INTEGRATING EDUCATIONAL COMICS IN HIGH SCHOOL SCIENCE

by

Stephanie K. Milam-Edwards

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of

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DEDICATION

For my husband, Les, who left us too soon, but remains the wings behind me and protection above me.

For my two daughters, who believe their mom can do anything she puts her mind to, even when I don't know if I believe it myself.

My upmost thanks and appreciation to Dr. John Graves, who didn't give up on me and always provided unending encouragement and gentle support.

Thank you to Suzanna Soileau who not once, not twice, but three times agreed to be my science reader. Your feedback was invaluable.

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ABSTRACT

The purpose of this paper is to provide teachers with a guide to create educational comics from curriculum resources they already have to enhance student learning. When at-level reading comprehension skills are deficient, through low retention or barriers to language acquisition, it creates a roadblock to understanding scientific concepts at proficient levels. By pairing at-level scientific reading with constant visual cues, like that found in comic and graphic novels, two modalities for learning are utilized to achieve scientific literacy simultaneously in a format that students already recognize. When students have true scientific understanding, it makes them more confident and better equipped to make decisions that ultimately will benefit society and the world.

CHAPTER ONE

INTRODUCTION AND BACKGROUND

Context of the Study

During the Middle Ages, it was only the clergy or upper echelon that were taught to read and write. Schools as we know them today did not exist for the majority of the poor. Churches were used to facilitate learning, but without the construct of reading or writing. One such church was the Basilica of Saint Frances of Assisi in Italy which was constructed over the years 1239 to 1253 AD. In order to still teach the masses, the walls of its upper basilica (basilica superior) were covered with frescoes that depicted various stories in the Bible. It was used as a center of education to teach the Bible to an illiterate public using pictures.

Even in present-day schools, when children are first learning to read, they are taught phonetics using pictures; for example, A is for apple, B is for bat, etc. Picture books are read to children and are used to teach reading through the use of pictures. Students then progress to reading books with very few pictures and a lot of text as they move from grade level to grade level. Textbooks, aptly named for their text heavy pages, are used to impart knowledge to students at the secondary and post-secondary levels. But is this the best way to teach scientific concepts?

The educational landscape has changed vastly over the last decade. Students now have more access to digital resources delivered through multiple platforms. With the invention of the internet and subsequent streaming platforms, the use of textbooks, even digital ones to teach concepts has become outdated. Students can view videos on the same concepts that they can read

about in textbooks or articles. Information is now delivered to students in smaller chunks as to keep their interest in a world full of distractions.

Unfortunately, this does not bode well for having a literate society. Students still need the skills of reading and comprehension. They need to ascertain the meaning of what they are reading and know how to apply the concepts they are learning to their lives. While videos provide information, they do nothing to improve reading skills. In addition, traditional textbooks, even those well-written and illustrated with the best pictures, do not hold the interest of students maturing in a society of sound-bites and memes.

Visual narratives such as graphic novels and comics provide an opportunity to teach concepts through pictures, but also with written dialogue and captions that encourage reading and literacy. Plus, they are already quite popular. Bookstores and book fairs are increasingly adding more titles that are graphic novels to meet the demand. Their use may provide a bridge between textbooks with few pictures and videos with few words while supporting needed literacy skills and engaging students with content.

Focus Statement

I utilized existing educational resources to create robust educational comics to teach, review, and evaluate student learning of science concepts.

CHAPTER TWO

CONCEPTUAL FRAMEWORK

The Comic Stigma

In 1933, the first comic book was inadvertently created with two employees from the Eastern Color Printing Company took scrap of comic strips from newspaper and creating a magazine with them. Between 1935 and 1954, their popularity grew. Some educators did see the potential of the use of comics in the classroom. In 1944, W.W.D. Sones, a professor at the University of Pittsburgh published "The Comics and the Instructional Method," published in the *Journal of Sociology*. He recognized that youth ages 8 to 14 were already quite interested in comics and that educators might capitalize on this fact in the classroom. He recognized that the combination of textual and visual elements could aid in memory and retention and cited several studies that suggested this might be the case (Sones, 1944). Teachers even began to create comic-supported curriculum. In 1949, a comic developed by the University of Pittsburgh and the Comic Workshop of New York University, *Puck - the Comic Weekly,* was even placed in hundreds of American classrooms to study their effectiveness (Hutchinson, 1949)

However, a psychiatrist in New York City, Dr. Frederic Wertham, stumbled upon comics while studying troubled youth. He found that many of his subjects were reading comics, the majority of which at the time depicted violence and horror in graphic form. He penned an opposition to comics in 1954 by alluding to comics as an influence in the delinquency of minors. As a result, prejudice against the use of comics by young people began. Opposition to their use increased enough for Congress to convene a subcommittee on juvenile delinquency. Fearful of

possible government censorship, comic book publishers formed the Comic Magazine Association of America and established the Comics Code Authority, regulating the content of comics. Comics came to be viewed as an entertainment, their subjects mainly focusing on the supernatural or superheroes like Superman or Iron Man (Farinella, 2019).

In the late 1950s and 1960s, companies like General Electric produced several non-fiction energy-related comics on subjects from electricity to jet power (Figure 1). These comics were designed to advertise, clarify, and inform the public of the new technologies quickly becoming available. However, these types of publications were not adopted by other companies and were scarcely used. For decades, comics were viewed as a hobby for children or adult collectors, but not as a possible tool for teaching, at least in the United States (Farinella, 2019).

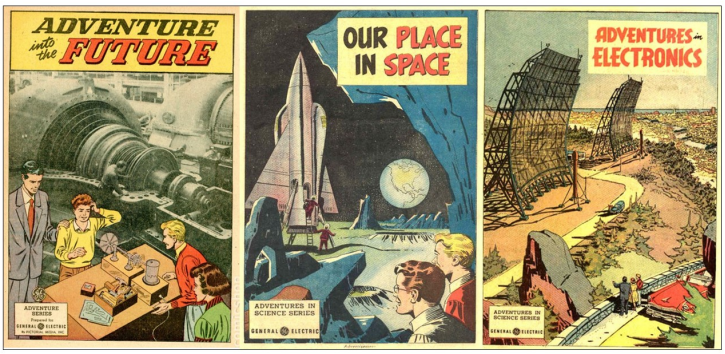


Figure 1. General Electric Comics Published in the 1950s and 1960s (mycomicshop.com).

Not so in Japan, where manga, the name given to Japanese graphic novels, had been established in their culture in the late 19th century, first as black and white publications and eventually being printed in color. Manga was expanded to not only be for entertainment

purposes, but also for education in the form of science textbooks like the 2009 publication of *The Manga Guide to Physics* used in secondary classrooms (Figure 2).

Figure 2. Cover and Pages from the Manga Guide to Physics Textbook (amazon.com).

In the United States, textbook authors have certainly recognized the importance of using pictures or diagrams. More and more textbooks are written with colorful headings and printed with vivid pictures and diagrams used to help explain all sorts of science topics not just from physics, but every scientific discipline. However, it has not been until recently that graphics, which provide visual narratives, have been seriously studied or even considered as tools in the classroom (Price, 2013).

Graphic Novels to Teach Business

In 2013, undergraduate business students were engaged in two studies using graphic novels to teach business concepts (Price, 2013). Each student group was given excerpts from *Atlas Black: The Complete Adventure*, one group in the form of a traditional textbook and the

other in the form of a graphic novel. The group exposed to the graphic novel were able to perform better on a post-assessment, identifying direct quotes verbatim. In a related study, students were asked to compare the experience to that of the textbook and found that 80% of the students felt the graphic novel compared favorably to the textbook. Students did not feel that graphic novels somehow did not provide the same content knowledge as the textbook (Short et al., 2013).

Visual Language

In 2014, a cognitive scientist outlined how graphic novels and comics are written in a visual language, much in the way a textbook could be translated into English or Spanish. Graphic novels and their less lengthy cousins, comic books are considered visual narratives that provide pictures and dialog or narration in a sequential order. This may help to explain the results of Short et al in 2013. The structure of comic book panels provides the reader with a sequential order of images and narratives that are clear. That clarity helps readers to connect with the content in ways that text alone does not. Comics are not merely words with pictures, they are a way to tell stories, depict metaphors, and help to visualize abstract topics (Cohn, 2014).

Comics Versus Illustrated Text or Infographics

In a 2019 study, distinctions were made between data comics, otherwise known as educational comics, versus illustrated text and infographics basing their differences on two criteria: 1) *Text-picture-Integration* - how close the pictures are to the text and 2) *Reading Guidance* - how the reader is guided through the text (Figure 3). Illustrated text can be thought of as modern-day textbooks where a picture is placed near the narrative passage it is referring to.

Some guidance is given to the reader, but the pictures are not truly integrated with the text. Infographics are the opposite. Text is integrated with lots of pictures, but the graphics provide little sequential guidance to the reader. Comics do both, integrating pictures with text while providing guidance to the reader on how to proceed in reading the narrative (Wang et al., 2019).

