

Aquaponics System Design

Kaitlyn Dryer

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Purpose

This project will spread the word about a useful and efficient type of gardening and clear up widespread confusion about how to build an aquaponics system from scratch. Users will gain understanding of how aquaponics works and why it's an important technology for the future. Furthermore, they will gain confidence that if they wanted to they could build their own aquaponics system.

Description

Content will include a diagram of an ebb and flow system, illustrations and explanations of all parts, video and audio of the system in action, and animations of the results someone would witness while troubleshooting the most difficult part of the setup: the bell siphon. Animation and interactivity will enhance users' understanding of aquaponics. Users will learn from visual and audio cues in order to build a virtual system.

Target Audience

The target audience is gardeners interested in trying out aquaponics and potential hobbyists (anyone curious about what it is and how it works). The audience will primarily be adults, although children planning a science fair project could also be interested. Users with special needs are not anticipated, nor is this project directed at individuals of any specific ethnic background.

Interactivity

Users will build a bell siphon on-screen and make adjustments until the siphon works properly. They will need to click and drag parts to create a working setup. Arrows and instructions will clarify expectations for the user. More parts will be available than are needed to build the siphon, and the user will be able to connect such parts to view the results. Each possible setup will produce a visual and audio result, some clearly more successful than others, so that the user can understand in practice, not just in theory, exactly what is happening. Once the user has built a successful bell siphon, he or she must activate the water pump by plugging it in (clicking the plug and dragging it to the outlet). As a reward for completing the goal, the user will see the system in action, with young plants sprouting, fish swimming happily, and siphon creating lots of bubbles as it shoots water down to the fish tank. Unplugging the system will turn it off again.

Time

The time required to build the bell siphon will depend on whether the user is interested in the results of alternative setups or simply interested in reaching the goal. Some users will try several setups before they successfully build the siphon; others will get a working setup very quickly. In the second case, a few may return to the trial and error process intentionally out of curiosity. Younger users will likely move through the lesson very quickly, perhaps reaching the goal in a minute or less. Older users are likely to spend more time reading the instructions and explanations and orienting themselves in the flash environment. They may have a longer attention span and could spend as much as five or ten minutes exploring the lesson.

Limitations

The project will be a web application included as part of a website on designing and troubleshooting aquaponics systems. Screen size will be limited in order to fit comfortably in most browser windows without scrolling. Load time for the application will limit size of the SWF (ideally 20MB or less).

Resources

I will create all audio and video clips for the project myself by recording my working aquaponics system in action with a digital camera. Using Audacity and Adobe Media Encoder to edit and convert the files, I will prepare them for use in flash. I will need videos of:

- a. water from the pump flowing into the grow bed
- b. the siphon starting

- c. the siphon not stopping (interesting but incorrect result)
- d. the siphon stopping correctly

I will edit each of the videos in Adobe Media Encoder to select the exact frames I need and to reduce the file size. I will need audio clips of:

- a. water from the pump flowing into the grow bed (sound of continuous flowing over rocks)
- b. the siphon starting (dripping sound, followed by flowing and then rushing sound)
- c. the siphon not stopping (cycle of flowing, rushing, and gurgling sounds without end)
- d. the siphon stopping correctly (gurgling sound, followed by choking sound, dripping sound, and silence)
- e. water flowing out of the grow bed without a siphon (sound of continuous flowing into water)

I will create these five complex sounds by taking videos and then using Encoder to edit them into MP3 files. I will then edit the sounds into smaller clips for more flexible use with the animations:

- a. rockflow
- b. waterflow
- c. drip
- d. rush
- e. gurgle
- f. choke

Project schedule for production

Activity	10/30	11/6	11/13	11/20	11/27	12/4
Collect movie content	X					
Format images and drawings	X					
Create animations	X	X				
Create advanced interactions		X	X			
Peer Evaluations			X	X		
Usability Testing					X	
Submit Project						X

Identify Interactive elements that are active or dynamic in the scene:

