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THE EYES HAVE IT: USING EYE TRACKING TECHNOLOGY TO ASSESS THE USABILITY OF LEARNING MANAGEMENT SYSTEMS IN ELEMENTARY SCHOOLS

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Abstract:

Twenty-six students from a sixth grade math class in Upstate New York received guardian approval to participate in a study that gathered data pertaining to student navigation ability, information retrieval ability, and satisfaction in regards to the Learning Management System (LMS) their school utilized. Data collection began with the researchers attending math classes for observation and to conduct cognitive walkthroughs with the students to gather information about their experiences and navigation through the LMS. An eye tracker and the associated eye tracking software were utilized to monitor and detect patterns of eye movements when the students were looking at a device screen. For this study, students were monitored by the eye tracker while they attempted to complete several tasks from the experiment. By measuring the length of time taken by students as they completed tasks on the LMS, quantitative data can be collected and used later in the experiment. After analyzing the time metrics and the eye tracking data produced and feedback given on the questionnaire distributed at the beginning of the experiment, a targeted LMS page was slightly modified in hopes to increase the effectiveness of the page, based on user interface design standards. Well defined organization, accessibility, and usability in an LMS is essential to allow learners to focus to be on their curriculums, and not how to access their assignments. An in-depth analysis of navigation through an LMS will allow for a better understanding of how users interact with the structure of their curriculum in an electronic format. The study described in this paper intended to address the question of whether an LMS used

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in an elementary school setting can provide users with an interface that optimizes the accessibility and usability of their class materials.

Keywords: learning management systems, eye tracking, usability, human computer interaction, education

1. Introduction

Knowledge is created where there is change; it is a complex process of the capability to produce, learn, and become skilled and capable in the use of new methods, not just obtain best practices as products (Fullan, 1999; Hall & Hord, 1999). In order to initiate the change processes, involvement must be encouraged. It is the duty of an organization to acquire knowledge among its constituents to become aware of the necessity for change (Fullan, 2001; Harvey, 2002; Kirkpatrick, 2001). Innovation is about discovery (Satell, 2013).

In the past three decades, educators have developed their curriculums to meet the possibilities that come with instant access to resources, substantial increases to storage, unlimited bandwidth, and technology hardware diminishing in scale to become handheld portable devices – all relating to the improvement of learning (November, 2010). There is a pursuit to personalize learning for students through technological innovations due to its capabilities of being the component to accomplish the task (Gerger, 2014). Teachers and Instructors must encompass teaching and learning in the classroom. 21st century skills such as communication, collaboration, creativity, and critical thinking (Bransford et al, 2000) must embrace the integration of technology to enable essential digital literacy skills including computer/technological literacy, information literacy, visual literacy and global awareness (Warschauer, 2006). It is essential for teachers and instructors to be receptive of new technology provided to schools to ensure it is used effectively (Carlson and Gadio, 2003) when implemented into current curriculum that has not achieved fluent integration to technology.

Over the past several years, applying the use of Information and Communications Technology (ICT) has been recognized for the significant role it has played in the improvement of education (Kangro and Kangro, 2004). Through observations, technology has been concluded to increase communication between instructors and students in and out of the classroom setting. Students generally have a better ability to grasp lesson material because of the technology used within the classroom. When using technology, students are encouraged to collaborate with their peers, provide helpful comments to one and another, and engage in rich discussions (Boticki et al, 2015).

Fulton (1997) utilized the term, technology fluency, to describe the evolving definition of essential information students need to effectively utilize technology. Fulton's research indicated that instructors model technology fluency in the classroom by applying technology to classroom tasks, utilizing technology throughout the curriculum, and facilitating teamwork and collaboration amongst the students. (Furio et al, 2015) claimed that due to technology, children have a larger variety of opportunities to investigate what they are learning from a multitude of different perspectives.

Multiple studies have shown promising results when observing students utilizing technology within the classroom. A study conducted by Gerger (2014) stated that the level of engagement of students and their drive to accomplish educational tasks had increased within the classes that utilized technology. Results in another study showed that students are more engaged when technology is being utilized to perform learning activities (Lu et al, 2014). Pamela (2006) stated that the entire teaching body had an agreeing conclusion that ICT is a significant and valuable tool to enable them to better convey and present their learning material. Results further concluded that students observed in the study were more self-motivated and looked forward to go to classes where faculty conducted their lessons with multimedia rather than presenting material in a traditional or conventional method. Churchill and Wang (2014) concluded in a study conducted at a higher education level that due to the substantial positive results within research being developed around technology in education, that the possibility of technology being used as an instrument in primary schools could reinforce students' learning process as a direct result of the high motivational effects recorded during their study. Education has been affected by ICT; it is affecting the way instructors teach, the way students learn, and the process in which research is conducted. A study conducted by (Yang et al, 2015) had stated that enabling access to information is an important technology learning impact.

A national survey spanning 503 web-based interviews with US pre-K-12 teachers, conducted by PBS Learning Media (2013), showed the following advancements in the classroom led by technology:

- Three-quarters of teachers surveyed link educational technology to a growing list of benefits, saying technology enables them to reinforce and expand on content (74%).
- More than two-thirds (68%) of teachers expressed a desire for more classroom technology and this number is even greater in low-income schools (75%).

- Sixty-five percent of teachers reported that technology allows them to demonstrate something they cannot show in any other way.

As this technology has become more readily available to schools and the general public, it can be difficult to obtain the proper technology that could benefit students. Commonly, businesses within the private sector attempt to persuade and compel schools into applying new unnecessary technological devices and services to their curriculums to make a profit (Hargreaves and Shirley, 2012; Lee and Winzenried, 2009).

Primarily due to the misapplication of technology in schools, researchers like Christensen et al (2008), Cuban (2001), and Erneling 2010), believe that the funds applied to making technology better for students of all backgrounds has brought little to no results. This may be in part caused by a lack of funding from administration to obtain technology that meets all necessary objectives. Although the cost of devices is constantly dropping, other fees such as software, maintenance, technical support, and training add to the overall cost of technological innovation. Positive application of technology to schools and classrooms require more than hardware; it needs a series of actions and investments brought about by good leadership (Lee and Winzenried, 2009; Zucker, 2008; Gerger, 2014).

"Students need the opportunity to become independent and design their learning while teachers facilitate the process. Technology is the tool to assist this shift within teaching and learning"

(Gerger, 2014)

In order to make this a reality, long-term, extensive conversations have to occur about what teaching, learning, and being educated mean in the context of new innovations (Richardson and Postman, 2013). Technology has made its presence known in classrooms regardless of level. Blair (2012) notes a dramatic shift occurring at all age levels where students are becoming increasingly fluent with the technology that adults have to study and manipulate to comprehend their features.

"For these students, simply watching videos or images during class, playing an Internet multiplication game, or even taking turns at an interactive whiteboard is no longer enough. These new 21st century learners are highly relational and demand quick access to new knowledge. More than that, they are capable of engaging in learning at a whole new level. With the world literally at their fingertips, today's students need teachers and administrators to re-envision the role of technology in the classroom"

(Blair, 2012)

In order for a technological environment to be beneficial for students, it is important the teachers and instructors know how to correctly implement it throughout their curriculum. Technology can be implemented in a multitude of ways. For this review, technology relating to the use of LMSs in education settings will be the prime focus.

