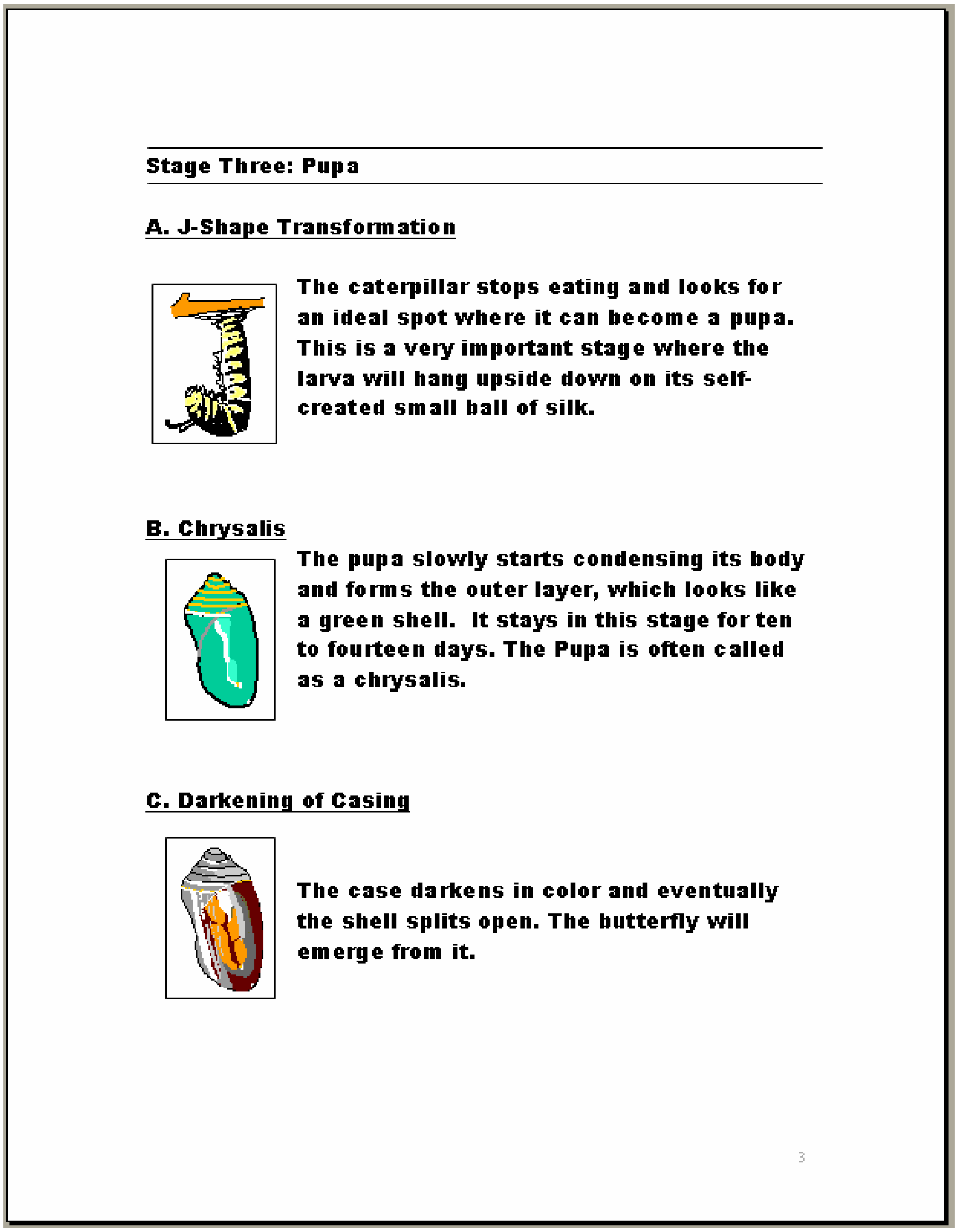
C. Adult Caterpillar

Head
Thorax
Abdomen

After the final molt, the adult caterpillar reaches its growth size. These are the basic body parts of the mature caterpillar. When the caterpillar reaches its full-grown size it hangs itself upside down in a J-shape.

2

Figure 3.13: Image scan of paper based instruction (Page 2)



Stage Three: Pupa

A. J-Shape Transformation

The caterpillar stops eating and looks for an ideal spot where it can become a pupa. This is a very important stage where the larva will hang upside down on its self-created small ball of silk.

B. Chrysalis

The pupa slowly starts condensing its body and forms the outer layer, which looks like a green shell. It stays in this stage for ten to fourteen days. The Pupa is often called as a chrysalis.

C. Darkening of Casing

The case darkens in color and eventually the shell splits open. The butterfly will emerge from it.

3

Figure 3.14: Image scan of paper based instruction (Page 3)

Development of Pretest and Posttest

The questions on the pretest and posttest were prepared by the researcher and were reviewed by the content specialist and thesis advisor. While preparing the pretest and the posttest, importance was given to technical aspects such as clarity, recall, retention, comprehension, item analysis, reliability and validity of the tests. The questions were selected from the developed content of the instruction set. Initially approximately 60 questions were created. Through the reviewing process, the questions were the filtered down to seven questions per test. Each test had five multiple-choice questions, two fill in the blank questions and one two-line answer question. For clarity, static images also were grouped with the question. These questions addressed all the objectives laid out for the topic. Pretests and posttests contained a few questions which were similar in content.

Pre- and Posttest Design Consideration

Several considerations were followed while designing the test. Arrangement of the test layout was done so that the entire items with the same format questions were grouped together. Thus, keeping all the multiple type questions in the first few questions, fill in the blanks together and short descriptive questions at the end. This reduced the number of times students had to shift their response mode (McMillan, 1997).

The printing of the test and layout was prepared so as not to overwhelm students. The test was one page in length, with reasonable spacing. Multiple-choice questions were arranged horizontally rather then vertically to avoid overcrowding. Space was left for small essay type question.

For younger students it is best to minimize transfer of answers by having them circle or write the answer in the space provided in the item. This approach to arranging the test was followed (McMillan, 1992).

To make students comfortable, the accompanying adults and students were introduced to the study objectives. To make students feel comfortable, they were told that the scores would not be reported to their school. The anticipated time of the treatment was indicated to the subjects to inform the exact time length involved in the study. Rushing up the test was avoided to make them feel at ease.

Overall procedure of the experiment

This study was conducted using the following sequence:

1. IRB approval was obtained.
2. Approval was obtained from Childrens Folsom Zoo, Lincoln, Nebraska.
3. The child and parent consent was obtained for child to participate in the study.
4. Pretest was arranged for each group participant.
5. Participants were randomly assigned to the animation or graphics group.
6. Following the visual treatment subjects took the tour of Butterfly Pavilion.
7. Posttest took place at the other end of the Butterfly Pavilion

CHAPTER IV

RESULTS

The data from the experiment was analyzed using ANOVA. ANOVA classified the variance of scores into between group, and within group components. The dependent variable was the score obtained by the subjects in pretest and posttest. The factor in the experiment was the method of instruction (treatments). There were two levels in method of instruction, i.e. animation and graphics-with-text.

It is important to note that the formation of the groups was done by random assignment of the participants. The study revealed that there was no significant difference between the means scores of the posttest in between two groups.

ANALYSIS

ANOVA is a parametric procedure that has the same basic purpose as the t-test: to compare group means, and to determine the probability of being wrong in rejecting the null hypothesis. However, while a t-test compares two means, ANOVA has the capability of comparing two or more means.

A test of great importance is whether or not the means of the scores obtained from the pretest and the posttest in the control group and the experiment groups are equal. In this study, the researcher compared two types of visual treatments: animations-with-text and graphics-with-text. The dependent variable was the score of the posttest of the two groups.

HYPOTHESES

One hypothesis tested for this study was:

Null: There **is no** significant difference between the performance of subjects from animation and graphic groups.

Alternative: There **is** a significant difference between the performance of subjects from animation and graphic groups.

Figures 4.1 through 4.3 and Tables 4.1 through 4.5 show the analysis of the data set using Statgraphics®.

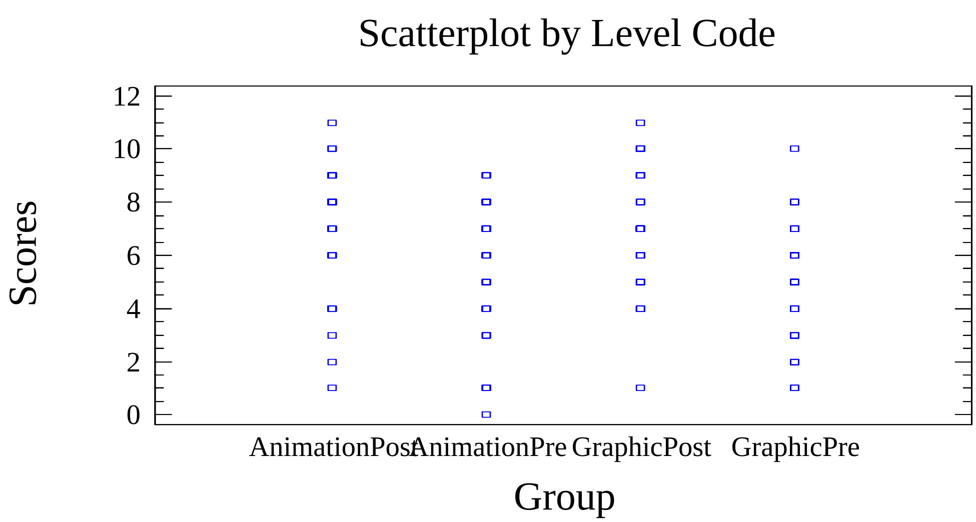


Figure 4.1 Scatter plot for the pretest and posttest scores for two groups

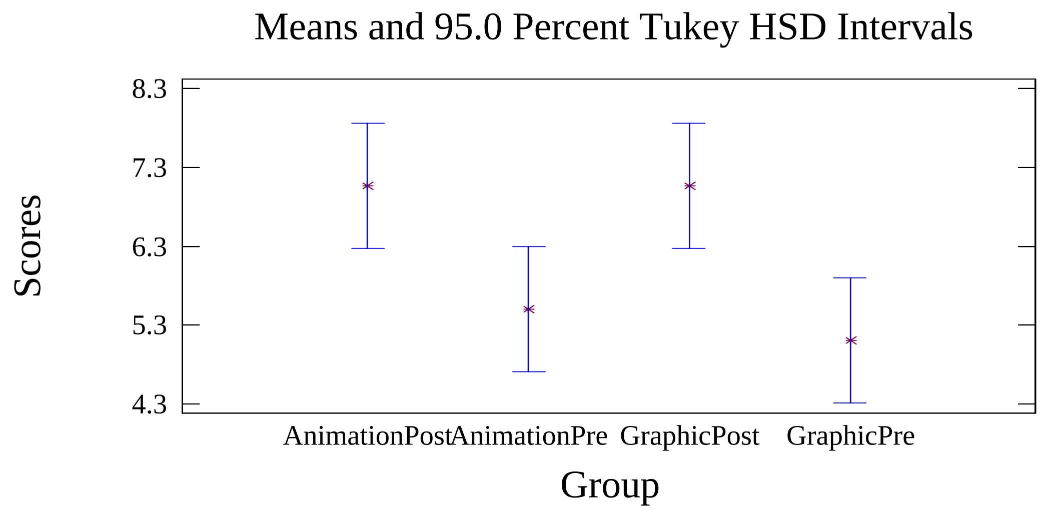


Figure 4.2 Means and Tukey plots for the pretest and posttest scores for two groups

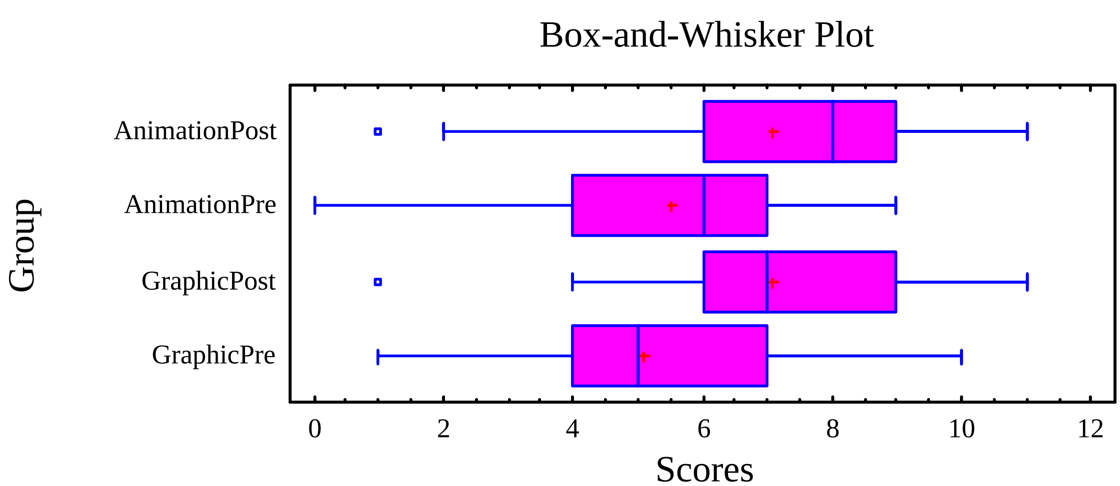


Figure 4.3 Box-and-Whisker plots for the pretest and posttest scores for two groups

ANALYSIS SUMMARY

Dependent variable: Scores
Factor: Group

Number of observations: 120
Number of levels: 4

Table 4.1 Summary Statistics for Scores

Group	Count	Average	Variance	Standard deviation	Minimum
AnimationPost	30	7.06667	5.85747	2.42022	1
AnimationPre	30	5.5	6.53448	2.55626	0
GraphicPost	30	7.06667	5.09885	2.25806	1
GraphicPre	30	5.1	4.64483	2.15519	1

Table 4.2 ANOVA Table for Scores by Group

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	96.033	3	32.011	5.78	0.0010
Within groups	641.933	116	5.53391		
Total (Corr.)	737.967	119			

Table 4.3 Multiple Range Tests for Scores by Group

Group	Count	Mean	Homogeneous Groups
GraphicPre	30	5.1	X
AnimationPre	30	5.5	X
AnimationPost	30	7.06667	X
GraphicPost	30	7.06667	X

Table 4.4 Multiple Range Tests for Scores by Group

Contrast	Difference	+/- Limits
AnimationPost - AnimationPre	*1.56667	1.20302
AnimationPost - GraphicPost	0	1.20302
AnimationPost - GraphicPre	*1.96667	1.20302
AnimationPre - GraphicPost	*-1.56667	1.20302
AnimationPre - GraphicPre	0.4	1.20302
GraphicPost - GraphicPre	*1.96667	1.20302

* denotes a statistically significant difference.

Table 4.5 Variance Check

Variance Check

Cochran's C test: 0.295202   P-Value = 0.831391
Bartlett's test: 1.00854   P-Value = 0.808041
Hartley's test: 1.40683
Levene's test: 0.340111   P-Value = 0.796355

EXPLANATION OF RESULTS

The F-test in the ANOVA Table 4.2 tests whether there are any significant differences among the means. If there are, the Multiple Range Tests tell us which means are significantly different from each other. In order to account for outliers, the Kruskal-Wallis Test, which compares medians instead of means is used to show the results as shown in Table 4.3. The various plots help judge the practical significance of the results, as well as allow a visual presentation for possible violations of the assumptions underlying the analysis of variance.

The ANOVA table (Table 4.2) decomposed the variance of scores into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 6.43205, is a ratio of the between-group estimate to the within-group estimate. Since the P-value of the F-test is less than 0.05, there is a statistically significant difference between the mean scores from one group to another at the 95.0% confidence level. The means that are significantly different from others are depicted in the multiple range tests (Table 4.3 and Table 4.4).

Table 4.3 depicts the multiple comparison procedure that determined which means are significantly different from others. Table 4.4 shows the estimated difference between each pair of means. An asterisk placed next to 4 pairs is indicating that these pairs show statistically significant differences at the 95.0% confidence level.

Table 4.3 shows that two homogenous groups are identified using columns of X's. Within each column, the levels containing X's form a group of means within which there are no statistically significant differences. The method used to discriminate among the means is Fisher's least significant difference (LSD) procedure. With this method, there is a 5.0% risk of calling each pair of means significantly different when the actual difference equals 0.

According to Table 4.3 we observe that the pretest scores of graphics-with-text group (GraphicsPre) and animation-with-text (AnimationPre) group fall under the same group. This implies that the pretest proved that the two sample populations had same prior knowledge about the tested material. In other words, it validates the random assignment of the subjects to their respective groups. Once the pretest scores of both groups show equality, it means that any significant difference that is observed among the post test scores can be attributed to the treatments that the corresponding groups underwent.

Further, Table 4.3 shows that the graphic-with-text group's posttest scores have a significant difference in mean scores from their mean pretest scores. Similarly, Table 4.3 also shows that the animation-with-text group's posttest scores have a significant difference in mean scores from their mean pretest scores. The above implies that knowledge was imparted to the students in both the groups, and there was a significant difference in the measure of pre treatment knowledge level to post treatment knowledge level.

However, Table 4.3 shows that the posttest scores from both the treatments were classified under same group that means that there was no significant difference in the performance level of the students in the two groups. In other words, the null hypothesis has to be accepted and the alternative hypothesis has to be rejected.

The four statistics displayed in Table 4.5 test the null hypothesis that the standard deviations of Scores within each of the 4 levels of Group are same. Of particular interest are the three P-values. Since the smallest of the P-values is greater than or equal to 0.05, there is no statistically significant difference among the standard deviations at the 95.0% confidence level.