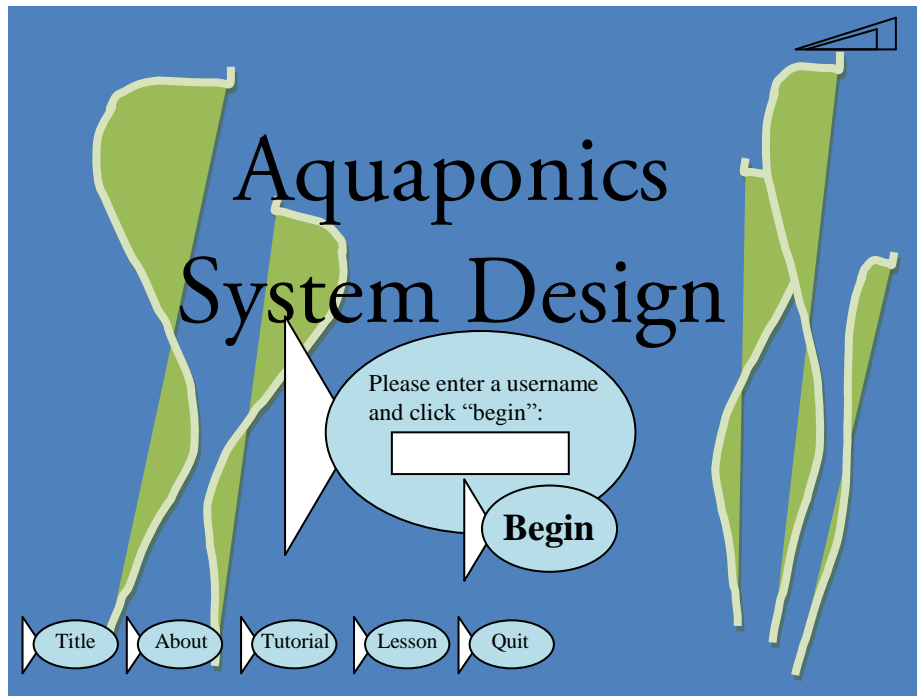
- Movie clips with names and location on main timeline (ex. frame number or label)
 - Animation description or actions
 - Interactive elements: sliding bars, buttons, clickable objects, etc.
 - Audio and video including size of files and estimated download times
1. List Static media needed for the scene: 2D, 3D, Text, etc.
 2. Identify the required project elements (1 to 8) implemented in the scene (Review the Interactive Animation Project Guidelines PDF document). Make this text bold or a different color in your storyboard for easy review.

Storyboard

Stage Size: 800 (W) x 600 (H) pixels

Screen 1 (Title)

The title page will entice users to try out virtual aquaponics.



Interactive Element	Effect
Menu Buttons	Buttons will swim onto the title screen but will not be interactive until the big fish “username_mc” swims onto the screen
Input Text	The text field will allow user input for use in Screen 5
Begin Button	The begin button will take users to the “About” scene

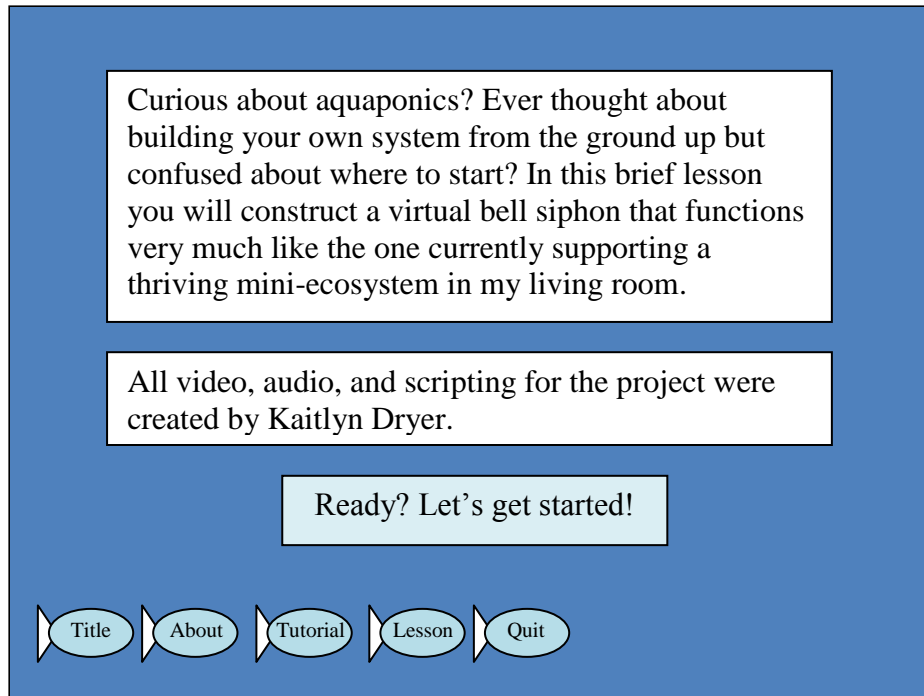
Media	Description and Type(Static, Dynamic, Interactive, etc)
Animation	The title will arrive via motion tween animation
Buttons	The fish-shaped menu buttons will swim onto the screen via motion tween animation (interactive after movement is finished)
Audio	Background ambience will be provided in the form of peaceful water sounds
Mask	A mask will be used to create the illusion of moving water and plants

Req #	Description
1	Title Screen
4	Basic Animation – Title and buttons will be animated. Transition to the next project scene will also be animated
6	Navigation/Interface Design, all navigation will continue throughout the project
8	Audio
3	Input Text

Stage Size: 800 (W) x 600 (H) pixels

Screen 2 (About)

The about screen will clarify what the user can expect from this lesson.