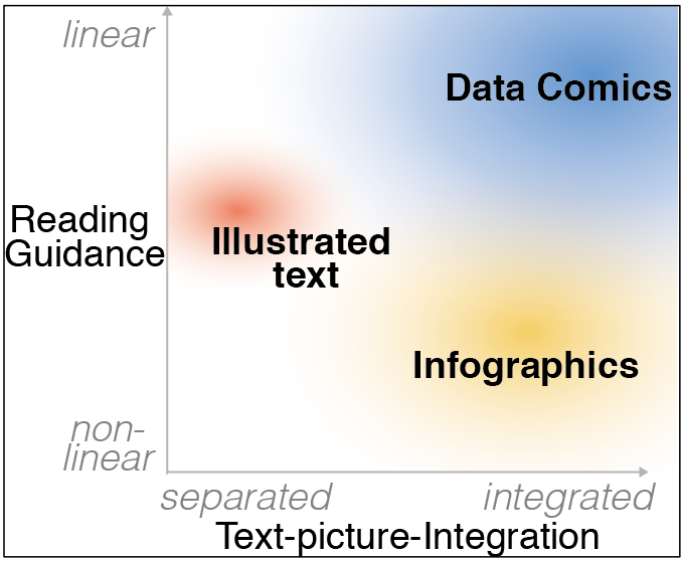


Figure 3. Visual Communication Trends (Wang et al., 2019). On the x-axis, separated *Text-picture-Integration* indicates that pictures are far removed from the text in which they referred while integrated means that the text and picture seamlessly appear together. On the y-axis, linear *Reading Guidance* indicates that the reader can easily follow a sequence of events as described by the text while non-linear requires the reader to infer event sequencing.

In a similar study, three test groups were exposed to the same information using the three different modalities; comics, illustrated text, and infographics. Participants were graded on their ability to recall specific facts or quotes (3 points), general trends (2 points), and vague recall (1 point). The researchers found that participants exposed to comics scored 35% on recall, those exposed to illustrated text scored 32% recall, and those exposed to infographics scored 30%

recall suggesting that reader guidance helps in comprehension. One to four weeks later, the same questionnaire was sent to participants and the responses illustrated that comics caused subjects to retain on average 55% of the information, followed by infographics at 43% and illustrated texts at 41% (Figure 4), suggesting that comics might also increase the percentage of information retention versus both illustrated texts and/or infographics (Wang et al., 2019).

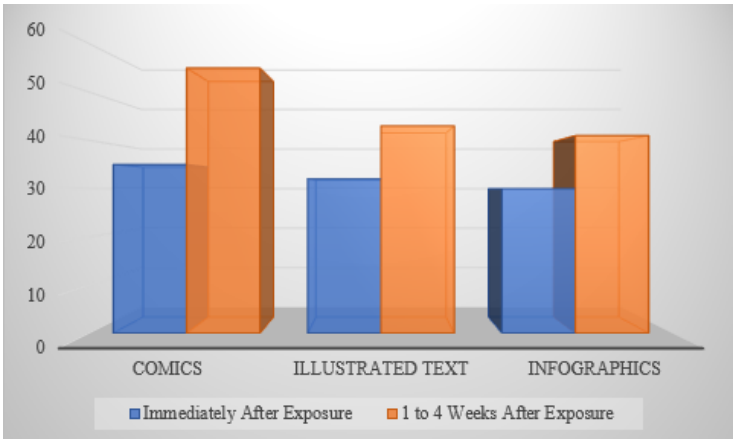


Figure 4. Bar Graph Comparing the Percent Retention of Different Modalities.

Current Research on Comics

From an educational standpoint, comics may provide several advantages over textbooks. Comics integrate text and pictures, they have a multi-modal nature that potentially can increase reader engagement and learning, and given that some comics use characters and situations to tell stories, students may relate to them facilitating an emotional connection with content and facilitate retention. Comics have the potential to reach more people, specifically people who

might gravitate toward the graphic arts, but who would not normally be interested in scientific concepts. Unfortunately, studying comics and graphic novels for use in presenting scientific concepts in an educational setting has not been extensive. This project serves to test the use of visual narratives such as comics or graphic novels in teaching science concepts and compare their use to the use of illustrated textbooks on the same concept. It is the hope that this action research project will help increase the understanding of the potential of visual narratives in the classroom.

Envisioning Comics in the Classroom

It is important to make the distinction that educational comics as envisioned here are not that of a Sunday comic strip nor that of a graphic novel. The intent is to pair the constant visuals that comics provide with at-level reading so that the student can use both to make sense of difficult scientific topics. With the on-demand thirty-second sound bites, Tik-Tok videos, and Instagram posts that today's students consume, chunking at-level reading with comic panels may help to increase scientific literacy while strengthening reading stamina and comprehension.

CHAPTER THREE

INSTRUCTIONAL STRATEGIES

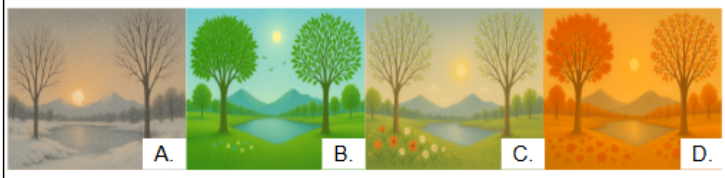
Integrating Comics Within Existing Lessons

There are two tiers of instructional resources provided in this paper. The first tier includes a variety of self-created templates intended to provide teachers frameworks for developing educational comics for placement within a unit where the teacher finds they might be most useful. Also provided are my examples of how these templates could be used to augment the learning within a unit. Integrating comics can be as simple as using one comic panel to creating a full comic page. They can be used to discern prior learning, identify misconceptions about scientific topics, introduce concepts, as formative assessments, to review topics, or as a culminating activity to evaluate student learning in lieu of a traditional summative assessment. The second tier of resources provide a narrative on tools teachers can use to source both images and grade level text to create educational comics from their own curriculum resources.

Assessing Prior Learning

A simple comic strip can be used as an informal pre / post assessment using the template for Pre/Post Assessments (Appendix A). A formative assessment was created consisting of a brief at-level paragraph summarizing four comic panels. It was then paired with a variety of questions in which students use the visuals of comic panels to answer the questions instead of using text-based questions alone (Figure 5).

UNIT 7.21c | Reasons for the Seasons



As the Earth orbits the Sun, it experiences noticeable and predictable changes in weather throughout its year. These changes may be felt as changes in temperature, changes in the amount or type of precipitation falling, the length of daylight hours, and the solar intensity striking the surface. Based on your knowledge of Earth's seasons, answer the following questions:

1) **Which images (pick two) begin with equal periods of daylight and nighttime?**
A) Winter C) Spring
B) Summer D) Autumn

2) **Which image represents the season that starts with the longest day of the year?**
A) Winter C) Spring
B) Summer D) Autumn

3) **Which image represents the season that starts with the shortest day of the year?**
A) Winter C) Spring
B) Summer D) Autumn

4) **Which images (pick two) represent seasons that begin with an equinox?**
A) Winter C) Spring
B) Summer D) Autumn

5) **Which images (pick two) represent seasons that begin with a solstice?**
A) Winter C) Spring
B) Summer D) Autumn

6) **Which image shows the season that occurs in the Northern Hemisphere when the Earth is farthest from the Sun?**
A) Winter C) Spring
B) Summer D) Autumn

7) **Which image shows the season that occurs in the Northern Hemisphere when the Earth is closest to the Sun?**
A) Winter C) Spring
B) Summer D) Autumn

8) **Which image represents the season when the Earth gets the least direct sunlight?**
A) Winter C) Spring
B) Summer D) Autumn

9) **Which image represents the season when the Earth gets the most direct sunlight?**
A) Winter C) Spring
B) Summer D) Autumn

10) **What causes Earth's seasons to change throughout the year?**

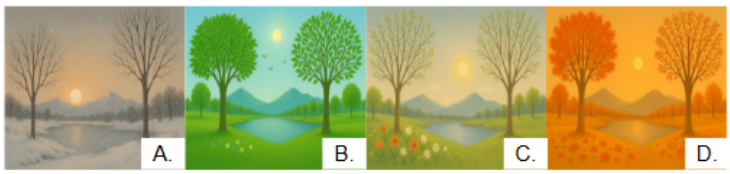
(all images generated with ChatGPT)

Pre / Post Assessment | Reasons for the Seasons

Figure 5. Pre / Post Assessment | Reasons for the Seasons

The same assessment can be used after students have engaged in lessons or labs designed to inform the students that it is in fact the tilt of the Earth and not its proximity to the Sun that causes the seasons to identify whether remediation, reteaching, or enrichment is needed moving forward. The key to this assessment is provided (Figure 6).

UNIT 7.21c | Reasons for the Seasons **KEY**



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10) **What causes Earth's seasons to change throughout the year?**

When the North Pole tilts toward the Sun, the Northern Hemisphere gets more direct sunlight and longer days, creating summer. Six months later, when the North Pole tilts away, it results in winter, with shorter days and less sunlight.

(all images generated with ChatGPT)

Pre / Post Assessment | Reasons for the Seasons

Figure 6. KEY to the Pre / Post Assessment | Reasons for the Seasons

Identifying Misconceptions

Misconception probes are an excellent way of identifying gaps in learning so that these gaps can be addressed in the upcoming lesson or revisited through remediation. They guide instruction by gathering information on how students have connected to the concepts they have

been taught and if those connections demonstrate an accurate understanding of the concept (Keeley, 2005). An example was created using the template for identifying misconceptions (Appendix B). Comic panels can be used to illustrate this phenomenon (Figure 7).