CHAPTER V

SUMMARY AND CONCLUSION

INTRODUCTION

The research questions will be considered in order. They are re-listed below for convenience.

RQ1. Does using animation-with-text instruction increase learning?

RQ2. Does using graphics-with-text instruction increase learning?

RQ3. What differences exist between the animation with text instruction as compared to graphic with text in recall, inference and comprehension levels of the scientific concept taught?

RESEARCH QUESTION # 1

On the animation-with-text group pretest and posttest scores, since the P-value of the F-test is less than 0.05, there is a statistically significant difference between the mean scores from one level of the group to another at the 95.0% confidence level. The mean values of 5.5 and 7.1 respectively show that there was a significant difference on the pre and post results analyzed by ANOVA test. Animations increased learning.

RESEARCH QUESTION # 2

On the graphics-with-text group pretest and posttest scores, since the P-value of the F-test is less than 0.05, there is a statistically significant difference between the mean Scores from one level of the group to another at the 95.0% confidence level. The mean values of 5.1 and 7.1, respectively show that there was a significant difference on the pre and post results analyzed by ANOVA test. Graphics increased learning.

RESEARCH CONTRIBUTIONS AND CONCLUSIONS OF RQ1 AND RQ2

It seems important for instructional designers to be aware of an instructional treatment that has been shown to increase the performance based on the visual treatment pretest and posttest results. This study indicates the value of instructional materials that increase the learner's chances of building connections between words and pictures.

RESEARCH QUESTION # 3

On the animation and graphics with text instruction, posttest scores with the mean values of 7.1, 7.1 respectively imply that there was not a statistically significant difference between the two groups. However, the pretest scores of animation-with-text (AnimationPre) group and graphics-with-text group (GraphicsPre) fall under the same group. This implies that the pretest proved that the two sample populations had same prior knowledge about the tested material. In other words, it validates the random assignment of the subjects to their respective groups. Once the pretest scores of both groups show equality, it means that any significant difference that is observed among the posttest scores can be attributed to the treatments the corresponding groups underwent.

RESEARCH CONTRIBUTIONS AND CONCLUSIONS OF RQ3

Both treatments lead to similar learning gains. In this setting, it did not matter whether students used animation or graphics.

RECOMMENDATIONS FOR FURTHER WORK

It might be interesting to look more closely to the interaction provided in the animation-with-text instruction. This study presented text and animation concurrently; instead it would be useful to see if differences arise by presenting the speech instead of words slightly after the subsequent visuals.

This study was not undertaken to investigate the effect of the age of individual students on learning. It would be interesting to see if age of the students could contribute towards designing and improving the instructional message design.

The animation-with-text group instructions in this study lack the tracking feature, which could help track users interaction with animation in terms of the time spent on each animation clip by the users. Adding this feature could be helpful in analyzing the details like the maximum and minimum time spent on animation clip by the users, could this infer more time spent on the animation is due to the difficulty of the topic or due to some other variable. This could be helpful in understanding the instructional design elements and the psychology behind the content covered in the animation clip.

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APPENDIX A

UNL IRB APPROVAL LETTER

APPENDIX B

CONSENT FORMS

Parental/Guardian Consent Form

Effect of computer animations on learning

Investigators:

Dr. David W. Brooks
Professor of Chemistry Education
118 Henzlik
University of Nebraska-Lincoln
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Dr. Tiffany M. Heng-Moss
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Sushma Jolly
Graduate Student,
Curriculum and Instruction
University of Nebraska-Lincoln
Phone: (402) 466-4686

You are invited to permit your child to participate in this research study. The following information is provided in order to help you to make an informed decision whether or not to allow your child to participate. If you have questions please do not hesitate to ask.

Your child is eligible to participate in this study because your child falls in the age group of grade 6th students.

The purpose of this study is to investigate the effect of computer animations on learning. The entire study will take about 12 minutes to complete. Your child will be asked to fill out a questionnaire before and after viewing a computer or reading a text regarding the life cycle of a Monarch butterfly. The questionnaire attempts to estimate the amount of information that was learned by your child by quizzing them to recall and inference the scientific concepts presented to them.

The information obtained from this study will help us answer the question if applying a visual treatment in the coursework at primary schools helps break complex events into simple functional procedural events; and if the use of these animations increases the student involvement and learning.

____

Initials of Parent/Guardian

There are no known risks or discomforts associated with participating in this study.

The data collected will be stored in one of the investigators' office and will only be seen by the investigators involved in this study. Findings obtained in this study may be published in journals or presented at academic meetings but the data will be reported as aggregate data.

Your child's rights as a research subject have been explained to you. If you have any additional questions concerning your child's rights as a research subject that have not been answered by the investigator, you may contact the University of Nebraska – Lincoln Institutional Review Board, telephone 472-6965.

You are free to decide not to enroll your child in this study or to withdraw your child at any time during the study without adversely affecting their or your relationship with the investigators or the University of Nebraska. Your decision will not result in any loss of benefits to which your child is otherwise entitled. All the children participating and completing the study will be given one Lincoln Folsom Zoo's train ride ticket free at the end of the study.

A copy of the findings will be made available to interested participants.

Thank you.

DOCUMENTATION OF INFORMED CONSENT

YOU ARE VOLUNTARILY MAKING A DECISION WHETHER OR NOT TO ALLOW YOUR CHILD TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE CERTIFIES THAT YOU HAVE DECIDED TO ALLOW YOUR CHILD TO PARTICIPATE HAVING READ AND UNDERSTOOD THE INFORMATION PRESENTED. YOU WILL BE GIVEN A COPY OF THIS CONSENT FORM TO KEEP.

____ _______________

SIGNATURE OF PARENT/GUARDIAN **DATE**

Child Assent Form

Effect of computer animations on learning

Investigators:
Dr. David W. Brooks
Professor of Chemistry Education
118 Henzlik
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Sushma Jolly
Graduate Student,
Curriculum and Instruction
University of Nebraska-Lincoln
Phone: (402) 466-4686

We would like to invite you to participate in this study. We are asking you because you fall in the age group of grade 6^{th} students.

In this study we are trying to find the effect of computer animations on learning. To do the study we will ask you to view a computer or read a text regarding the lifecycle of a Monarch butterfly. You will be asked to take a quiz before and after you view a computer or read the text. The quiz tries to find the amount of information that was learned by you through the animation or text.

The reason we are doing this study is to help improve ways of teaching and to make learning more interesting at primary schools.

Your parents/guardian will also be asked to give their permission for you to take part in this study. Please talk this over with your parents before you decide whether or not to participate.

You do not have to be in this study if you do not want to. If you decide to participate you can stop at any time. You will be given one Lincoln Folsom Zoo's train ride ticket free when you complete this study.

If you have any questions please ask one of the researchers.

IF YOU SIGN THIS FORM IT MEANS THAT YOU HAVE DECIDED TO PARTICIPATE AND HAVE READ EVERYTHING THAT IS ON THIS FORM. YOU AND YOUR PARENTS/GUARDIAN WILL BE GIVEN A COPY OF THIS FORM TO KEEP.

______________________________________ ______________

SIGNATURE OF SUBJECT **DATE**

______________________________________ ______________

SIGNATURE OF INVESTIGATOR **DATE**

APPENDIX C

PRETEST & POSTTEST

PRETEST
Name: ______________________________________ **Age:** _______ **Grade:** _______
School: ____

A. How many hours each week do you use a computer?
☐ 0 ☐ 1 ☐ 2 ☐ 3-4 ☐ 5 or more

B. Where do you use a computer? (Check all that apply to you)
☐ Home
☐ School
☐ Library
☐ Other (Please specify)____________________________________

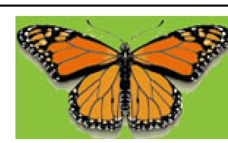
1. Which of the following predators like to eat monarchs?
☐ Bird
☐ Insect
☐ Frog
☐ None of the above

2. How much time does it take for the caterpillar to emerge from the egg?
☐ One week
☐ One year
☐ One month
☐ Four days

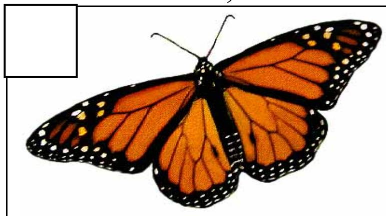
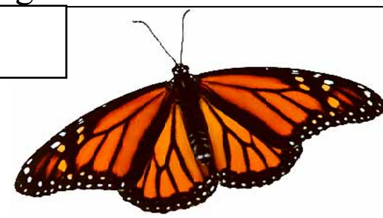
3. What parts of its body does a monarch use to find food?
☐ Proboscis
☐ Eyes
☐ Head
☐ Legs

4. The monarch's life cycle. Suppose you saw the stage of the Monarch shown on the right.

In the boxes below, write:
An "F" for the stage that this stage came from
A "T" for the stage that this stage will change to



5. Check the box, which of the following is a male Monarch.

☐  ☐ 

6. What is metamorphosis?

____

____

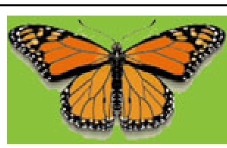
____

____

7. Write the name of the stages

____

____



____

____

THANKS!

POSTTEST

Name: ________________________________ Age: _______ Grade: _______

School: ____

1. When the caterpillars hatch from the eggs what do they eat first?

- Tulips
- Milkweed
- Their own eggshell
- Grass

2. How much time does it take for the caterpillar to emerge from the egg?

- One week
- One year
- One month
- Four days

3. What parts of its body does a monarch use to find food?

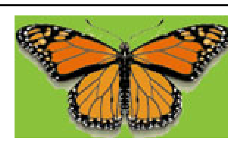
- Proboscis
- Eyes
- Head
- Legs

4. The monarch's life cycle. Suppose you saw the stage of the Monarch shown on the right.

In the boxes below, write:

An "F" for the stage that this stage came from

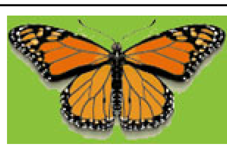
A "T" for the stage that this stage will change to



5. Check the box, which of the following is a male Monarch.

6. What is metamorphosis?

7. Write the name of the stages



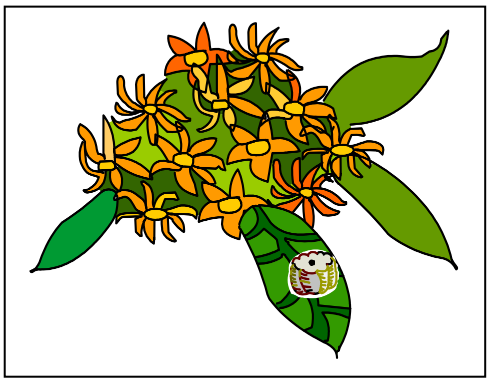
THANKS!

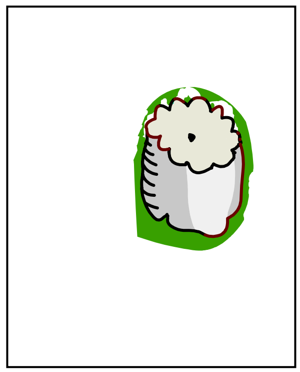
APPENDIX D

PAPER-BASE INSTRUCTION

The Life-Cycle of Monarch Butterfly

Stage One: Laying Eggs





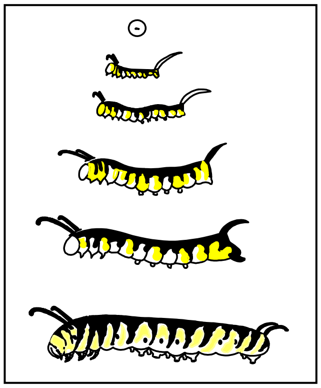
A female monarch butterfly lays her eggs on the leaves of milkweed plants.

Stage Two: Larva/Caterpillar

A. Caterpillar emerging

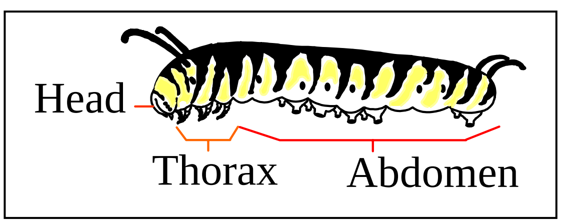
Within three to five days, the eggs hatch and a small caterpillar comes out. It also is called a larva. The caterpillar eats its eggshell, which is a good source of protein.

B. Molting Stage



The function of the larva (caterpillar) is very simple: to eat and grow. It eats so much that it is too big for its skin. It wiggles and finally splits its tight skin open. Then it crawls out. This process of shedding its skin is called molting. It molts four times during the larval stage. Under normal temperatures it stays in this stage from nine to fourteen days.

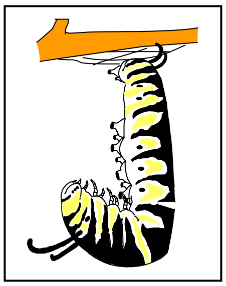
C. Adult Caterpillar



After the final molt, the adult caterpillar reaches its growth size. These are the basic body parts of the mature caterpillar. When the caterpillar reaches its full-grown size it hangs itself upside down in a J-shape.

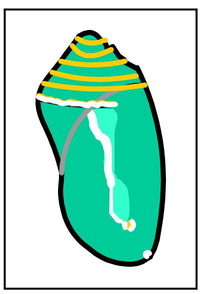
Stage Three: Pupa

A. J-Shape Transformation



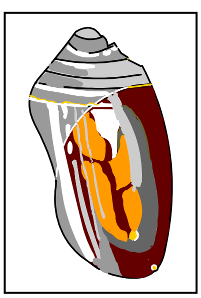
The caterpillar stops eating and looks for an ideal spot where it can become a pupa. This is a very important stage where the larva will hang upside down on its self-created small ball of silk.

B. Chrysalis



The pupa slowly starts condensing its body and forms the outer layer, which looks like a green shell. It stays in this stage for ten to fourteen days. The Pupa is often called as a chrysalis.

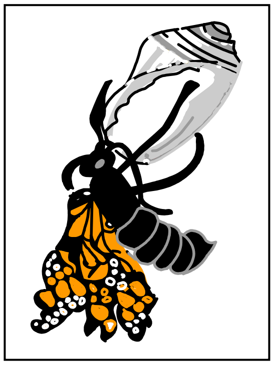
C. Darkening of Casing



The case darkens in color and eventually the shell splits open. The butterfly will emerge from it.

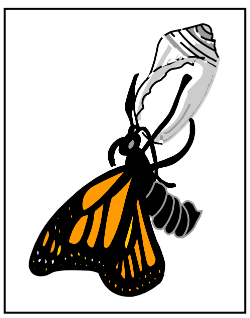
Stage Four: Butterfly Emerging

A. Emerging



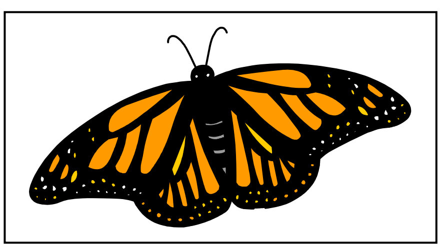
The butterfly pulls its wings and abdomen out of the shell. The case is split and the color of the wings can be seen.

B. Pumping of wings



After several hours, the butterfly has expanded and hardened its wings.

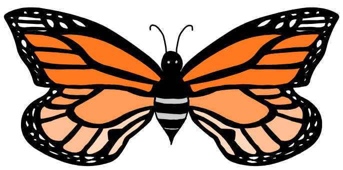
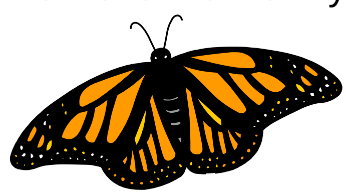
C. Adult Butterfly



The butterfly is ready to fly now. If it’s a summer generation it lives for three to four weeks. If it’s a fall generation it lives for about nine months.

Difference between Male and Female Monarch Butterflies

Butterflies are found in both the genders male and female. The difference between the two is explained below.

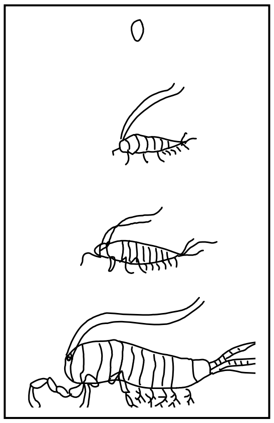
Male Butterfly	Female Butterfly
 The black spots on the hind wings show that this is a male butterflv	 Female butterflies have thicker webbing and no black spots.

What is Metamorphosis

Most insects undergo changes in shape or form during their development this is called metamorphosis. Some may have no modifications while others may have major modifications in their growth. There are three different types:

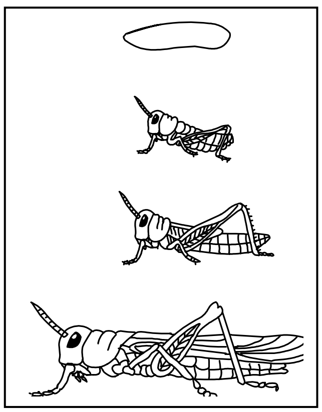
1. No Metamorphosis
2. Incomplete Metamorphosis
3. Complete Metamorphosis

No Metamorphosis



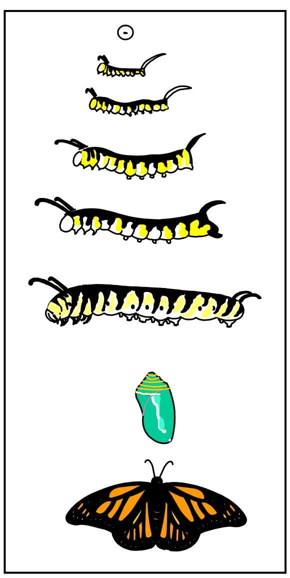
This is an example of no Metamorphosis where the body in the immature stage looks similar to the adult, only smaller. This is a bristletail. This insect only changes in size when it grows from an immature into a mature insect.