2. Implementing Technology in the Classroom

Introducing and integrating technology into the classroom is not limited to instructing students how to operate computers and other devices, but is more about enabling teachers and instructors to utilize technology as a means for learning (Sheingold and Tucker, 1990). Technology and devices transform so quickly over time that is has become essential for schools to maintain a stock of current technology, and instructors that have adequate knowledge to utilize these technology instruments optimally (Hinostroza, 2011).

> *"The success and the value of technology integration in teaching and learning settings largely depends on the willingness, intention and the technological skills of the teachers, and how well and efficiently it is used by the students and the teachers"*
>
> (Kayalar, 2016)

Teachers and instructors introduce and integrate technology into their classroom and curriculum to progressively support their program of studies and develop classroom instruction (Smerdon et al., 2000). Technology may have a beneficial impression on teaching and learning between instructors and students. Therefore, it is important for teachers and instructors to acquire information pertaining to the successful integration of technology within the classroom (Smerdon et al., 2000). In order to introduce and integrate technology effectively into the classroom, best procedures include understanding appropriate methods to do so.

> *"…how, when, and why technology can be infused into education to improve learning outcomes. Poor technology integration planning can center on including too much technology in the classroom as well as too little". For the majority of instructors, the premise of teaching 21st century principles such as digital collaboration can be a taxing effort"*
>
> (Scalise, 2016)

It is essential to promote training and education to teachers and instructors who were qualified to teach preceding the development of digital technologies within the classroom, who are not already technologically skilled. As children enter school, they are deemed not only 21st century learners, but also 'digital natives' who spend the majority of their exploring and amusing themselves on information and communication technologies such as smartphones or tablets (De Silva et al, 2016).

In a study conducted in 2009 on successful technology incorporation, (Su, 2009) claims that, within the traditional learning environment, teachers and instructors have obtained the same content when they were students themselves in primary education, and the resources provided to them by schools, in means of resources and textbooks, have not changed over the years. Currently, within a constructivist learning environment, teachers are constantly learning and obtaining new information. New technology enables teachers and instructors to reinvent and transform the traditional resources for improved teaching and learning results throughout different implications in the classroom.

In some cases, implementing technology can have unwanted results. This can be caused by teachers' and instructors' inability to apply new technology within the classroom. A study conducted by Safitry et al. (2015) produced data stating that teachers who utilized Information Communication Technology within their classroom's activities made them feel depressed. The difficulties appeared to be caused by the lack of technology fluency in regards to ways to apply Information Communication Technology and information about software/websites/resources to support teaching, as well as the low amount of technical support available within the schools.

In a meta-analysis study conducted by (Cheung and Salvin, 2011), they conclude that the classroom utilization of education technology will unquestionably continue to increase taking part in a growing significant role within public education in coming years as technology develops and becomes less costly to instate in schools. They state that the technology method most schools invest in, particularly supplemental computer-assisted education, have the least confirmation of efficiency. Access to technology at every school is vital to ensure economically disadvantaged students who have considerably less access to technology at home than their fortunate peers, including countries with the highest overall rates of access (OECD, 2005).

2.1 Hardware in the Classroom

There are a multitude of different tools and technologies available for schools to implement into the classroom.

> *"Students develop the four C's, critical thinking, creativity, communication, and collaboration, thus effective application of these significant skills in a technology-based life requires acquiring them in a technology-based learning environment. This environment includes two elements: Technology must be put in the hands of students and we must rely on them through more contemporary technology use. For student performance to approximate student potential, students need access to a constantly evolving series of technological tools and activities that involve innovation, teamwork, decision-making and problem-solving"*
>
> (Blair, 2012)

Schools, such as the Upstate New York Elementary School focused on in this study, have often focused on providing technology for every student to utilize within the classroom. Factors such as lower cost, lightweight laptops, and the increasing accessibility of wireless access that combine to create one-to-one (1:1) initiatives obtainable in a large scale (Penuel, 2006).

A study conducted by (Clariana, 2009) comparing students in one-to-one and one-to-five laptop classrooms, found that students performed better in the one-to-one classrooms. Clariana went on to theorize that the higher success rate was due to a change in teacher's approach to implementing their curriculum, but wasn't able to generalize the findings due to limited information gathered. A review of literature created from 2004 through 2014 that reviewed published, peer-reviewed, empirical studies of 1:1 technology in K-12 schools, concluded that:

> *"…commonalities across findings served to support the more generalizable notion that 1:1 device implementation can positively influence achievement in a variety of content areas for students of many grade levels"*
>
> (Harper and Milman, 2016)

Imbalance within the allocation of devices to the quantity of students may generate complications regarding the success of the course, due to some students' inability to access information as easily as their peers, resulting in a need for the instructor to manipulate the way they teach within the classroom (Kayalar, 2016). Similarly, in a study conducted by (Dixon & Tierney, 2012), it was claimed that the Bring Your Own Device (BYOD) had consequences leading to a need for teachers to tutor and accommodate the student with the least powerful device. Teachers would also have to compensate with students not having all of the same programs and applications uploaded to their personal devices.

Many schools, including the Upstate New York elementary school described in this study, have adapted to use Chromebooks, a cost-effective alternative to laptops and iPads. A recent stated study on the use of Chromebooks in schools analyzed the benefits of utilizing the Google product in comparison to other technology:

> *"A Chromebook's boot time is a fraction of that on traditional PC laptops: they take one to two seconds to boot, whereas traditional PCs can take one minute or more. Further software issues with the device, a simple hard reset and students are able to log straight back in and access their cloud content. Of course, with its heavy reliance on web availability, a sturdy wireless network is critical."*
>
> (Quinn, 2016)

Some schools seeking a cost-effective alternative to one-to-one programs have sought out technology that can be utilized by the entire class in a communitive way. Previous research states Interactive Whiteboards (IWBs) were found to be capable of developing new technological pedagogic practices by reducing the instructor's cognitive load by offering a 'invisible script' that permits the instructor to 'multi-task' in innovative manners by providing more mental capacity to create observational assessments for education during 'whole-class teaching' (Lewin et al, 2008). Stroud et al (2014) describe that when instructors utilize the interactive whiteboard occasionally, without employing all of the advantageous interactive features, it is insufficient to obtain the value described in the literature. Even more so, research conducted by Kennewell et al (2008) explored the impression of interactive whiteboards on teacher-learner communication. It was observed that the interactive whiteboards failed to assist the intended shift of control from the instructor to self-directed student learning.

2.2 Software in the Classroom

One way schools are providing constant access to students is by utilizing a Learning Management System (LMS). These are e-learning platform information systems that are operated by an admin that manages electronic-learning courses and keeps track of student progress (Brown and Johnson 2007). LMSs area web-based technology that enables the ability to plan, distributes a learning plan, and distributes learning material with examination of a particular learning process (Ayub et al, 2010). Once implemented, LMSs become vital for subject matter development that allows students to complete tasks and assignments, and manage their use of online programs (Aybay and Oguz, 2002).