Interactive Element	Effect
Ready_btn	Clicking takes the user to the tutorial screen
Menu buttons	Allow navigation to any part of the flash movie at any time

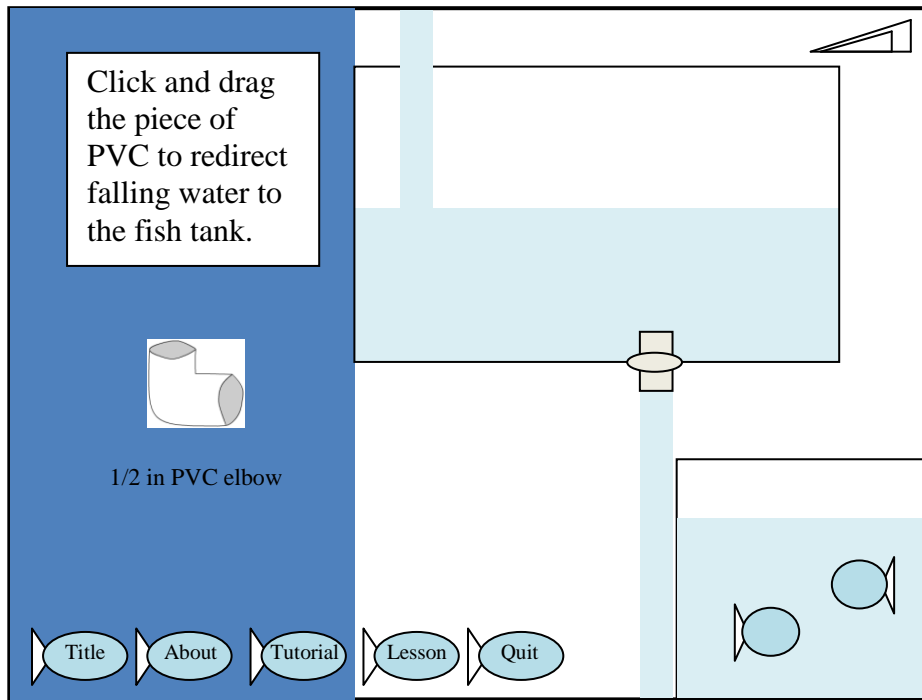
Media	Description and Type (Static, Dynamic, Interactive, etc)
Text	Static, purely informative

Req #	Description
2	About screen—includes purpose, target audience, resources, and my name. Appears after the title screen
6	Navigation/Interface Design, all navigation will continue throughout the project

Stage Size: 800 (W) x 600 (H) pixels

Screen 3 (Tutorial)

The tutorial will clarify what the lesson expects of the user. This screen will guide the user through how to drag and drop parts of the siphon, with an immediately visible effect.



Interactive Element	Effect
waterflow_mc	Water flows in continuously playing animation, in from the top of the screen and out the bottom, until a correctly dropped elbow stops this movieclip
elbow_mc	Dragging the elbow element and dropping it in the correct position will redirect water flow before the viewer's eyes by calling a function that stops waterflow_mc and plays redirected_mc
redirected_mc	Water flows continuously through the pipe and into the fish tank below.
Menu buttons	Allow navigation to any part of the flash movie at any time

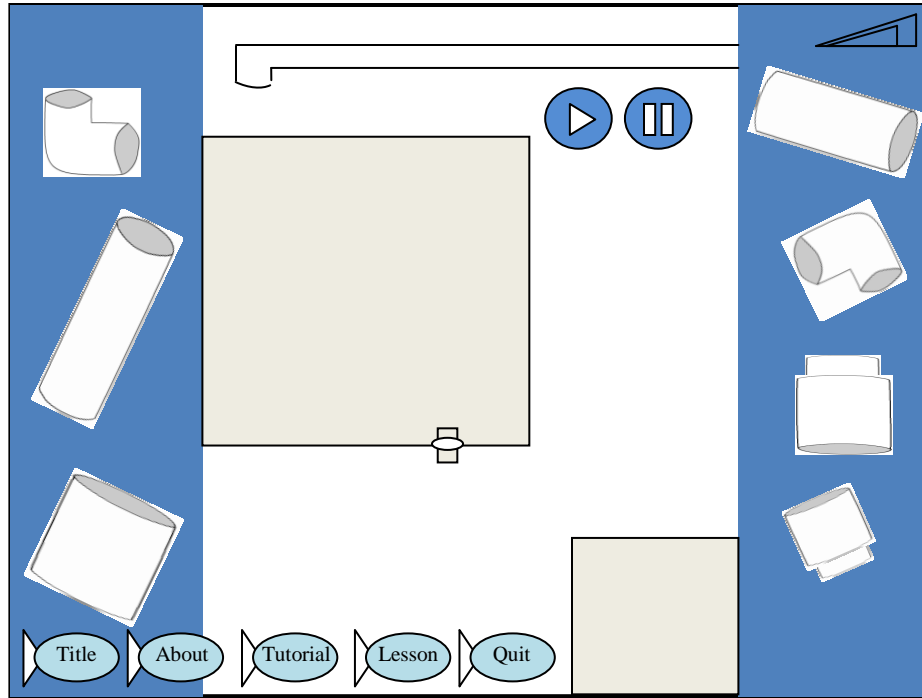
Media	Description and Type (Static, Dynamic, Interactive, etc)
Text	Static, provides instructions for this screen
Animation	Interactive, altered by user through drag and drop
Audio	Sound effects accompany animation, sliding volume control at top right