Incomplete Metamorphosis



This is an example of incomplete Metamorphosis where there is great change in the appearance between the immature and adult. One of the main changes is the development of wings on the adult. Grasshoppers exhibit this type of metamorphosis.

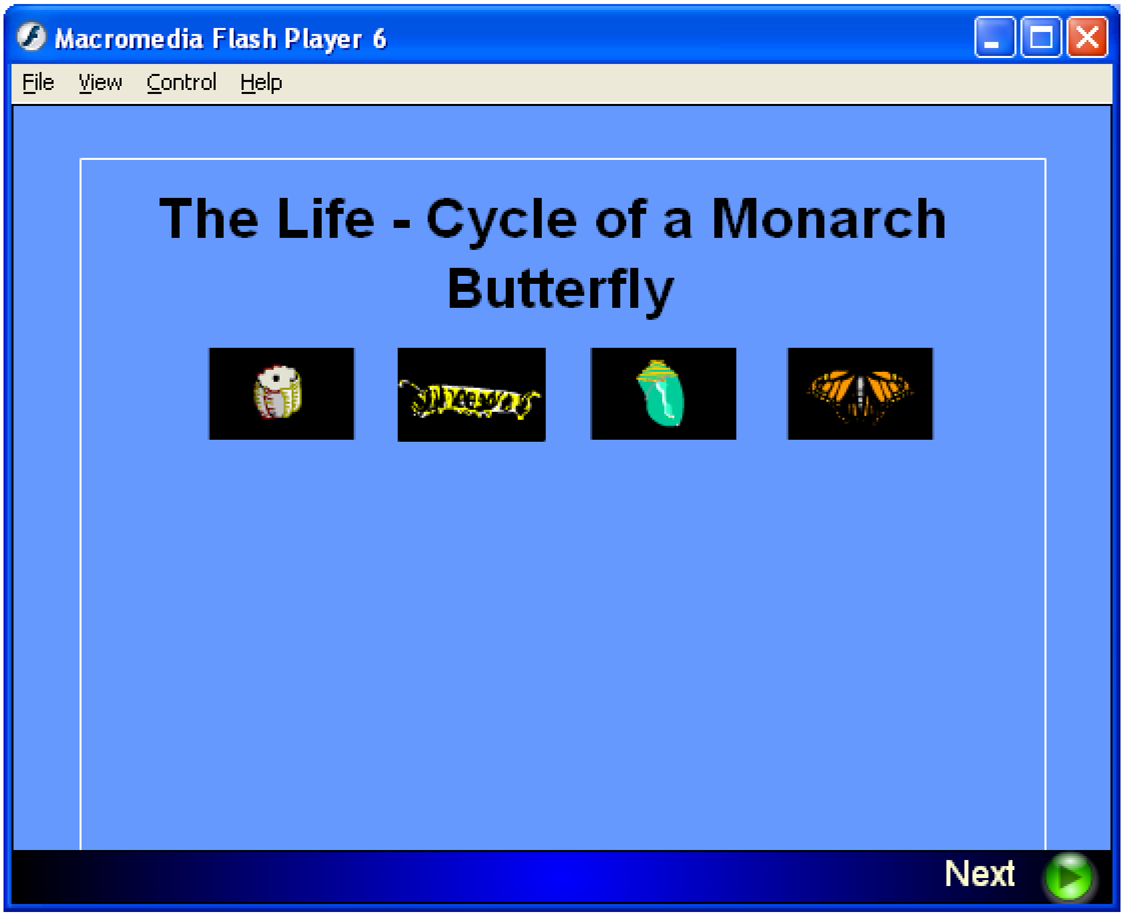
Complete Metamorphosis



In complete metamorphosis, the insect undergoes a drastic change during development between the immature and adult stages. A monarch shows complete metamorphosis.

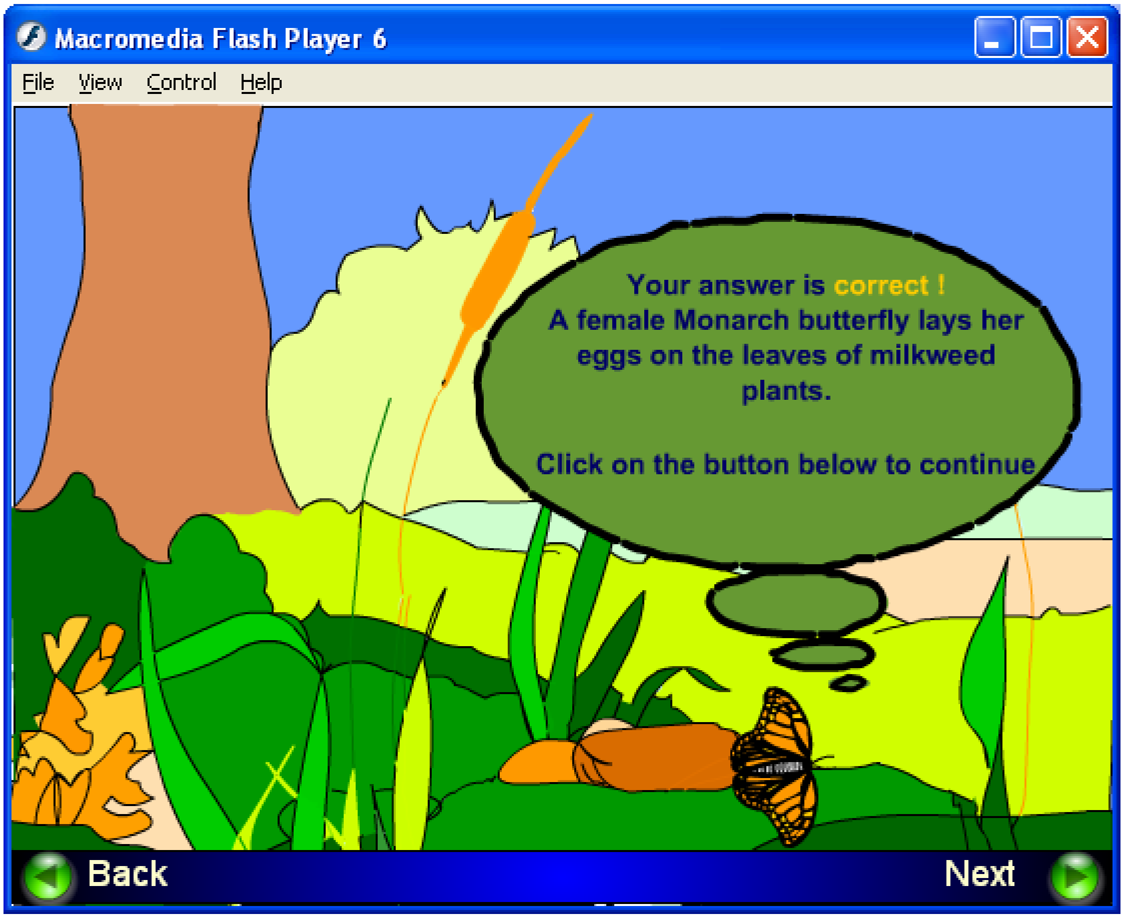
APPENDIX E

COMPUTER-BASE INSTRUCTION (ANIMATION PRINTOUT)


Macromedia Flash Player 6
File View Control Help
The Life - Cycle of a Monarch Butterfly
Next


Macromedia Flash Player 6
File View Control Help
I am looking for the right
spot to lay my eggs...
Do you think laying eggs
on the rocks might be
the right spot ?
Choose the correct answer
YES
NO
Back
Next


Macromedia Flash Player 6
File View Control Help
Sorry, your answer is incorrect.
A female Monarch butterfly lays
her eggs on the leaves of
milkweed plants.
Click on the button below to
continue
Back
Next


Macromedia Flash Player 6
File View Control Help
Your answer is correct !
A female Monarch butterfly lays her eggs on the leaves of milkweed plants.
Click on the button below to continue
Back
Next


Macromedia Flash Player 6
File View Control Help
I think dry leaves are also not a good spot.
Click on the button below to continue
Back
Next


Macromedia Flash Player 6
File View Control Help
Do you think I should lay my
eggs on these milkweed leaves?
Select your answer
YES
NO
Back
Next

Macromedia Flash Player 6
File View Control Help
Correct!
Once the caterpillars hatch
they will be able to feed on
these milkweed leaves

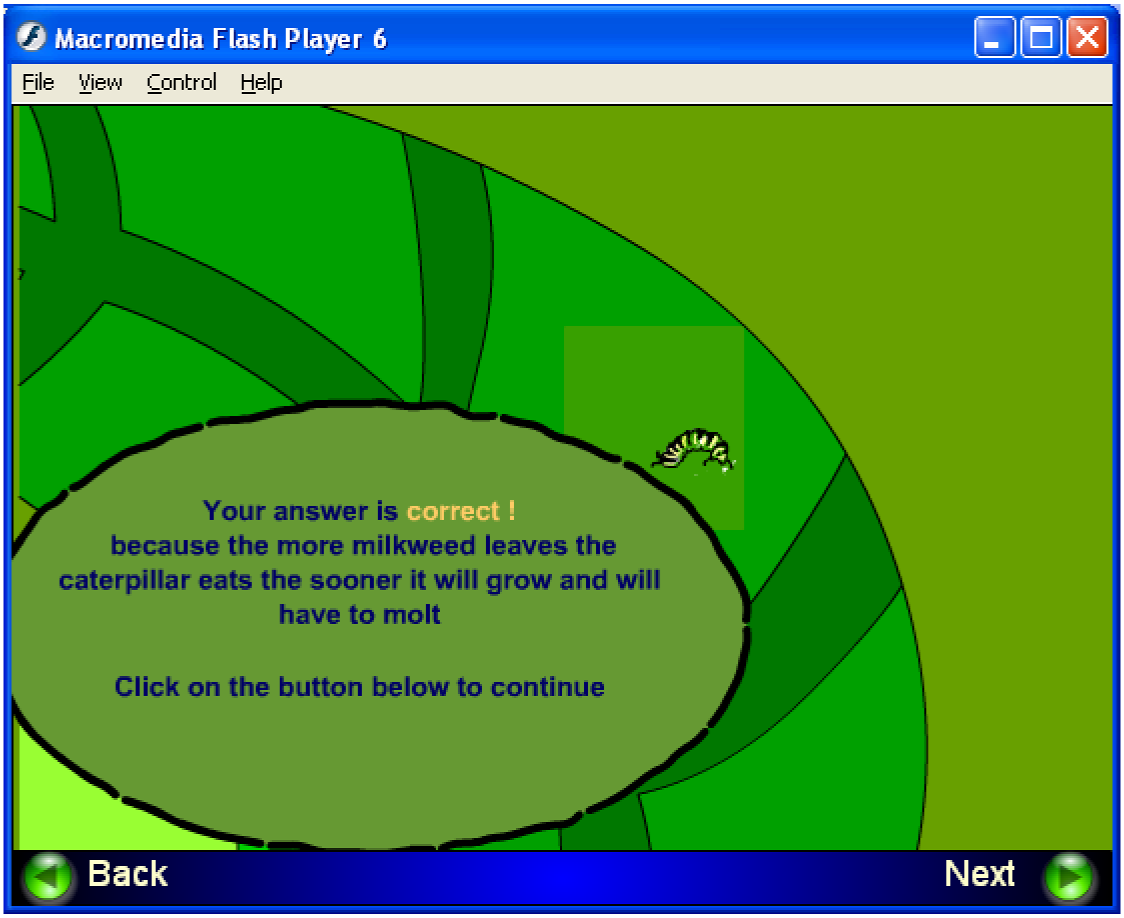
Click on the button below to
continue
Back
Next

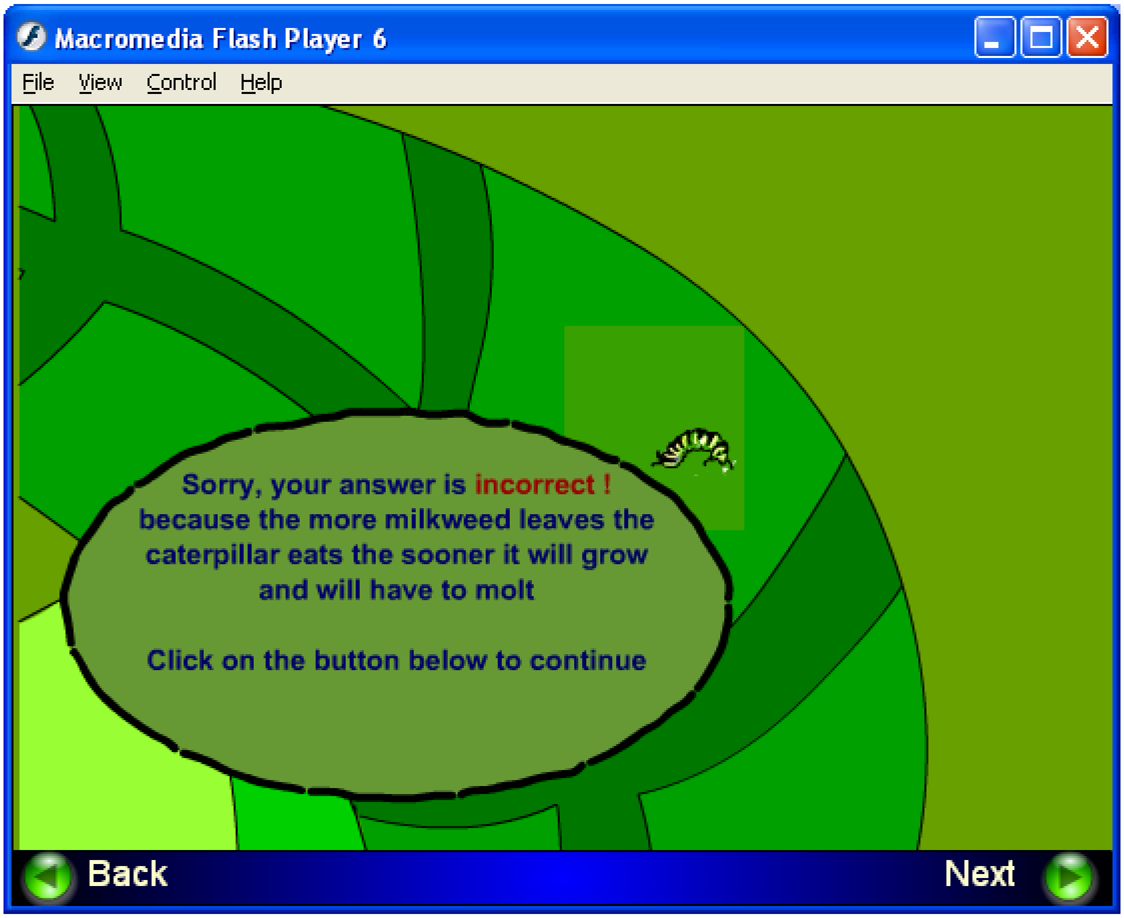

Macromedia Flash Player 6
File View Control Help
Sorry, your answer is incorrect because once the caterpillars hatch they will be able to feed on these milkweed plants. Thus, these leaves are the correct place to lay eggs
Click on the button below to continue
Back
Next


Macromedia Flash Player 6
File View Control Help
EGG STAGE
A female Monarch butterfly lays her eggs on the leaves of milkweed plants. Within four days, the eggs hatch and a small caterpillar comes out and feed on the milkweed plants. It is also called as larva.
Click on the button below to continue
Back
Next


Macromedia Flash Player 6
File View Control Help
LARVA STAGE
The caterpillar loves to eat. The caterpillar eats its eggshell, which is a good source of protein. Later it chews away at the milkweed leaves. Under normal condition it stays in this stage for nine to fourteen days .
Click on the button below to continue
Back
Next

