IMPROVING USABILITY IN ‘CIRCLE’

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ABSTRACT

This paper describes how the System Usability Scale (SUS) has helped in improving and making a software tool called the Classification, Identification, and Retrieval-based Collaborative Learning Environment (CIRCLE) more efficient to use. In an SUS survey, participants are asked to rate 10 predefined questions on a scaled range from strongly agree to strongly disagree.

The first survey was done where the participants also indicated the positive and negative points about CIRCLE along with some additional comments. A Sitemap was developed using GoJS tool which helps in designing a graphical image of the same and makes it more user friendly as it also tracks the current location of the user and also directs the next pages where he can move from the current location.

A second survey was conducted and a comparison of the first and second survey results was made.

ACKNOWLEDGEMENTS

Though only my name appears on the cover of this dissertation, a great many people have contributed to its production. I owe my gratitude to all those people who have made this dissertation possible and because of whom my graduate experience has been one that I will cherish forever. My deepest gratitude is to my advisor, Dr. Brian Slator for the useful comments, remarks and engagement through the learning process of this master paper. I am very grateful to Dr. Otto Borchert for his valuable advice that helped me sort out the technical details of my work and providing with data for writing the review about surveys and also letting me to add a new feature in his amazing project CIRCLE.

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INTRODUCTION

Surveys can be conducted to gather information through a printed questionnaire, over the telephone, by mail, in person or on the web. This information is collected through the use of standardized procedures so that every participant is asked the same questions in the same way [1].

The usability of educational media, or any software system, is of paramount importance to its success. The Information Superhighway is littered with the rusting hulks of software systems that were hard to understand and use.

One such survey is System Usability Scale (SUS; Brooke, 1996). SUS has become an industry standard and a reliable tool for measuring usability. In an SUS survey participants are asked to rate 10 predefined questions on a 5-point scale ranging from “strongly agree” to “strongly disagree”. Based on these comments and rating, changes are made to improve the software [2].

This paper compares the results obtained by SUS survey done on CIRCLE with its early and later version. CIRCLE (Collaborative Identification, Retrieval and Classification Learning Environment) is a system which lets the students learn and gain some real time knowledge of classifying objects like plants and animals or rocks and minerals. With the comments thus obtained classification is made based on the information gathered with CIRCLE.

In the first review users found that navigating around CIRCLE was confusing as they were unable to track their own movement. This was considered as the biggest negative aspect about CIRCLE. Therefore, it was decided building a sitemap would help the users to track the path in which they travelled, their current and their possible next moves by describing it in a graphical representation using different color formatting.

After implementing the sitemap into CIRCLE another survey was conducted. The results of this review showed a dramatic change when compared with the first, as the users are now more comfortable in moving around the CIRCLE than previously. In this way SUS helped in improving CIRCLE and made it more user friendly.

BACKGROUND

System Usability Scale (SUS)

In an SUS survey, participants are asked to rate 10 predefined questions on a 5-point scaled ranging from “strongly agree” to “strongly disagree”. The survey has been used to determine the usability of a wide range of computer applications (Bangor, Kortum, & Miller 2008) [8] and provides an excellent test of CIRCLE’s usability.

Based on these comments and rating, changes are made to improve the software.

Table 1: Ten questions used in CIRCLE’s version of the System Usability Scale (SUS) survey.

1. I think that I would like to use CIRCLE frequently
2. I found CIRCLE unnecessarily complex
3. I thought CIRCLE was easy to use
4. I think that I would need the support of a technical person to be able to use CIRCLE
5. I found the various functions in CIRCLE were well integrated
6. I thought there was too much inconsistency in CIRCLE
7. I would imagine that most people would learn to use CIRCLE very quickly
8. I found CIRCLE very cumbersome to use
9. I felt very confident using CIRCLE
10. I needed to learn a lot of things before I could get going with CIRCLE

SUS Scoring

The SUS score is calculated by performing the following steps: 1) For odd numbered SUS questions subtract one from the user response 2) For even numbered SUS questions subtract the user response from 5 3) This scales all values from 0 to 4 (with 4 being the most positive response) 4) Add up the converted responses for each user and multiply that total by 2.5. This converts the range of possible values from 0 to 100 instead of from 0 to 40. [16]

CIRCLE (Classification, Identification, and Retrieval-based Collaborative Learning Environment)

The CIRCLE system was developed to help students learn how to classify and identify real world objects. Students work collaboratively to 1) gather specimens, 2) identify important observations and experiments about those specimens, 3) classify the specimens with respect to the results of these experiments, 4) provide a name or other identification for the specimens, and 5) play games dynamically generated based on the information gathered by the users (Borchert, Hokanson, Peruri, & Slator 2015) [9]).

CIRCLE players begin by finding interesting objects in their environment (Figure 1), providing intrinsic motivation to the task (Deci & Ryan 2000) [11]. Players take pictures of these objects, referred to as specimens, using their mobile devices. CIRCLE is suitable for any classifiable objects; examples include trees, birds, rocks, or weeds.

Instructions

On this page, you'll make hypotheses about the identity of your specimens. Click/hover over the buttons for more information.

Specimen Information

Name:Unknown
Description:Specimen 1-A

Experiments / Observations

Name	Results
Leaf Venation	Text: pinnate
Leaf Margin	Text: doubly serrate
Leaf Arrangement	Text: alternate
Leaf Type	Text: simple
Leaf Shape	Text: oblong
Fruit Type	Text: samaras
Leaf Persistence	Text: deciduous

Add Unlisted Hypothesis

Current Hypotheses

None

Figure 1. The interface for identifying a specimen with all of the multimedia and experimental results for an individual specimen (Borchert 2015, image used with permission).

After gathering specimens, group members suggest experiments and observations to perform on the specimen. Possible experiments for leaves might include leaf shape, leaf arrangement, or bark color. These suggestions are then performed by the gatherer, with the results being stored in the game for use in future tasks.

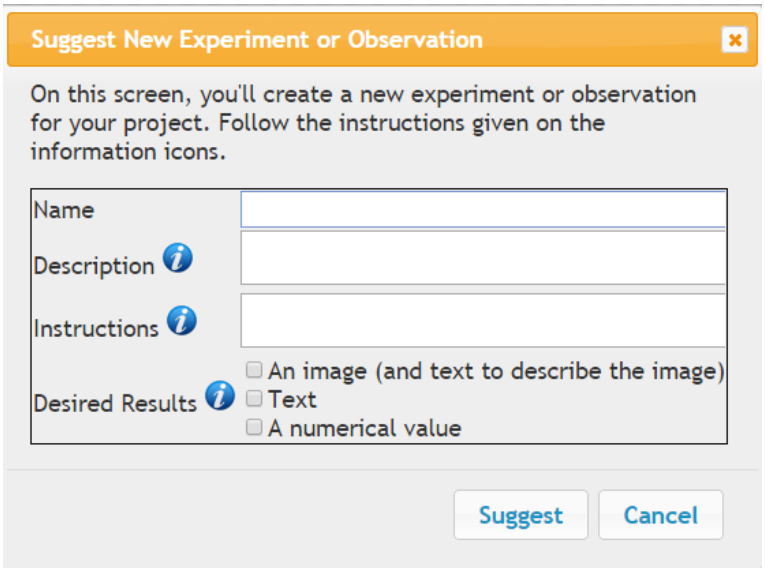

Figure 2. The interface for suggesting new experiments. After an experiment has been suggested, the gatherer needs to complete the instructions using either an image, text or numerical result.

After a number of experiments have been performed, players are able to create classification structures based on this data (See figure 3). Students use a click and drag interface to create a classification tree. Branches of the tree refer to individual experiments, while leaves in the tree correspond to specimens. The classification is deemed correct when all specimens that have been gathered can be classified by the structure.

After classification, players identify the individual specimens. Students create a hypothesis to name each specimen group from the classification structure. All players in the group then vote on which hypothesis they surmise accurately identifies the specimen. Whenever a majority has voted for a specimen name, it is given that name in the interface.

After all of these tasks are completed, players unlock a game interface, where they can play games based on the data they collected: the specimens, experiments/observations and results of those experiments/observations, classification structures, identities, and any gathered multimedia. This data is used to create a game that helps solidify student knowledge through

retrieval learning (Karpicke 2012) [12]. Rather than simply attempting to memorize their specimens, they need to actively retrieve their knowledge from memory.