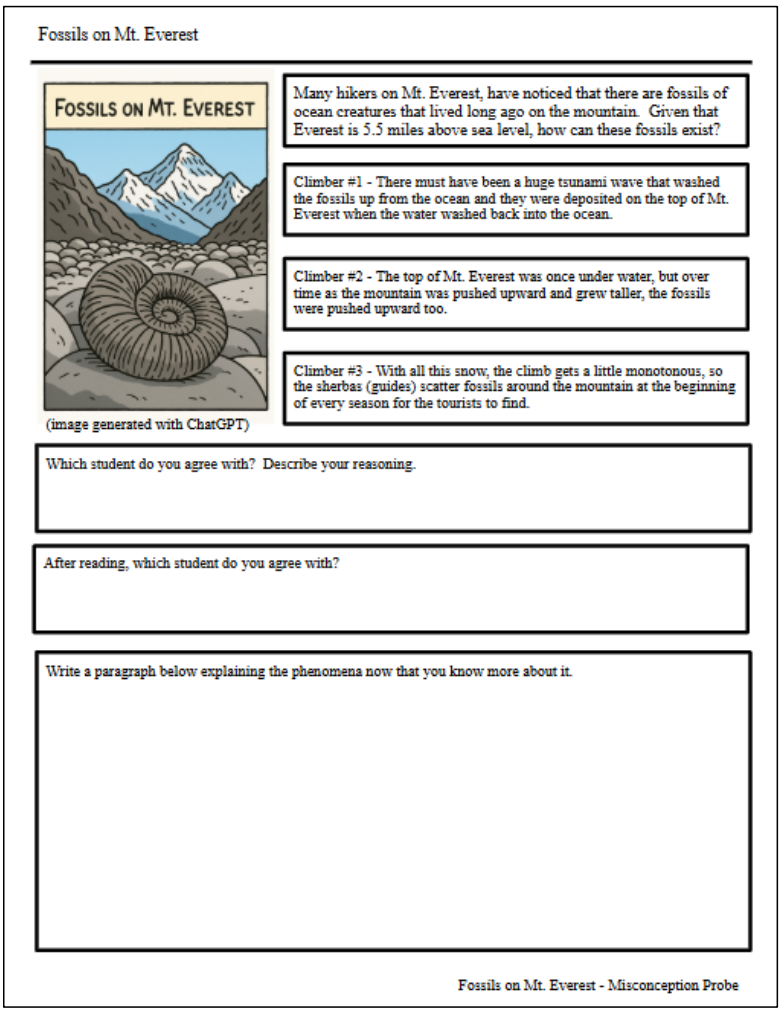


Figure 7. Misconception Probe | Fossils on Mt. Everest

Once students have identified the person with whom they agree and written their reasoning, teachers can revisit the topic either that day or later within the unit by provided the "antidote" to the misconception, the accepted explanation of the phenomena (Figure 8). Student can then revisit their previous thinking and write a summary of their new understanding.

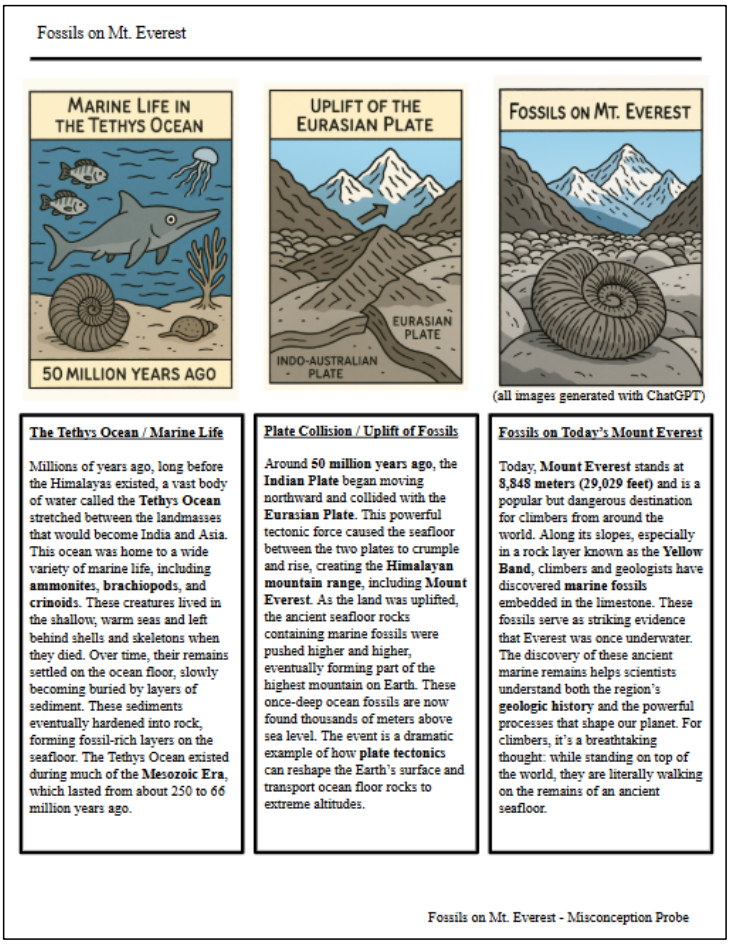


Figure 8. Explanation Misconception Probe | Fossils on Mt. Everest

Introduction of Concepts

Comics could be used to introduce a concept as pre-reading to a section of a textbook chapter used traditionally. In this case, rather than mostly a text-based reading with perhaps a picture provided somewhere on a textbook page, the panel is paired with the at-level reading. Questions are provided so that students reflect on what they have learned from the comic. An example was created using the template for concept introduction (Appendix C). This example introduced the different theories about how Earth's moon was formed. The comic could be used to briefly discuss the theories prior to discussing them more in depth in a lesson or as part of an investigation (Figure 9).

The Formation of Earth's Moon

The Fission Theory: One early idea suggested that the young Earth spun so quickly that a piece of it broke off and formed the Moon. This theory aimed to explain similarities in composition between Earth and the Moon. However, scientists later determined that Earth would have needed to spin at an unrealistically high speed for this to happen, making the theory unlikely.

The Capture Theory: This theory proposed that the Moon formed elsewhere in the solar system and was later captured by Earth's gravity. While this could explain differences in composition, capturing such a large body into a stable orbit without it crashing or escaping is highly improbable, given how large the moon is.

The Co-Formation Theory: This theory suggests that Earth and the Moon formed together from the same cloud of gas and dust in space. It explains some similarities in their composition. However, the Moon lacks the same ratio of elements as those found on the Earth making this less likely.

The Giant Impact Hypothesis: The most widely accepted theory today is that a Mars-sized body, named Theia, collided with the early Earth. The impact ejected a vast amount of debris into orbit, which eventually combined to form the Moon. This explains the Moon's composition and its orbit around Earth.

(all images generated with ChatGPT)

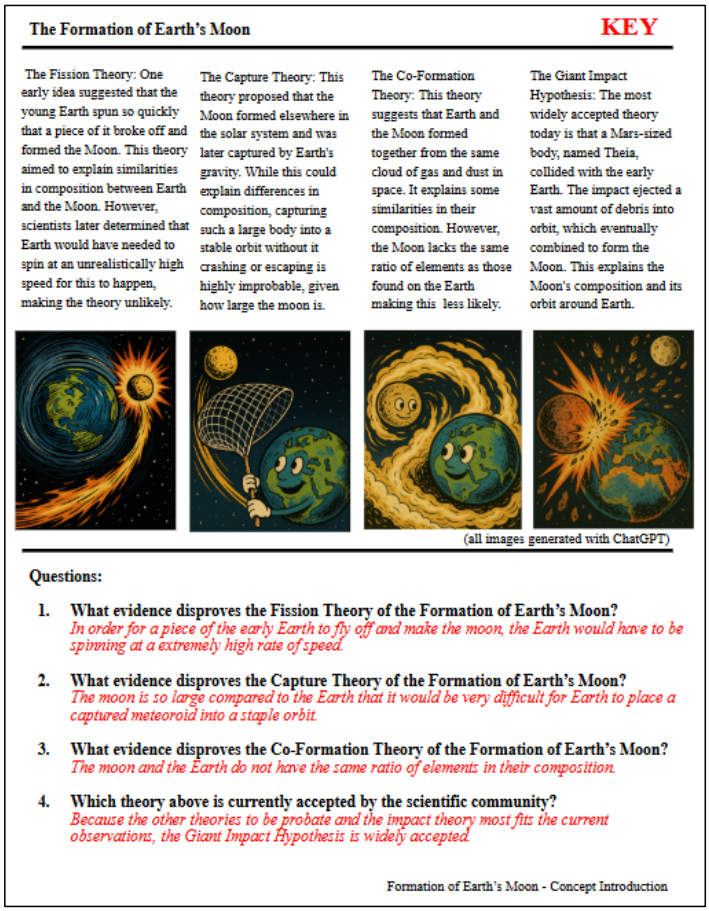
Questions:

1. **What evidence disproves the Fission Theory of the Formation of Earth's Moon?**
2. **What evidence disproves the Capture Theory of the Formation of Earth's Moon?**
3. **What evidence disproves the Co-Formation Theory of the Formation of Earth's Moon?**
4. **Which theory above is currently accepted by the scientific community?**

Formation of Earth's Moon - Concept Introduction

Figure 9. Concept Introduction Student Worksheet | Formation of the Moon

Utilizing simple questions help students to reflect on what they have read and allow the teacher to quickly ascertain whether the basics of the concept have been assimilated by the student (Figure 10).