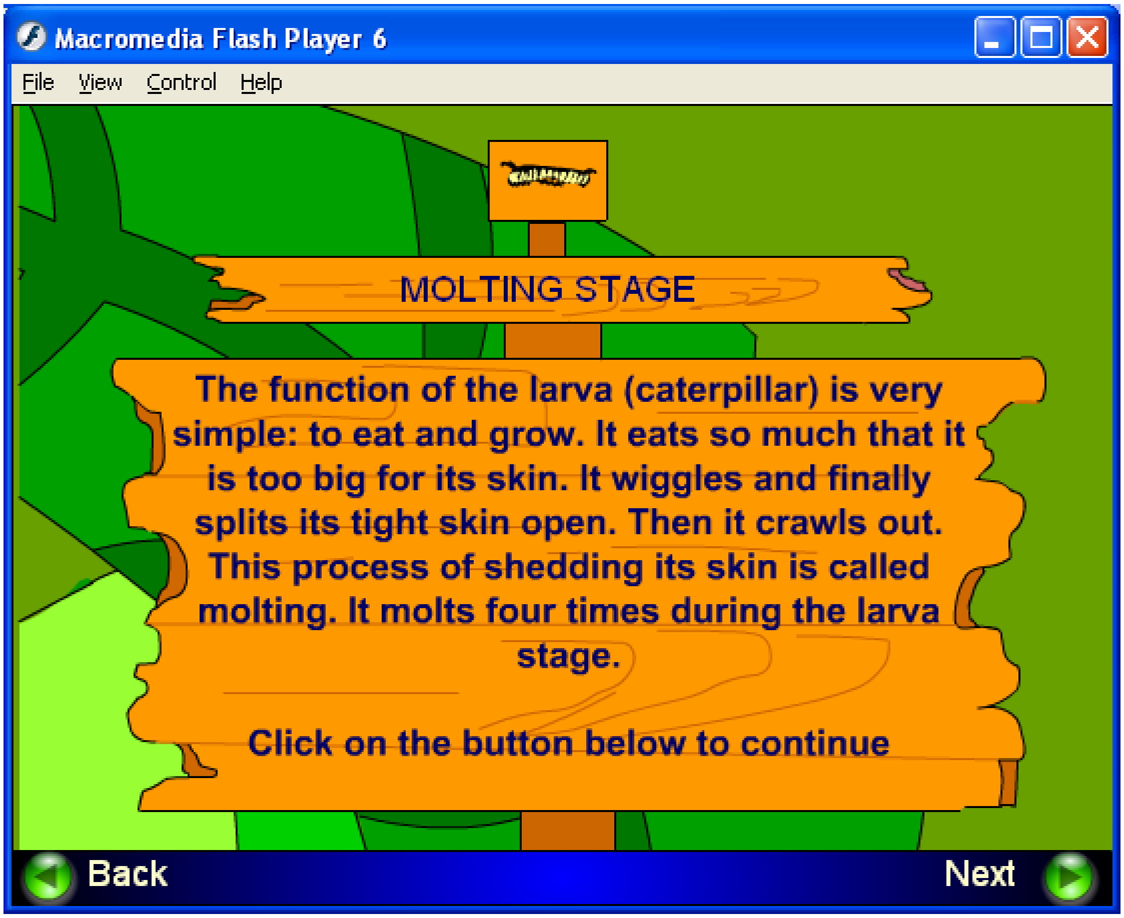

Macromedia Flash Player 6
File
View
Control
Help
After munching on its egg shell,
do you think the caterpillar
should eat green milkweed leaves?
Choose the correct answer
YES
NO
Back
Next

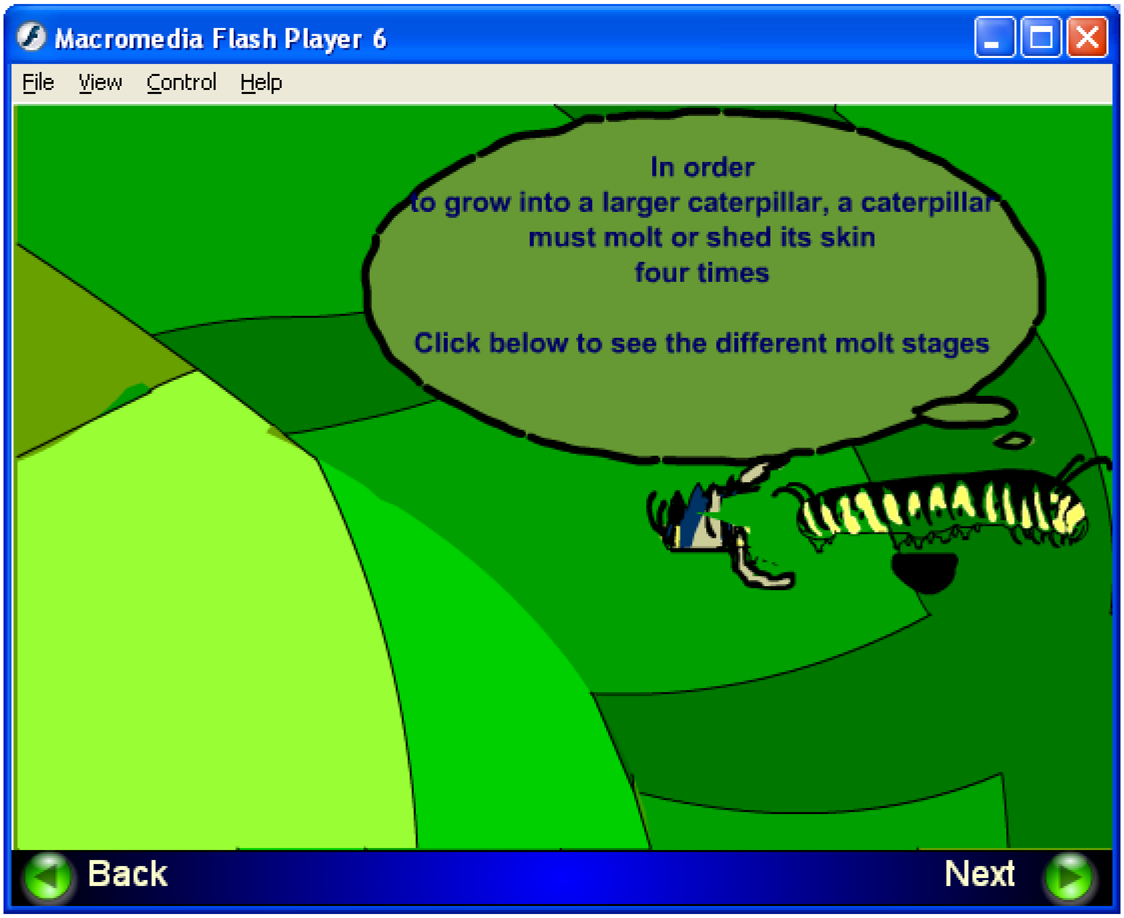

Macromedia Flash Player 6
File View Control Help
Your answer is correct !
because the more milkweed leaves the caterpillar eats the sooner it will grow and will have to molt
Click on the button below to continue
Back
Next


Macromedia Flash Player 6
File View Control Help
Sorry, your answer is incorrect !
because the more milkweed leaves the
caterpillar eats the sooner it will grow
and will have to molt
Click on the button below to continue
Back
Next

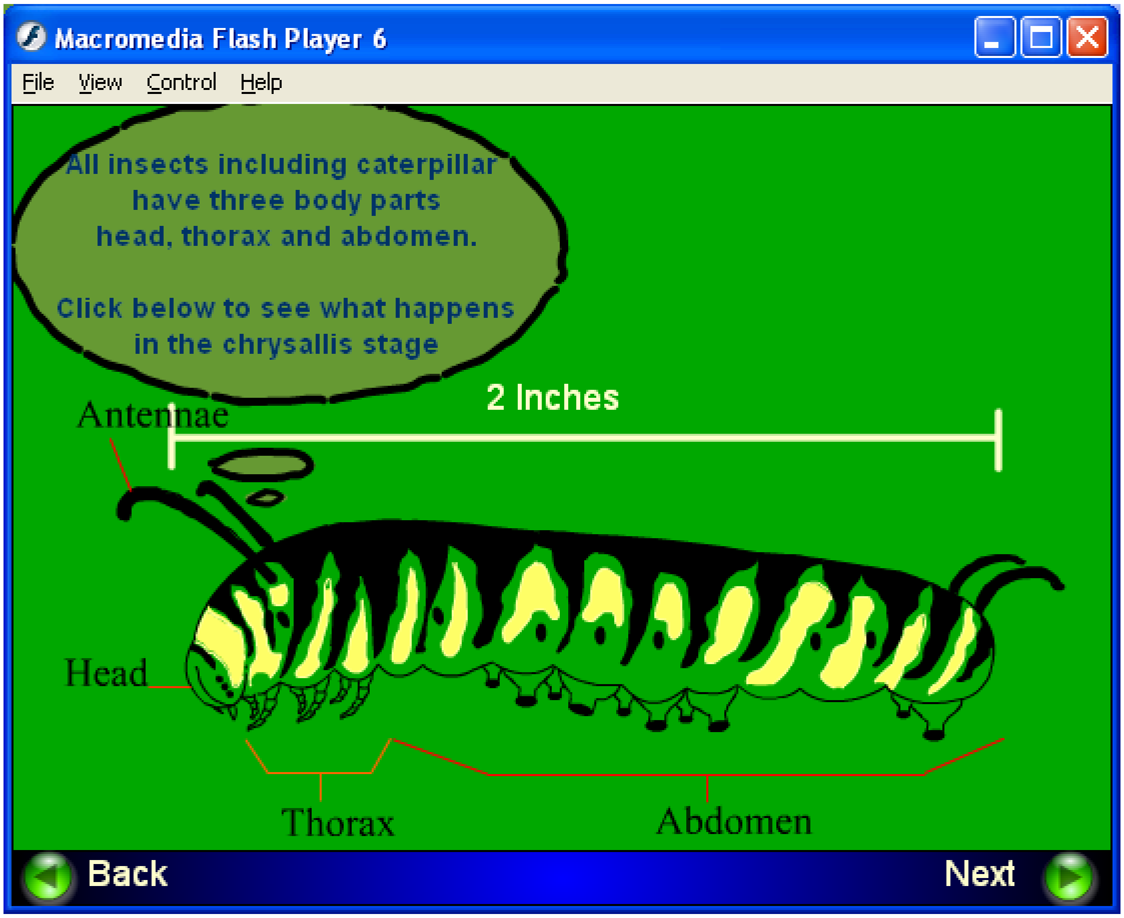

Macromedia Flash Player 6
File View Control Help
Eat, eat and eat...
This is the only way I can
grow and get ready to molt

Click on the button below to
continue
Back
Next


Macromedia Flash Player 6
File View Control Help
MOLTING STAGE
The function of the larva (caterpillar) is very simple: to eat and grow. It eats so much that it is too big for its skin. It wiggles and finally splits its tight skin open. Then it crawls out. This process of shedding its skin is called molting. It molts four times during the larva stage.
Click on the button below to continue
Back
Next


Macromedia Flash Player 6
File View Control Help
In order
to grow into a larger caterpillar, a caterpillar
must molt or shed its skin
four times
Click below to see the different molt stages
Back
Next

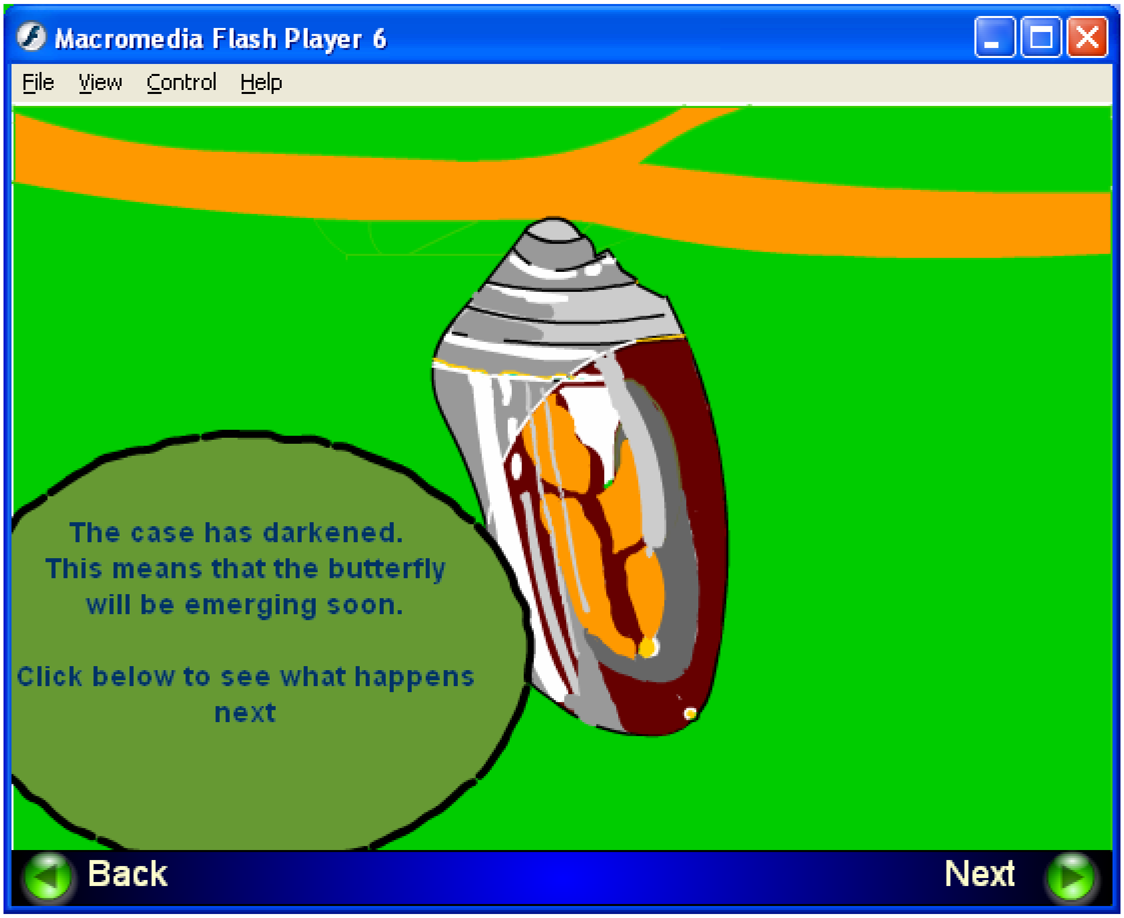

Macromedia Flash Player 6
File View Control Help
There are four different caterpillar stages that a monarch butterfly undergoes before becoming a pupa.
Click on the button below to see a caterpillars body parts
Back
Next


Macromedia Flash Player 6
File View Control Help
All insects including caterpillar
have three body parts
head, thorax and abdomen.
Click below to see what happens
in the chrysallis stage
2 Inches
Antennae
Head
Thorax
Abdomen
Back
Next


Macromedia Flash Player 6
File View Control Help
PUPA STAGE
After the final molt, the adult caterpillar reaches its grown size and hangs itself upside down in a J-shape. At this stage the caterpillar stops eating and looks for an ideal spot where it can become a pupa. It stays in this stage from ten to fourteen days.
Click on the button below to continue
Back
Next

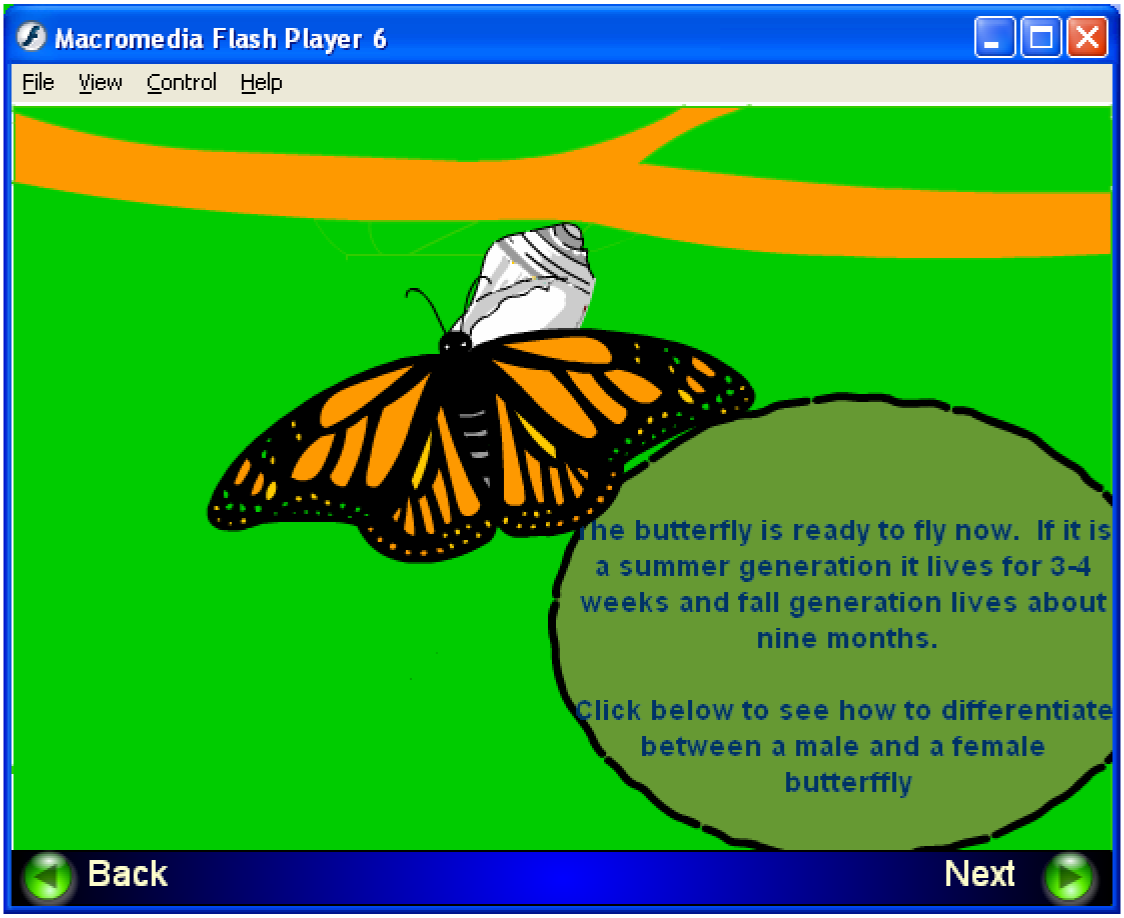

Macromedia Flash Player 6
File View Control Help
I am ready for the chrysalis stage. After hanging myself upside down in a J-shape, I will be encased in a shell soon.
Click below to see what happens next
Back
Next