The appeal of technology in education can be partially attributed to the increase of affordability and functionality of the devices, both within the hardware and software (Kinash et al, 2012). In order for an LMS to operate efficiently, it must be designed in a suitable manner to promote the user (students/teachers/faculty) would not encounter any errors when utilizing it (Ayub et al, 2010). Navigational controls within the platform of the LMS allow students to control their way around the interface. If properly organized, the LMS should empower students, users, or lecturers to remember information while utilizing the system (Mandel, 1997).

Unfortunately, the majority of research conducted on LMSs do not include many studies at elementary school levels. Even with the extensive extent of high level implementation of LMSs in many countries, the majority of application is within higher education institutions (Piña, 2013). However, the limited research that has been undertaken involving school-related LMSs show how student-learning practices can change as a result of the opportunities provided on the LMS platform (Snodin, 2013). While an LMS provides immediate remote access to student's course materials, interfaces for different level students may be difficult to navigate. Testing for usability throughout a learning managements system, with a variety of different level students, is a possible method to some issues students may have. Usability testing is an example of a method that could be implemented, and may be utilized in identifying problems pertaining to the user interface of the LMS by students (Nakamichi et al, 2006).

One of the significant components of a usable LMS is to deliver an atmosphere that enables learning and instruction without restricting users of their time due to attempting navigation, lack of ability to utilize the system, or distance from a campus (Epping, 2010). Students utilizing an LMS should easily be able to learn and adapt to the features provide, in a timely manner (Stuikyr et al, 2006). Research conducted by Inversini et al (2006) indicated that usability had become a significant concern for electronic learning and LMSs advancement. The majority of practitioners in the field recognized usability as a key component in electronic learning application's planning and usage. Problems within the LMS design could decrease a user's satisfaction when attempting to navigate and operate the system's features (Inversini et al, 2006).

To avoid these issues, a simple LMS user interface should be implemented to promote fluent interaction between instructors, students, and systems (Ghoniemy and Fahmy, 2010). From a user standpoint, utilizing a LMS is restricted by the student's perceptual and cognitive abilities (Thuseethan, 2014). By applying usability standards to an existing LMS, improvements can be made to enhance the learning experience for users (Tselios et al, 2008), in addition to their academic performance. In order to improve the usability of a LMS, human computer interaction standards can be implemented to play a key role in obtaining an improved user performance (Sung and Mayer, 2012). De Lera et al (2010) mention research in this field that offers substantial insight for technology usability and attentiveness to the user's needs for the design element of human computer interaction.

Well defined organization, accessibility, and usability in an LMS is essential to allow learners to focus to be on their curriculums, and not how to access their assignments. An in-depth analysis of navigation through an LMS will allow for a better understanding of how users interact with the structure of their curriculum in an electronic format.

3. Material and Methods

The study described in this paper intended to address the question of whether an LMS used in an elementary school setting can provide users with an interface that optimizes the accessibility and usability of their class materials.

3.1 Participants

In total, 26 participants from an Upstate New York elementary school will take part in the study. The participants will be broken up in different groups, based on their class schedules. Each class contains approximately 20 students. All students have the same math instructor, who had agreed to have the study take place in their classrooms. The student's ages are within a small range, as they are all in the sixth grade (ages 11-12).

3.2 Instrumentation

The following tools were used to obtain data to analyze and assess the LMS and to investigate if it is meeting the needs of the student user population.

- **Eye Tracking Software:** A Gazepoint eye tracker and the associated eye tracking software was utilized to monitor and detect patterns of eye movements when the students were looking at a device screen. For this study, students were monitored by the eye tracker while they attempted to complete several tasks from the experiment.
- **LMS:** Schoology is the LMS utilized by the school district in which the experiment took place – hence this was the LMS used for this experiment. Participants were asked to complete several tasks with in the LMS in this experiment. After the results and data had been analyzed, several visual adjustments were made to the interface and participants were then asked to repeat the same tasks.

- **Questionnaires:** A basic questionnaire was used to gather basic demographic information pertaining to the participant's gender, their access to technology at home, and their understanding of the technology used to access information regarding assignments and their curriculum. The questionnaires were made available via an online platform.
- **Qualtrics Online Survey Software*:*** The Qualtrics Software will be used due to its ability to allow participants access to the survey via the previous mentioned direct link. The data will then be downloaded and further explored using SPSS.
- **SPSS:** The statistical software package, SPSS, was utilized to perform data entry and analysis and to create tables and graphs. This software was selected due to its capability to manage large amounts of data, in particular the large datasets from the eye tracker.
- **Adobe Suite Software:** Photoshop, Illustrator, and InDesign software was utilized to visually alter the targeted webpages to increase participant completion of tasks

3.3 Data Collection and Method

After obtaining clearance from the University's Institutional Review Board, clearance from the principal of the school, and parental/guardian permission signatures, the experiment began.

3.3.1 Phase 1: Observation

Initially, the researchers spent a number of days observing the students using the LMS to complete day to day tasks. The observation phase involved watching both the full classroom and also spending time with an group of more advanced students who were separated into an advanced placement subgroup based on their mathematical ability and aptitude. During this phase a detailed record of how the student participants interacted with the technology in the classroom was made. At the conclusion of this phase, the questionnaire was introduced and completed online using the Schoology LMS via a direct link to the Qualtrics Online Survey Software. Participants were allotted a fixed amount of time to complete the survey. The questionnaire provided qualitative data to be later used in the experiment.

3.3.2 Phase 2: Cognitive Walkthrough

The cognitive walkthrough method is a usability inspection method used to identify usability issues in interactive systems (such as the LMS which is the subject of this study). Cognitive Walkthroughs focus on how easy it is for new users to accomplish tasks with a system. The method is rooted in the notion that users typically prefer to learn a system by using it to accomplish tasks, rather than, for example, studying a manual. A cognitive walkthrough starts with a task analysis that specifies the sequence of steps or actions required by a user to accomplish a task, and the system responses to those actions. The user of the software then attempts to complete the steps explaining their thinking and reasoning as they progress. Data is gathered during the walkthrough, and afterwards a report of potential issues is compiled.

3.3.3 Phase 3: Eye Tracker Data Collection

During this phase the eye tracker and associated software was set up on a PC in the classroom. Prior to the data collection, participants will be notified that software is being utilized to collect data on how they access information on the Schoology interface. When the students sat down, the laptop had the LMS login page ready, with eye tracking software engaged. Students were timed from beginning to end how long it takes them to accomplish a set of tasks.

Participants will review written instructions prior to conducting tasks to ensure their understanding of the session and reduce any errors that will greatly manipulate performance time. The tasks the students were asked to complete were as follows:

1. Log onto the learning management system
   1a) Utilize original learning management system log in method
   1b) Utilize an edited log in method to access the learning management system
2. Access a specified course
3. Access a previously completed assignment
4. Verbalize the grade they received for the assignment
5. Log out of the learning management system

Students were observed while they interacted with the technology to assess and deal with any difficulties they encountered while using the LMS. Data on errors encountered by the students was also collected.

The eye tracking software collected data on where participants looked the most on the screen. Data was collected from 26 different participants, summarized layouts displaying the average of the most looked at areas of the layout provided insight into any discrepancies within the design of the targeted pages.