Req #	Description
4	Basic Animation
5	Advanced Interaction
6	Navigation/Interface Design, all navigation will continue throughout the project
8	Audio—Sound effects accompany animation, sliding volume control at top right

Stage Size: 800 (W) x 600 (H) pixels

Screen 4 (Trial and Error)

At last, the user will see all the pieces needed to build the siphon and have the chance to interact. Each possible setup will produce a realistic effect to assist the user in finding and understanding the correct setup.



Interactive Element	Effect
Click and Drag	All of the pieces on the two sidebars will be draggable when animation is turned off.
Animation Buttons	Clicking to turn on the animation will allow the user to view water moving through the setup he or she has created.
Menu Buttons	Allow movement to another screen of choice.

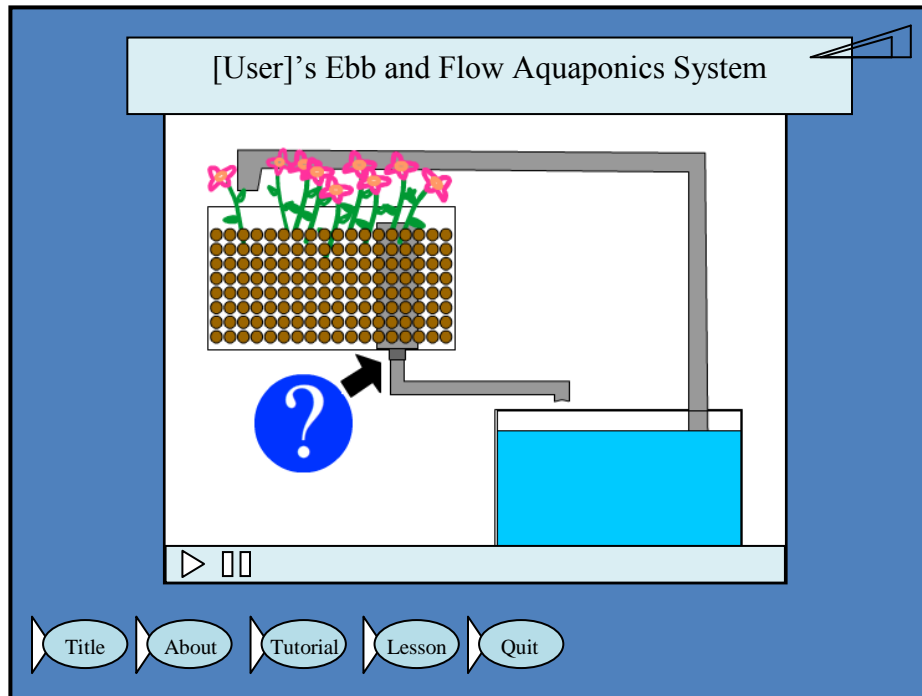
Media	Description and Type (Static, Dynamic, Interactive, etc)
Labels	Interactive—each piece PVC will have a label that appears on mouseover
Animation movieclips	Interactive--There will be animation movieclips for water pouring straight down, water pouring through a pipe and into the tank, water filling the bed, a vacuum being created as the last of the air in the siphon disappears, water pouring quickly, water being pulled up through the siphon, water pouring in short spurts, and water dripping. These animations will be triggered by the user dragging and dropping specific pieces to build the siphon.
Audio	Sound effects will accompany each animation. Volume can be raised or lowered.

Req #	Description
4	Basic Animation—at least 6 seconds, includes play and pause buttons
5	Advanced Interaction—Click and drag for each of the parts
6	Navigation/Interface Design, all navigation will continue throughout the project
8	Audio—Upon turning on the pump (clicking play), the user will hear as well as see a specific result based on which pieces have been put in place

Stage Size: 800 (W) x 600 (H) pixels

Screen 5 (Action!)