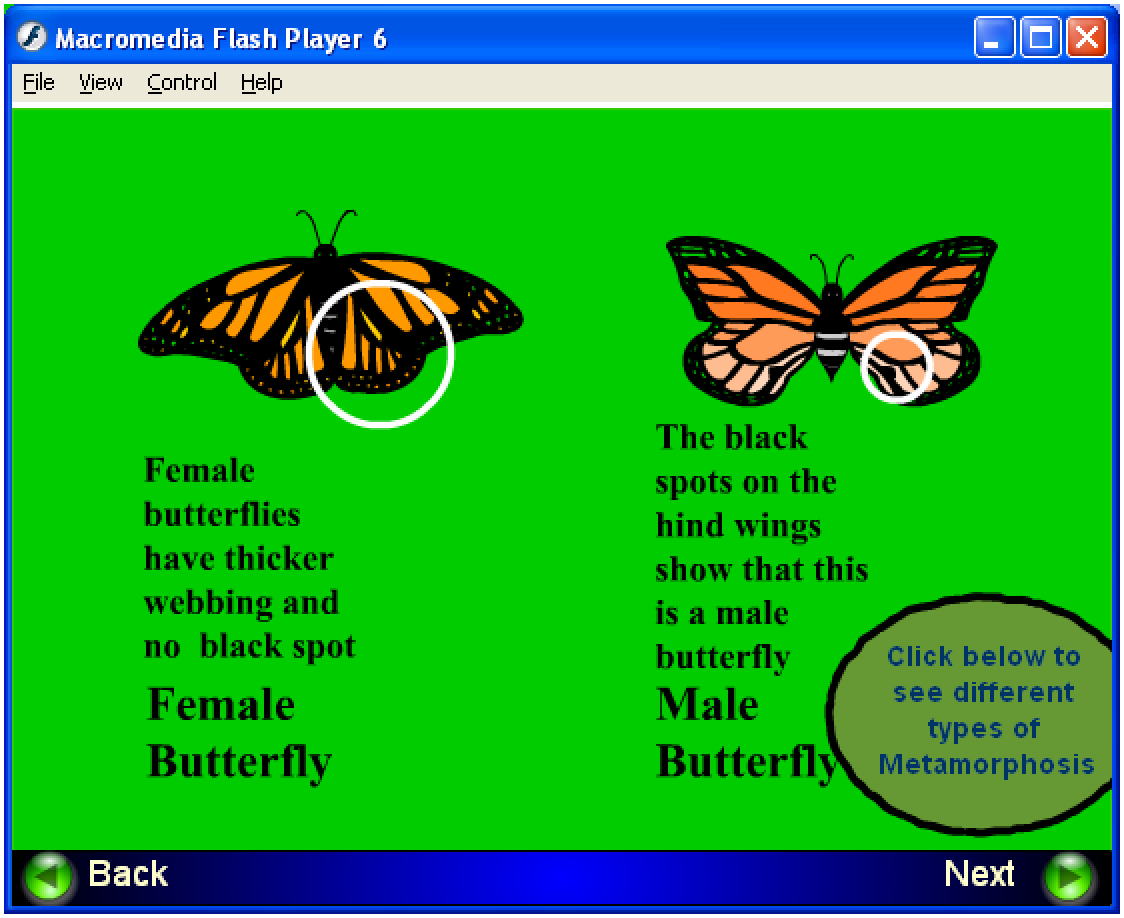

Macromedia Flash Player 6
File View Control Help
he pupa slowly starts condensing its
ody and forms the outer layer, which
ooks like a green shell. The pupa is
often called a chrysalis.
Click below to see what happens
next
Back
Next

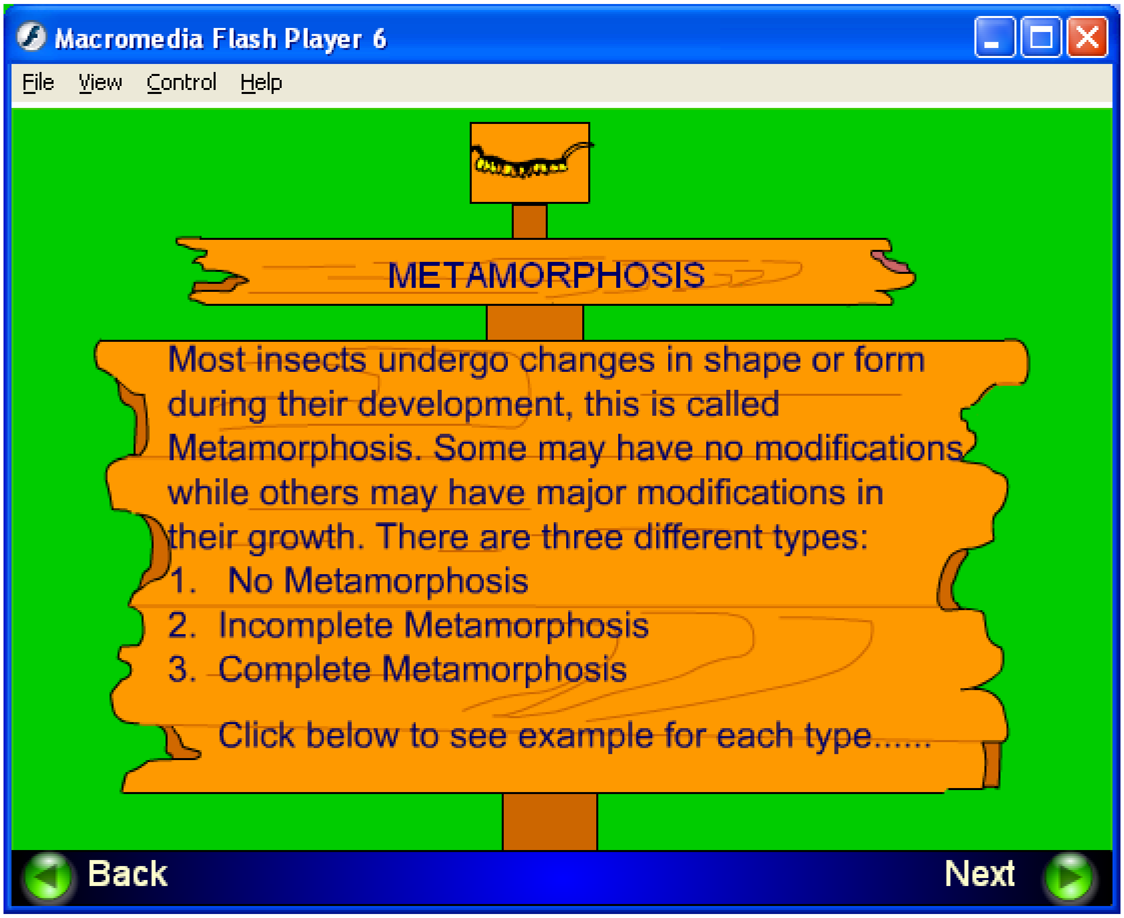

Macromedia Flash Player 6
File View Control Help
The case has darkened.
This means that the butterfly
will be emerging soon.
Click below to see what happens
next
Back
Next


Macromedia Flash Player 6
File View Control Help
The butterfly pulls its wings and abdomen out of the shell .The case has split now and the color of the wings can be seen.
Click below to see what happens next
Back
Next


Macromedia Flash Player 6
File View Control Help
After several hours, the butterfly has expanded and hardened its wings.
Click below to see what happens next
Back
Next


Macromedia Flash Player 6
File View Control Help
The butterfly is ready to fly now. If it is a summer generation it lives for 3-4 weeks and fall generation lives about nine months.
Click below to see how to differentiate between a male and a female butterfly
Back
Next


Macromedia Flash Player 6
File View Control Help
Female butterflies have thicker webbing and no black spot
Female Butterfly
The black spots on the hind wings show that this is a male butterfly
Male Butterfly
Click below to see different types of Metamorphosis
Back
Next


Macromedia Flash Player 6
File View Control Help
METAMORPHOSIS
Most insects undergo changes in shape or form during their development, this is called Metamorphosis. Some may have no modifications while others may have major modifications in their growth. There are three different types:
1. No Metamorphosis
2. Incomplete Metamorphosis
3. Complete Metamorphosis
Click below to see example for each type......
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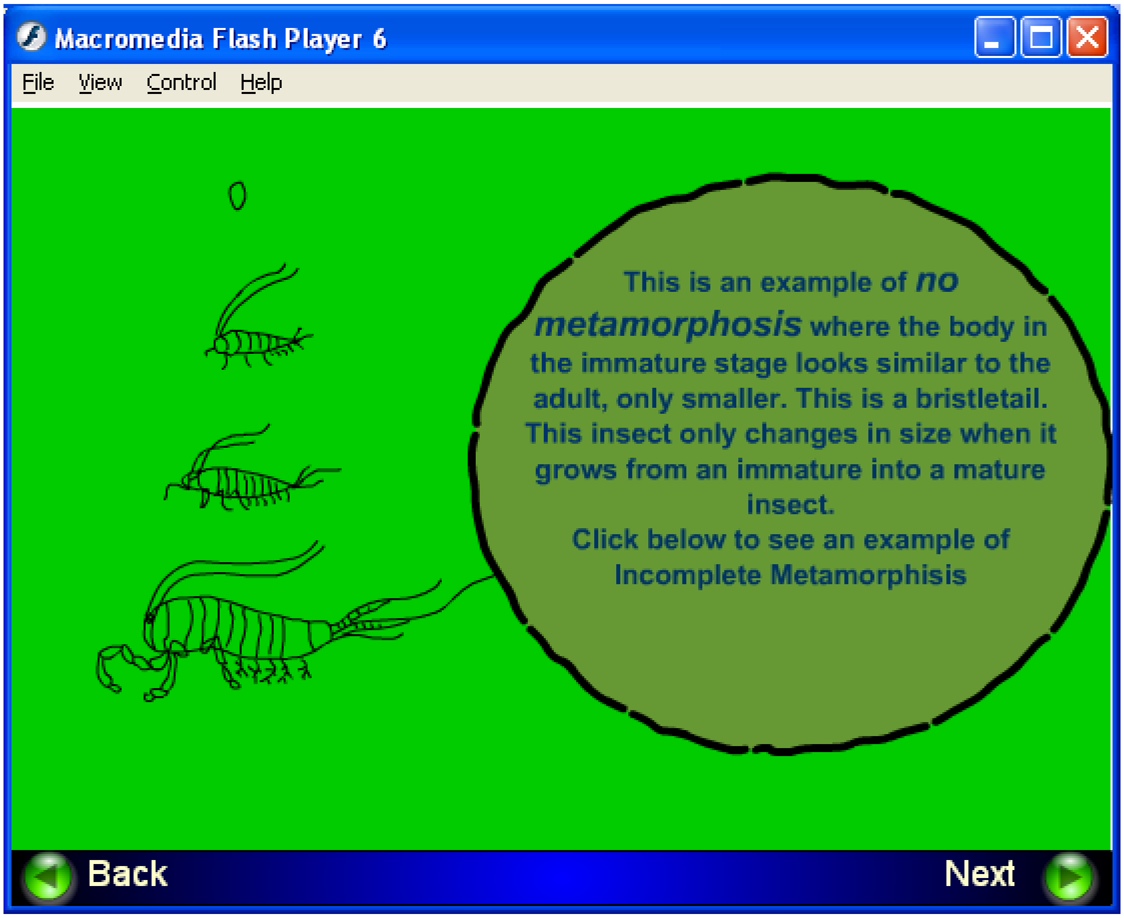
Next