By measuring the length of time taken by students as they completed tasks on the LMS, quantitative data can be collected and used later in the experiment. After analyzing the time metrics and the eye tracking data produced and feedback given on the questionnaire distributed at the beginning of the experiment, a targeted LMS page was slightly modified in hopes to increase the effectiveness of the page, based on user interface design standards. Knowledge and guidelines taken from the literature was used to apply standards to the LMS interface to create more usable pages. All changes were undertaken using Adobe Suite software. Changes did not take place on the LMS itself, but only on imagery of the site created for the purpose of this experiment.

After the redesign of the LMS pages is completed, another experimental session will be undertaken. During this phase the eye tracker and associated software was once again set up on a PC in the classroom. Students were again timed from beginning to end how long it takes them to accomplish the same set of tasks. Students were observed while they interacted with the technology to assess and deal with any difficulties they encountered while using the LMS. Data on errors encountered by the students was once again also collected.

3.3.4 Phase 4: Analysis

After all the data is collected, a two sample paired T-Test will be conducted to determine whether an adjustment in the design of the LMS improved participant efficiency in the time taken to perform the series of tasks in the LMS.

4. Results

Twenty-six students from a sixth grade math class in Upstate New York received guardian approval to participate in a study that gathered data pertaining to student navigation ability, information retrieval ability, and satisfaction in regards to the learning management system (LMS) their school utilized. Data collection began with the researchers attending math classes for observation and to conduct cognitive walkthroughs with the students to gather information about their experiences and navigation through the LMS.

4.1 Phase 1: Qualtrics Questionnaire

At the beginning of the experiment, all participants were asked to take part in a questionnaire to obtain qualitative and quantitative information. Forty-eight participants responded to the questionnaire, twenty-nine males and nineteen females. Based on the data from Table 1, it can be seen that the participant pool contained more males than females and more 11 years olds than 12 year olds. Although the participants did some work at home, the majority preferred to complete homework at school. All of the students stated that they knew how to login to Schoology and over 90% stated that they knew how to access the assignments within the LMS. Interestingly, a third of the participants said that they did not enjoy using technology to complete their assignments.

Age		**11 Years Old (76.6%)**	**12 Years Old (23.4%)**		
Gender		**Male (60.4%)**	**Female (39.6%)**		
Work at Home		**Yes (31.2%)**	**No (68.8%)**		
Technology at Home		**Computer (25.5%)**	**Laptop (35.3%)**	**Tablet (29.4%)**	**Phone (4.5%)**
Assignment Location		**School (77.8%)**	**Home (22.2%)**		
Enjoy Technology to Complete Assignments		**Yes (69.6%)**	**No (30.4%)**		
Know How to Login		**Yes (100.0%)**			
Know How to Access Assignments		**Yes (93.6%)**	**No (6.4%)**		

Table 1: Information Gathered from the Online Qualitrics Questionnaire Regarding Schoolology Usage

4.2 Phase 1: Observation

First period begins at approximately 9:15am. Students generally sit in unassigned seats. This allows for movement and renegotiating arrangements throughout the classroom for students to collectively work on problem solving in teams. The class is broken down into two different groups based on their cognitive abilities, in conjunction with their scores received during an assessment earlier in the school year.

The top six students in each class are separated into a distinct advanced group that meets and works together in a separate location. These students work more rapidly on course material, and work in a different manner where efficiency is promoted as the key to their success with the material.

The advanced group meets in main classroom at the beginning of each class period, and is then subdivided by the instructor after announcements are made to the group as a whole. The advanced group then relocates to a corner area in the library located adjacently to the instructor's main classroom. Within the library, several other groups meet and have their own activities while the instructor distributes information. The students must be careful not to speak too loudly, as they are deemed guests within that space.

The library setting for the advanced math group is casual. Students sit in padded rocking chairs and sitting areas installed against the walls. There are no formal desks or tables for the students to sit at. Students work around a small whiteboard where they work together for most of their meeting time. As students go through the lesson, information is put on the whiteboard and they are challenged to identify if the information is correct or not.

4.3 Phase 2: Cognitive Walkthrough

A cognitive walkthrough was undertaken with the six students from the advanced placement group (three female, three male). At the beginning of the cognitive walkthrough, students were notified there was a survey listed under the instructor's math-page on Schoology, the LMS utilized by the school district. Students were instructed to be as verbally descriptive as possible as they navigated on the iPads to gain access to the survey and complete it. Verbal descriptions began from the point the iPads were picked up. Some of the more important observations from the cognitive walkthroughs are listed below.

1. Unlocking the iPad – slide the "bar" to unlock. (*Note: some iPads had passwords, others do not.*)
2. Layout of applications varies depending on iPad. Students are required to scroll through the iPad until the LMS application can be found or students go from the top of the screen via the pull-down screen to inquire whether the LMS application has been used recently on the particular iPad.
3. Login to the LMS depends on the browsing history on a particular device. The LMS may require a student to input the school zip code before being able to access a list of schools within the area.
4. Steps to login to the LMS vary depending on the technology. Students specifically commented on these inconveniences when using the LMS application on an iPad.
5. In some cases, the LMS requires students to enter an email or username provided by the school. Students explained that logging on requires several attempts usually.

(The logging on portion of walkthrough took several minutes out of the ten-minute cognitive walkthrough to accomplish).

6. To gain access to instructor's class, students often used menu buttons to pull up a list of options.
7. Students select "Courses" on list of options
8. Students select instructor's class amongst their individual course list.
9. Students scroll down to the survey component of the study, listed amongst a variation of other assignments, texts, homework, and schedule.

4.4 Phase 3: Eye Tracking Data (Task 1)

Of the forty-eight participants in the pool, twenty-six participants (twelve females and fourteen males) were able to participate in the eye-tracking component on the experiment due to time constraints. For the first task participants were asked to sign into Schoology using one of two different methods:

Task 1a: Participants were required to log onto the LMS. The current method requires users to input their zip code, then select a school from a list provided.

Task 1b: The same participants were asked once again to log onto the LMS. Several variables were preset to mimic a LMS log in with location services determining the institution they wished to enter online.

Participants accomplished tasks on the same computer, at the same work station. Participants were not given assistance unless they were unable to complete a task without help. Figure 1 compares the number of participants able to login to Schoology properly the first time in task 1a and 1b. Figure 2 shows a comparison in the time it took participants to complete tasks 1a and 1b.

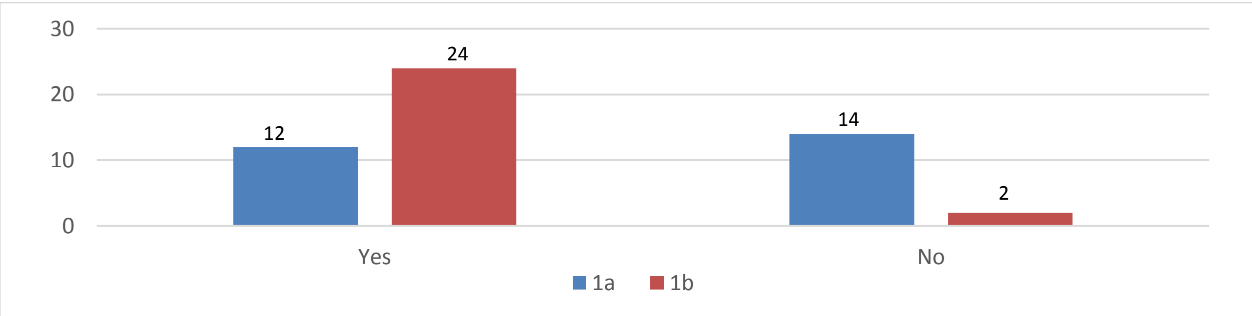

Figure 1: Comparison of Task 1a and 1b. Was the participant able to login to Schoology on their first try?

