Design Document

Proposed Game Title: GeoHolo Adventure

Designers: Hillary Gould, Michael Mott, Jason Snyder, & Erin Weaver

The team worked together on concept designs and idea formation. Unintentionally, roles emerged as various team members voluntarily took the lead on different aspects of the project. Erin volunteered as lead developer of the prototypes and Jason became the graphic designer and artist. Michael became project manager, reeling in the team's expectations and ensuring that realistic goals for deadlines were set and adhered to as well as submitting finished assignments. Hillary became the writer and editor, collecting and weaving the team's ideas into polished documents for assignment submissions. Michael and Hillary also did a lot of consulting, providing feedback for each step of prototyping and art and contributing ideas to the process.

Meeting Notes:

Client Meeting

According to Dr. Jacquet, student understanding of the basic laws underlying rock strata formation is foundational to successful mastery of introductory Geology concepts. These principles are presented to students within the first few weeks of introductory Geology coursework and are fundamental to its study.

The problem we seek to address through game design and development is related to this foundational concept. Dr. Jacquet noted in our client meeting that many students have difficulty understanding and interpreting geological cross-section diagrams. Specifically, she expressed that students struggle with mentally organizing the order of geologic events with respect to different factors that affect rock layers (deposition, erosion, faults, etc.) when looking at these diagrams. She also stated that students are often confused by the concept of "unconformities" and their representation on cross-section diagrams. Our team sought to address these issues through the design and development of *GeoHolo Adventure*.

In our first meeting with Dr. Jacquet, we were able to gather preliminary information regarding the context in which this game will be presented to students and ascertain her expectations for its design. We discovered that Dr. Jacquet intends for this game to be presented as a supplement to regular course materials. Students will be exposed to the laws related to rock strata formation initially through lecture materials. Dr. Jacquet hopes to incorporate a game to test student knowledge of these topics in the form

of either a homework assignment or quiz that forces learners to apply the concepts discussed in class and reinforces their understanding. She envisions an interactive game that is entertaining for students to play. Dr. Jacquet mentioned a personal preference for board games, card games, and strategy games but envisions a web-based game to address this problem. She also noted a game called *Adrian's Fossil Collection* that she played and reported enjoying the idea and experience.

Team Discussions and Meeting Details:

We started very early on in the project communicating as a team via Canvas email. Collectively we found this to be the easiest with the difference in all of our schedules. At this point in the project, we are up to over 130 emails! Typically the communications presented in the emails were geared toward the progress of a specific assignment or who on the team is taking "lead". As a team we really focused on identifying our strengths and allowing the strongest member of the team to play capitalize on their abilities.

As a team we had a few "touch base" Zoom calls throughout the time we worked on this project. In most cases the Zoom calls were used to either cement any idea we had been discussing via email or focus on the required vTime meetings. As an example, March 1st we had our first Zoom call to lock down what assignment for module 4 we were going to work on first. Leading up to the Zoom call, we had several communications via email talking of possible ideas - specifically on if we should focus on the prototype first or not.

Early on we decided we were far enough along in our email communications that we could have our vTime discussions and we tried to accomplish them in one or two sessions. Unfortunately we had some technical difficulties and ended up having to redo some of the recordings. For the vTime recordings we did Game Elements, Achievement & Assessment, and Prototyping. We discussed other topics in Mozilla Hubs.

Another aspect of our discussions were generated on Google Drive. As a team, we created several documents that we used to collaborate on assignments and communication. A good example of this was our "Assignment Timeline" document. We created a document consolidating all the expected projects and due dates which gave us the ability to identify who was responsible for it, if others needed to assist, and when we completed as well as submitted the assignment.

Overview:

Vision Statement

Our team's vision is to develop a serious game that will help to reinforce the learning objectives presented in an introductory level undergraduate geology course. Our

approach is for a fun and easy to navigate game that focuses on the learning objectives while engaging the player.