Macromedia Flash Player 6
File View Control Help
This is an example of *no metamorphosis* where the body in the immature stage looks similar to the adult, only smaller. This is a bristletail. This insect only changes in size when it grows from an immature into a mature insect.
Click below to see an example of Incomplete Metamorphisis
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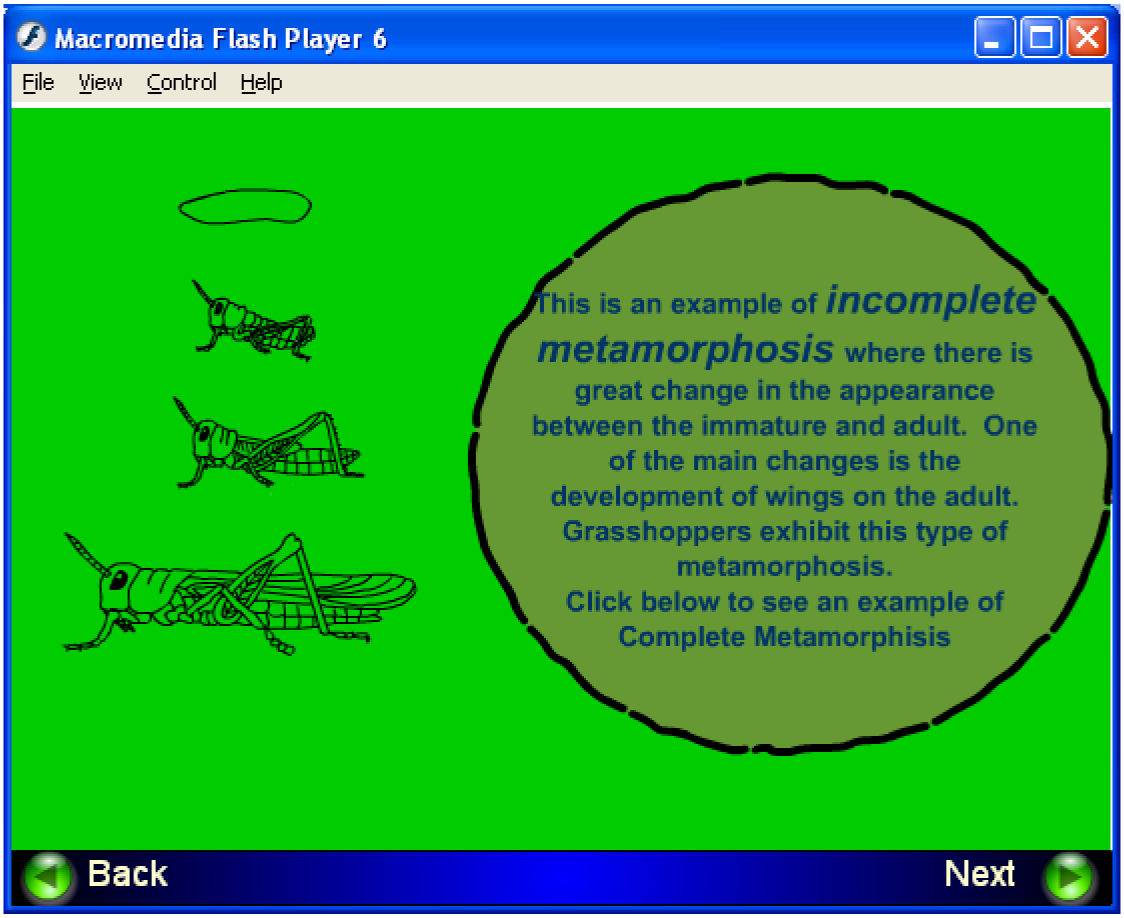
Macromedia Flash Player 6
File View Control Help
This is an example of incomplete metamorphosis where there is great change in the appearance between the immature and adult. One of the main changes is the development of wings on the adult. Grasshoppers exhibit this type of metamorphosis.
Click below to see an example of Complete Metamorphisis
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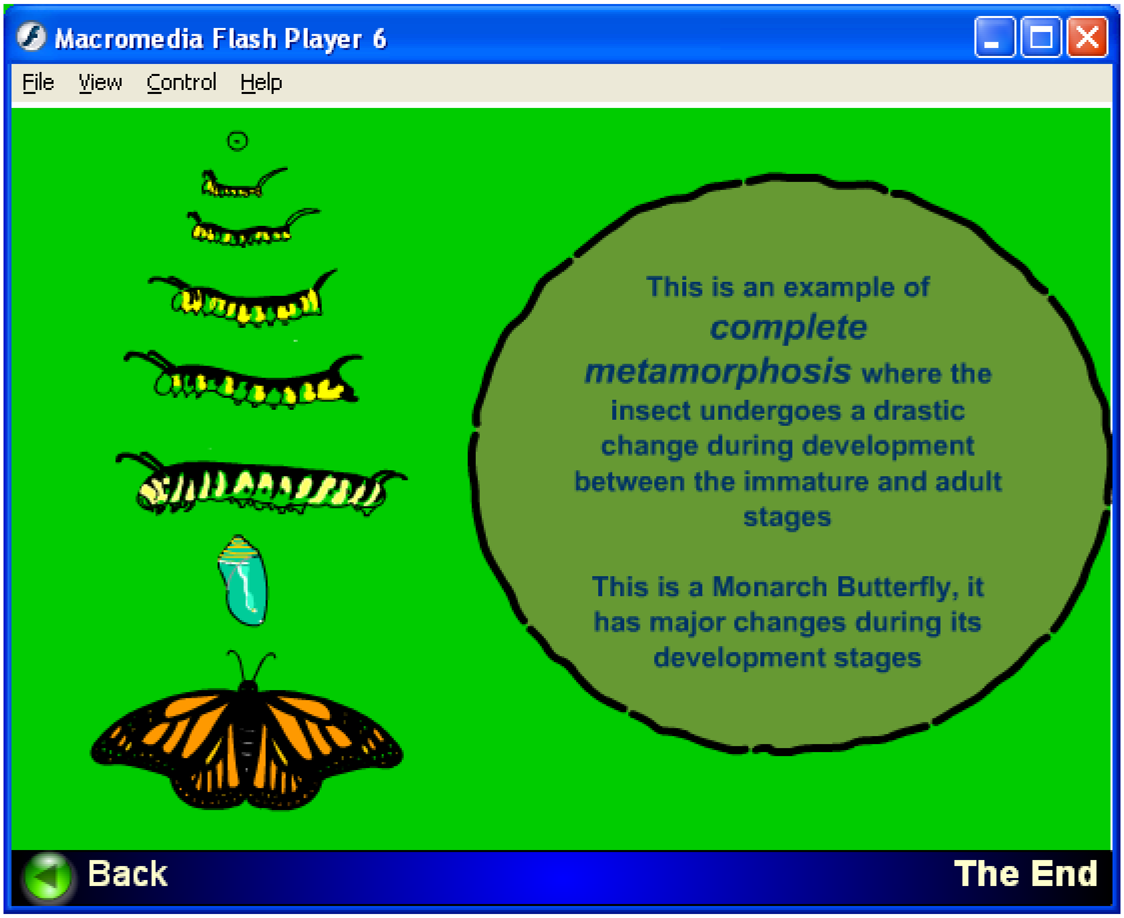
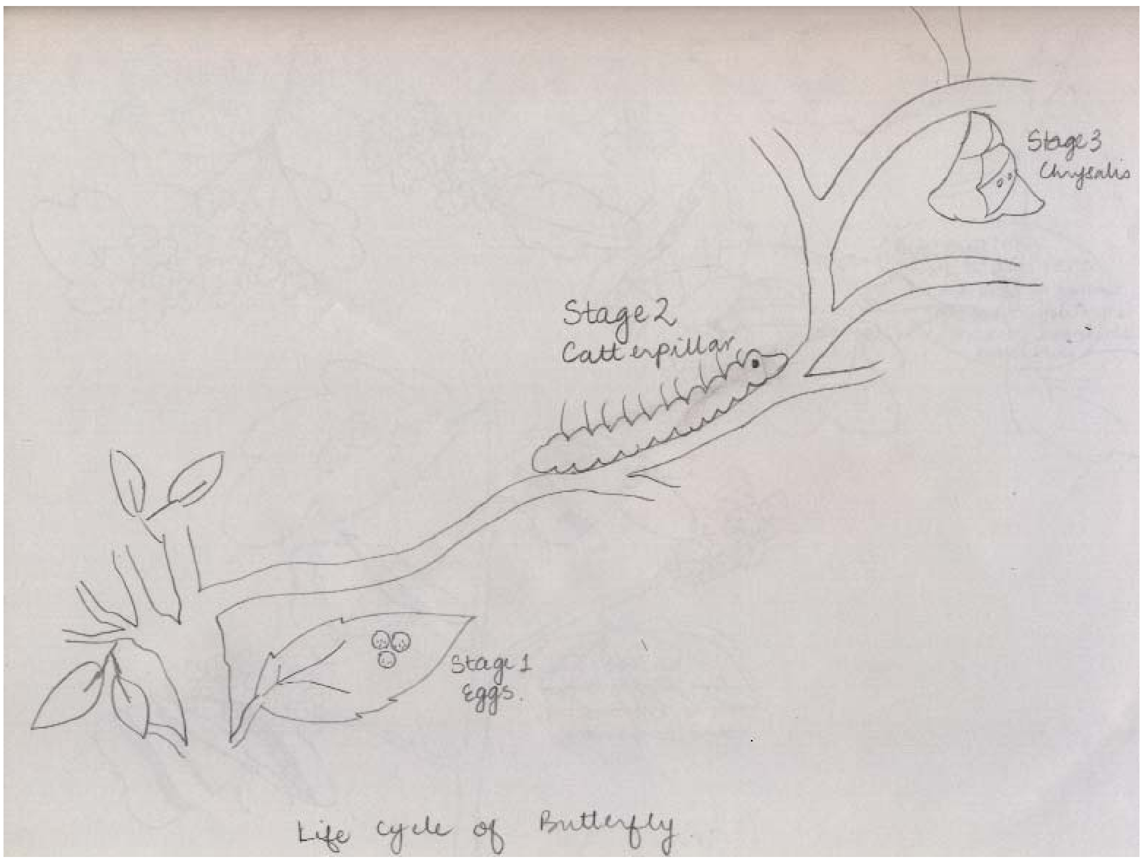
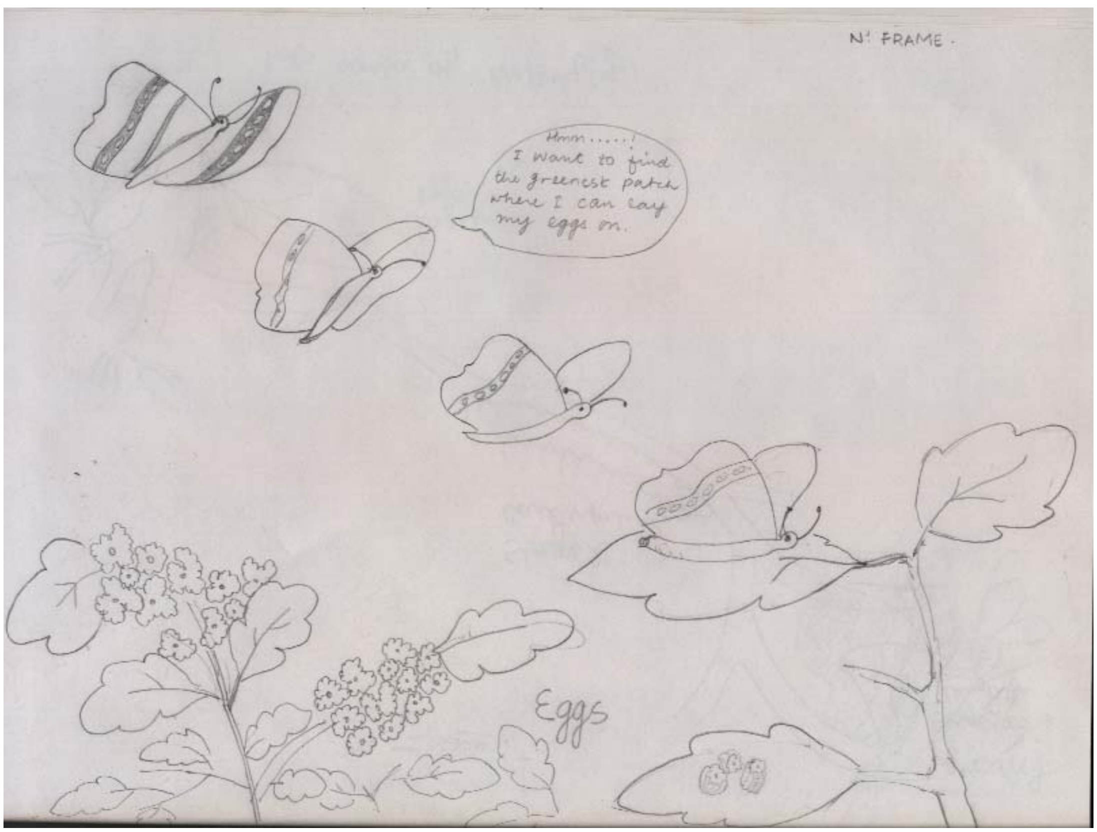
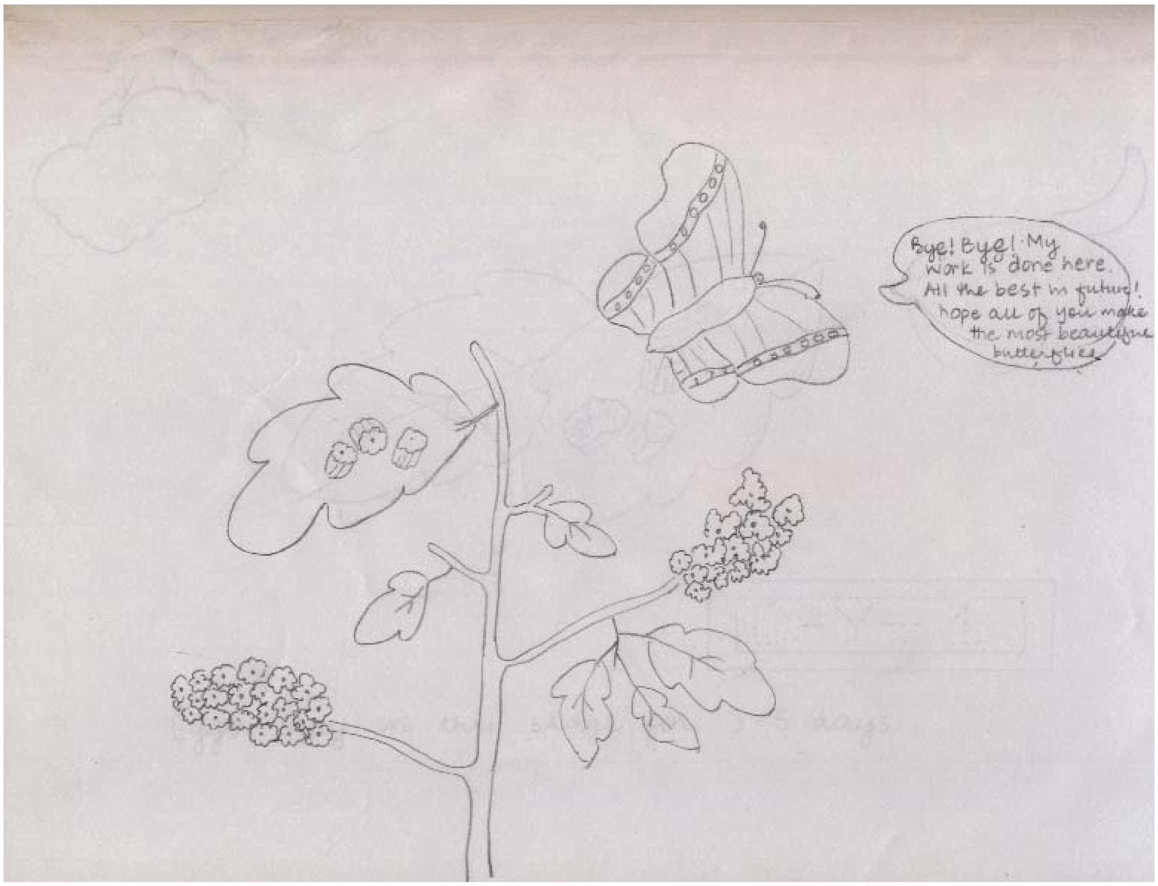

Macromedia Flash Player 6
File View Control Help
This is an example of
complete metamorphosis where the insect undergoes a drastic change during development between the immature and adult stages
This is a Monarch Butterfly, it has major changes during its development stages
Back
The End