The Formation of Earth's Moon **KEY**

The Fission Theory: One early idea suggested that the young Earth spun so quickly that a piece of it broke off and formed the Moon. This theory aimed to explain similarities in composition between Earth and the Moon. However, scientists later determined that Earth would have needed to spin at an unrealistically high speed for this to happen, making the theory unlikely.

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(all images generated with ChatGPT)

Questions:

1. **What evidence disproves the Fission Theory of the Formation of Earth's Moon?**
   In order for a piece of the early Earth to fly off and make the moon, the Earth would have to be spinning at a extremely high rate of speed.
2. **What evidence disproves the Capture Theory of the Formation of Earth's Moon?**
   The moon is so large compared to the Earth that it would be very difficult for Earth to place a captured meteoroid into a staple orbit.
3. **What evidence disproves the Co-Formation Theory of the Formation of Earth's Moon?**
   The moon and the Earth do not have the same ratio of elements in their composition.
4. **Which theory above is currently accepted by the scientific community?**
   Because the other theories to be probate and the impact theory most fits the current observations, the Giant Impact Hypothesis is widely accepted.

Formation of Earth's Moon - Concept Introduction

Figure 10. KEY Concept Introduction Student Worksheet | Formation of Earth's Moon

Checks for Understanding

Comics can be used to assess student learning as a check after a lesson or concept has been taught. In this case, students are presented with a comic and then asked questions that illicit an understanding of what a comic might be depicting about a concept. The idea is that a student should be able to analyze the comic, determine how it relates to the concept, and in some cases whether

the comic is actually portraying the concept correctly. An example was created using the template for a check for understanding (Appendix D). The latter suggests a deeper level of understanding than merely identifying a concept or figure (Figure 11).

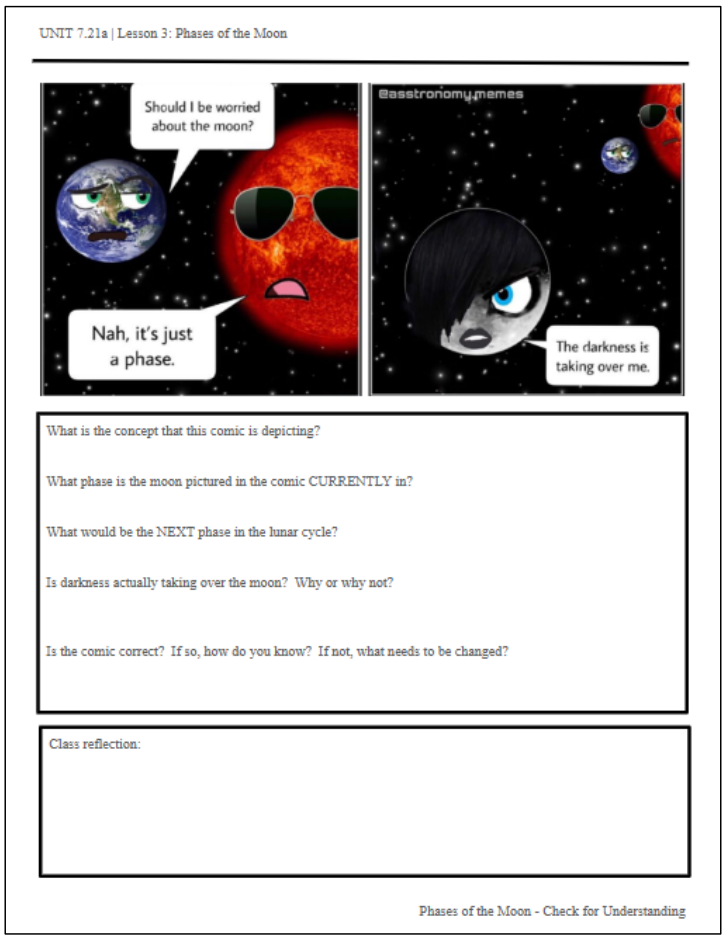

Figure 11. Check for Understanding Student Worksheet | Phases of the Moon

A teacher would ideally give this worksheet to students following a lesson about the lunar cycle and the its phases, allowing students time to analyze the comic panels and answer questions before eliciting answers from the class and facilitating a class reflection to ensure all students ultimately understood the comic and its connection to the concept (Figure 12).

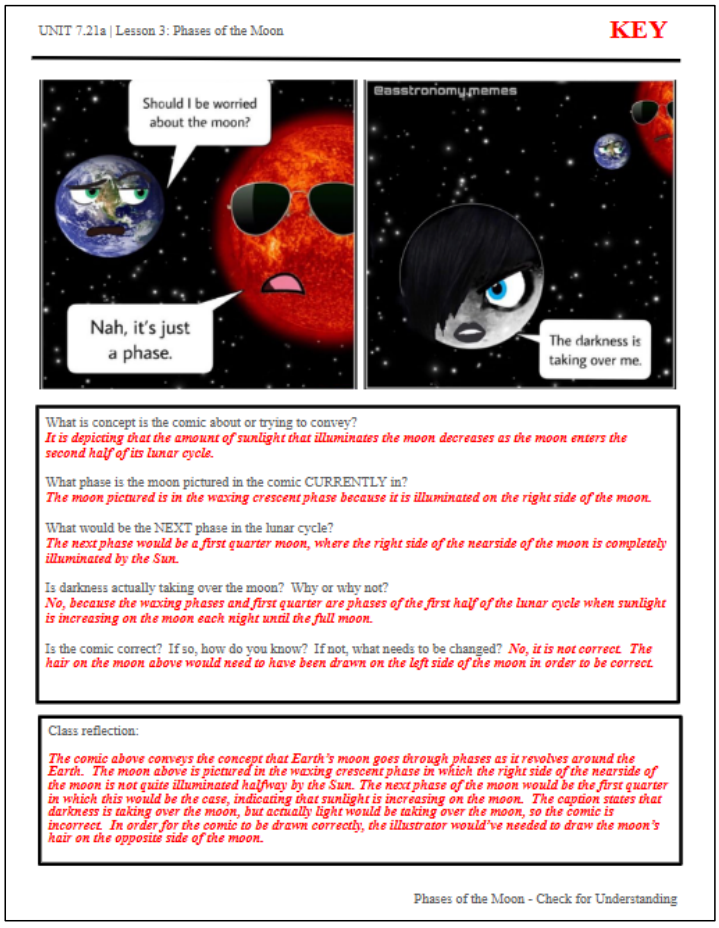

Figure 12. Phases of the Moon – Key to Check for Understanding Student Worksheet

Reviewing of Concepts

Instead of assigning a summary reading or reading guide before a summative assessment, educators can create a comic style review utilizing the same text, but also adding strategically placed comic panels throughout the reading. These panels provide visual clues and break up the reading to increase stamina all while still having students practice reading at their appropriate grade level. An example was created using the template for concept review (Appendix E) to create a review on how surface water becomes groundwater (Figure 13). The teacher can then add questions about the content, have students define words or describe processes using clues from the text, or use existing questions from their own textbook resources.

Another way this could be used is to provide the text and have a student group create the comic panels to accompany the text, assigning different panels to different students within the group. In this instance, the review utilizes high-thinking skills to demonstrate sense-making through drawing instead of merely writing a response to a question. Or comic panels could be given to the student group and the students would be instructed to create the text that describes the panel. This also invokes high-thinking skills and supports writing skills. Students could be asked to generate different Depth of Knowledge (DOK) level questions to accompany their review. Student can generate DOK 1 (questions requiring basic define and recall questions responses), DOK 2 (questions requiring classification, compare/contrast, interpretative responses), or DOK 3 (questions requiring analysis, interpretation, inference, and development based on evidence). These comic concept reviews could be shared amongst groups of students to be critiqued and improved upon through peer review.