(Once the user has achieved the correct setup, he or she can watch the entire system in action.)



Interactive Element	Effect
FlvPlayer	The component skin provides the user control over when the video plays
ebbandflow_mc	This could be an animation or 1-4 real video clips (they could be played side by side using multiple instances of the flvPlayer)

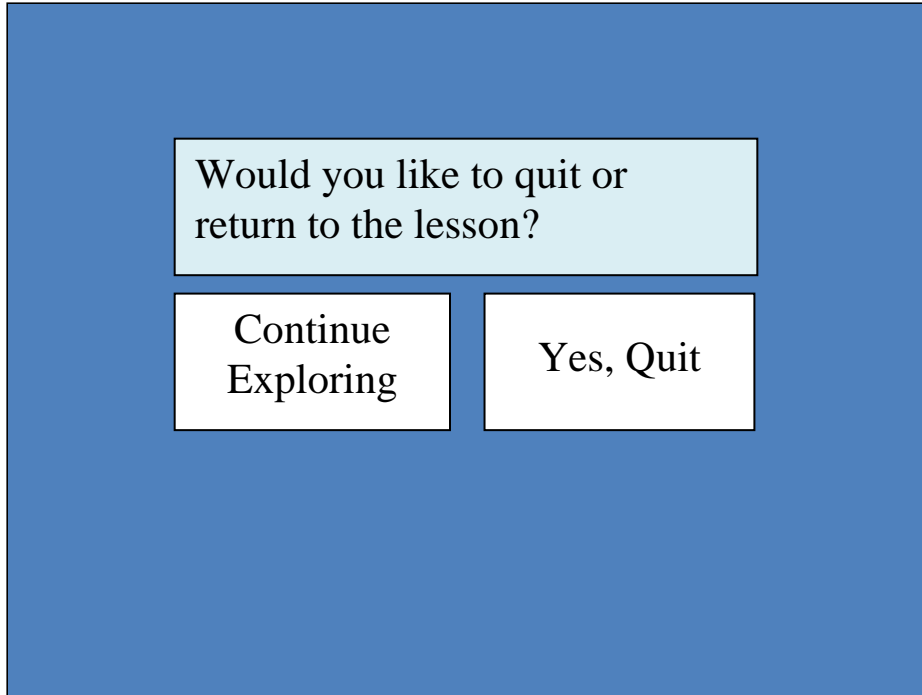
Media	Description and Type (Static, Dynamic, Interactive, etc)
video clips	Most likely actual scenes from my aquaponics system—the user cannot interact with these videos besides clicking play or pause; however including real footage would take the lesson from the theoretical to the actual
audio	User can adjust the volume (interactive)
text	The chosen username from Screen 2 appears in the video title, giving the user ownership in his or her success (dynamic)

Req #	Description
3	Input text displayed in movie title
6	Navigation controls allow the user to skip to another page at any time
8	The video(s) will contain audio, and the user can adjust the volume

Stage Size: 800 (W) x 600 (H) pixels

Screen 6 (Quit)

Having reached the end of the lesson, the user will have the option to quit or return to the lesson.



Interactive Element	Effect
Buttons	"Continue" returns users to the screen the user came from, while "Quit" displays "Goodbye, [user]!"

Media	Description and Type (Static, Dynamic, Interactive, etc)
Text	static text
Goodbye	dynamic text

Req #	Description
3	Input text displayed in goodbye message
7	Quit screen, includes option to return to whichever screen the user came from

Evaluation Report: Building a Bell Siphon

Kaitlyn Dryer

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The screenshot shows an interactive tutorial interface. On the left is a dark blue sidebar with the title "Tutorial" at the top. Below the title, it says "1/2 in PVC Elbow" and shows a white PVC elbow icon. A text box contains the instruction: "Oh no, the water is dripping on the floor! Quick--click and drag this pvc elbow to re-direct falling water to the aquarium." At the bottom of the sidebar are five navigation buttons: "Title", "About", "Tutorial" (which is highlighted), "Lesson", and "Quit".

The main area of the interface shows a diagram of a "Growbed" and an "Aquarium". The "Growbed" is a rectangular container filled with a grid of brown circles representing substrate. A white PVC pipe is inserted into the bottom right corner of the growbed, with a small amount of blue water dripping from its end. A grey pipe is visible at the top of the growbed. Below the growbed, a blue water droplet is shown falling towards the "Aquarium". The "Aquarium" is a rectangular container filled with blue water and contains three colorful fish.