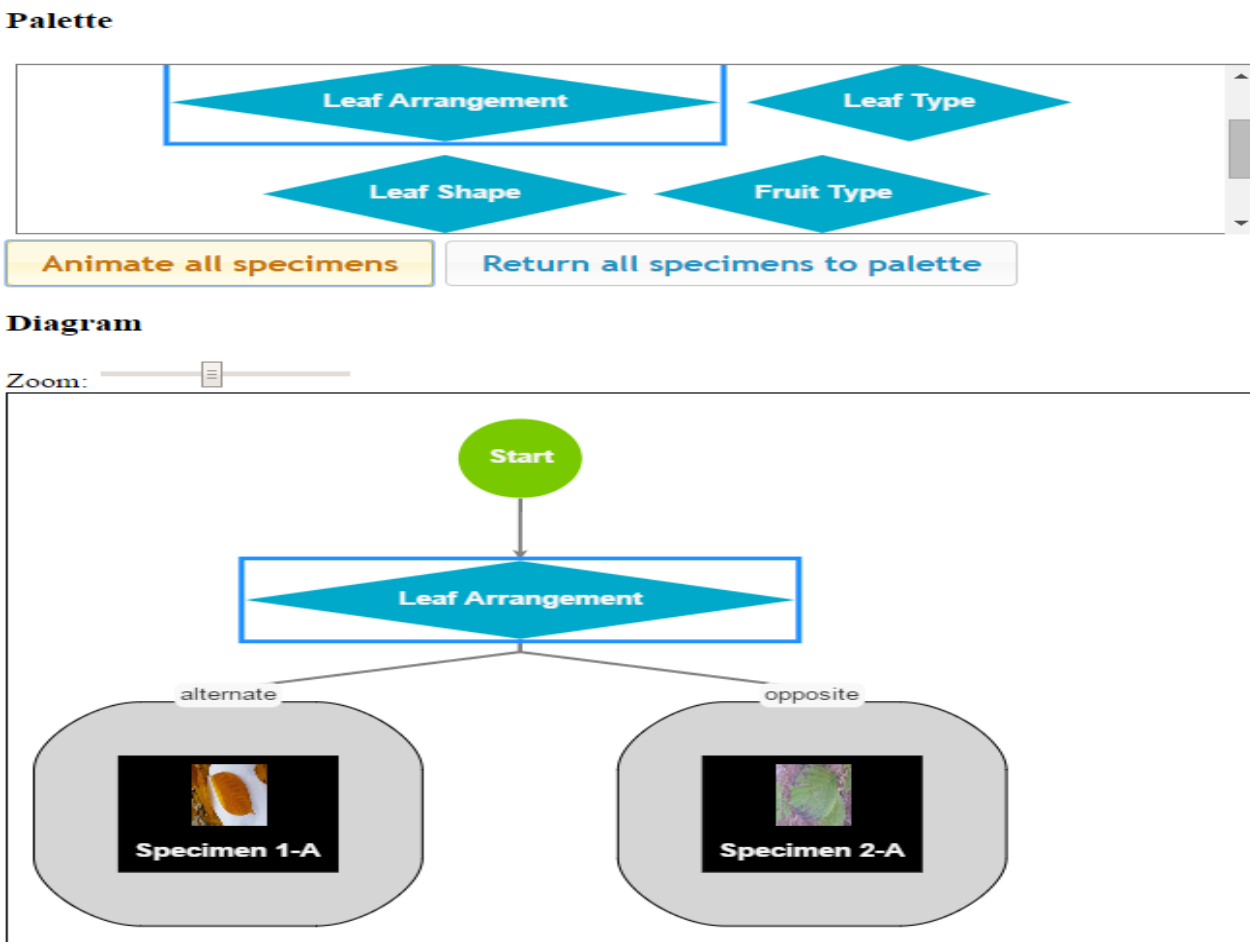

Figure 3. A screenshot of the classification interface. Students are able to drag experiments from the palette at the top into the diagram area at the bottom. These actions are displayed to all players in real time. Specimen A and B are in the same specimen group and will be assigned the same name.