Instructional Objectives

Dr. Jacquet identified several lower-level learning objectives that she would like our game to address. She hopes that after gameplay students will be able to…

i. Explain the 4 laws of geology (law of superposition, law of original horizontality, law of cross-cutting relationships, and law of lateral continuity).
ii. Based on a geological cross-section, identify the oldest and youngest formations.
iii. Explain the importance of Hutton's observation at Sica Point and what an unconformity is.
iv. Assess the rock layer sequence based on fossil position.

Based on these client-identified learning objectives, our team has developed corresponding higher-level learning objectives to be addressed by our game design. Students will be able to…

i. Create an example formation resulting in a given cross-section diagram.
ii. Analyze a cross-section diagram for possible causes of anomalies.

Intended Audience

The intended audience for the game will be college aged learners, specifically in an Introductory Geology class. The game will focus on the learning concepts and objectives taught in this level of class.

Platform & Game Engine

This game will be designed for play on a web browser. Initially, we will host the game on itch.io. The game engine our team selected is Construct 3. This engine was chosen for several reasons. First, our group members have familiarity with using this game engine. Second, we feel that a 2D game would be sufficient for meeting our learning objectives. Construct 3 is a game engine specifically geared towards developing 2D games quickly and easily. This game engine also has the functionality we need to export games to the web/HTML-5.

Concept Testing:

For this section, we had to come up with a game that would cover four principles assigned to us by our client. We needed to look at the 4 laws of geography, identify

youngest to oldest rock formations, explain unconformity, and know how fossils correlate to rocks. After discussions with the client, we came up with multiple ideas for how we could accomplish this after doing research on existing games. In looking at the games currently on the market, they either tended to lean into the younger demographic or did not cover all the ideas our client needed.

The following are summaries of games we found currently on the market. “Rock On! A Geology Game” is designed as a board game. The game was found on the website of iLaughnLearn which had the description and information about the game. In this educational game, the player is tasked with collecting the most rocks (real samples of 40 rock types) by correlating the rock sample with the card they draw. The core dynamic for this game is a combination of Collecting and Matching to attempt to be the biggest rock star. The Geology Game, found on Steam, is a turn-based game that appears to put the player in a position of collecting exhibits for a museum. The game teaches the basics of geology and rock identification. The game mechanics appear to be a point and click type mechanic, with the player picking a location and assigning tasks to their team of geologists to complete. The loop appears to be: pick a site, identify roles, collect exhibits, then repeat. According to the information in the Steam store, the game is suitable for adults, students, middle school, and hobbyist rock collectors. I don’t think the game is specifically meant to be a learning-based game, but it has some aspects that allow for learning. Traptris is a Tetris-like game except that the blocks are differentiated by lithology - source, reservoir, or seal. Tetris rows create geological cross-sections in the display after they connect and disappear. Adrian’s Fossil Collection is a web-based game found on the educational game platform “Legends of Learning”. The game places learners in the role of a mole named Adrian who works at a mine and loves rocks & fossils. Players are introduced to the principle of superposition, the concept of relative dating, and the concept of absolute dating. As they learn new concepts, players are asked to maneuver their avatar to uncover fossils based on whether they are younger or older than other objects or dates. They must also avoid and fight enemies lurking underground. The core dynamics of this game are “collecting” and, to a lesser degree, “solution” as well as “outwit.” We took this into consideration and began to hone our ideas before we settled on our current idea for the game.

With our prototype in place, we reached out to some teachers for their feedback over the game we had created so far. Overall, the findings were positive and, even with one tester not liking the game or wanting to use the game in an educational setting, she was still overall positive. Two of the teachers had quite a bit to say that was positive. One said, “I liked the game, it was interesting for the content. I don’t know what level would need to use this but it was pretty fun,” and another stated, “I really liked the content of the game, it was something I was familiar with so it was really easy.” There was some great and

pointed feedback given which will allow the team to look over the game and make a decision based on some of the findings. In the end, there will need to be a balance between the findings from the external testers and what the client wants. The findings of the game showed that the mechanics of what we are doing are sound and that everything we are hoping to work on is still on the right track.