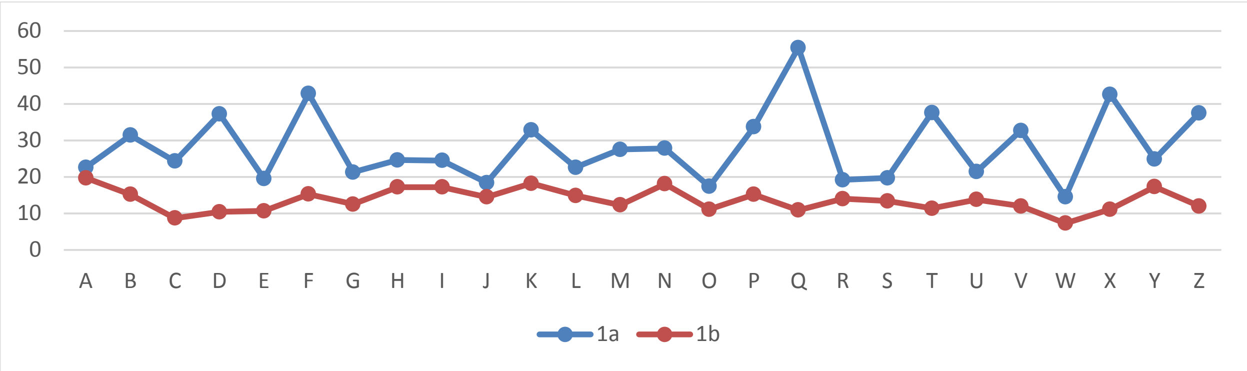

Figure 2: Comparison of Task 1a and 1b Completion Times.

To compare the efficiency of these login methods, a paired t-test was performed. There was a significant difference in the scores for Task 1a ($\bar{x}$ = 28.109, σ = 10.234) and Task 1b ($\bar{x}$ = 13.655, σ = 2.844) conditions; (t (25) = 6.36, p < .0001). These results suggest that implicating location services to determine which school a student wants to login to significantly reduces the amount of time needed to obtain access to the LMS.

4.5 Phase 3: Eye Tracking Data (Task 2)

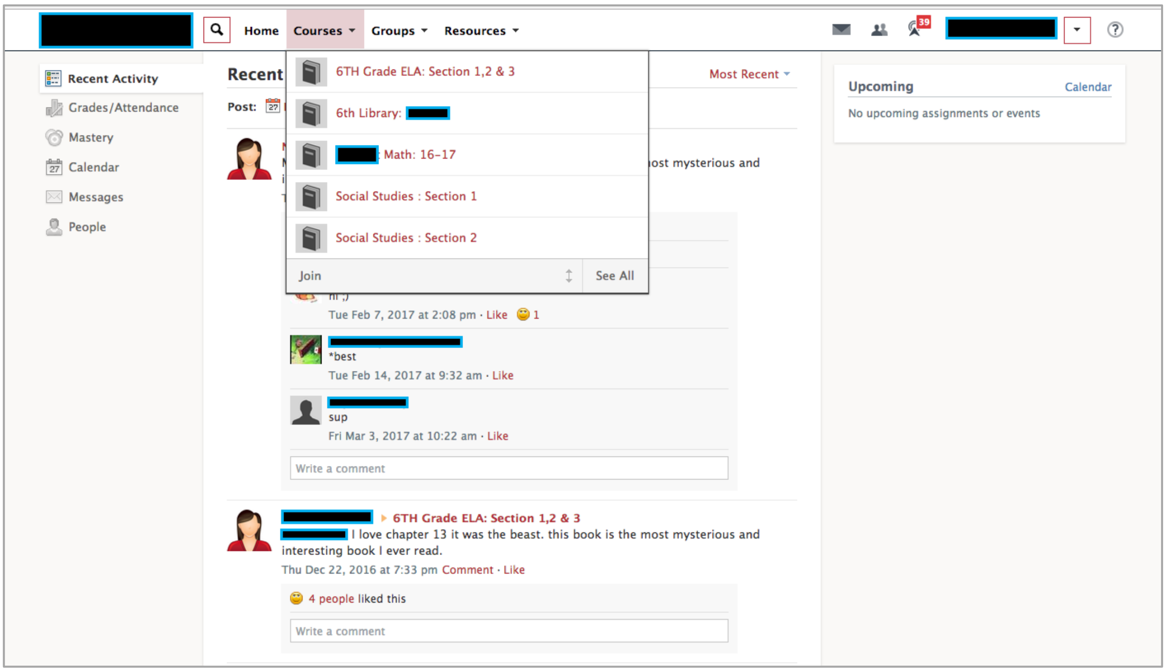

Figure 3: Schoology interface landing page without participant Gazepoint data

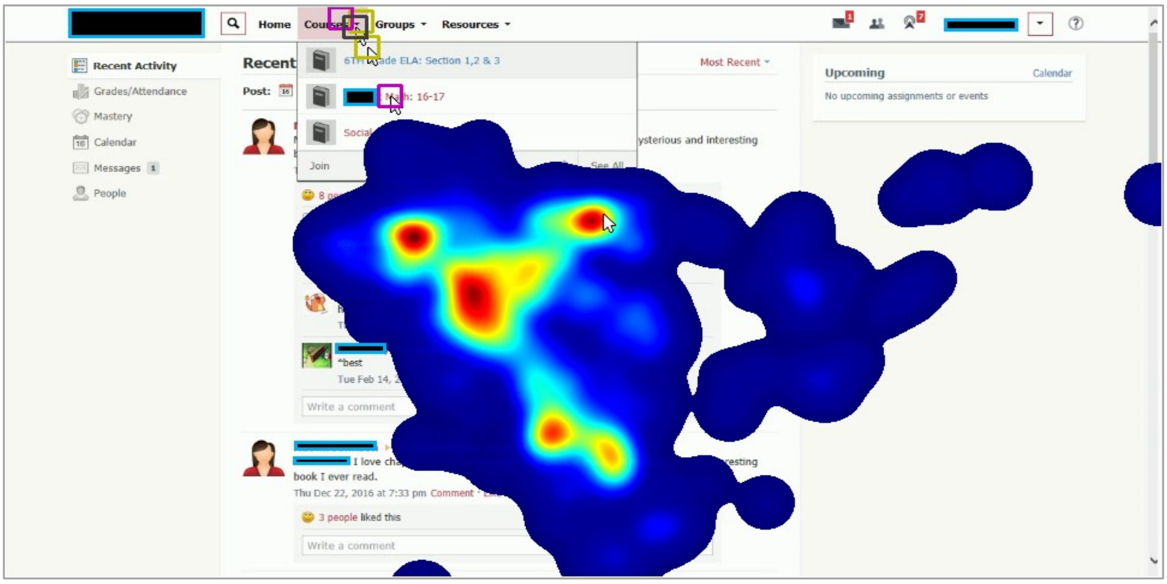

Figure 4: Heat mapped visualization of eye-tracking data retrieved during the second task

Figure 3 shows the Schoology interface for Task 2 of the eye-tracking experiment. Students were asked to access a specified class from their course list. Approximately 19% of participants required multiple attempts to access the specified class. 40% of errors were due to participants selecting "Groups" instead of "Courses". The remaining 60% were caused by participants selecting the wrong class. Censored information is blocked by a black rectangle. Figure 4 illustrates the tracked eye movement via heat map visualization on several participants with viable retrieved data. Gray, yellow and pink stroked squares mark each location a participant clicked.