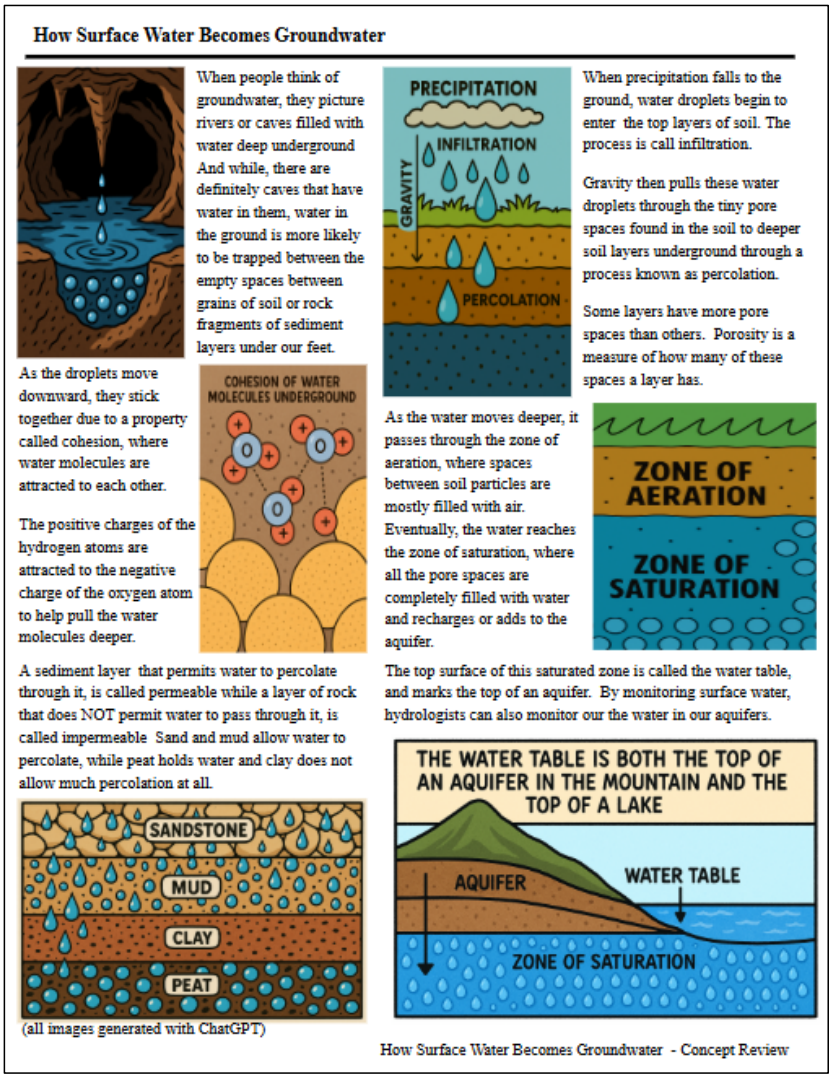

Figure 13. Comic Panel – Concept Review | How Surface Water Becomes Groundwater

Utilizing Comics as a Non-Traditional Assessment

Educational comics can be used as an alternative to a standardized test. Having students create comic panels with accompanying narratives, requires students to synthesize their learning and represent the concepts in a concise and meaningful way. Creating comics engages both verbal and visual learning styles. Verbal learners gravitate to the construction of narratives while visual learners gravitate to the drawing of comic panels.

Concept Wall

Educational comics can be used to create a concept wall that can be displayed as the class advances to more complex concepts, similar to creating a word wall to remind students of previously defined vocabulary words. For example, students could be tasked to create comic flyers about several basic geology at the end of a quarter that focused on basic geology concepts. A grading rubic (Appendix F) and a variety of concept wall templates from which to choose (Appendix G) could be provided to each student. Students then produced an educational comic on their assigned concept. Concepts included classes of rocks, types of mass movements (Figure 14), characteristics of minerals (Figure 15), types of chemical and physical weathering, crystal systems, rock cycle processes, etc. Student products were displayed around the classroom as scaffolding as the class engaged with more complex topics such as the layers and composition of the Earth, plate tectonics, and resources.

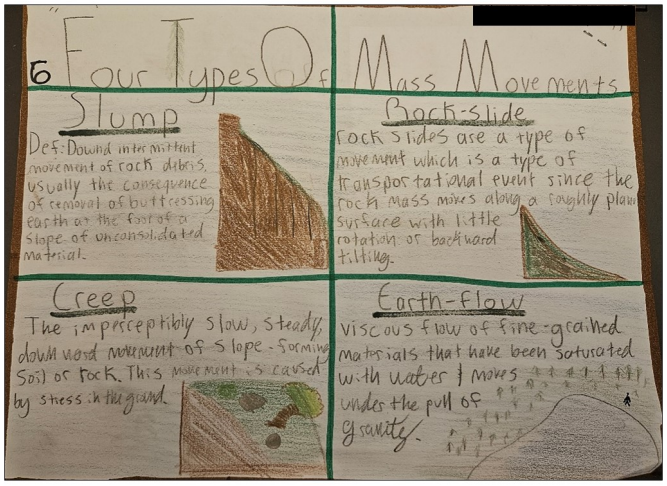

Figure 14. Example of Comic Wall Comic | Four Types of Mass Movements

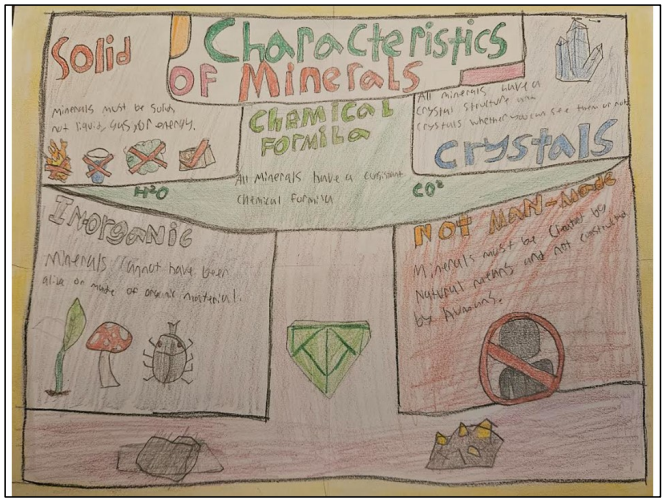

Figure 15. Example of Concept Wall Comic | Five Characteristics of Minerals

Gallery Walk

The concept of a gallery walk is not new. Usually, students are assigned a topic and tasked to create a whiteboard or a poster. Once students have had time to research the topic and create the product, they then walk the gallery gathering information from the products of other students. As an end to the unit on plate tectonics, each student could be given a location on the Earth and a template on how to construct the product (Figure 16).

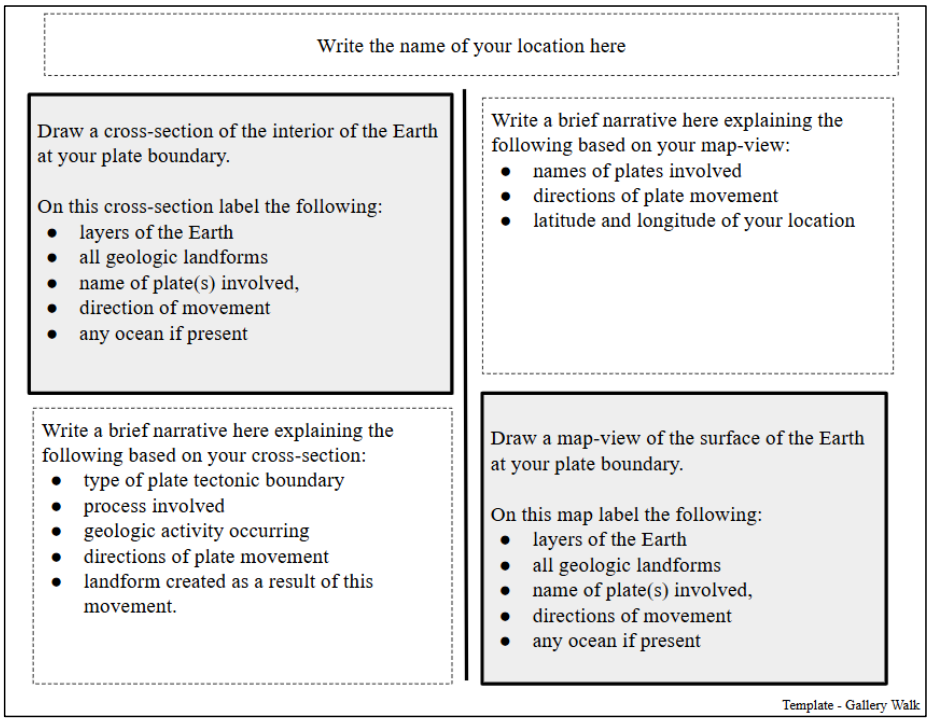

Figure 16. Template for Gallery Walk Comic | Plate Tectonic Boundary

These locations would be indicative of convergent, divergent, transform, or hot spot plate tectonic activity. Students could then exchange products, provide feedback, and then be able to

correct any mistakes before turning in a finished product for grading, like the example below (Figure 17).

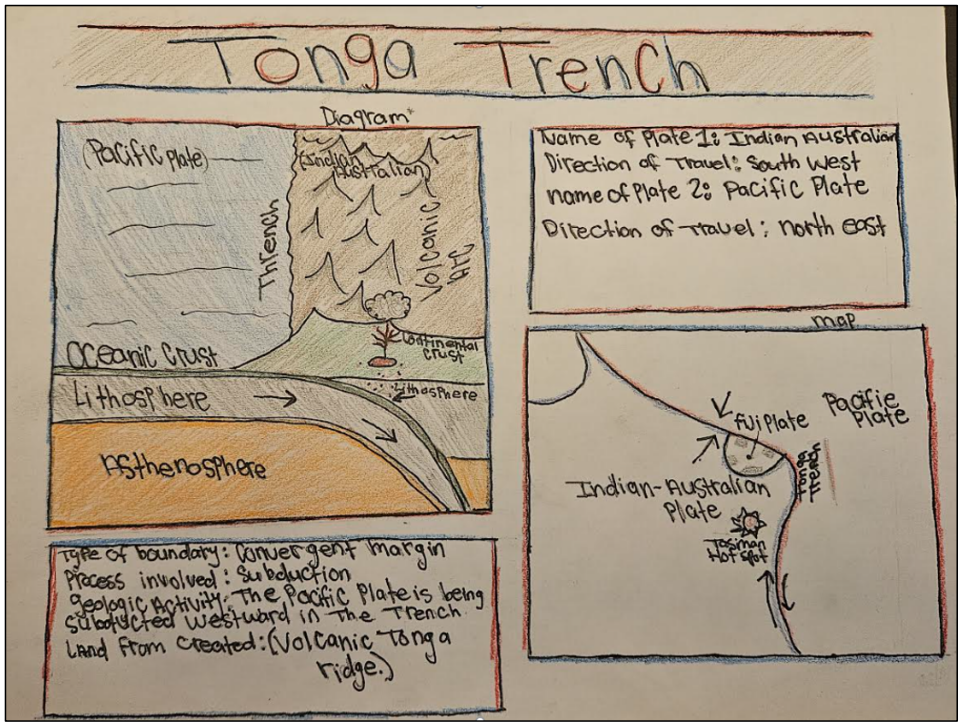

Figure 17. Example | Plate Tectonic Gallery Walk Comic

Using student constructed comics either as a concept wall or gallery walk or as any other culminating activity in which students need to synthesize information using different modalities, the pay-off can demonstrate a deeper level of learning than a simple multiple-choice assessment.