While looking at our prototype and the design work we have in place, the next step was to think to Gee's Principles and how our game fits into his framework for learning. The first looks at two principles, interaction and production - both which the player will do as they complete the levels in our game. Players will be pleasantly frustrated and have some agency over the game as they are playing it. Challenge and consideration were included after our discussion with the client to see where the average player would be at. This game covers quite a few of Gee's Principles and that was by design when looking at what makes a good learning game great.

For our game, the first characteristic that distinguishes it would be the art style and the unique characters in the game. There is a sense of direction as you are working to collect fossils for your new park and hope to become an amazing curator of geological knowledge. When looking at this learning that becomes the motivation, your goal for the game is not only to learn all the elements above but to help to start up a collection of fossils. Bringing in this collecting element will help to make the player want to continue learning and playing.

Game Elements:

The look and feel of the game is very simplistic and fun. As a team we are not focusing on a realistic look or focusing on "triple A" graphics for the game. We are using a cartoony look with hand drawn graphics, with the intention of a fun and playful vibe throughout the game. Mr. Geo, our narrator of the game, is inspired by "Mr. DNA" from the movie Jurassic Park. The purpose of this character is to not only introduce the player to the game and its objectives, but will pop up throughout the game to help facilitate the learning and reinforce the material. Aside from the hand drawn graphics, our overall design is one of earth tones and "muted" colors. For the game, the team has decided to not focus on flashy or "vibrant" colors for a visual aesthetic, but more of a color scheme that lends to the subject matter.

This visual representation is also translated in the assessment and the achievement screen. The assessment portion of the game is our interpretation of a geological cross section. This accomplishes the ideal - removing the "typical" formal look of a cross section and replacing it with a simplified version. For the achievement phase, represented by a

dinosaur skeleton, we continue the same earth tone aesthetic and cartoony hand drawn design.

The story for the game is very simple. The player is being given a new technology, the “Geologic Holographic Avatar system” from Geo Incorporated. Using this system, the player is able to navigate through game stages and the assessment cross sections. Every bit of the story is presented by the game's non-playable character, Mr. Geo. Other moments of the narrative are game mechanics - specifically the objective of acquiring the missing pieces of the Dinosaur Skeleton (achievement) and the learning materials presented throughout the game levels. The design for this narrative is to incorporate the learning at the same time as the game play to facilitate maximum competency.

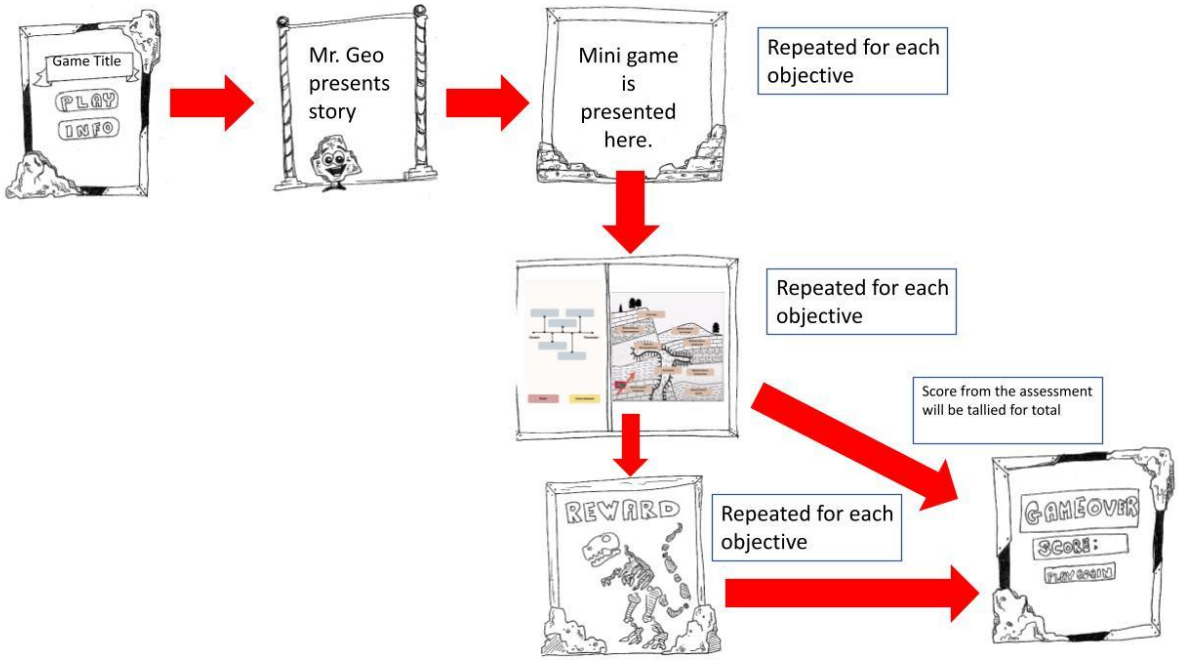
There is not an identified world for the game design, the environment of the game is a “playable cross section”. There is an identified corporation (Geo Incorporated) introduced in the beginning of the narrative, but nothing in the game develops the world that this entity exists in. The game design has two characters. One is a non-playable character by the name of “Mr. Geo”. This character will be used to inform the learners of the narrative and objective of the game. Mr. Geo also introduces the playable character, represented by the “Geo Holo” avatar. This character is the main character that the learner controls not only in the game but also in the assessment portions.