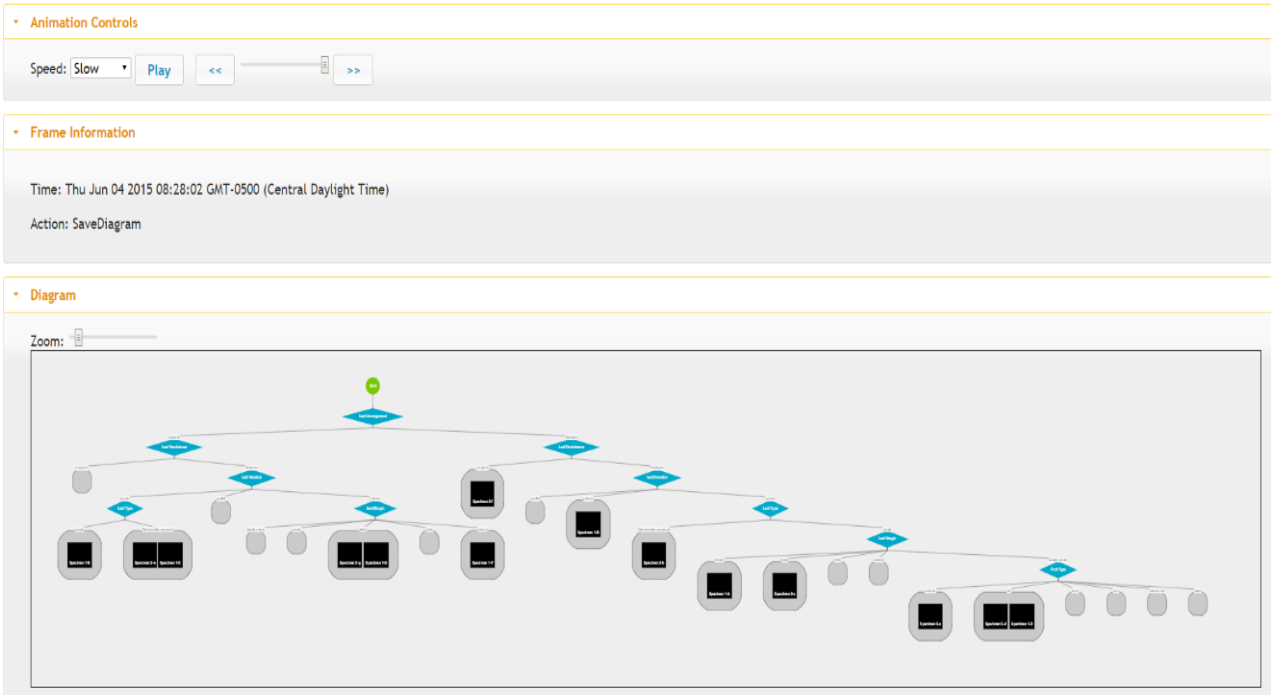

Figure 4. A more elaborate classification tree

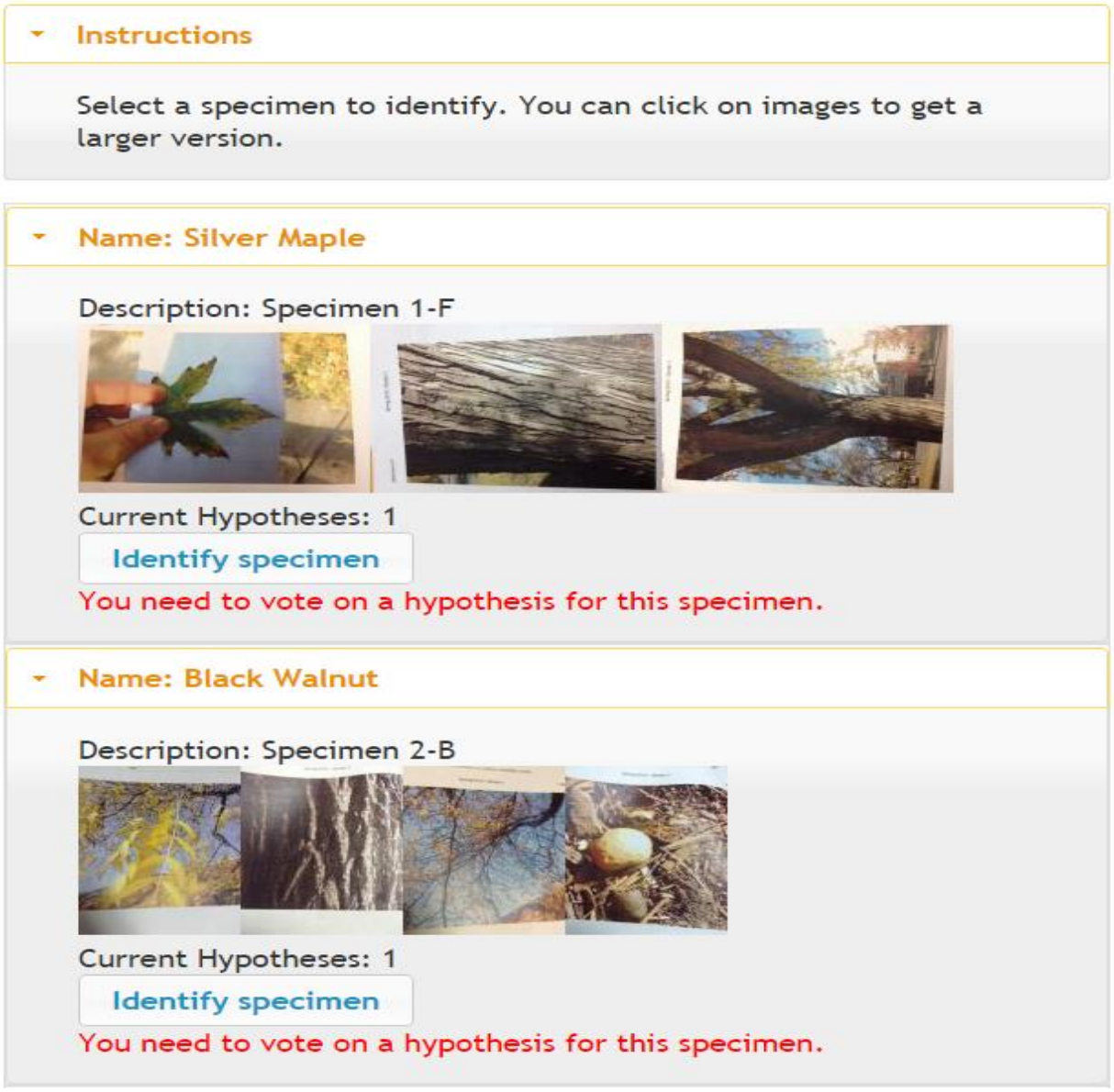

Figure 5. Two separate specimen groups that have been positively identified.

LITERATURE REVIEW

Classification System

Classification systems are a way of organizing things [14]. Classification systems are used for Inter Component Interactions and Classification [15]. Classification System has helped them in developing interactions in software components. Software architecture classification was used for estimating the cost of Commercial of the Shell (COTS) integration. The incompatibility classification and the effort estimation approach was useful for software developers to evaluate and integrate COTS software. This classification scheme might serve as the foundation for a COTS integration methodology, which would be useful for software developers [17].

Usability

System Usability Scale is one of the potential usability measure (SUS; Brooke 1996). It has been used to determine the usability of a wide range of computer applications [8] and provides an excellent test of CIRCLE's usability. A number of sociability measures have been developed that could be used in this research as well. The Social Space Scale measures the positive and negative behaviors that a group performs. Higher score on the "positive group behavior" factor would indicate a healthy social space, while a high score on the "negative group behavior" factor would indicate an unhealthy social space. The Sociability Scale measures the ability of an environment to create a social space [18] by asking users if the environment enables them to build social groups (Kreijns et al. 2007). The Social Presence scale measures the level to which a person feels that someone else in the environment is there or "present" [18]. This research focuses on using the System Usability Scale and the Social Space Scale.

METHODS

Methods: The First Survey

Undergraduate biology students used the first version of CIRCLE as part of a larger class exercise on tree phenology. Groups of two to four students were asked to visit a series of trees and use CIRCLE to identify and classify the trees. These participants were also asked to fill out a 10-item System Usability Scale survey (Table 1) and a 4-item open ended questionnaire administered as a means of gathering information about the ease of use of CIRCLE.

The open ended questions included “What things were good about CIRCLE? Why?”, “What was bad about CIRCLE? Why?”, “What should be changed about CIRCLE?”, and included an area to add additional comments. In the SUS instrument, users expressed an opinion on a 5-point Likert scale from “Strongly Agree” to “Strongly Disagree”.

The responses to the open ended questions were then correlated with individual SUS questions. For example, SUS question #5 is “I found the various functions in CIRCLE were well integrated” and user comments included (referring to using the color red as a visual cue in CIRCLE) “Red prompts for what to do next”

By contrast, SUS question #6 is “I thought there was too much inconsistency in CIRCLE” which was matched to a user saying “Unable to go back and change things”, and another to suggest “add home button”. A total of about 20 concrete and implementable suggestions were provided.

The next version of CIRCLE addressed many of the 20 suggestions offered by the pilot study group, and the next experiment administered another SUS questionnaire, with the responses tracked by SUS question number. In this way, we methodically tracked and measured the improvements in the second release version using changes in SUS scores.

Results: First Survey

The mean SUS score for the first experiment was 41.1, well below average for an application like CIRCLE (Bangor, Kortum, & Miller 2008) [8]. Student answers to the open ended questions provided insights into the low SUS score. Answers were categorized to identify the most important issues to address. The top five answers to "What was bad about CIRCLE?" were related to tree construction, not liking working in groups, being unsure what to do next, difficulty in navigating, and bugs in the software. The top four answers to "What should be changed about CIRCLE?" were: improve directions, improve tree construction, make the interface more user friendly, and remove group work. Despite student objections, group work was not removed. This is a hallmark of the CIRCLE experience and is grounded in educational theory. The other issues were matched with specific developer tasks in an effort to improve system usability.

Tree construction improvements included 1) a complete rewrite of the classification tree interface; 2) the creation of a tutor dialog box that appears when students unlocked a component of their classification tree: specimens, experiments, and results; 3) creation of a tutorial video for developing a classification tree; 4) inclusion of embedded node data, allowing users to see the information related to a particular node in the tree. For example, clicking on a specimen would show its multimedia, name, and experiments in the information panel.

Directions were improved by implementing a series of tutor messages for each stage of the CIRCLE process, with special emphasis on interface elements. This is related to the issue of being unsure what to do next. In addition to the tutor messages, context-sensitive red text was

used to indicate what the user needed to do next. For example, when students are required to vote for a particular specimen, red text is shown next to those specimens in the list.

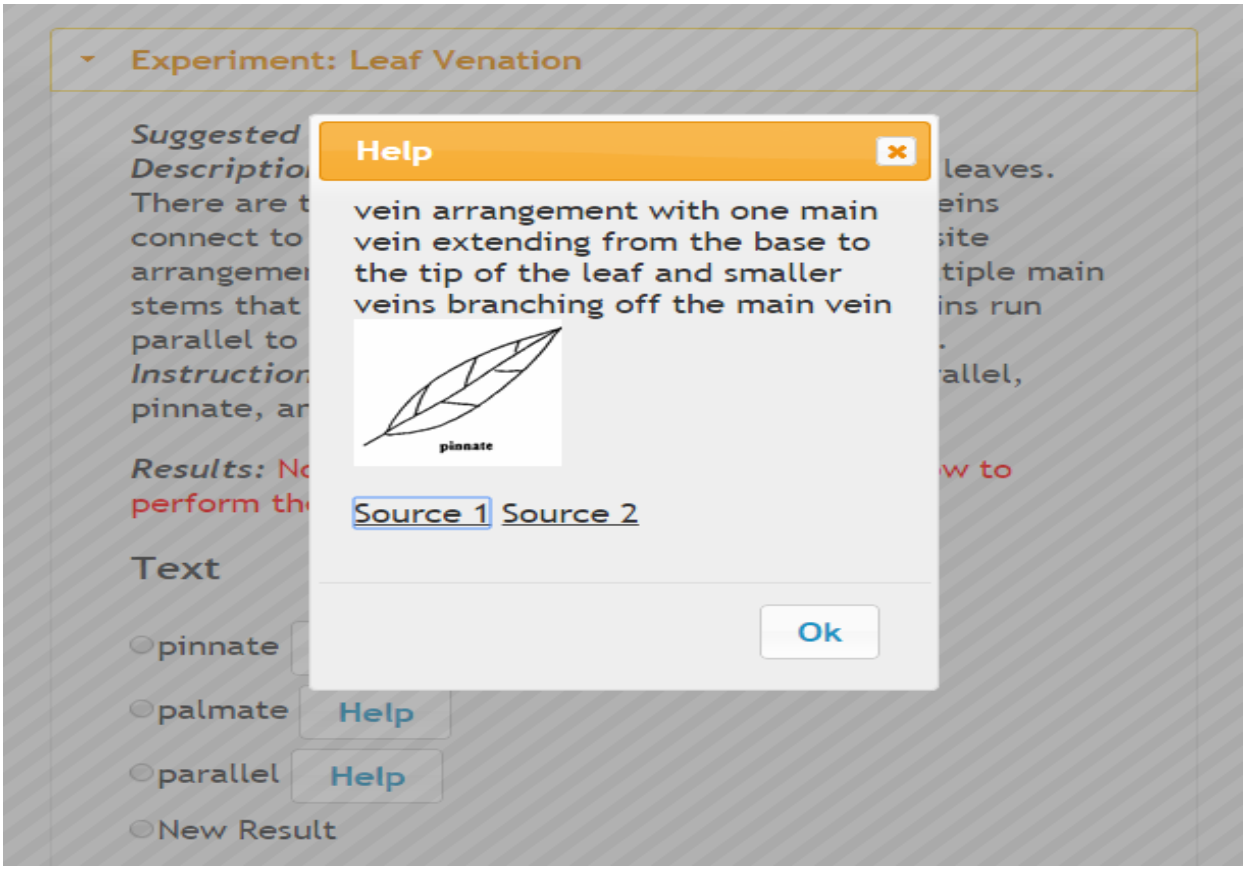

Figure 6. Improvements to CIRCLE included more help information. This help entry gives more information about a pinnate leaf arrangement.