CHAPTER 4

PROFESSIONAL REFLECTION

Integration

As with all types of activities and modalities educators utilize to teach their students, being successful at integrating comics into existing lessons involves deciding where they will have the greatest impact for the wanted outcome. Teachers make these decisions every day as they plan their lessons and evaluate the scope of sequences of the subjects they teach. What makes comics different is that resources are not readily available even with the wide range of the internet. As the topic becomes more complex, existing resources become that much more difficult to find. Educational comics are just not available. So, in many cases, teachers who see value in using comics will need to make the resources themselves.

Grade Level Text

Resources for grade level text are readily available. Textbooks usually have section or chapter summaries and tend to have well-written passage even if the images within the textbook are few and far between. These can easily be chunked so that the writing pairs nicely to a comic panel. Narratives can also be written from scratch or by asking artificial intelligence (AI) websites to generate text specifically for a comic panel. Below is the prompt I used with ChatGPT to generate a basic narrative for the Conception Introduction – Formation of Earth's Moon:

> *Generate a comic strip based on the following script, depicting the incorrect theories of how the moon was formed with the correct theory. Though there have been many theories*

as to how the moon formed, scientists now think the moon formed after a large object, about the size of a planet, hit Earth. The moon does not contain the same rock at the Earth so it cannot have been formed at the same time and it is too big to have been a captured meteoroid.

Text passages can be sourced much faster than images and I found it easiest to create a spreadsheet with the topic, allowing spreadsheet cell for each narrative passage. This reminded me to find an image for each passage. Narratives should be three to five sentences per comic panel to practice reading, but not overwhelm the student. Remember, these are educational comics and not to be confused with the fragmented text that accompanies comics for recreational purposes.

Images

Single comic panels, i.e. a cartoon or meme, are easy to locate with a Google image search. Once found, teachers can simply attach a narrative around the meme or cartoon to create the type of comic they need. I did this for the Check for Understanding – Formation of Earth's Moon (Figures 7-8). These types of comics usually required one or maybe two images. But in the case of more elaborate comics, where multiple panels are needed, finding images is difficult.

ChatGPT does generate images by selecting the *Create Image* function and teachers can type a prompt of their own making or ask the AI tool to generate images based on the narrative the teacher asked ChatGPT to create. Users can ask ChatGPT to generate images in a certain style (comic) or like a certain artist (Warhol). If it generates one image that you like, you can copy that image, paste it from ChatGPT back into the prompt section, and ask ChatGPT to generate other images with a different prompt in the same style. I did this for the Misconception

Probe – Fossils on Mt. Everest as well as the Concept Introduction – Formation of the Moon (Figures 3-6). It is extremely versatile.

But what if ChatGPT does not generate the image you were hoping for? This happens often, but ChatGPT has built-in a way to allow the user to amend the generated image. The user first needs to click on the generated image. This brings up a different prompt: "describe what you what to add, remove, or replace…" underneath the generated image. The user can then type instructions to add or remove a label, change where the label appears, change the color of the diagram, generate the image in a different style or with a larger or smaller font or even a different font.

Constructing Comics

Logistically, appendices A-F have been provided as possible templates to creating comic-based resources for a variety of uses within the classroom, but they are in no way the only formats in which a teacher can construct educational comics. The templates can be flipped in different orientations, comic panels or text boxes added, deleted, extended, or reduced, and the sizes of the templates themselves can be changed. I would recommend that when constructing comics, that the teacher create a template from each comic they make for future use so that they might change the comic panel and questions without re-inventing the wheel so-to-speak.

Once the text passages and comic panels have been sourced or created, creating the educational comic comes down to space, especially if the comic is to be printed rather than assigned digitally. The intent of educational comics as described here is to help students make sense of scientific concepts while using at-level text, more complex than what one would find in a graphic novel or on in a comic strip of the Sunday newspaper. Text needs to be concise to fit

what the panel is depicting, but complex enough practice reading comprehension skills. As the students increase their skills at using educational comics, so to will the skills of the teacher creating them.

Other Resources

When I originally started this project in 2020, resources for constructing comic panels from scratch were really limited. Finding images or cartoons was easy, after all, every educator knows how to use Google, but if a teacher wanted to create something specific on a process or concept, they might have to enlist the help of a colleague in the art department. Within four years, AI tools have made creating images and narratives much more accessible.

Achieving Quality Student Products

Not all teachers are artists. This holds true for students as well, but educational comics created by students engage critical thinking skills. Students must decide what to comic panel to draw and how to describe it in a concise manner, discerning what details are truly important. Like all skills, constructing comics from scratch needs scaffolding and as these skills are practiced, the products will improve. Simply giving students a simple rubric to follow like in appendix F or template like those provided in appendix G, can be an easy starting point for students to begin constructing comics of their own. As they practice over the course of a school year, teachers can require more of them by making the rubric more complex and removing a structured template until the students are really making educational comics that have complex drawing with robust grade level narratives.

Student Engagement

Probably the most telling part of using comics will be the level of student engagement and comprehension. My suggestion would be to conduct action research by creating materials in text-based and comic-based modalities. The control group would be given the text-based material and the test group the comic-based material. The researcher could then measure the level of engagement through time-spent, accuracy, and/or percent completion. Retention might be measured by assessments given immediately after the introduction of materials and weeks afterward. Students could be given surveys to discuss which type of modality they felt more comfortable with or that they felt they understood easier. Perhaps this is a topic a future MSSE candidate might pursue.

Professional Development

By no means does this paper cover all the possibilities of using comics within a class setting, but hopefully it provides a starting point with which an educator could start to utilize comics in a way that supports at-level reading comprehension, increasing scientific literacy through media that students already recognize and gravitate towards.

For myself, I really would like to investigate some of the more specific graphic design AI tools to create educational comics to actually make the educational comics that just are not available as resources for teachers. Based on the research, I do believe, if constructed with well-drawn pictures and narratives that are concise and at-level, educational comics could be used to create more scientifically literate students and thus, by default, a more scientifically literate public.

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APPENDICES

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APPENDIX A

TEMPLATE – PRE / POST ASSESSMENT

[insert title - i.e unit, subject, etc]

[insert comic panel here] A.	[insert comic panel here] B.	[insert comic panel here] C.	[insert comic panel here] D.
[text referring to panel]	*[text referring to panel]*	*[text referring to panel]*	*[text referring to panel]*

Questions:

[Type 5 to 10 questions of varying complexity to glean student understanding of material before and after teaching]

APPENDIX B

TEMPLATE – MISCONCEPTION PROBE

[insert title - i.e unit, subject, etc]

[insert comic panel or panels here]

Scenario:

Class reflection:

Class reflection:

Class reflection:

Which individual do you agree with? Describe your reasoning.

After reading, which individual do you agree with?

Write a paragraph below explaining the phenomena now that you know more about it.

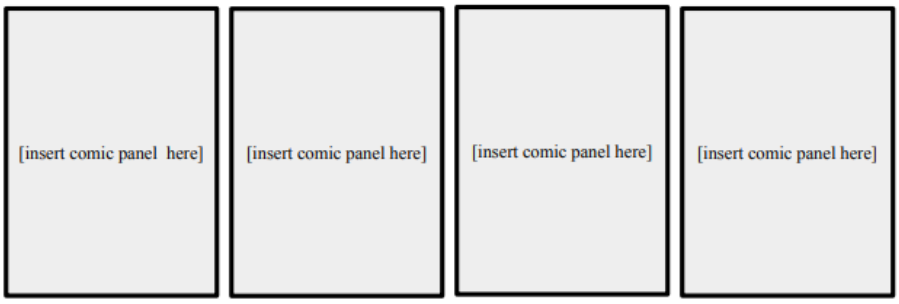
Template - Misconception Probe

APPENDIX C

TEMPLATE – CONCEPT INTRODUCTION

[insert title - i.e unit, subject, etc]

[text referring to panel] *[text referring to panel]* *[text] referring to panel]* *[text referring to panel]*



[Questions - text-based, inference, or comprehensive]

Template - Concept Introduction

APPENDIX D

TEMPLATE – CHECK FOR UNDERSTANDING

[insert title - i.e unit, subject, etc]

[insert comic panel or panels here]

[Include questions to illicit thoughtful discourse here- see EXAMPLES BELOW]

What is concept is the comic about or trying to convey?

Is the comic correct or incorrect in its depiction of the concept? Why or why not?

Why is the comic funny?

Could the comic be improved and if so, how?

What analogy is this comic making?