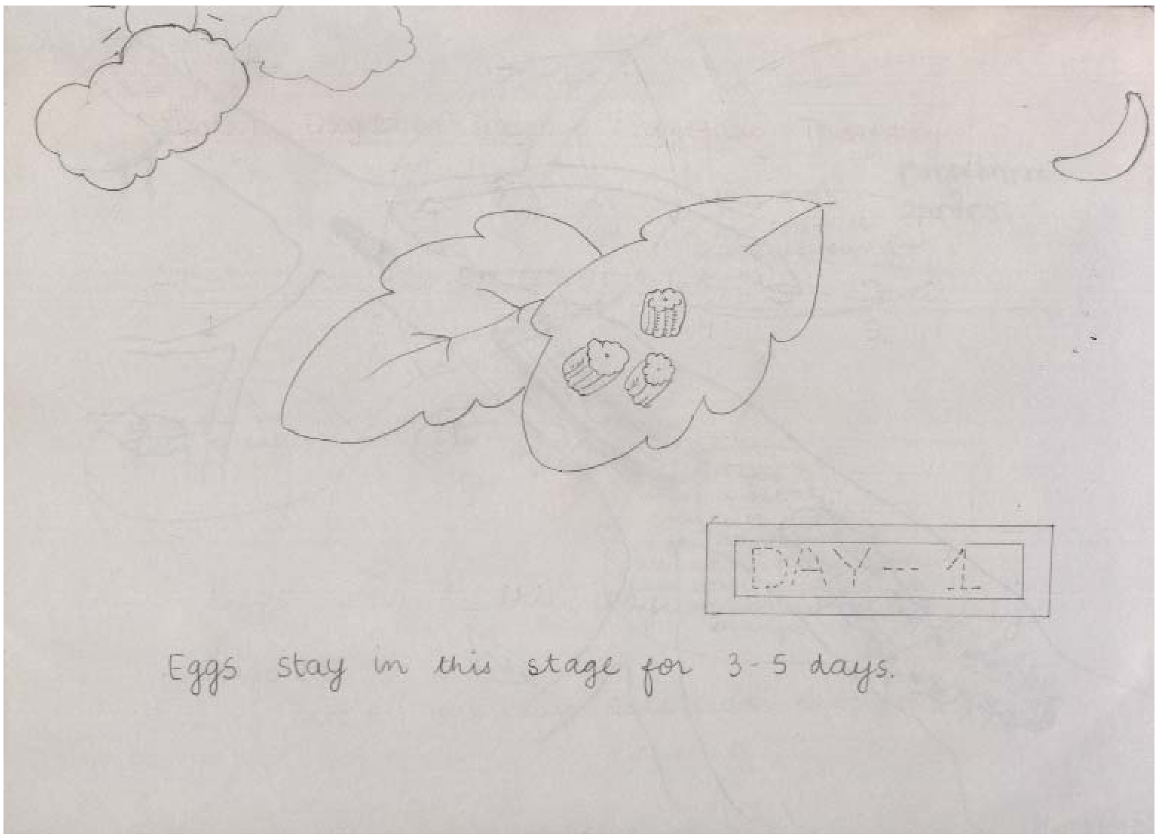
APPENDIX F

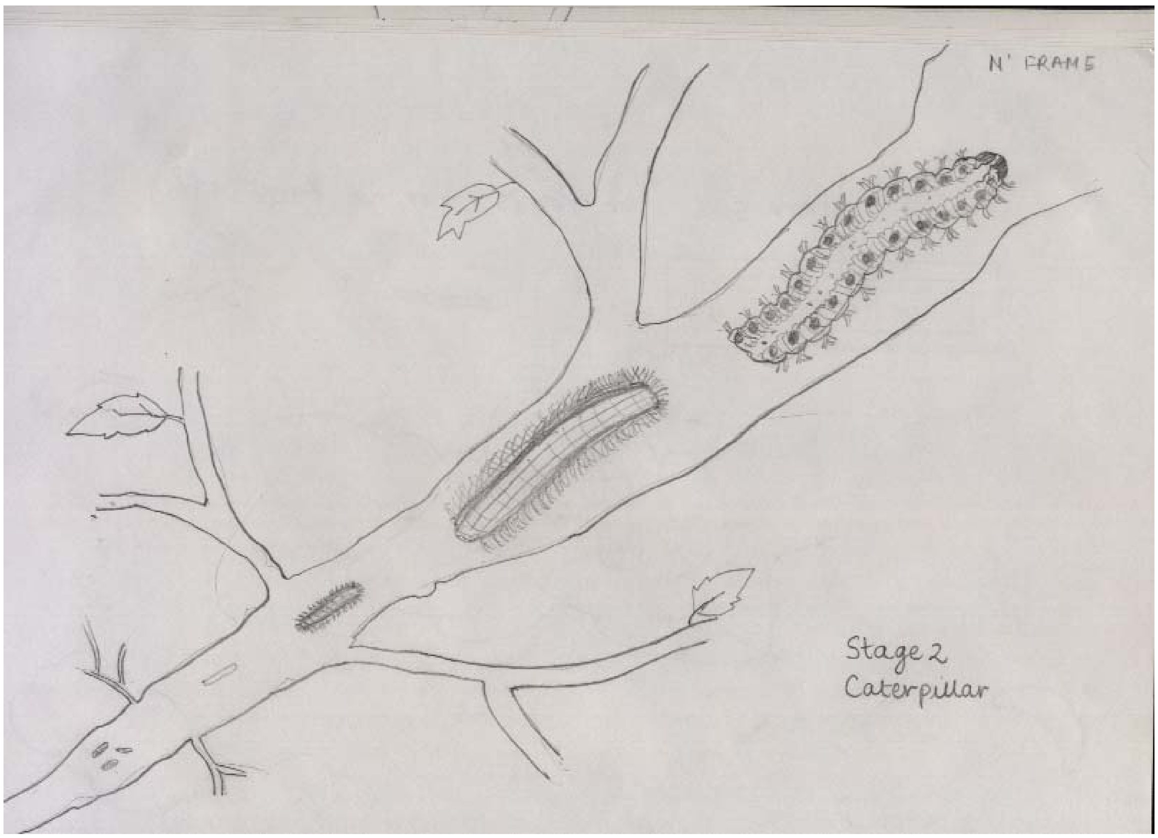
ANIMATION STORYBOARD

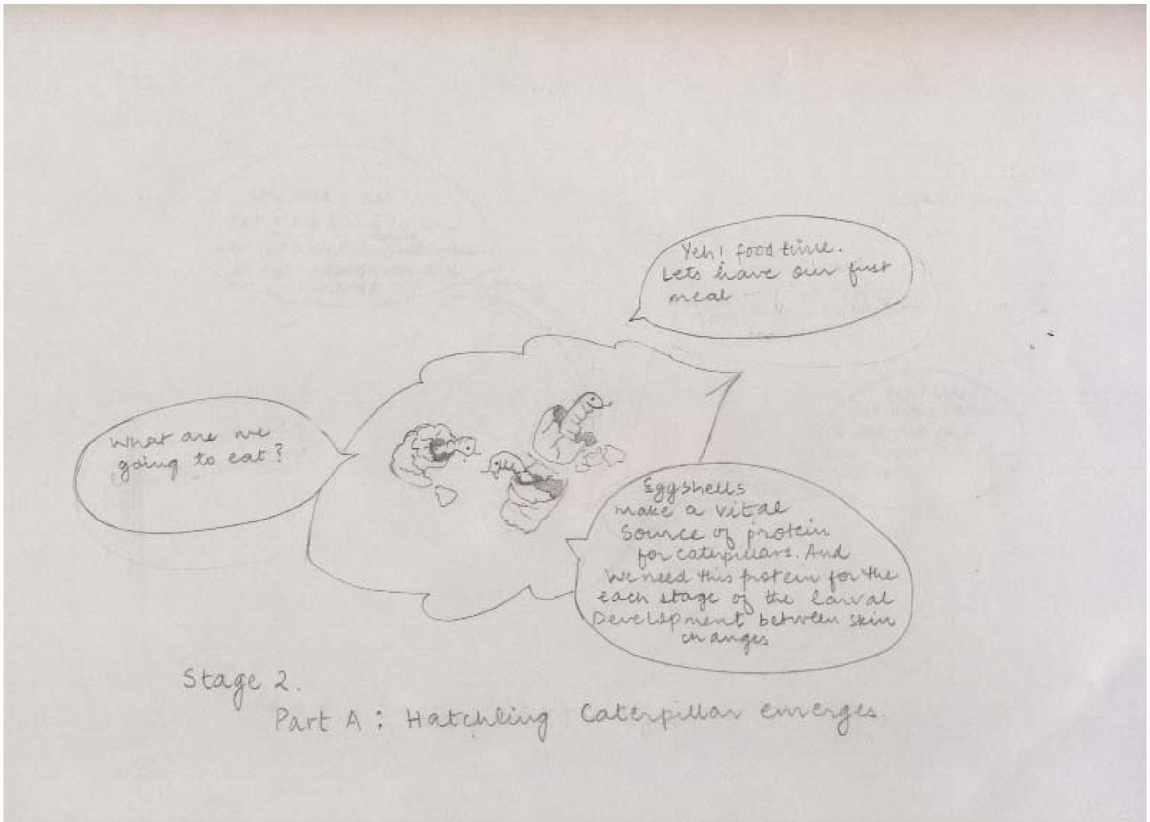

Stage 3
Chrysalis
Stage 2
Catterpillar
Stage 1
Eggs.
Life cycle of Butterfly

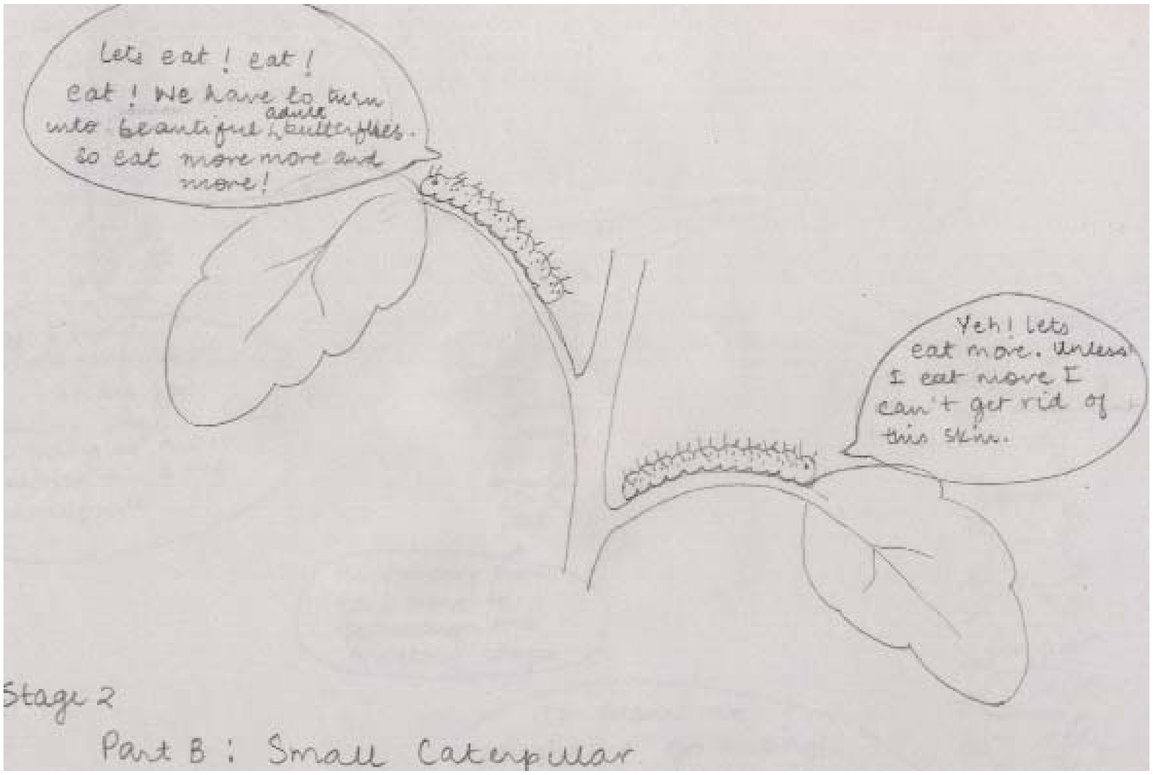

N! FRAME.
Hmm......!
I want to find the greenest patch where I can lay my eggs on.
Eggs

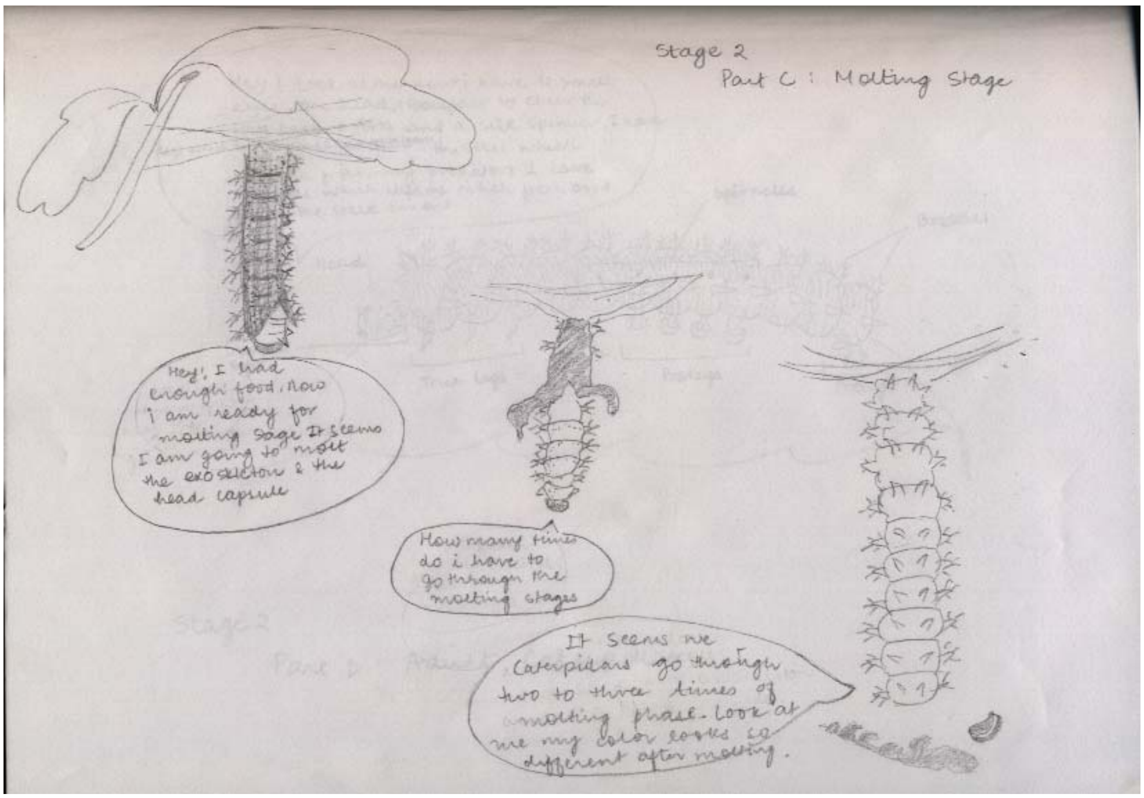

Bye! Bye! My work is done here. All the best in future! hope all of you make the most beautiful butterflies

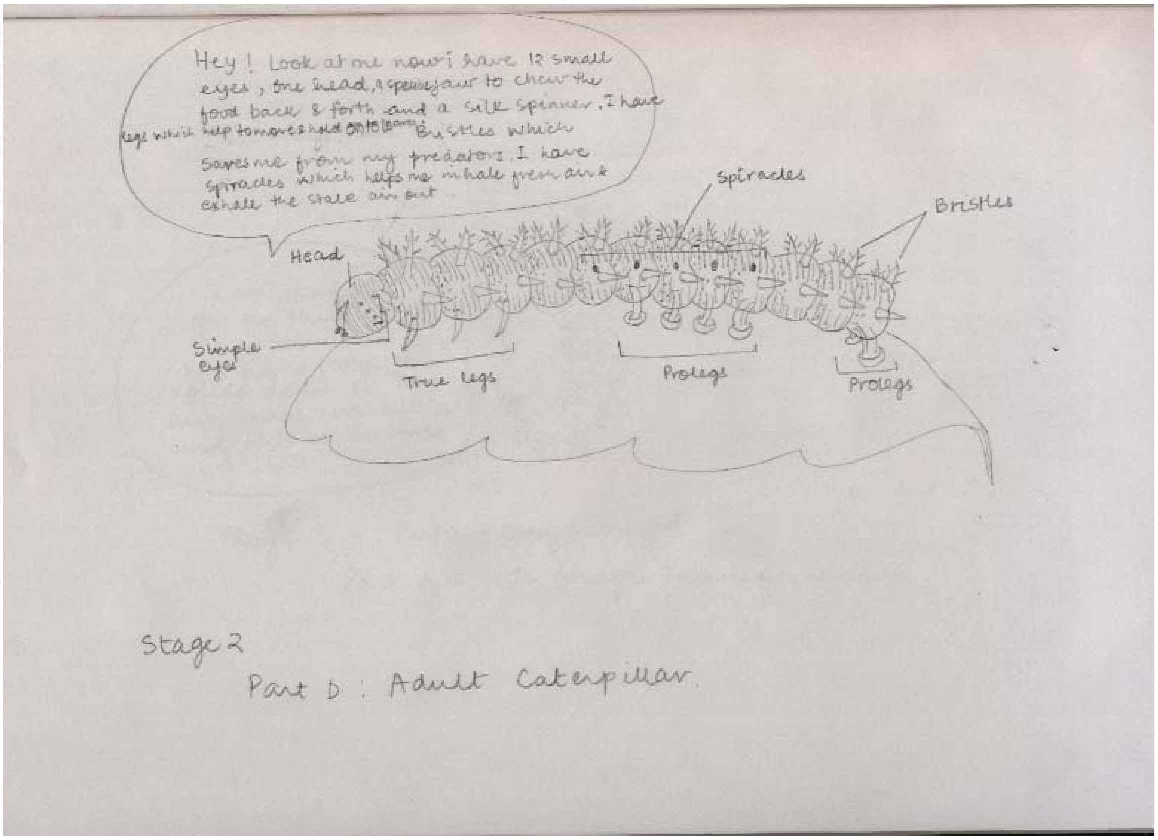

DAY - 1
Eggs stay in this stage for 3-5 days.

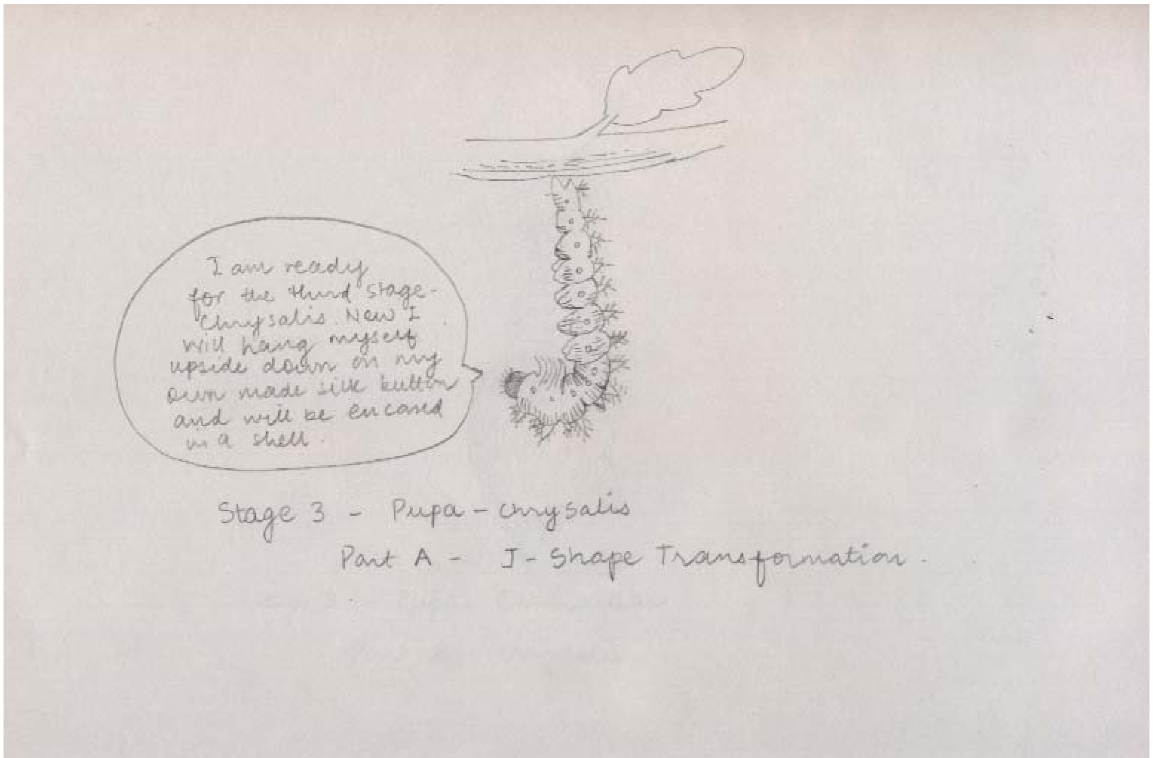

N' FRAME
Stage 2
Caterpillar

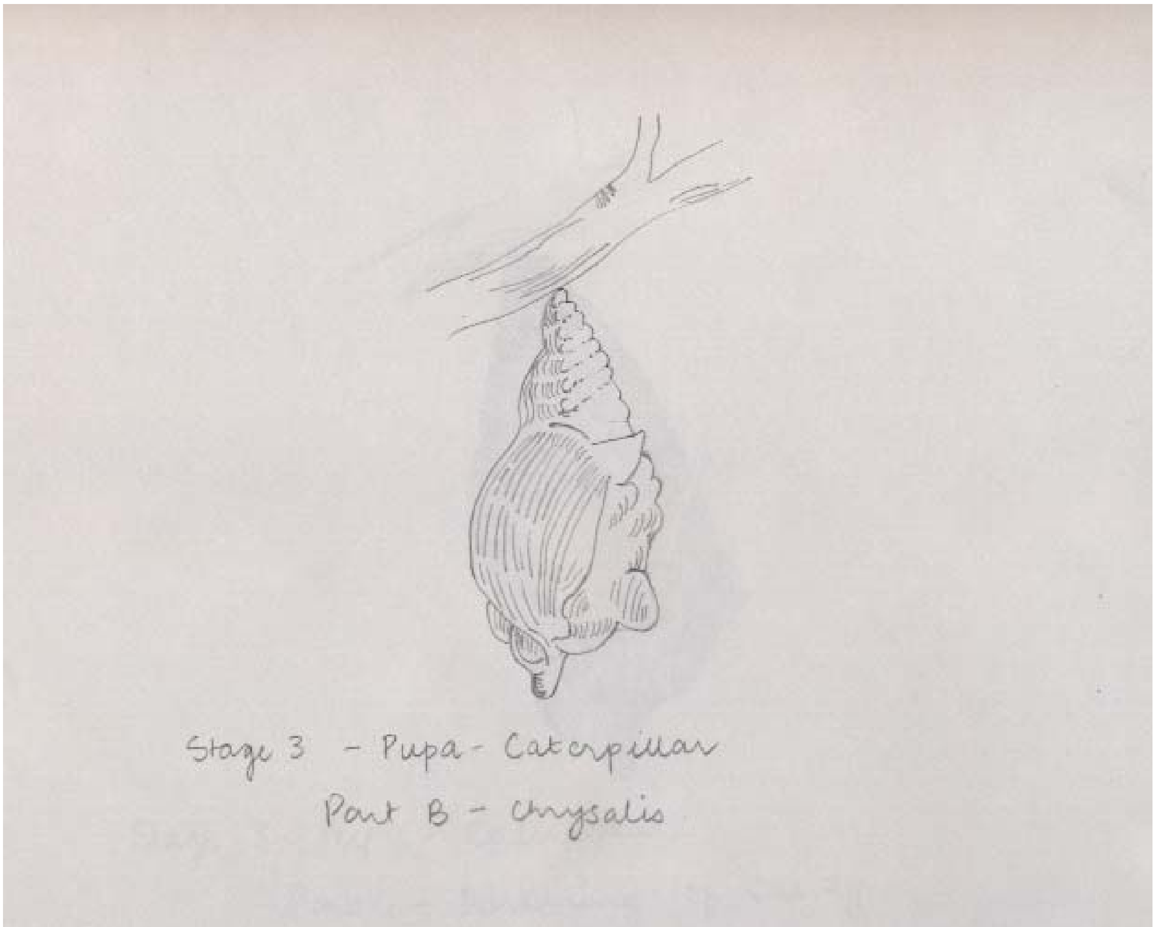

Yeh! food time. Lets have our first meal
What are we going to eat?
Eggshells make a vital Source of protein for caterpillars. And We need this protein for the each stage of the Larval Development between skin changes
Stage 2.
Part A: Hatchling Caterpillar emerges.