Difficulty in navigation was improved by creating the cookie crumb navigation bar. Prior to this, the navigation buttons were always on the bottom, and it was not always clear to students how to navigate the interface. A graphical site map was also developed.

User friendliness was increased by adopting the JQueryUI framework. This allowed the developers to quickly create more graphically pleasing and consistent interfaces without the assistance of a trained artist.

In addition to these written comments, it was noted by the instructor that students were not sure why they were performing the tree classification task. This was primarily because students were performing identifications using Internet-supplied dichotomous keys. This issue was alleviated by swapping the identification and classification tasks, so that classification came first. This also allowed for the ability of the classification tree to handle two specimens with the same experimental results, giving them both the same identification through the use of specimen groups.

										Scales		
Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS	Usabili	Learnability
I think th	I found thir	I thought	I think th	I found th	I thought	I would im	I found th	I felt very	I needed t	41.1	41.9	41.7
4	2	4	1	4	2	3	2	4	2	75.0	71.9	87.5
2	4	3	2	2	3	3	3		5			37.5
3	5	3	2	2	3	4	3	3	4	45.0	43.8	50.0
3	3	3	2	4	3	3	2	3	2	60.0	56.3	75.0
2	2	4	5	3	2	3	2	1	5	42.5	53.1	0.0
3	3	2	5	3	3	1	3	1	5	27.5	34.4	0.0
2	4	2	5	4	2	3	4	1	4	32.5	37.5	12.5
2	4	3	4	2	4	2	4	3	4	30.0	31.3	25.0
2	4	2	5	3	5	1	4	2	4	20.0	21.9	12.5
1	4	1	5	3	5	1	1	1	5	17.5	21.9	0.0
2	4	3	2	4	3	4	4	3	3	50.0	46.9	62.5
2	4	2	4	3	4	3	4	2	4	30.0	31.3	25.0
2	4	1	3	3	2	2	4	2	3	35.0	31.3	50.0
3	4	2	4	3	3	4	4	2	4	37.5	40.6	25.0
2	3	2	4	4	3	3	3	2	5	37.5	43.8	12.5
3	2	3	4	4	3	3	3	3	4	50.0	56.3	25.0
1	4	2	5	2	3	2	4	2	4	22.5	25.0	12.5
1	4	2	3	3	2	2	4	1	4	30.0	28.1	37.5
2	3	2	1	1	4	4	5	2	4	35.0	28.1	62.5
3	3	4	2	4	2	4	3	3	2	65.0	62.5	75.0
3	3	4	4	4	3	3	3	3	3	52.5	56.3	37.5
2	3	3	3	3	4	3	3	2	4	40.0	40.6	37.5
2	4	3	1	4	4	5	2	3	2	60.0	53.1	87.5
1	4	1	5	2	5	1	2	1	5	12.5	15.6	0.0
2	2	4	2	3	2	4	2	3	2	65.0	62.5	75.0
2	4	2	3	3	3	2	4	2	4	32.5	31.3	37.5
1	3	3	2	1	4	2	4	1	3	30.0	21.9	62.5
1	4	1	4	2	4	1	4	2	4	17.5	15.6	25.0
3	4	2	2	2	5	2	5	2	2	32.5	21.9	75.0
2	5	1	3	2	4	2	2	2	4	27.5	25.0	37.5
4	2	3	3	4	4	4	2	3	4	57.5	62.5	37.5
4	2	4	2	4	2	4	2	3	3	70.0	71.9	62.5
2	2	4	2	4	2	4	3	3	2	65.0	62.5	75.0
2	3	2	5	3	3	2	4	2	2	35.0	34.4	37.5
2	5	2	4	3	4	2	5	1	5	17.5	18.8	12.5
2	3	3	3	3	5	3	4	2	5	32.5	34.4	25.0
2	3	3	3	3	4	3	4	2	3	40.0	37.5	50.0
3	3	3	3	4	4	3	3	2	3	47.5	46.9	50.0
1	3	3	1	3	2	4	3	2	2	55.0	46.9	87.5
2	4	2	4	2	4	1	5	3	5	20.0	21.9	12.5
1	4	2	5	3	4	1	5	1	5	12.5	15.6	0.0
3	4	3	3	4	3	2	3	2	4	42.5	43.8	37.5
2	2	4	3	3	2	4	3	3	3	57.5	59.4	50.0
3	5	3	1	3	3	3	3	3	2	52.5	43.8	87.5
3	2	4	2	3	2	4	2	4	2	70.0	68.8	75.0
3	3	2	3	3	3	4	3	4	4	50.0	53.1	37.5
2	4	3	3	4	3	3	4	2	5	37.5	40.6	25.0
2	3	3	2	4	2	3	3	3	2	57.5	53.1	75.0

Figure 7. Indicates the scores given by the users for the 10 SUS questions of the first survey and SUS, Usability and Learnability mean scores are also calculated based on them.

Methods: The Second Survey

The next release of CIRCLE was deployed in a setting analogous to the first release. Data gathered during the first experiment was used to create binders of specimens with identities removed. Participants of the second survey used the binders in concert with a list of possible identities for the specimens to identify and classify the set of trees again. Groups of two spent approximately four hours identifying and classifying 11 different kinds of trees and playing retrieval-based games produced by CIRCLE.

Results: Second Survey

The mean SUS score for this study was 68.0, with a standard deviation of 15.3, this is significantly better than the score in the first experiment ($p < .001$ on a two tailed between subjects t-test). Comments were generally favorable. “Circle is a very educational website. It is good for us to learn more about tress [sic].” and “It's innovative and people can work together and interact.” Negative comments were centered on the help system, classification tree, and game play. Participants felt that there were too many unavoidable tutors, so it may be helpful in future studies to cut back on the number of dialogs, perhaps by having a hint button that users can click instead. Participants also had issues with the classification tree. Animations tended to run fairly slow on older laptops, and there was a very large amount of scrolling required to view the entire tree. Interface improvements need to be identified. Finally, participants felt confused by the select experiments game. It was not immediately obvious to them that their own classification tree was being used to create the games. As a result, they became quite frustrated when they lost points, even though they were generally correct. A better approach will be to only increase student points. Future studies will be performed to alleviate these concerns.

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Scales		
I think that	I found this :	I thought t	I think that	I found the	I thought t	I would im	I found thi	I felt very c	I needed to	SUS	Usability	Learnability
										68.0	68.2	67.4
3	4	3	4	4	1	3	3	3	2	55.0	56.3	50.0
5	2	5	1	5	2	5	2	5	3	87.5	90.6	75.0
4	2	3	1	4	3	4	2	4	2	72.5	68.8	87.5
3	3	3	3	3	3	4	3	4	4	52.5	56.3	37.5
3	2	3	2	5	2	4	3	2	2	65.0	62.5	75.0
4	2	5	2	4	1	5	2	4	1	85.0	84.4	87.5
4	3	4	1	5	2	5	2	5	2	82.5	81.3	87.5
4	3	4	2	4	2	4	4	4	2	67.5	65.6	75.0
4	2	2	4	2	3	4	3	4	4	50.0	56.3	25.0
4	4	3	3	3	2	3	3	2	3	50.0	50.0	50.0
2	2	4	1	2	2	2	4	4	2	57.5	50.0	87.5
4	2	4	2	3	3	5	3	3	3	65.0	65.6	62.5
5	1	5	2	5	1	4	1	5	1	95.0	96.9	87.5
4	3	3	2	4	1	3	2	4	2	70.0	68.8	75.0
4	2	4	2	2	2	4	3	4	4	62.5	65.6	50.0
5	2	4	3	4	3	5	1	4	2	77.5	81.3	62.5
3	2	3	3	4	2	3	2	3	1	65.0	62.5	75.0
3	2	4	2	4	2	4	2	4	2	72.5	71.9	75.0
3	2	4	1	4	1	5	2	3	2	77.5	75.0	87.5
3	2	4	3	5	1	3	3	3	1	70.0	68.8	75.0
4	2	4	2	5	2	5	1	4	1	85.0	84.4	87.5
4	1	5	1	5	1	5	3	4	1	90.0	87.5	100.0
3	4	5	1	4	1	3	1	4	1	77.5	71.9	100.0
2	4	3	4	2	4	3	5	2	4	27.5	28.1	25.0
4	2	4	2	3	2	5	2	4	4	70.0	75.0	50.0
4	3	4	2	4	1	4	2	4	2	75.0	75.0	75.0
4	3	4	2	4	3	4	4	3	5	55.0	59.4	37.5
2	3	3	3	3	3	4	3	3	5	45.0	50.0	25.0

Figure 8. Indicates the scores given by the users for the 10 SUS questions of the second survey and SUS, Usability and Learnability mean scores are also calculated based on them.