Executive Summary

As part of a website designed to promote aquaponic gardening, “Building a Bell Siphon” will clear up widespread confusion about how to build an aquaponics system from scratch. As users learn by trial and error how to construct a functional siphon, they will be guided by visual and audio cues that simulate real experience without the mess and costliness of real mistakes. The target audience is gardeners and potential hobbyists (anyone curious about what aquaponics is and how it works). The audience will primarily be adults, although children planning a science fair project could also be interested. Users with special needs are not anticipated, nor is this project directed at individuals of any specific ethnic background. Peer evaluation indicated a need for explicit instructions, hints, and written feedback at each step, so a significant amount of written content was added prior to usability testing.

Part One: Peer Evaluation Summary

A. Summary

Peer evaluation suggested that user input should not be optional but required. I agreed that this would fit the assignment better, despite concern that some users may prefer not to enter a username. Peer 1 reported that the tutorial page did not provide feedback and that the play button on the lesson page did not work. This surprised and alarmed me, as I had not encountered either issue when testing it myself. Peer 1 encountered no sound in the project, but that was due to the design problems previously mentioned, rather than an actual lack of audio features. Another issue was navigation buttons seeming to work at some times but not others. Going over the fla, I realized this was actually not due to a problem in the actionscript but to a lack of page titles. Peer evaluation primarily described a need for more textual content, as well as boundary setting the project apart from the rest of its page.

B. Project Changes

I created an error message that displays if the user fails to create a username. Fixing the tutorial and lesson page functionality required writing better instructions as well as adding animations, textual feedback, and further actionscript. I added page titles to all pages to prevent confusion over navigation. Incorporating the project into an aquaponics website I have been working on helped create context as well as form a natural boundary for the flash project. I added more content to the project itself as well.

Issue	Priority	Recommendation	Change
User can proceed without entering input	Medium	Add if...then statement to display	Added actionscript and error message

text		error message if user does not enter text	
In tutorial, dragging elbow to wrong place does not result in feedback	High	Give feedback! Expectations unclear.	Clarified instructions, made elbow snap back to original position if not positioned correctly. Added a hint that displays if elbow is dropped in the wrong place.
Play button on lesson page did not seem to work	High	Fix the button	Added instructions and hints, added animation for the button to play if clicked before instructions are carried out
Navigation was confusing, seemed buggy	Medium	Add page titles, fix actionscript for buttons	Added page titles. Made a note to observe during usability testing.
Purpose unclear	High!	Add textual content	Added textual content, positioned project in context of a website on the topic
No clear boundary for the project or for drag and drop	Medium	Change background color of webpage	Set the project within a bounding box on a web page with a different background color

Part Two: Usability Testing

A. User Observations

Summary of Users and Usability Tests

		Participant 1	Participant 2	Participant 3
User Profile	Age / Gender	22/female	70/male	21/male
	Internet Experience	Average	Average	Advanced
	Profession	Accountant	Retired	Student
Test Context	Usability Test Method	In person observation	Emailed link and tasks, telephone debriefing	In person observation
	Date of Test	11/28/2012	11/29/2012	11/30/2012

	Platform / Browser	Windows/Firefox	Windows/Chrome	Windows/Chrome

Summary of Observations

	Task 1	Task 2	Task 3
Task Description	Successfully complete the tutorial and move on to the next page.	Explore the lesson page at your own pace.	Complete the lesson by putting all the pieces in place.
Time spent to complete the task(s)	1 min, 1 min, <1 min	3 min, 4 min, 3 min	3 min, 25 min, 5 min
*Difficulty rating in completing task	easy, easy, easy	difficult, okay, easy	okay, okay, easy
Errors or problems identified by a user	Hard to hit exact drop point	<p>Unsure where pieces can be connected—above bulkhead wasn't a clear option</p> <p>Pieces are difficult to line up exactly, especially the glass</p> <p>Don't know what this is supposed to look like</p> <p>What is a bulkhead?</p>	<p>Video took time to load</p> <p>Expected to see animation of complete setup and was disappointed when it jumped straight to video</p> <p>Don't want to watch this video</p>
Overall user comments (likes and dislikes)	<p>Make drop area bigger.</p> <p>Easy to use Tutorial. The fish are cute and they start swimming around once the water is redirected to the aquarium.</p>	<p>Need a diagram of the completed thing as a hint.</p> <p>Positioning the glass is much more sensitive than any of the other pieces, which seem to just click in place if you are anywhere close. You might add a suggestion to "keep trying, as placing the glass in the tank is the most difficult part, but essential to proper operation."</p>	<p>I had a lot of fun going back through the lesson and testing each part after adding it. This way I got to see all the instructions/suggestions for each step. I was still disappointed that I didn't get to see the original model work, but was taken directly to the video. Perhaps you could add one additional step?</p>