4.6 Phase 3: Eye Tracking Data (Task 3)

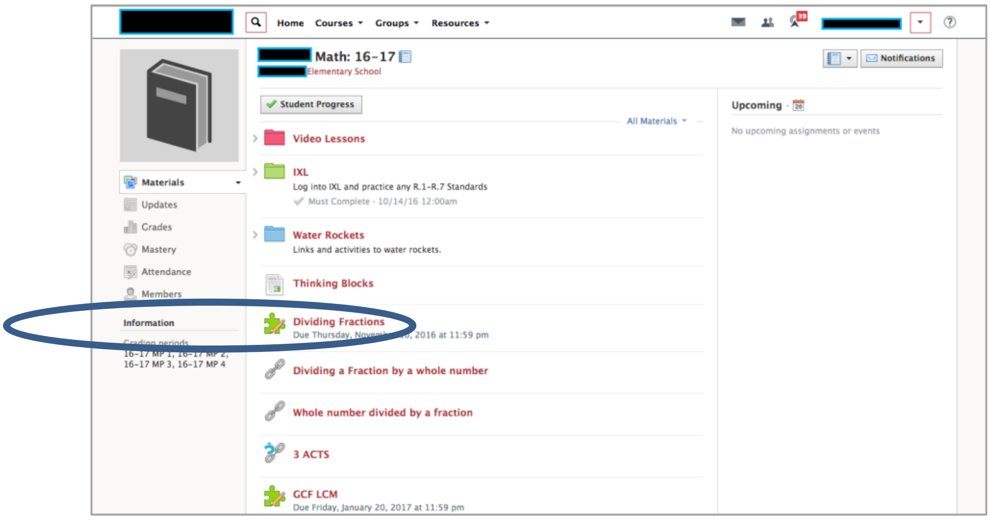

Figure 5: Math class page in Schoology interface, without participant Gazepoint data. Desired participant navigation selection is circled

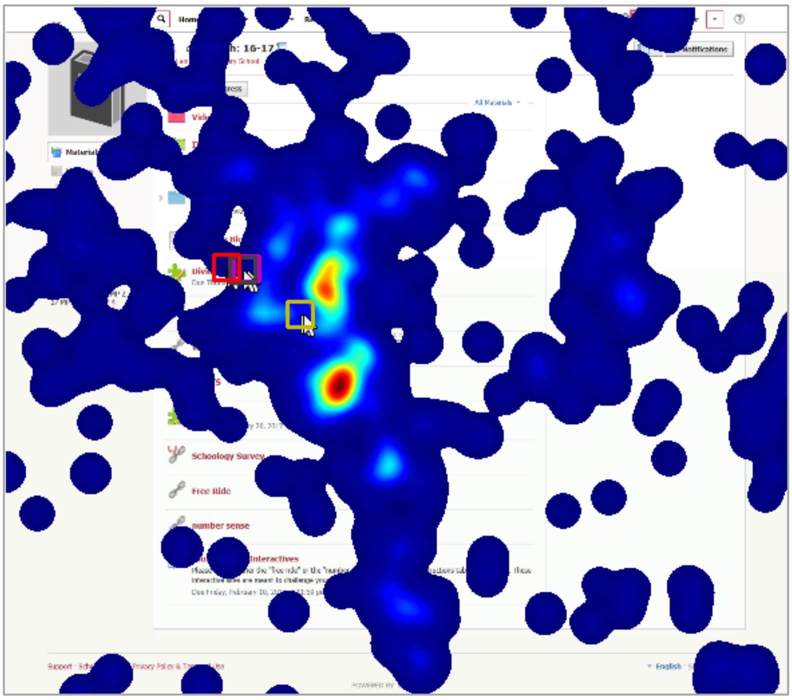

Figure 6: Heat mapped visualization of eye-tracking data retrieved during the third task, selecting a specified assignment listed within the participant's math class

Figure 5 shows the interface for the first component of Task 3 where participants were asked to access a specified, previously completed assignment. This involved students selecting "Dividing Fractions", a particular assignment on the specified class page. Approximately 16% of participants required multiple attempts to access the specified assignment. Censored information is, again, blocked by a black rectangle. A blue stroked circle outlines the position of "Dividing Fractions".

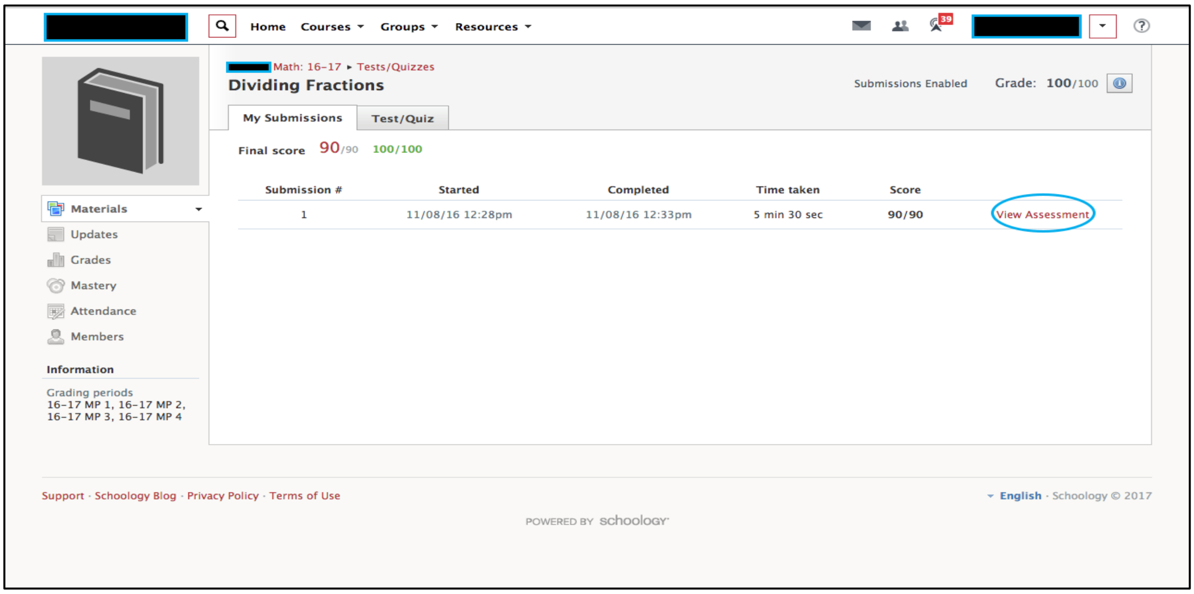

Figure 7: Assignment page in Schoology interface, without participant Gazepoint data. Desired participant navigation selection is circled