Table 2: Comparing the results of First and Second Survey

		SURVEY 1	**SURVEY 2**
SUS 1	MEAN	1.2	2.6
	STANDARD DEVIATION	0.8	0.83
	T TEST	0.000000000613	
SUS 2	MEAN	1.6	2.5
	STANDARD DEVIATION	0.9	0.84
	T TEST	0.0000261	
SUS 3	MEAN	1.6	2.8
	STANDARD DEVIATION	0.9	0.79
	T TEST	0.000000468	
SUS 4	MEAN	1.9	2.8
	STANDARD DEVIATION	1.3	0.94
	T TEST	0.001321	
SUS 5	MEAN	2.1	2.8
	STANDARD DEVIATION	0.8	0.99
	T TEST	0.001121	
SUS 6	MEAN	1.8	3.0
	STANDARD DEVIATION	1.0	0.86
	T TEST	0.000000445	
SUS 7	MEAN	1.8	3.0
	STANDARD DEVIATION	1.1	0.86
	T TEST	0.00000269	
SUS 8	MEAN	1.7	2.5
	STANDARD DEVIATION	1.0	1.0
	T TEST	0.002005	
SUS 9	MEAN	1.3	2.6
	STANDARD DEVIATION	0.9	0.82
	T TEST	0.00000000253	
SUS 10	MEAN	1.4	2.6
	STANDARD DEVIATION	1.1	1.25
	T TEST	0.000109	

After the t test is conducted to all 10 System Usability Scale questions, it was observed that all confidence values are $p < .001$, where 0.05 is the customary threshold for an experiment of this type. Therefore we can say that there is a significant difference in the results of survey 2 as compared with the survey 1 in every SUS questions. Which means there is a statistically significant difference in second version of CIRCLE than the first version of CIRCLE.

SURVEY ANALYSIS DETAILS

Report on First Survey

The CIRCLE is an efficient way to perform experiments and to identify the specimens which are obtained by answering some predefined question.

Good about CIRCLE

- CIRCLE is likely to be used frequently because:

SUS 5:"easy to navigate", "easy to access"- Users find it easy to navigate and access as it has clearly defined steps, An additional window should be implemented with a graphical map of the interface, where the player can easily see what links they have traversed, which windows they have visited, and which they have not. This makes the application a much better way to access.

- Various functions of CIRCLE were well integrated:

SUS 9, 11: "Red prompts for what to do next"- Red prompts what to do next made people to learn CIRCLE very quickly.

Bad about CIRCLE

- According to users CIRCLE is unnecessarily complex:

SUS 6: "tree construction"- as they found it more congested and lack of understanding. Tree construction can be made in more understandable format by placing the text on the nodes at the bottom and marking them with their respective numbers.

SUS 6, 8: "hard to navigate, improve direction, make easier to navigate" - as they were unsure what to do next so the graphical map helps them to keep track where you are.

SUS 6: "remove group work"- students feel more comfortable working individually then doing group works, so group work should be removed.

- Users think they need help of a technical person while using CIRCLE:

SUS 7, 8: “it becomes confusing sometimes”- new users to CIRCLE not completely aware of how to proceed further, so an instruction page should be created which helps them to know what to do next.

SUS 7: “trouble logging in”- some mentioned that they faced some troubles logging in but some were comfortable with logging in. The problem might have because of the raw interface. Once a proper interface is developed they might not face any problems while logging in.

SUS 7, 8: “uploading images” – after uploading the images the users were unable to view the image back again. Hence a link should be placed which will help the users to view the image even after uploading it. And also photos should be allowed from gallery.

- Too much of inconsistency in CIRCLE:

SUS 10: “Poorly organized UI”- Users found trouble in the user interface as it was poorly organized. Developing UI and making it in more understandable format and more visually appealing interface is necessary which makes the application more user friendly.

SUS 10: “Unable to go back and change things”, “add home button”- A back button and a home button should be placed which will help the users to go back and make required changes and edit button should be placed instead of delete to rectify the user’s mistakes.

SUS 10 “cannot edit initial description”- Changes that are required in CIRCLE are that after a specimen is added to tree, it should not be in options and initial description should be allowed to edit.

SUS 10: “Explain points score”- Explanation should be given about the score that is obtained that is points calculation steps should be mentioned and the overall goal should be known.

- Users find it cumbersome to use when

SUS 12: “the windows for suggesting experiments was too small”- the size of window can be increased to make the experiments more clear and understandable.

SUS 12: “hard to use on mobile device”- the application could not properly work on mobile device because of the different operating system that are used may not be compatible with the app. Hence updates should be provided which satisfies most the devices.

SUS 12: “pages did not load”- web browser such as google chrome or Firefox should be used rather than internet explorer for faster page loading.

SUS 12: make messages from group members more visible”- Problems arise during group work, as they preferred messages from group members should be more visible.

- Needed to learn a lot of things before one could get going with CIRCLE because:

SUS 14: “hard to remember specimen properties when creating tree”- Users found it difficult to use when they had to remember specimen properties when creating tree. Suggestions must be provided regarding the properties of that particular specimen.

Changes that are required to be made in CIRCLE are arranged based on their priority:

- Graphical user interface
- Graphical map should be implemented
- Tree construction should be improved
- Instruction page
- Home button, back button and edit button
- Link to view uploaded images and images in gallery
- Details about the score points
- The windows size for suggesting experiments should be increased

To classify the SUS under the user comments. And then make the required changes that people found cumbersome or lagging while using circle. Below are suggested implementation changes based on the previous bullet points. The implementation details in RED have been implemented in the April 28 version of CIRCLE.

- Graphical user interface

There are very few graphics in the current version of CIRCLE. Adding a consistent visual appearance that matches modern day web interfaces could improve the usability and acceptability of CIRCLE towards the target population. Specific suggestions include:

- Create graphics for navigation buttons
- Add user avatars (both default and customizable)
- Creating graphical symbols to indicate points with this indication visible when students receive those points
- Adding visual appeal to the chat and note interfaces, so that it is easier to follow conversations. Some examples include using user avatars, changing background color for different replies in a discussion thread)
- The graphical map (described next)
- Added JQueryUI as a graphical UI framework for displaying client content

- Graphical map

A map of potential "locations" for students to visit could improve usability and recognition of what task is next to be performed. As students unlock new locations, a visual

indication would guide students to the next task. So for example, the map at the start would simply have a "gather specimens" node, with a greyed out "perform experiments" node (with a '?' that users can click on to get information on how to advance to that node).

- Tree construction should be improved

Some possibilities:

- As students collect specimens and suggest and perform experiments, they would get a dialog box saying that they had unlocked a component of their classification tree.
- After a minimal set of components was unlocked, they would be able to complete a tutorial on how to use the classification tool.
- Rather than building the classification structure for them, students would be able to drag and drop components together in an almost "visual programming" style.
- Clicking on an individual component would should the full information for that component. Ex: Clicking on a specimen would show its multimedia, name, experiments, etc in a special area. Same for experiments and results.

- Instruction page

The instructions for CIRCLE are quite brief. Expanding the wiki at https://circle.cs.ndsu.nodak.edu/wiki/index.php/Main_Page could be one start. Another would be to create videos of people playing individual modules of the game, similar to the Virtual Cell tutorials.

- A basic tutoring interface is now included with CIRCLE. This allows a dialog box to appear with text describing what the user can do on the current page or on individual elements.

- An “information icon” provides context sensitive help in some places in CIRCLE.

- Home button, back button and edit button

There is a back button on every screen, but it is located at the bottom of the interface. Moving it to a more prominent location (along with the addition of a home button) would not be difficult. An "edit" button is more problematic, but I'm fairly certain this edit button is mostly for multimedia and descriptions created during the gathering stage, since there is currently no way to edit that.

- Link to view uploaded images and images in gallery

This problem is equivalent to the edit button problem. Editing gathered multimedia when first gathering specimens should be possible.

- Details about the score points

Here, I was planning on creating a status window, which would indicate when any member of the group scored points, and how they did it. If the person "playing" scored points, a more active dialog would appear, congratulating them and giving them information about how they scored the points, with the option to not show the dialog in the future. This is done via the tutoring interface.

- The windows size for suggesting experiments should be increased

This could be accomplished by either statically increasing the size of the window, or adding some JavaScript that dynamically increased the size of the window as the user typed

information into the text field. This was built using a JavaScript JQuery library called auto grow. (Static is obviously easier)

Another student complaint that I was aiming to solve was wondering about the purpose of identification. I plan on swapping the identification and classification tasks, so that classification comes first, then identification.