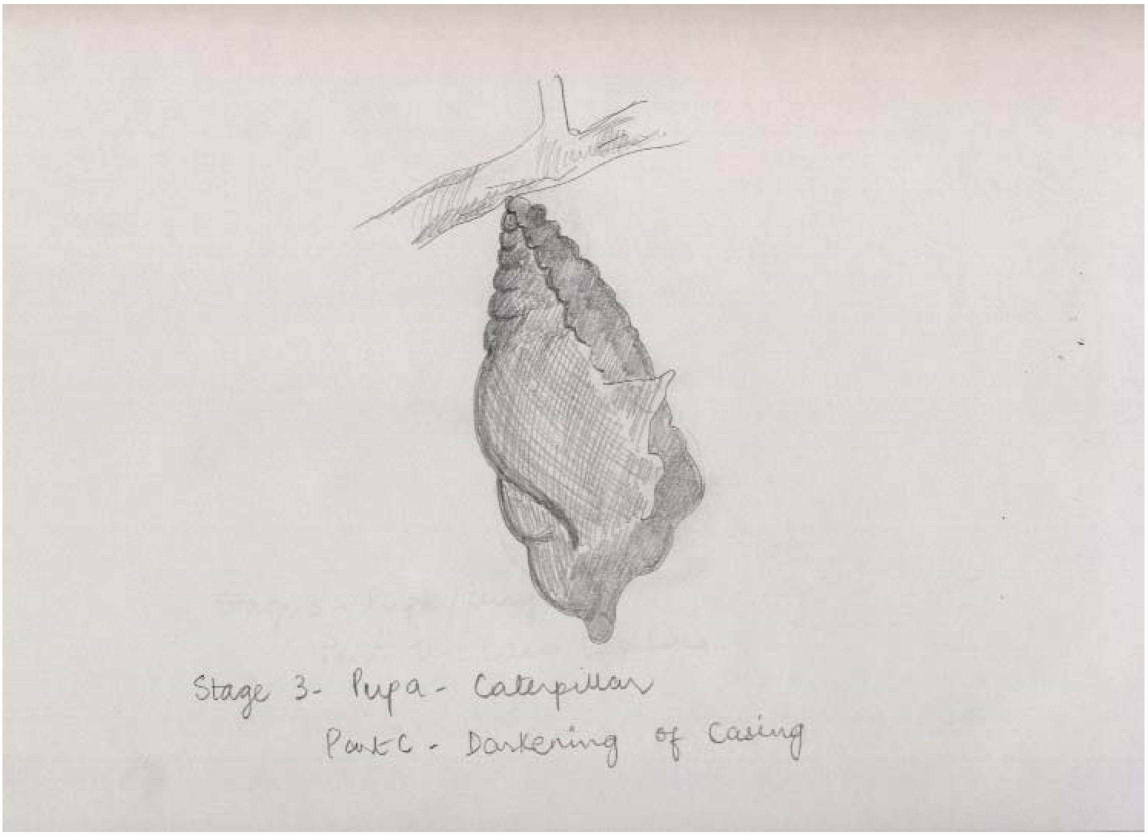

Lets eat! eat! eat! We have to turn into beautiful adult butterflies. so eat more more and more!
Yeh! lets eat more. Unless I eat more I can't get rid of this skin.
Stage 2
Part B: Small Caterpillar

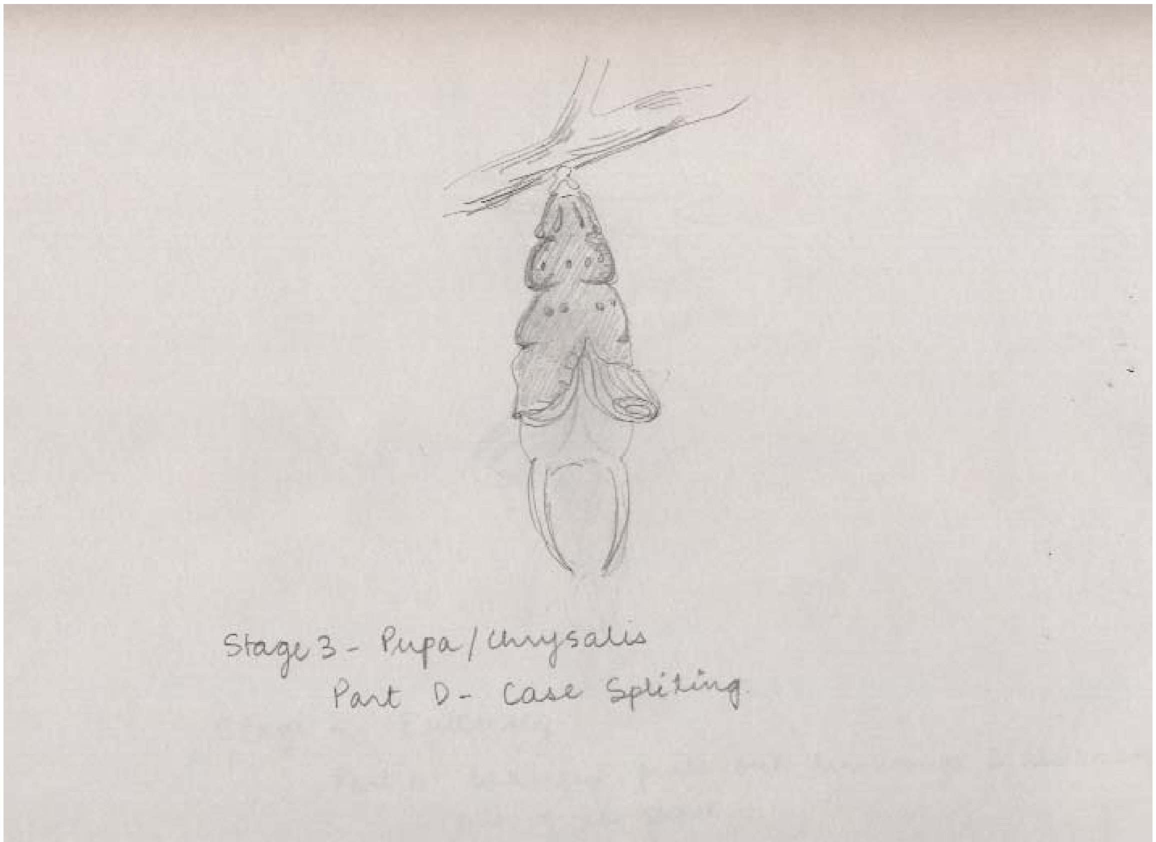

Stage 2
Part C : Molting Stage
Hey!, I had enough food. now i am ready for molting sage It seems I am going to molt the exoskeleton & the head capsule
How many times do i have to go through the molting stages
It seems we Caterpidars go through two to three times of molting phase. Look at me my color looks so different after molting.

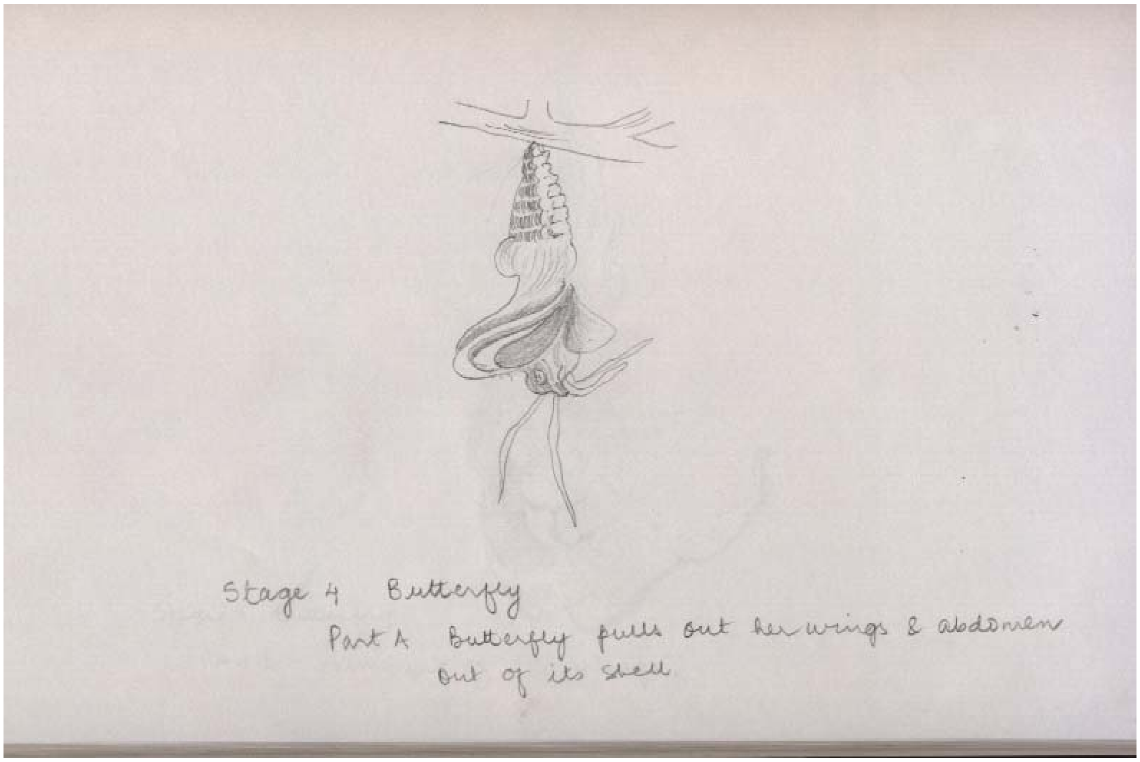

Hey! Look at me now I have 12 small eyes, one head, a jaw to chew the food back & forth and a silk spinner. I have legs which help to move & hold onto leaves. Bristles which saves me from my predators. I have spiracles which helps me inhale fresh air & exhale the stale air out
Head
Spiracles
Bristles
Simple eyes
True legs
Prolegs
Prolegs
Stage 2
Part D: Adult Caterpillar.

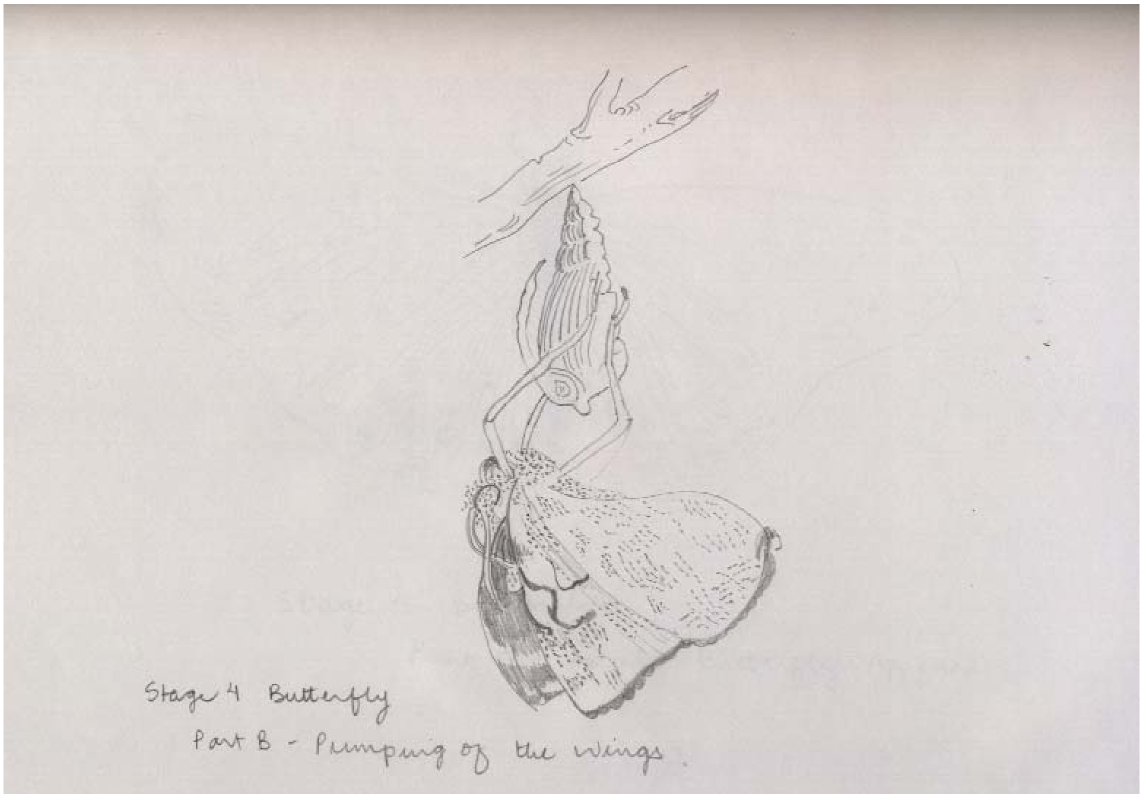

I am ready for the third stage- Chrysalis. New I will hang myself upside down on my own made silk button and will be encased in a shell.
Stage 3 - Pupa - Chrysalis
Part A - J-Shape Transformation.


Stage 3 - Pupa - Caterpillar
Part B - Chrysalis

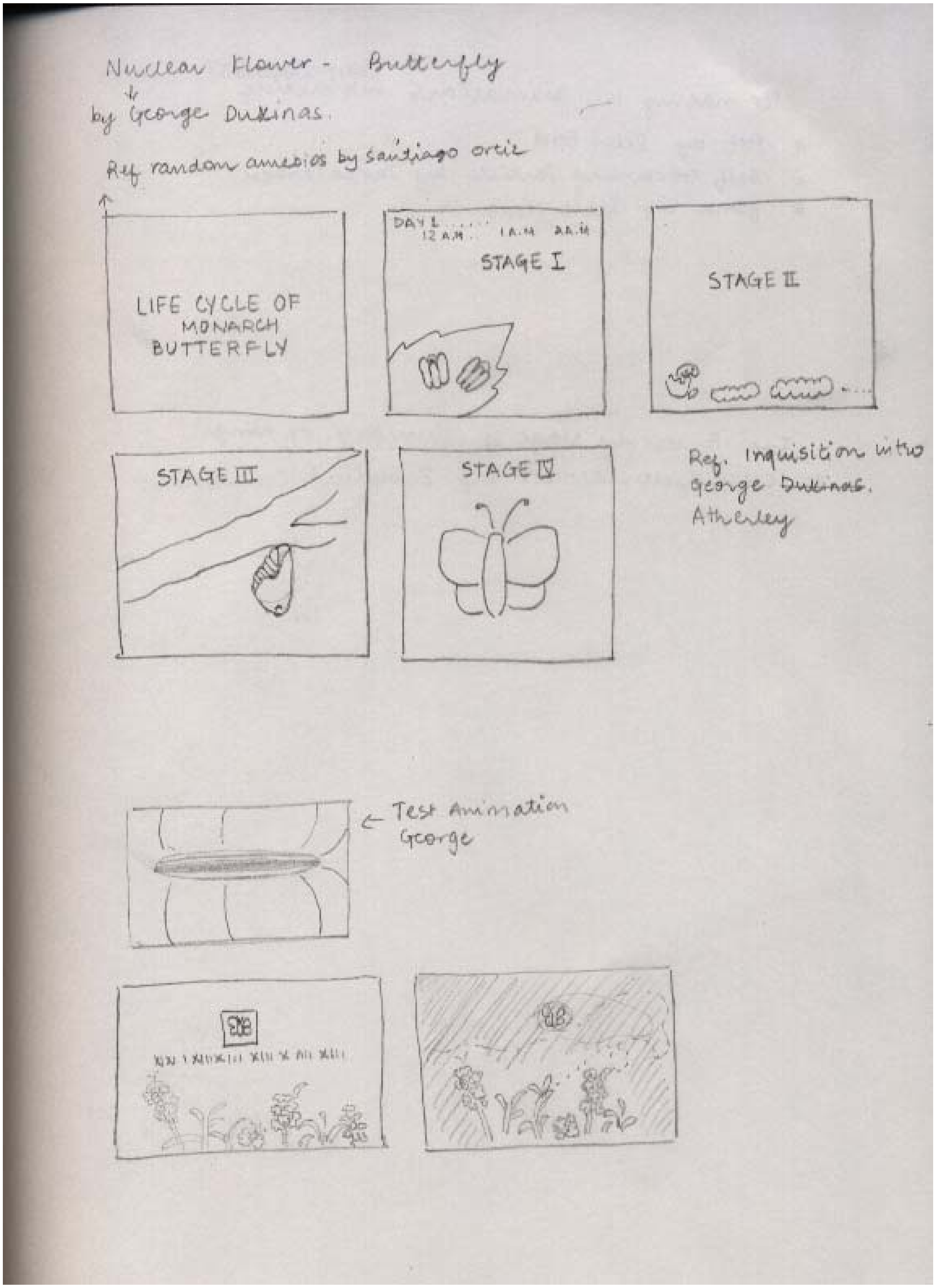

Stage 3- Pupa- Caterpillar
Part C - Darkening of Casing


Stage 3 - Pupa/Chrysalis
Part D- Case Spliting


Stage 4 Butterfly
Part A Butterfly pulls out her wings & abdomen
out of its shell


Stage 4 Butterfly
Part B - Pumping of the wings


Stage 4. Butterfly
Part C - Adult Butterfly Appears



Nuclear Flower - Butterfly
by George Dukinas.
Ref random amebios by Santiago ortiz
LIFE CYCLE OF MONARCH BUTTERFLY
DAY 1
12 A.M.
1 A.M
2 A.M
STAGE I
STAGE II
STAGE III
STAGE IV
Ref. Inquisition into George Dukinas. Atherley
Test Animation George