The gameplay designed for this game is similar to most web based 2D games. As a team, we decided the main controls would be based on keyboard commands, using the spacebar and arrow keys to navigate around the given map and occasionally clicking to proceed. The player uses the controls to move the Geo Holo avatar to collect various pieces in order to complete the given objective for the map. There is a “dexterity” based level, requiring the player to keep the avatar on the holo board during the earthquake, but this level relies on the same gameplay controls. Overall, the player will play each minigame, achieve a reward, and then complete an assessment of the learning objective introduced in the recently played level.

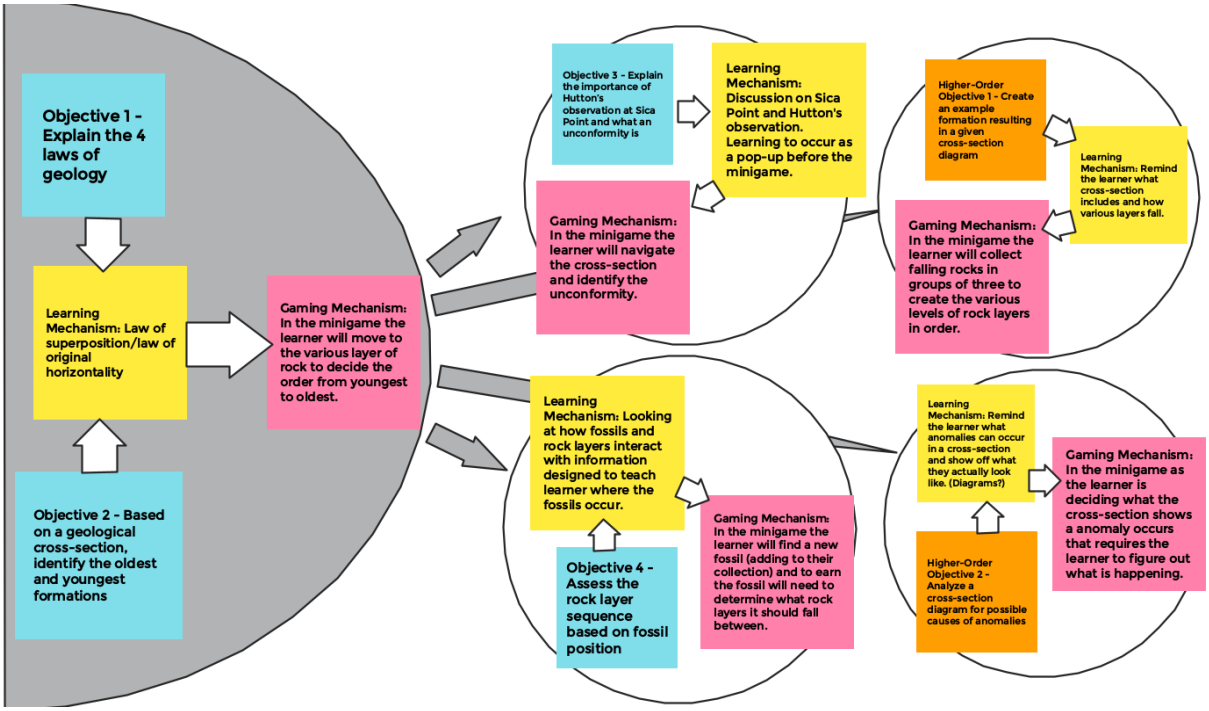
The core dynamic of the game is achieved once the player collects all of the pieces of the dinosaur skeleton and plays through all of the assessments presented at the end of each mini game. Upon completion, the player will be presented with an assessment score that is calculated from the attempts of the level assessments. The primary mechanic of the game is collecting. The design of the game has the avatar being moved throughout the levels collecting pieces to accomplish an end goal. During the assessment phase, players move the avatar over pieces collecting them to add to the assessment timeline, identifying comprehension of the learning material. Even the achievement is based on collection.