Class reflection:

Template - Check for Understanding

APPENDIX E

TEMPLATE – CONCEPT REVIEW

[insert title - i.e unit, subject, etc]

[insert comic panel here]

[text referring to panel]

[text referring to panel]

[insert comic panel here]

[text referring to panel]

[text] referring to panel]

[insert comic panel here]

[text referring to panel]

[insert comic panel here]

[text referring to panel]

[insert comic panel here]

Template - Concept Review

APPENDIX F

RUBRIC – CONCEPT WALL

CONCEPT WALL FLYER				_____ of 15 points possible	
Name:		3	2	1	0
TITLE	*Easily readable* *Correct Spelling* *Larger font size*	Meets all criteria listed	Does not meet 1 of the criteria listed	Missing or does not meet 2 of the criteria	Missing or does not meet 2 of the criteria
TOPIC HEADERS	*Easily readable* *Correct Spelling* *Medium Font size*	Meets all criteria listed	Does not meet 1 of the criteria listed	Missing or does not meet 2 of the criteria	Missing or does not meet 2 of the criteria
BORDER	*Border present and neatly constructed* *All sides colored*	Meets all criteria listed	Does not meet 1 of the criteria listed	Missing or does not meet 2 of the criteria	Missing or does not meet 2 of the criteria
		6	4	2	0
NARRATIVE (one per topic)	*Correct spelling* *Correct description* *Text is readable*	Meets all criteria listed	Does not meet 1 of the criteria listed	Does not meet 2 of the criteria listed	Missing all criteria
PICTURES	*One pic per topic* *All pictures colored* *Captions present*	Meets all criteria listed	Does not meet 1 of the criteria listed	Does not meet 2 of the criteria listed	Missing all criteria

APPENDIX G

TEMPLATES – CONCEPT WALL

[topic title here]

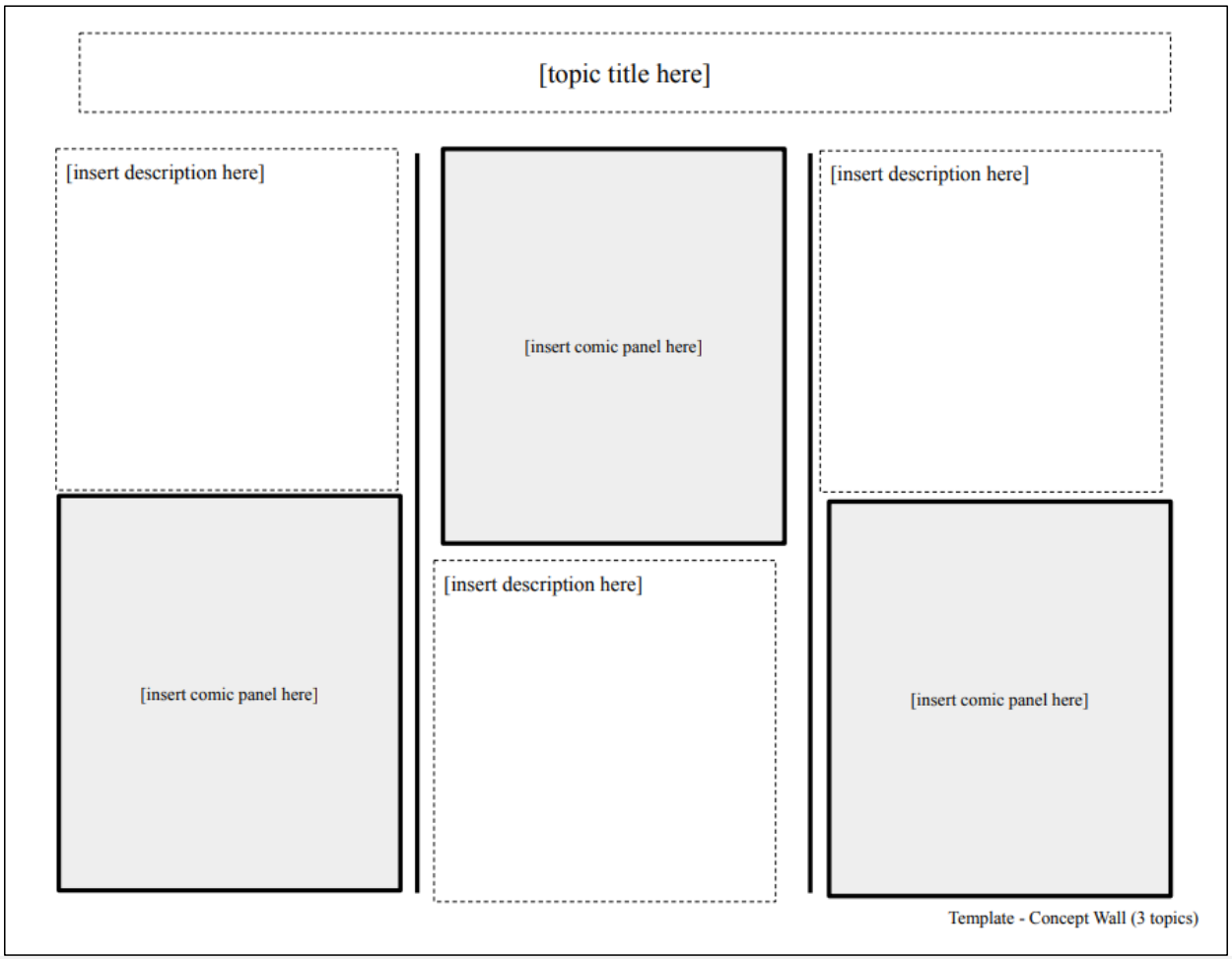
[insert description here]

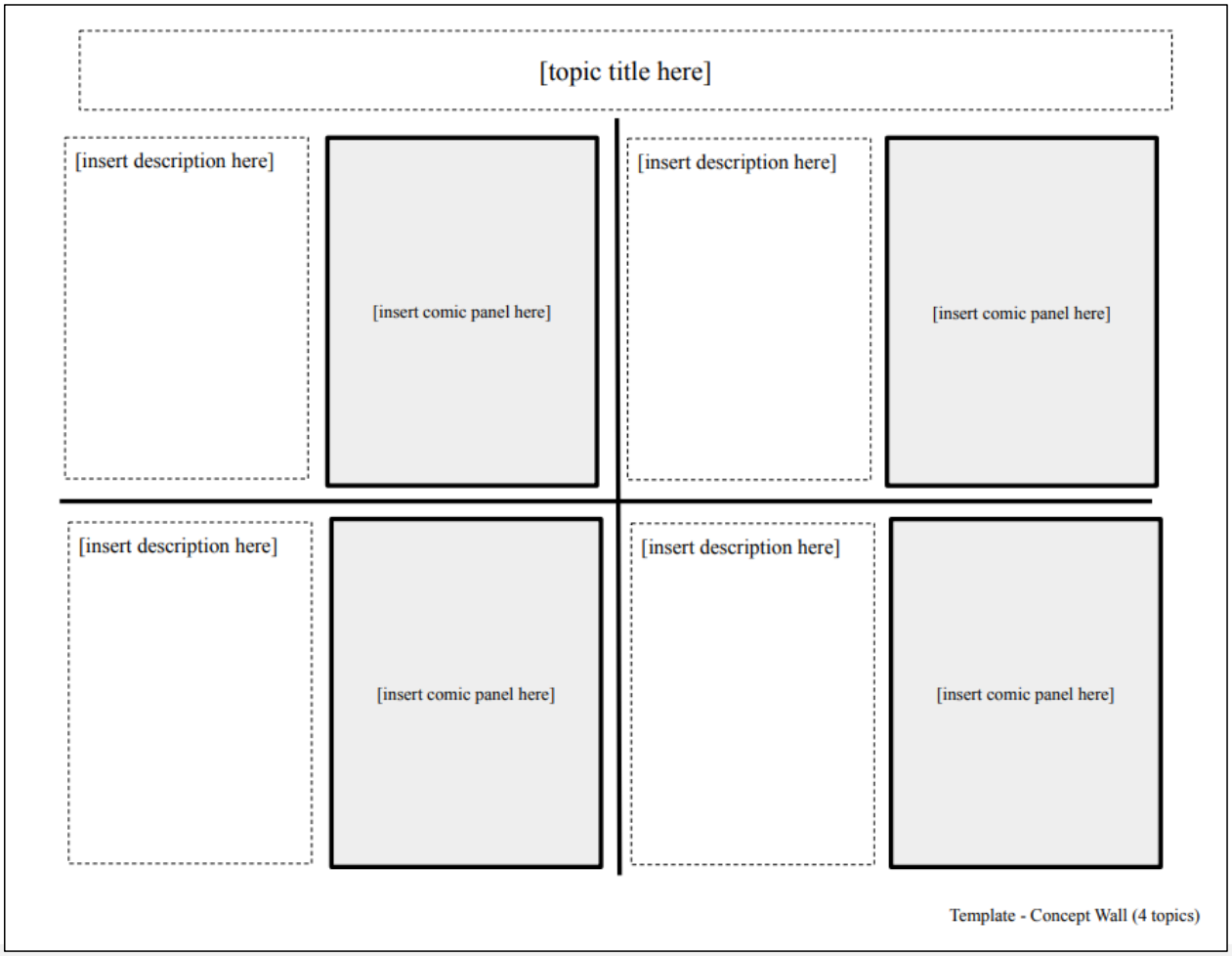
[insert comic panel here]