Report on Second Survey

Good about CIRCLE

- SUS 5, 9, 11, 13: Users find it simple and easy to navigate around CIRCLE.
- SUS 9, 11: It is helpful in learning real time subjects.
- SUS 5, 9: The architecture of CIRCLE which is displayed in the form of a tree attracted the users the most.
- SUS 13: Tutorial videos helped users to learn more about CIRCLE.
- SUS 5, 13: Due to interactive and active memorization, it helped in learning more in short time.
- SUS 7: GUI of CIRCLE was well laid out which made users easy to understand.

Bad about CIRCLE

- SUS 12: Users felt that loading of diagrams would take more time and would even crash at some times. And the table animation needs improvement as it had to start over every time a classification type was put on.
- SUS 8: The tree animation was not appropriate as the whole image would not fit at a time on the screen.

- SUS 6: Too many pop-up notifications, which leads to freezing the application you are working on and the diagram is not friendly to all smart phones.
- SUS 7: Found difficulties while choosing a problem.
- SUS 6: Users generally missed the 8 minute instructions because it was long but were then confused. It should be made mandatory to watch the video.
- SUS 12: The UI could be made more user friendly.
- SUS 14: Difficulty in uploading pictures.
- SUS 10: Found lots of repetitive stuff which were not that useful and also dependent on other users as it would not allow to proceed from step 3 to 5.

Things need to be changed

- A description should be provided for the scoring process. As users get confused on losing points for various reasons.
- Next, finish buttons should be placed at the bottom of the page rather than at the top.
- Classification tree can be more user friendly.
- Right answers must be shown if wrong answer is selected which will help to learn more.
- Merge “elaborate specimen” and “modify specimen”. Allow both at the same time.
- Add a save button for “elaborate specimen” rather than saving each procedure automatically.

Features which need to be added

- Back button

Even though many issues have been solved after the first survey, few issues have repeated and some issues in classification structure and tree animation have increased. Some new

problems were faced with the pop up notifications and long tutorials. The number of users complaining about these issues are comparatively more in second survey as compared with the first. This effected the overall SUS mean score as these comments were not expected. So this is main reason for not getting a very good score in second survey. These issues are to be solved in future work.

IMPLEMENTATION

A sitemap is a listing of the pages in the website. It shows how the pages are organized, and is usually done as an outline or diagram. A graphical sitemap is used in this project which is depicted in the form of a state chart diagram. This map is a potential of "locations" for students to visit could improve usability and recognition of what task is next to be performed [5]. As students unlock new locations, a visual indication would guide students to the next task. So for example, the map at the start would simply have a "gather specimens" node, with a greyed out "perform experiments" node (with a '?' that users can click on to get information on how to advance to that node).

Architecture of Sitemap

A website navigation or a sitemap is a collection of user interface components. The primary goal of navigation is to help users find information and functionality, and encourage them to take desirable actions. Based on the pages and the navigation from one page to another a graphical image is created for CIRCLE. This image has been designed using Visual Paradigm software. Each state depicts each different pages of the website and arrows corresponds to the different pages we can visit through [6].

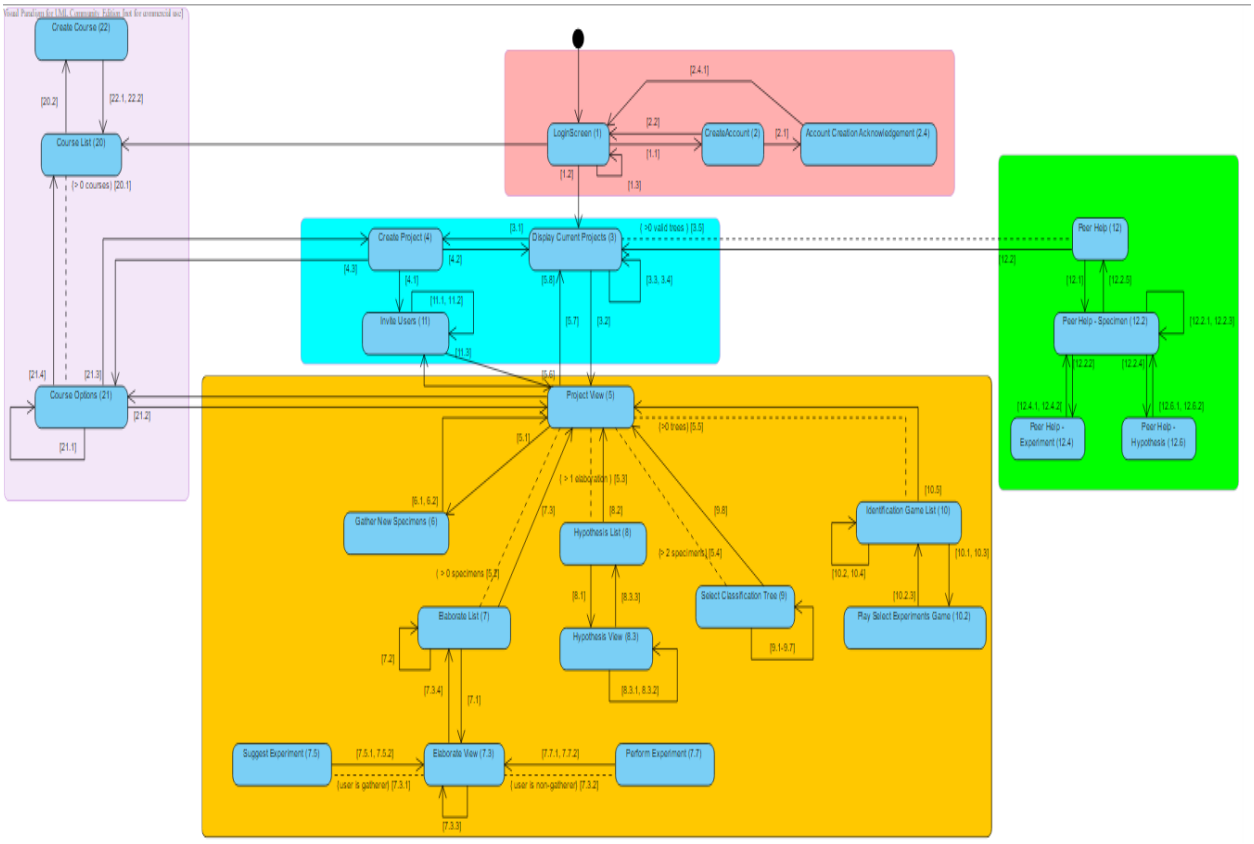

Figure 9. A Visual Paradigm image of the Sitemap

The whole project is divided into 5 different menus where each menu is divided into multiple submenus of it and is classified into different pages. The startup page of CIRCLE is the login page. The user can register a new account for himself by clicking on ‘Create’ to sign up a new account. An acknowledgement is sent to mail with username and password credentials. Once the user is logged into the system they are free to move and play around with the game. The architecture of CIRCLE was developed in such a way that we need follow the particular path to go from one page to another, pages cannot be skipped in between. Like the experiment cannot be performed without gathering the specimens. Hence, to remove this redundancy some pages have been locked which cannot be unlocked without satisfying its required conditions.

Designing Sitemap

The graphical image of the sitemap which is used in CIRCLE is designed in GoJS. GoJS is a JavaScript library for implementing interactive diagrams across modern web browsers and platforms. GoJS makes constructing diagrams of complex nodes, links and groups easy with customizable templates and layouts. GoJS is pure JavaScript, so users get interactivity without requiring roundtrips to servers and without plugins. It normally runs completely in the browser, rendering to an HTML5 Canvas element or SVG without any server-side requirements and it does not depend on any JavaScript libraries or frameworks, so it should work with any HTML or JavaScript framework or with no framework at all [7].

The first step started by drawing the required nodes and links using the State Chart format of the GoJS. Each node is named on the basis of its functionality on that particular state. For example if we click on the node stating “Login” it will direct us the login page. The transition of the links can also be described which is easier to understand for the users. The diagram model is saved in JSON format.