Though in this design, the player is not actively controlling the avatar to collect the pieces, but rather acquiring them to complete the game.

Storyboard:



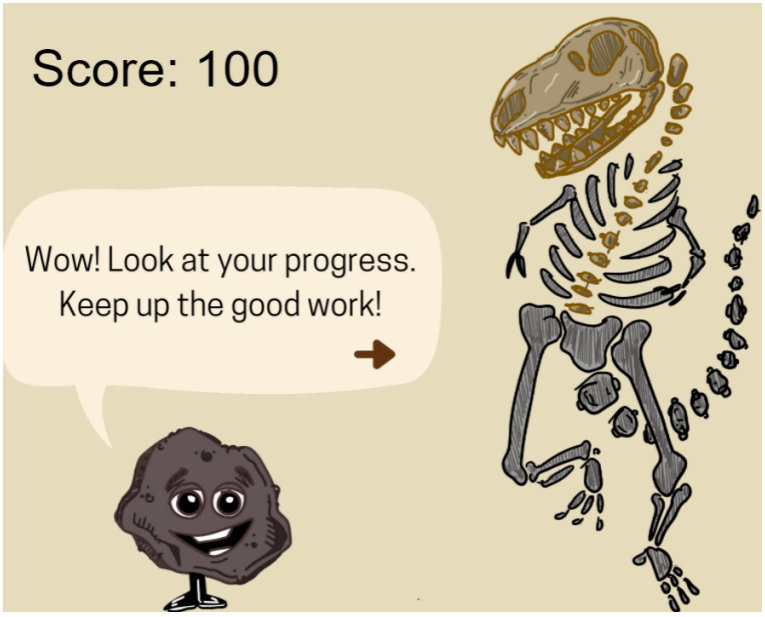
LM-GM Mapping



Achievement & Assessment:

The players of our game are assessed based on whether or not they complete all game levels successfully. In order to pass a level, the pattern of geological events the player inputs must match the given cross-section diagram. We are focusing on formative assessment - assessment for learning, but the last level also serves as a summative assessment - an assessment of whether or not the learner understands how to recreate the most complex diagram. Players will not be able to proceed without successfully identifying each sequence. If the sequence of events matches the geological history represented by the level diagram then the player has achieved the learning outcome for that level and may continue. In addition to matching, the other core dynamic utilized is collecting.

Upon the completion of the introduction, players are shown the outline of a T-Rex they are seeking to "build" by completing all levels. For each level that a player successfully completes, they will receive a portion of a T-Rex fossil (i.e. after level 1 they receive its skull, etc.).