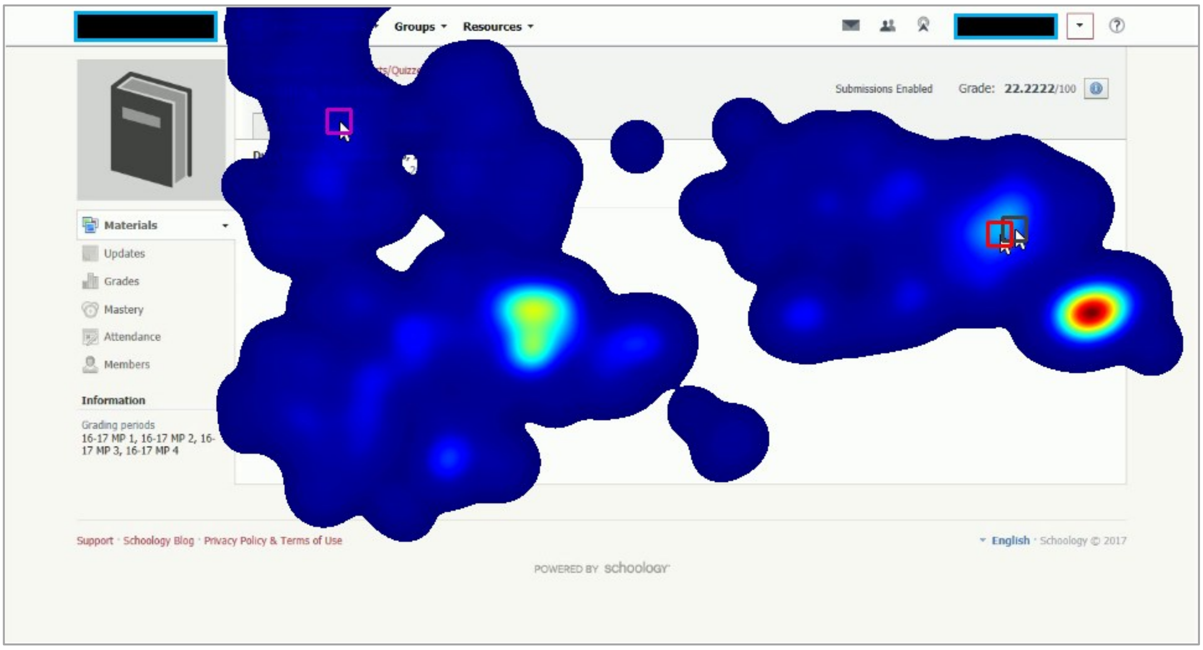

Figure 8: Heat mapped visualization of eye-tracking data retrieved during the third task, selecting to view an assessment for a specified assignment listed within the participant's math class

Figure 6 illustrates the tracked eye movement via heat map visualization on several participants with viable retrieved data. Gray, yellow, red, and pink stroked squares mark each location a participant clicked. Figure 7 shows the interface for the next part of Task 3 where the participants had to select "View Assessment", a button on the specified assignment page to access their score given by the instructor. Approximately 30% of participants clicked and scrolled throughout the submission details before selecting "View Assessment". Censored information is, again, blocked by a black rectangle. A blue stroked circle outlines the position of "View Assessment". Figure 8 exhibits the tracked eye movement via heat map visualization on several participants with viable retrieved data. Gray, yellow, red, and pink stroked squares mark each location a participant clicked.

4.7 Phase 3: Eye Tracking Data (Task 4)

Figure 9 shows the interface for Task 4 where participants were asked to verbalize their score received for the specified, previously completed assignment. Although the score was located prominently in the upper right hand corner, as denoted by a blue circle in Figure 9, approximately 65% of participants scrolled through the entire page to locate their submission score. Approximately 46% of participants required verbal assistance to locate their submission score. Censored information is, again, blocked by a black rectangle with cyan stroke. Figure 10 illustrates the tracked eye movement via heat map visualization on several participants with viable retrieved data. Gray, yellow, red, and pink stroked squares mark each location a participant clicked.

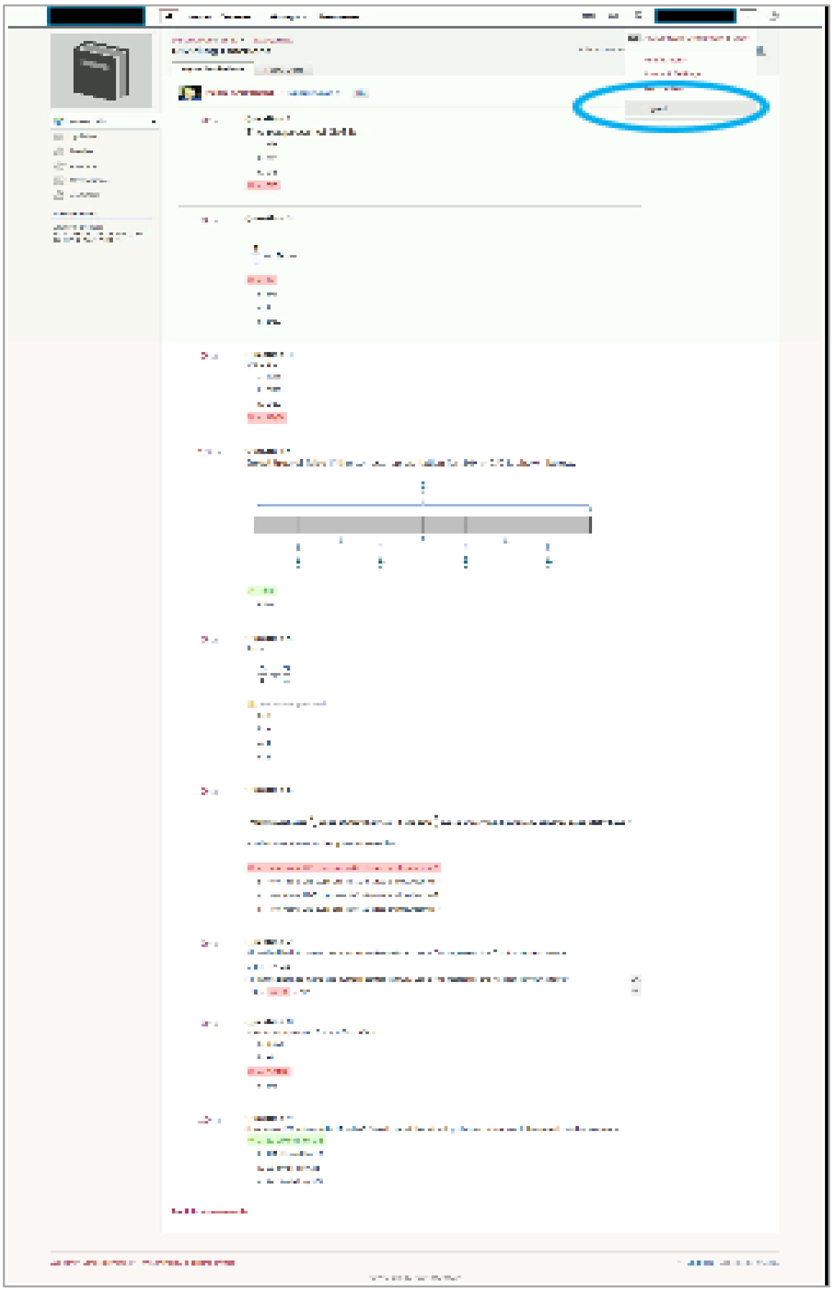

Figure 9: Assignment assessment page in Schoology interface, without participant Gazepoint data. Desired participant navigation selection is circled

4.8 Phase 3: Eye Tracking Data (Task 5)

Finally for Task 5, the participants were asked to log out of the LMS after they completed verbalizing their assessment score to the moderator. Approximately 32% of participants clicked back on several screens to get to the default home page before selecting the dropdown arrow and clicking "logout". The students did not realise they could log out from any page within the LMS.