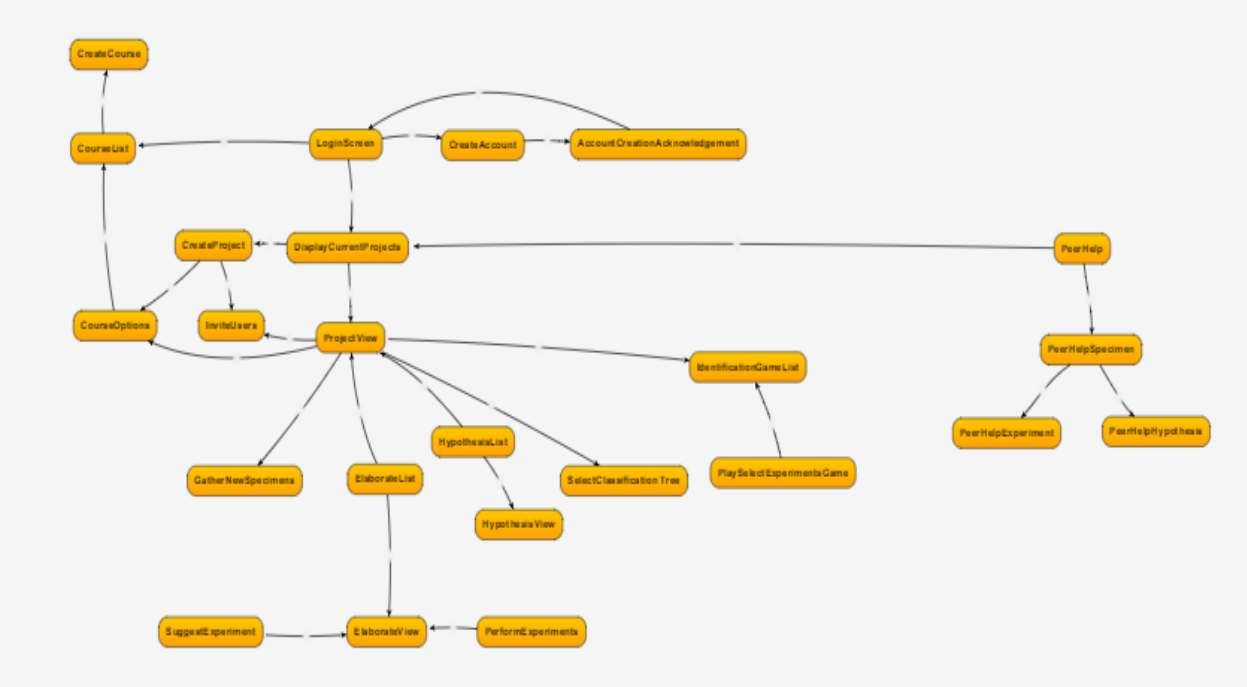

Figure 10. Sitemap architecture in GoJS

Developing Sitemap

The implementation of the sitemap was done in JavaScript where the code for producing the sitemap diagram which consists of all the required nodes of the CIRCLE is obtained from GoJS software which is further saved in a file and is called when were it is necessary [7]. Sitemap is a guide which helps you to move around CIRCLE by letting you know the next steps. It is enhanced with another feature which tells you in which page you are in and which page you visited by using different color coding like the red color indicates the pages you visited and the light blue color is for the current page.

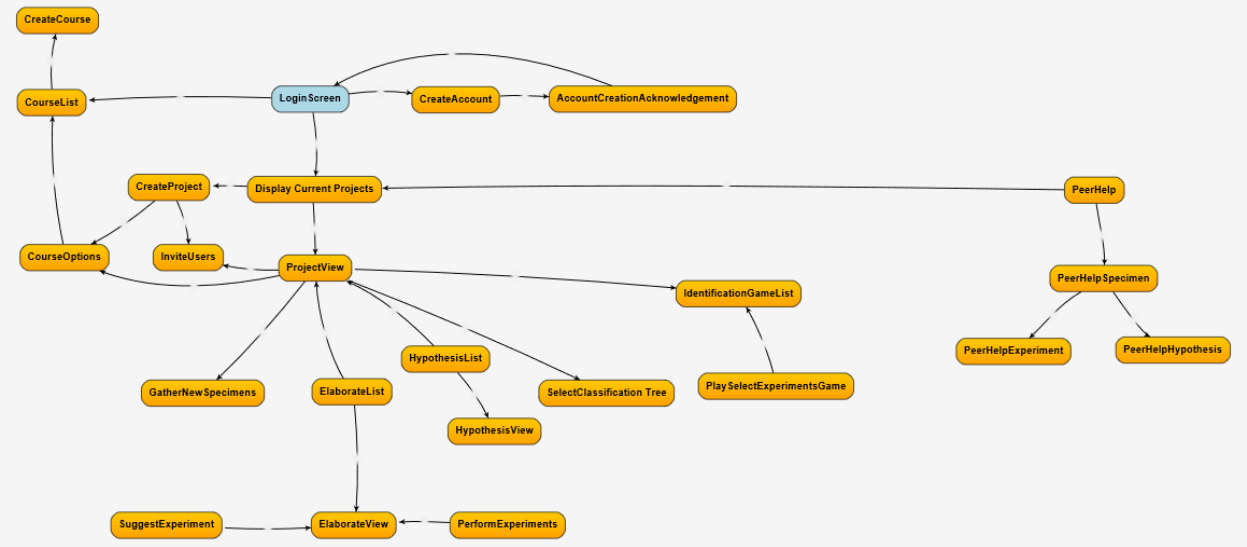

Figure 11. Indicating Login Screen as current location of the user

The above diagram indicates that indicates that the current location of the user is Login Screen as it is indicated in light blue.

nodeDataArray[0].color = "red";

myDiagram.model = new go.GraphLinksModel(nodeDataArray, linkDataArray);

var obj = myDiagram.model.toJson();

The nodeDataArray is an array which stores the values of the recently visited pages and the value which gets loaded into the nodeDataArray is depicted in red color. As the user enters the login screen now he can either start playing if he has an account which redirects him to Display Current projects page or he can create a new account if he does not have one before starting the projects which redirects to Create Account page.

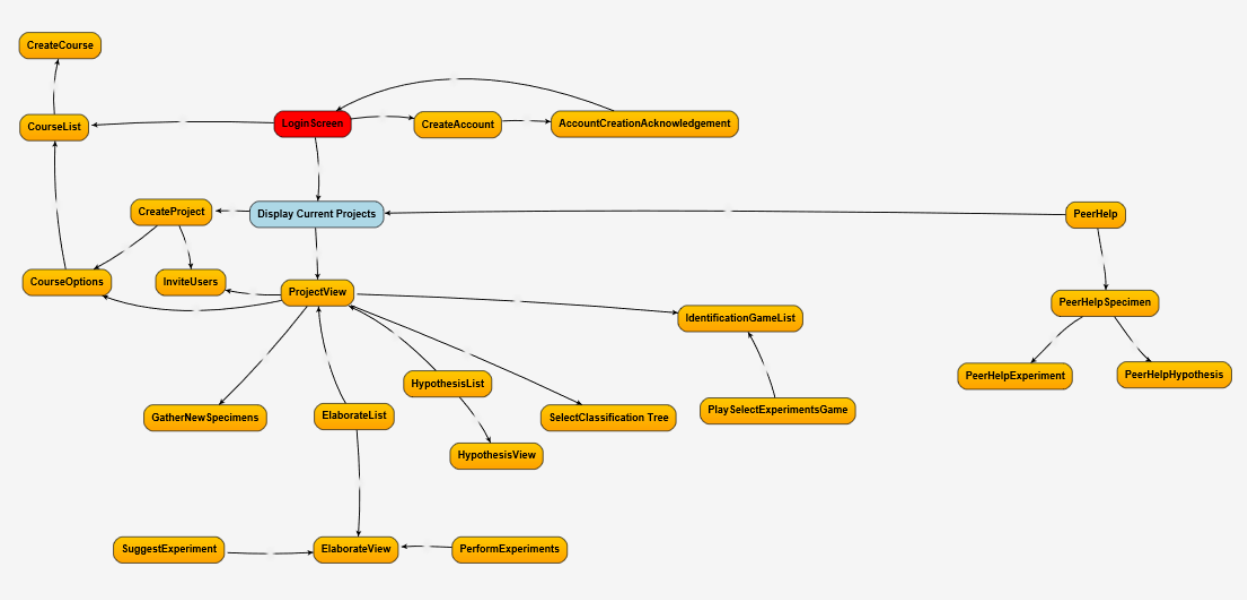

Figure 12. Indicating Display Current Projects as current location of the user and Login as visited page.

Here, Figure 12 shows the Login Screen in red as the user has now moved from Login Screen to Display Current projects. Hence Login Screen has become recently visited page and Display Current projects page is the current location of the user from where he clicked the sitemap button.

CONCLUSION AND FUTURE WORK

This project helps in improving the usability of CIRCLE by analyzing and writing the report on the first survey of CIRCLE where the report classifies the positive and negative aspects about using CIRCLE. The survey has helped in understanding the project from the user's point of view in order to employ the System usability scale questionnaire based on their comfort and understanding level while using CIRCLE. The comments thus obtained gave a second chance to improve the user interface and its efficiency. The idea of developing a sitemap was very effective as it helped the users to navigate around CIRCLE. These results were depicted when the second review was conducted, as the number of comments were reduced and the positive aspects of CIRCLE increased. Users experienced a better performance than before.

Future work will involve improving the efficiency of CIRCLE by rectifying the drawbacks which showed up in the second survey. Like providing an instructions page which will help the users know what to do next, tree animation and uploading images should be made more user friendly. The performance of the system can be improved as the system freezes sometimes resulting in some loss of data. A few buttons can be added like the save button for "Elaborate specimens" rather saving each procedure and a back button will be more helpful to modify or make changes as necessary.