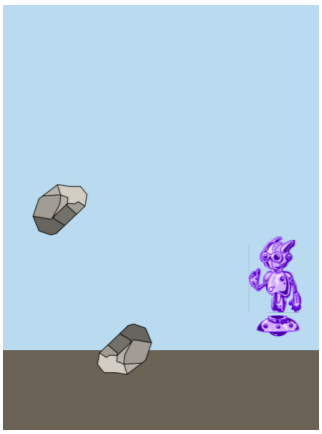
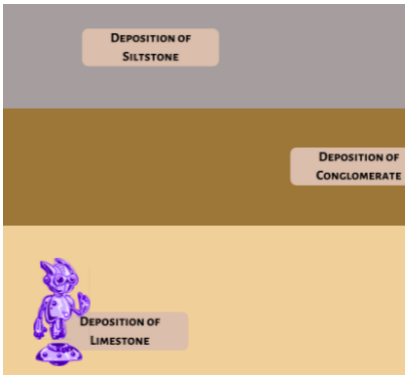
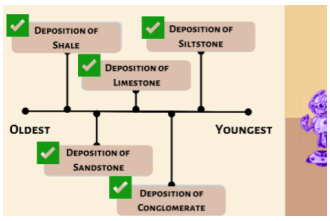
Players are given each new piece as a reward for completing the level. Players will also be able to collect smaller fossils as they progress throughout a level and are, for example, required to collect three rocks to form a layer.

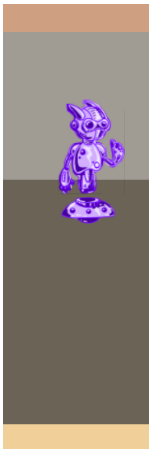
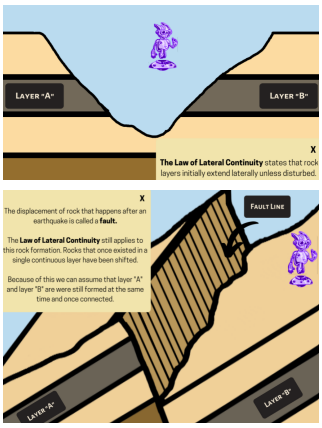
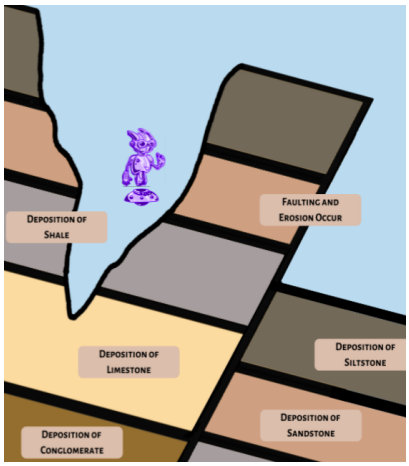
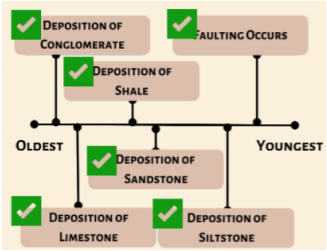
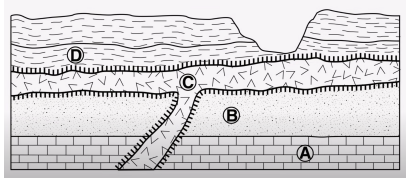
Players are not allowed to progress without successfully completing each level. We used arrays to ensure that the player's sequencing order matches the given diagram. If a player incorrectly selects a sequence, a pop up appears with a suggestion for review. Players have the option to reset the level and try again until they successfully complete the level task. If a player presses restart three times, they are required to go back and repeat the content level that goes with the assessment. This will ensure that players cannot guess and check until they are able to pass. There is some score deduction for additional attempts required to complete the assessment correctly. Players can always play through again to achieve the max score if they are turning in a screenshot for their homework in the undergraduate geology course.

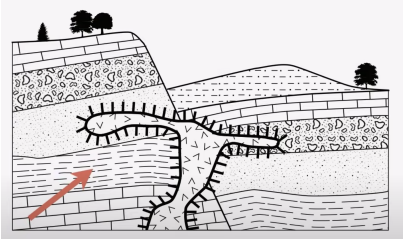
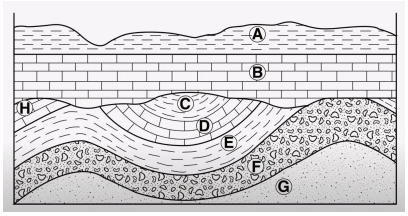
Players progress through the game via levels that are mapped to our learning objectives. The player's progression throughout the game is part of their achievement from the assessment. Below is a map of how each learning outcome aligns with a specific game level and activity prompt.