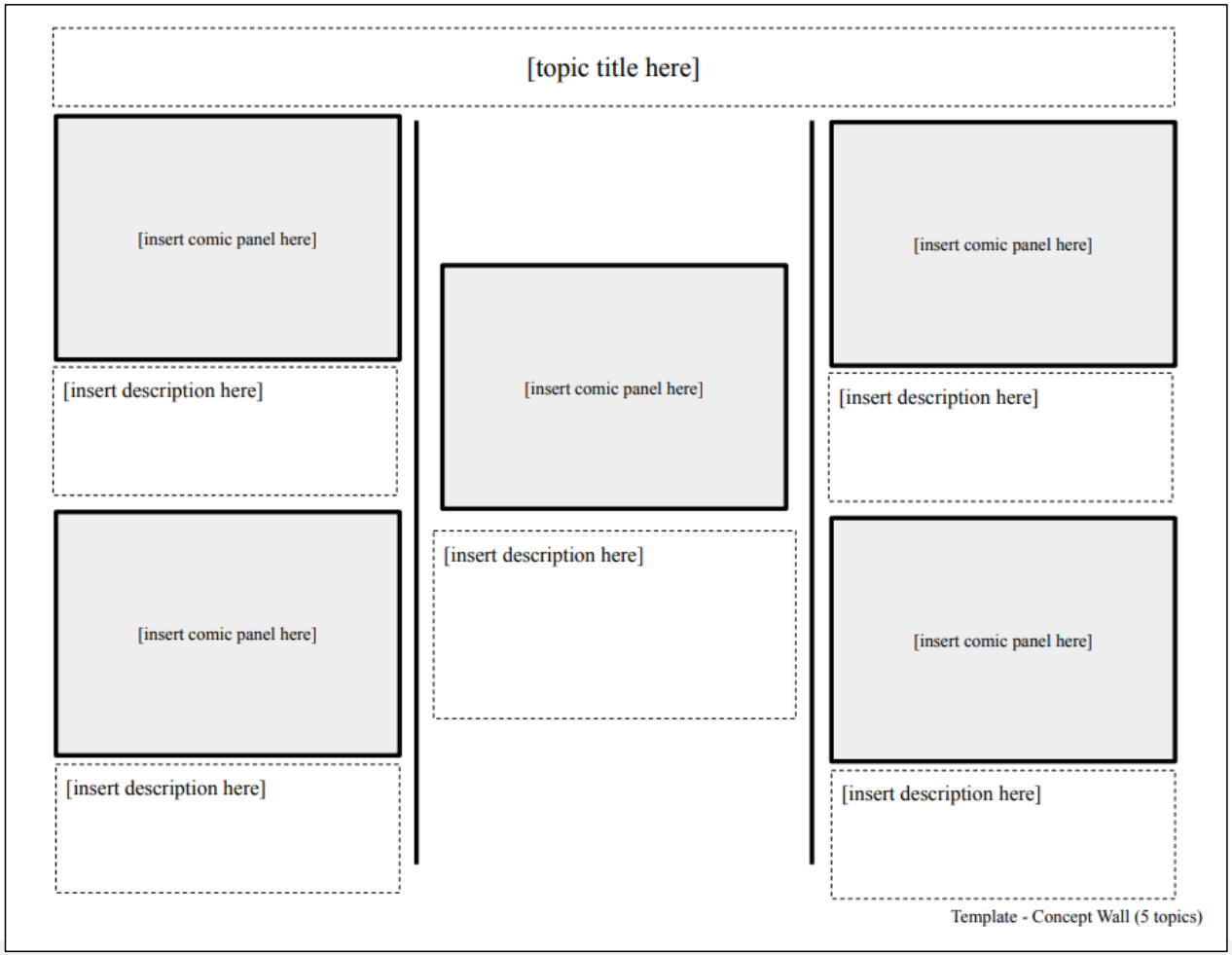
[insert comic panel here]

[insert description here]

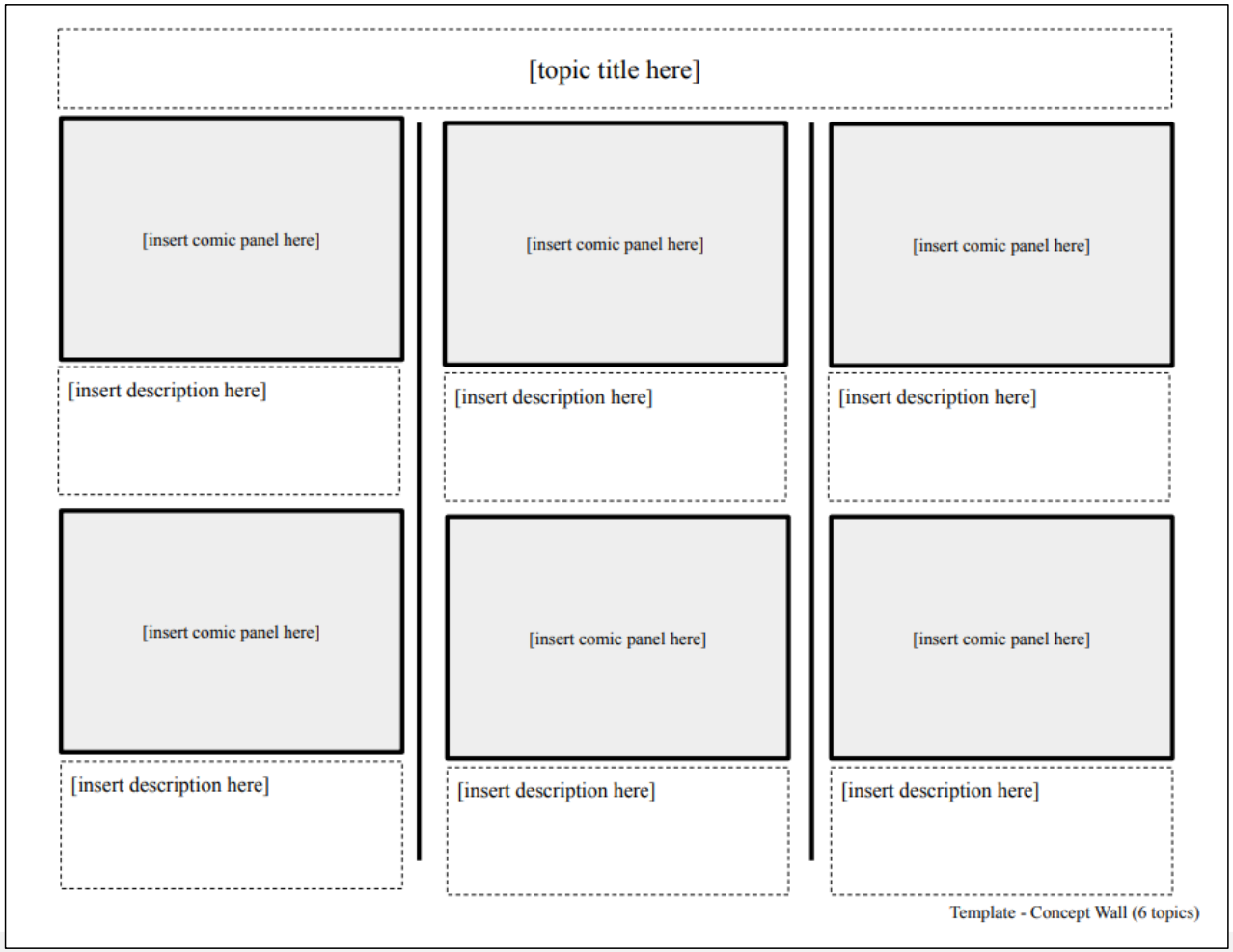
Template - Concept Wall (2 topics)


[topic title here]
[insert description here]
[insert comic panel here]
[insert description here]
[insert comic panel here]
[insert description here]
[insert comic panel here]
Template - Concept Wall (3 topics)


[topic title here]
[insert description here]
[insert comic panel here]
[insert description here]
[insert comic panel here]
[insert description here]
[insert comic panel here]
[insert description here]
[insert comic panel here]
Template - Concept Wall (4 topics)



Template - Concept Wall (5 topics)


[topic title here]
[insert comic panel here]
[insert description here]
[insert comic panel here]
[insert description here]
[insert comic panel here]
[insert description here]
[insert comic panel here]
[insert description here]
[insert comic panel here]
[insert description here]
[insert comic panel here]
[insert description here]
Template - Concept Wall (6 topics)

APPENDIX H

TEMPLATE – Plate Tectonic Gallery Walk

Write the name of your location here

Draw a cross-section of the interior of the Earth at your plate boundary.

On this cross-section label the following:

- layers of the Earth
- all geologic landforms
- name of plate(s) involved,
- direction of movement
- any ocean if present

Write a brief narrative here explaining the following based on your map-view:

- names of plates involved
- directions of plate movement
- latitude and longitude of your location

Write a brief narrative here explaining the following based on your cross-section:

- type of plate tectonic boundary
- process involved
- geologic activity occurring
- directions of plate movement
- landform created as a result of this movement.

Draw a map-view of the surface of the Earth at your plate boundary.

On this map label the following:

- layers of the Earth
- all geologic landforms
- name of plate(s) involved,
- directions of movement
- any ocean if present

Template - Gallery Walk