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APPENDIX A. SYSTEM USABILITY SCALE SURVEY

This survey was given as a post-treatment assessment during all beta tests and experiments.

Username (NOT real name): _____

1) I…

   a) Liked using CIRCLE

   b) Thought using CIRCLE was ok

   c) Did not enjoy using CIRCLE

   d) Don't know how I feel about playing CIRCLE

2) What things were good about CIRCLE? Why?

3) What was bad about CIRCLE? Why?

4) What should be changed about CIRCLE?

For questions 5-14, check a box that corresponds with your opinion of each statement ranging from strongly disagree to strongly agree.

I think that I would like to use CIRCLE frequently

Strongly Disagree				Strongly Agree
_____	_____	_____	_____	_____

I found CIRCLE unnecessarily complex

Strongly Disagree				Strongly Agree
_____	_____	_____	_____	_____

I thought CIRCLE was easy to use

Strongly Disagree				Strongly Agree
_____	_____	_____	_____	_____

I think that I would need the support of a technical person to be able to use CIRCLE

Strongly Disagree Strongly Agree

_____ _____ _____ _____ _____

I found the various functions in CIRCLE were well integrated

Strongly Disagree Strongly Agree

_____ _____ _____ _____ _____

I thought there was too much inconsistency in CIRCLE

Strongly Disagree Strongly Agree

_____ _____ _____ _____ _____

I would imagine that most people would learn to use CIRCLE very quickly

Strongly Disagree Strongly Agree

_____ _____ _____ _____ _____

I found CIRCLE very cumbersome to use

Strongly Disagree Strongly Agree

_____ _____ _____ _____ _____

I felt very confident using CIRCLE

Strongly Disagree Strongly Agree

_____ _____ _____ _____ _____

I needed to learn a lot of things before I could get going with CIRCLE

Strongly Disagree Strongly Agree

_____ _____ _____ _____ _____

5) Any other comments?

APPENDIX B. DATA FOR FIRST SURVEY

1) What things were good about CIRCLE? Why?

Changes that need to be made	Number of users voted for that change
• Gathering Specimen	16
• Easy to navigate	6
• Group work	5
• Good idea	5
• No problems logging in	4
• Learned about plant	4
• User Friendly	3
• Showed score	3
• Red prompts for what to do next	3
• Liked unlocking	2
• Clearly defined step	2
• Suggesting experiments was good	2
• Initial steps were goo	2
• Easy access to data	2
• GPS Coordinate	1
• Well organized home page	1
• Chat feature	1
• Easy to access	1
• Confusing at time	1
• Easy to follow directions to get point	1
• Shared view of observation	1
• Voting on hypothese	1
• No idea	1

2) What was bad about CIRCLE? Why?

Changes that need to be made	**Number of users voted for that change**
• Tree construction	17
• Didn't like working in group	8
• Unsure what to do next	6
• Hard to navigate	5
• Didn't work	5
• Trouble logging in	4
• Point assignment was a mystery	3
• Poor instruction	3
• Had to remember specimen properties when creating tree	2
• Pages didn't load	2
• Elaboration	2
• Uploading images didn't work	2
• Not user friendly	2
• Didn't help identifying tree	2
• Unable to go back and change thing	2
• Can't access pictures after uploading	1
• UI	1
• Can't edit initial description after creating specimen	1
• Not enough emphasis on experiments/scientfic metho	1
• After a specimen is added to tree, should not be in options	1
• Busy work	1
• Poorly organize	1
• Difficult to use	1
• Nothing	1
• Wouldn't let you redo hypotheses	1
• Window for suggesting experiments was too small	1
• Didn't like gamification	1
• Hard to use on mobile device	1

3) What should be changed about CIRCLE?

Changes that need to be made	Number of users voted for that change
• Improve direction	15
• Improve Tree Construction	11
• More user friendly	4
• Make easier to navigate	3
• Remove group work	3
• Allow upload photos from gallery	1
• Add tree leaf comparison	1
• Combine experiment/hypothesis/response	1
• Show which specimens were taken by each member	1
• Improve load time	1
• Make intro presentation	1
• Allow to be used on laptop	1
• Add home button	1
• More visually appealing interface	1
• Access pictures you've already uploaded	1
• Nothing	1
• Make messages from group members more visible	1
• Show overall goal	1
• Explain points score	1
• Should help you identify (give examples)	1
• Fix bug	1
• Add edit button instead of delete	1
• Menu	1
• Didn't understand / no opinion	1
• Add ways to elaborate	1

4) (Asked at the end of the survey) Any other comments?

Changes that need to be made	Number of users voted for that change
• None	32
• App could be awesome	7
• More instruction	3
• Should know how to identify before using app	2
• Should not use students as beta tester	2
• Explain expectation	1
• Need more work	1
• Make pictures larger	1
• Let students know observation will be used to build tree	1
• Project was not goo	1
• Remove group work	1

Data for Second Survey

1. What things were good about CIRCLE? Why?

Simple navigation and easy to navigate

Good tutorial, link with video. It is help people to understand and use it.

The tree animation was awesome.

Interactive and active memorization. Learned more in short time.

The collecting specimens was cool, how you could directly upload the pictures from your phone to the website. And the games could be beneficial for studying purposes.

The GUI was generally well laid out.

It's innovative and people can work together and interact.

Circle is a very educational website. It is good for us to learn more about tress.

Classification tree was very helpful and useful for classification purposes.

Could definitely use some more in program instructions and possibly a tool tip and for how to proceed early. Adding a defined objective or mission would also give users a sense of purpose for using the program. Example would be, "to construct a game that pertains to studying identification of trees and later use the game to quiz myself or others." Otherwise pretty fluid program with some minor bug testing needed.

Was a responsive interface to use and could be good to enhance learning for visual learners beyond that of sitting in a classroom.

2. What was bad about CIRCLE? Why?

The phylogeny type option and using the experiments were pretty difficult and hard to understand what it wanted from us.

It was hard to work the diagram tree. Trying to organize the trees was a good thing, but a lot of scrolling up and down. A little hard to work with.

The table animation needs improvement. Had to start over every time we put a classification types. No need for flowing animation on screen, too slow to progress.

The diagram step is not a smartphone friendly.

If experiments work into the points schematic for the game, then they should be more related to tangible aspects such as bark color rather than various specific terms that are not known to the test subjects.

Instead of having the buttons at the top that need to be clicked to get back to the project home/specimen list/etc., add a done button at the bottom of the page. I found myself confused a

few times after completing a page but not seeing a next/complete/done/etc. button at the end of the step I was doing.

The website server was down once in a while.

Games instructions not very clear. Unsure which experiments to perform on first.

During the first game it would erase everything in the red box and make you re do it instead of letting you drag the correct one down.

The instructions weren't always clear. We tried to skip the 8 minute instructions for how to build the classification tree because it was long but were then confused. You might need to require that be watched at least once

It could be more visually pleasing to the eye. It served its main goal of trying to teach others the material but for a younger audience it might be hard to keep their attention with the current layout.

I believe it was sort of tedious. Lots of repetitive, which may or may not have helped me learn.

Making classification tree is not that easy as we need a lot of information and a lot of specimen first.

Little time consuming and a little disturbing since even if you answer correctly you lose points because you did not conduct all the required experiments.

It needed a group member to proceed from step 3 to 5. In this way one is largely dependent on others. Hence was not able to finish up the last task i.e. game play.

3. What should be changed about CIRCLE?

Making it easier to understand the last 2 options.

Sometimes the buttons were glitch. Other than that it was smooth.

May be improve diagram

Probably don't give a negative score to people

Use interface can improve.

If the classification tree could be more user friendly it would be nice.

Making the games section a little bit more clear and making the phylogeny tree clearer.

Erasing things instead of letting you drag them down. An explanation is needed for the identification factors.

Make sure that when the Web page automatically updates, it doesn't change any answers

Having a mobile application for CIRCLE would be helpful for people who may use it through their smartphones, but now everything can be done well by using internet browser on smartphone too except the part where you have to make a tree.

I don't think it is necessary to have a partner on this.

Add some sort of better directional feature (like walkthrough) that teaches but also lets the subject get something done instead of just view a video or read. Less freezing up. This could be resolved (or made less stressful) through the incorporation of an auto save system of sorts. Explain WHY this is beneficial to the subject before they begin to gain interest.

4. Any other comments?

Test results may not be as encouraging for your research, but maybe a before and after test could have made a benefit.

After using circle for a little bit I figured out how to use it, but I think those pop-ups could better understand how to use things.

Overall it was a good learning tool, with a little tweaking could be a great learning tool!

If group member means the person I worked with rather than the study then this feedback doesn't apply. The program is good and concepts are good, the red box thing should be fixed, and the need for agreeing with someone's comment could really hinder this study because it requires someone else for you to pass on.