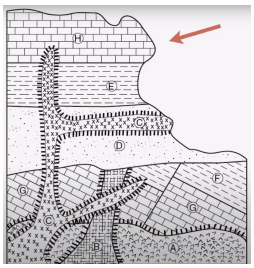
For our prototype, only objectives one through three are complete. The remaining text describes how we would design these lessons and assessments into the game.

Map of Learning Outcomes**

Level	Concept/ Learning Objectives	Assessment	Correct Answer
#1	Law of superposition (*Objectives i & ii**) 	Players collect falling rocks to form layers in real time (left) and then reinforce the learning by identifying the order of events (below). 	Player collects the events in the following order:  Remediation will remind players of the law of superposition: 

#2	Law of original horizontality (*Objectives i & ii**) 	As players collect rocks like shown above, the horizontal layers forming are shown (left). They are also required to correctly order the sequence of events that took place to produce a cross-section similar to the one above. The assessment in the cell above combines objectives 1 & 2 and the assessment in the cell below combines objectives 1, 2 & 3.	Player selects the events in the order in the cell above and in the cell below for the later assessment which reinforces original horizontality when other geological events come into play. *Remediation will remind players of the law of original horizontality
#3	Law of lateral continuity (*Objectives i & ii**) 	Players are required to correctly order the sequence of events: 	Player correctly orders the events:  *Remediation will remind players of the law of lateral continuity
#4	Law of cross-cutting relationships (*Objectives i & ii**) A visual similar to above would display the intrusion occurring much like erosion and earthquakes were demonstrated with a mini game of the	Players will be required to correctly order the sequence of events that took place to produce a cross-section similar to the ones below:  Or	Player selects the events in the following order Sequence of Events 1. Deposition of A 2. Deposition of B 3. Deposition D 4. Intrusion C 5. Contact Metamorphism 6. Uplift 7. Weathering and Erosion Or

	player surfing around lava or riding the intrusion as it disrupts the existing cross section in real time.	 We have not built this level into the game, but we would design something like the previous assessments that introduces a cross-cutting relationship into the assessment.	Sequence of Events 1.Deposition of Limestone 2.Deposition of Shale 3.Deposition of Sandstone 4.Deposition of Conglomerate 5.Deposition of Limestone 6.Deposition of Siltstone 7.Faulting 8.Uplift 9.Weathering and Erosion 10.Intrusion 11.Contact metamorphism *Remediation will remind players of the law of cross-cutting relationships
#5	Unconformity (*Objective iii**) Similar to the erosion display, we would show uplift, erosion, and subsidence occurring and then have the player collect rocks to form two layers on top after it occurs, showing the end result similar to the diagram (right).	Players will be required to correctly order the sequence of events that took place to produce a cross section similar to the one below  We have not built this level into the game, but we would design something like the previous assessments that introduces an unconformity into the assessment.	Player selects the events in the following order: Sequence of Events 1. Deposition of Sandstone 2. Deposition of Conglomerate 3. Deposition of Shale 4. Deposition of Limestone 5. Deposition of Shale 6. Folding 7. Uplift 8. Weathering and Erosion 9. Subsidence 10.Deposition of Limestone 11.Deposition of Shale 12.Uplift 13.Weathering and Erosion *Remediation will remind players of details about the formation of an unconformity
#6	Use fossils to correlate rock layers (*Objective iv**) This would be demonstrated by a mini-game where the player encounters dinosaurs and jumps	Players required to correctly order the age of several fossils based on a cross section similar to below:	Player selects the fossils in the following order from oldest to youngest 1. Fossil from layer G 2. Fossil from layer F 3. Fossil from layer D 4. Fossil from layer E 5. Fossil from layer H

	on them to defend their holo avatar, followed by watching the dinosaurs get buried into the layers and fossilize to demonstrate how it happens over time.	 (Fossil pictures to be added)	*Remediation will remind players of the law of inclusions and the principle of faunal succession.