*Difficulty rating: 1 = easy, 2 = okay, 3 = difficult

B. Performance Outcomes

Debriefing

Questions	User Answer
Overall, was the flash project easy or difficult to use?	Participant 1: Medium Participant 2: Easy to use Participant 3: Easy—drag and drop is easy
Did anything work differently than you expected?	Participant 1: No Participant 2: I wasn't sure about the function of the glass since the model seemed to work pretty well even before it was added, and then I didn't get to see the difference it would make. Participant 3: Not really
What was the most frustrating or difficult part of testing?	Participant 1: Pieces wouldn't stay, lack of mental picture Participant 2: Being sent too quickly from the model to the video. Participant 3: The last three pieces
What was the most interesting part of testing?	Participant 1: Playing with water and seeing and hearing the effect Participant 2: Seeing the complete instructions/suggestions (if needed) at each step, and the working or not-working of the system. Participant 3: Watching the water animations fill and refill
What do you think of this flash project overall?	Participant 1: Cool and interactive Participant 2: Super! Participant 3: It's good.
Further questions or observations?	Participant 1: I learned how to build a siphon. Participant 2: You used the term "bulkhead", which I was unsure what that referred to. I guess the bottom of the tank? Or is it the drain hole? Participant 3: Nope, it's really good.

Yes, the basic purpose is met. Could use a better introduction to what a siphon is before users are expected to build one though.

C. Usability Form Summary

Usability Form (Participant 1, Participant 2, Participant 3)

	Strongly Disagree		Neutral		Strongly Agree
1. I think the Flash website was easy to use and navigate	1	2	3 X	4 X	5 X
2. I was not overwhelmed by the numerous options and complexity of the Flash website	1	2 X	3	4	5 X X
3. The Flash website performed the way I expected	1	2	3	4 X X	5 X
4. I found it easy to determine my location in the Flash website (i.e., path, linear or hierarchical order, etc.)	1	2	3	4 X	5 X X
5. All interaction elements, such as buttons or movable objects, worked as expected	1	2	3 X	4 X	5 X
6. I thought the visual design was pleasing	1	2	3	4	5 X X X
7. The content was easy to understand and was aligned with the purpose of the Flash website	1	2	3	4	5 X X X
8. I found the technical functioning very good regarding audio, video, animation speed, and content display	1	2	3	4 X	5 X X
9. The visual design and media (text, audio, video, and animation) work together to form one cohesive program	1	2	3	4 X	5 X X
10. My overall experience with the Flash website was very good.	1	2	3	4	5 X X X

Participants indicated a need for clearer goals and better understanding of what the final piece (the “bell” of the bell siphon does), as well as larger drop areas allowing for some margin of error when placing each piece. I need to label the bulkhead and provide an animation for the correct setup, making the video optional rather than essential to this project.

Participant 1 disagreed with statement #2, indicating that she found the options and complexity overwhelming. She had the shortest time for each of the tasks and didn’t read any of the hints, possibly because she found the extra text overwhelming. On the other hand, Participants 1 and 2 may have found that the hints made everything else less overwhelming. I’m going to add a “siphon theory” screen prior to the lesson screen to clarify expectations and decrease the amount of text on the lesson screen. Hopefully this will help!

C. Project Changes

After peer review, I added textual feedback to the tutorial and lesson page, as well as an animation for when the user clicks play without adding any pvc pipes. I also made user input on the title screen mandatory and added page titles.

After usability testing, I added a pop-up help screen at the beginning of the lesson page that describes in theory what a siphon should look like and what it needs to do. The screen includes some of the hints and instructions from the lesson page, which helps make the lesson page less cluttered. This help screen appears until hidden by the user and can be accessed at any time from the lesson page by clicking the new “Help” fish. I labeled the bulkhead “bulkhead” on the help screen and labeled the upside down glass “bell”. I also added an animation that plays upon lesson completion, to show the siphon in action. The video screen can now be reached from a new fish button that appears when the siphon is complete.

Problem Rankings

Source	Issue Priority	Issue Description	Recommendation	Changed (Yes/No)
PE	High	In tutorial, no feedback for dragging elbow to the wrong place	Give feedback! Clarify instructions	Yes
PE	High	Play button on lesson page did not seem to work	Fix the button	Yes
PE	Medium	User can proceed without entering input text	Display error message if user does not enter text	Yes
PE	Medium	Navigation was confusing, seemed buggy	Add page titles, fix actionscript for buttons	Yes

UT	High	Drop area is too hard to hit, especially for the final piece	Make the “correct” area larger	No: Level of Difficulty. Tried to fix this, but larger drop areas makes the problem worse. The drop area for the glass already overlaps the others, which is causing most of the issue; however, since the glass needs to go over the other two pieces it will always overlap.
UT	High	Above bulkhead wasn’t a clear option for connecting pieces	Add a diagram of the completed system as a hint	Yes, although I believe adding a diagram would defeat the learning process. Instead, I added a pre-lesson screen showing key parts and explaining in theory what the siphon is to accomplish so that the user can create a mental picture
UT	High	Disappointment that completed siphon jumps straight to video	Add an animation of working siphon	Yes
UT	Medium	“bulkhead” referred to but undefined	Point out what this is	Yes
UT	Low	Video took time to load	Reduce size	No: Size is already small, issue only encountered once. Since I am adding an animation though, the video will not be the only option