*Learning Objectives:
i. Explain the 4 laws of geology (law of superposition, law of original horizontality, law of cross-cutting relationships, and law of lateral continuity).
ii. Based on a geological cross-section, identify the oldest and youngest formations.
iii. Explain the importance of Hutton's observation at Sica Point and what an unconformity is.
iv. Know how to use fossils to correlate rock layers.
** Images taken from Sammartano, Mike. (2014, May 11). *Relative Dating of Rock Layers* [Video]. YouTube. https://www.youtube.com/watch?v=fYSeM63Fv0s

Prototyping:

Our prototype consists of two content levels and two assessment levels from our game. We chose Construct 3 as our game engine because we had familiarity with it from previous coursework and felt that a 2D game would fit our learning goals. Initially, we prototyped out two of our ideas. One idea, based on a sandbox building concept, proved difficult to develop given our current knowledge of the game engine. We also discovered that assessment in regard to this idea would be very complex. There are a wide variety of ways that a player can be correct or incorrect when utilizing this idea, and, in the end, we felt that this complicated things beyond what we were able to address within our given timeframe.

The other idea we sought to prototype initially was a drag and drop style assessment level. While we felt that this worked well to measure student ability to understand the learning objectives, we found the idea to be less "game-like" than we wanted it to be. It played more like a quiz than a game, which did not align with our goals. After playing through both of these prototypes, our team chose to continue with our second idea. Because assessment is vital to serious game design, we felt that we should pursue the idea that gave us the best chance of developing a prototype with a functioning assessment.

Due to the dry and quiz-like nature of our second initial prototype, we decided to go back to the drawing board and gamestorm ways to make the content delivery and assessment portions of the game interactive and fun for players. To make the assessment more interactive, we decided to insert a sprite that users would manipulate to "collect" rock layer tokens in the correct order. To allow users to relate the order in which they

collected these tokens with geologic time, we incorporated a timeline that populated with each token as the player collected it. Overall, we felt that this prototype successfully added player interactivity to the assessment and further reinforced our learning goals.

In order to make the content delivery portion of our game more interactive, we settled on an idea to insert mini games into each level that would allow us to deliver the necessary definitions and concepts. Two ideas for these mini-games emerged, and we set about attempting to expand our prototype to include them. Our first mini game consisted of players being required to "collect" falling rocks using a sprite. These falling rocks would correspond with rock layers and, as players collected a certain number of rocks, a new rock layer would populate in a rock strata diagram. We felt that this idea would allow users to "see" the way in which layers of rock would be deposited over time, enable us to insert key definitions, and be fun for players to interact with.

Our second mini game concept dealt with the effect that geologic events such as erosion and faulting have on rock strata. For this mini game, we decided to allow users to experience graphic representations of these events. First, we allowed players to initiate a period of erosion and view its effects. Next, we incorporated a section that allowed players to initiate an earthquake. In order to insert interactivity, we decided to incorporate movement of our sprite's "holoboard" that paralleled the movement caused by the earthquake. Players would then be required to stay on their "holoboard" for the duration of the earthquake to continue. We felt that this was a fun way to keep players engaged, but still delivered the necessary content.

After expanding our prototype to include two mini games and two interactive assessments, we sought to add in a scoring component so that players can gauge their success. We added in reward sublevels in which players are awarded with a piece of a dinosaur fossil for their efforts, and a basic point system based on how well a player is able to complete each level. If players hit the "reset" button on the assessment too many times, points will be subtracted from their total score. The purpose of this was to allow us to account for players that might randomly collect sprites and hit the reset button multiple times to check for the correct answers, rather than think through the scenarios presented. We also expanded our prototype to include a title screen, an introductory section that explained our narrative, and an ending screen. Upon completion of our first complete draft of the game prototype we spent a large amount of time testing our levels within our group, making changes, and testing again in order to make improvements. This included making many changes to the text pop-ups, sprite movements, aesthetic components, as well as the scoring and assessment elements.

Link to Prototype: https://eaweaver.itch.io/geo-holo