*UT= Usability Test, PE = Peer Evaluation

E. Project Reflections and Recommendations

In designing “Building a Bell Siphon” I had hoped to simulate as closely as possible the hands-on experience of constructing a siphon. I wanted users to learn by trial and error, just as I had when setting up a real aquaponics system, and to succeed through immersion in the visual and audio experience. In many ways, the idea was not unlike that of an educational game. However, the actual product fell short; of five basic factors that make a game rewarding, my project succeeded in only two.

Factors that make a game rewarding to play include “self-governance, immersion, clear goals, immediate feedback, and game feasibility” (Kickmeier-Rust 651). The navigation buttons of “Building a Bell Siphon” allowed free movement between scenes and the lesson page included animation for many possible setups; in this sense, the project succeeded in allowing self-governance. Considering the project limitations, I also believe game feasibility was accomplished as well as it could have been. In all of the possible setups, water behaved approximately as it should if real physics were involved, and real, recorded sounds played to match the animations. The inclusion of actual footage also contributes to feasibility.

Immersion is trickier to accomplish, and would require that the user not be distracted by limitations or frustrations of the flash interface. Because the correct position for drag and drop interactions was precise, invisible, and hard to hit on the dot, participants in the usability testing frequently had to make multiple attempts to drop pieces, even when dropping them in what appeared to be the correct place. Additionally, having a great deal of text on the screen discouraged total immersion in the activity and reliance on the sounds and animations. For a truly immersive environment, background information and expectations would need to be presented before the lesson page, and the lesson itself should include few, if any words, with feedback and stimuli being solely presented through audio, video, and animation.

The primary deficiency noted in usability testing was a lack of clear goals. "Do I need to use all the pieces? Is that what we're going for?" one participant asked, and later said, "Ah yes, I see. I water flowing into the tank, but I don't think that's how it's supposed to get there." The participant had put the bottom three pieces in place. There was a brief pause, and then she stopped the animation, dragged a piece for the first time into the growbed rather than under it, and exclaimed, "The pieces can connect here too!" Before the participant made this discovery, I had wondered why she was dragging pieces to places they obviously couldn't connect; now I understood she was trying to use them all below the growbed, not realizing that she had more space for building the siphon. The expectation—and even the sense of what a siphon might be—was extremely unclear. Her suggestion, to include a diagram, would in many ways defeat the learning process I was trying to create. Yet my instructions stating that users must use the pvc pipes to connect the growbed to the tank were no more effective than telling them that to build an elephant they must merely create something that looked it could walk. What my users needed was not a physical picture, but a mental picture of what a siphon ought to be, and I failed to define that goal.

In terms of providing immediate feedback, my project falls somewhere in the middle of succeeding and failing. Feedback is provided for nearly every possible action. Yet, that feedback often goes unnoticed or unheeded. Perhaps a rewarding sound, such as a pleasant "Ding!" should have been implemented instead of words and explanations, which often went unread. Or perhaps, the new words appearing on screen as feedback might have appeared in a more eye-catching fashion. The best solution I've found for the present is to move the majority of text onto a separate help screen so that only text that adapts to the present situation appears on the lesson screen.

All in all, my project supports its stated purpose but could do so in a much more engaging and rewarding way. Among the complaints most often heard regarding online learning are "problems like missing motivation or a lack of instructional guidance." (Kopeinik 1). Without a clearly described goal and the opportunity to create a mental image, users will be missing the motivation and guidance needed to learn from the project as I had hoped. Nevertheless, participants in the usability testing completed their siphons successfully and reported having learned how a siphon works. It's a useful start, and I hope that my changes as a result of usability testing will reflect a better understanding of how to make educational animations also fun.

Works Cited

- Kickmeier-Rust, et al. "Immersive Digital Games: The Interfaces for Next-Generation E-Learning?" Ed. C. Stephanidis. *Universal Access in Human Computer Interaction Applications and Services*. Berlin: Springer. 4556 (2007): 647-656. Web.
- Kopeinik, Simone, et al. "The Artificial Mentor: An assessment based approach to adaptively enhance learning processes in virtual learning environments." Ed. T. Hirashima et al. *Proceedings of the 19th International Conference on Computers in Education*. Chiang Mai, Thailand: Asia-Pacific Society for Computers in Education (2011). Web.