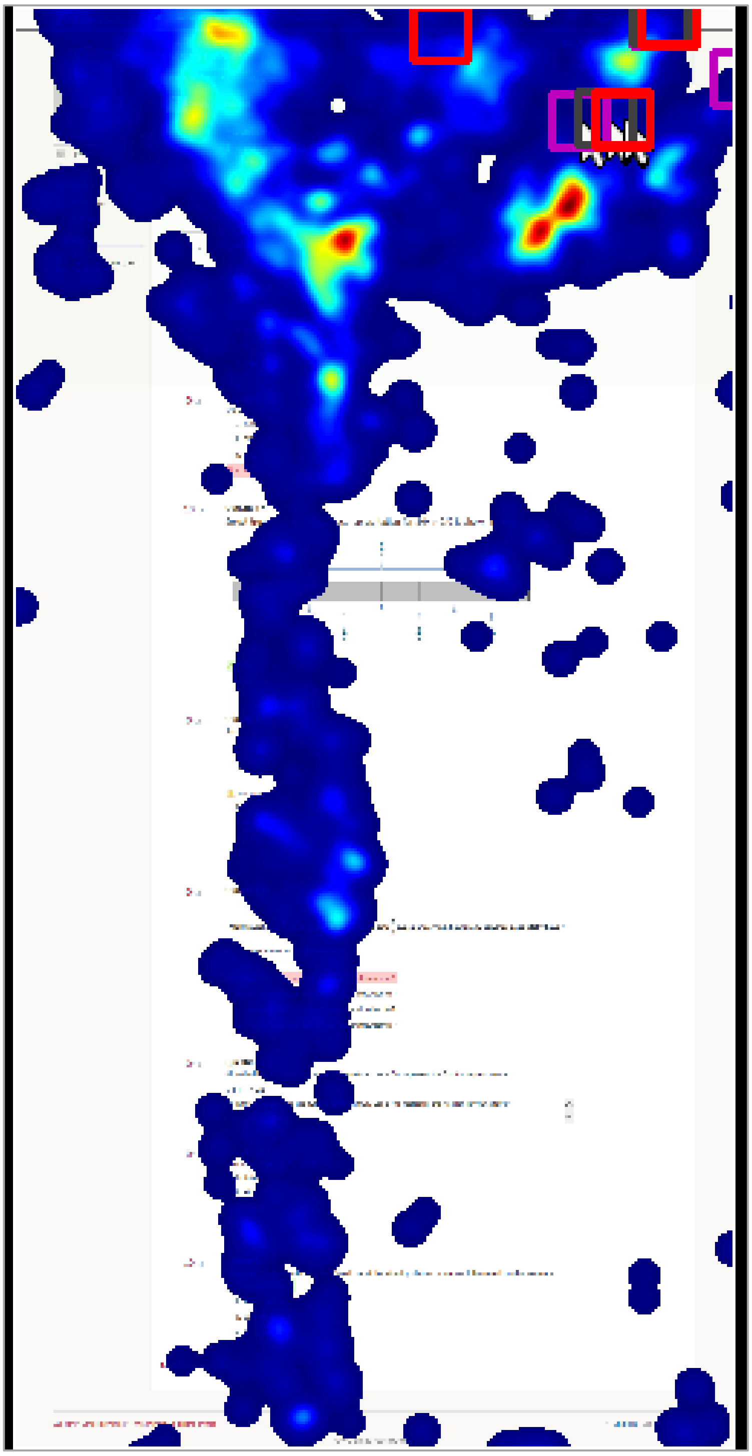

Figure 10: Heat mapped visualization of eye-tracking data retrieved during the fourth task, reciting the assessment score for a specified assignment listed within the participant's math class

5. Discussion

Within each of the phases of the project a number of problems were identified and analysed. These problems and their potential solutions are discussed below

5.1 Phase 1: Observation

The advanced placement classroom subgroup students work conjointly between iPads, a traditional style workbook, and the whiteboard used by the instructor. This appears to be problematic due to the inability to place items easily with the absence of desks and/or tables.

A. Problem 1:

Utilizing iPads can cause a distraction for some students: During class, one advanced student was able to conceal that they were drawing instead of working on the current math problem. The student was able to remove the drawing before their instructor had noticed it. The ability to misuse technology may possibly hinder student attention to assignments and lessons.

Suggested Solution:

There is a need for an environment where students would be able to sit at a standard desk in a standard chair. This type of environment could promote better focus, as the casual environment in the library, containing lounge seating, may serve to distract the students rather than comfort them. Also using software that allows the instructor to observe what each student is writing on the iPad would help keep the student's focus on the task at hand.

B. Problem 2:

There is a constant shift between different tools utilized for the lesson which can sometimes hinders progress. Students continuously lost their place within the traditional style workbook where the lesson problems were located.

Suggested Solution:

Introduce digital workbooks to be used during class. If the GUI of a digital workbook was able to present the problems and an interactive "whiteboard" area for them to work on within the iPad simultaneously, traditional workbook usage could be eliminated within the classroom.

As noted by Kayalar (2016) and Dixon and Tierney (2012); imbalance within the allocation of devices to the quantity of students may generate complications regarding the success of the course, due to some students' inability to access information as easily as their peers, resulting in a need for the instructor to manipulate the way they teach within the classroom. Teachers often have to compensate with students not having all of the same programs and applications uploaded to their personal devices.

5.2 Phase 2: Cognitive Walkthrough

Students from the advanced placement group were utilized for a cognitive walkthrough due to the instructor's suggestion of their competence with the technology.

A. Problem 1:

There is a lack of consistency in the use of technology: At the beginning of the cognitive walkthrough, several students stumbled upon attempting to access the iPads; several of them required a passcode to gain access.

Suggested Solution:

Remove all passcodes from technology students utilize to access information. This school has not obtained a 1:1 program where individual pieces of technology are assigned to students to carry throughout their day in school and home. Therefore, there is no justification to have a password that prevents the students gaining immediate access to technology.

Also, previous research has shown that students perform better in one-to-one classrooms, where technology is available for every student (Clariana, 2009). There is a generalizable notion that 1:1 device implementation can positively influence achievement in a variety of content areas for students of many grade levels (Harper and Milman, 2016).

B. Problem 2:

Each iPad has application organization variations, hence there is a variance in the location of the LMS application shortcut or icon. Students often have to search for specific applications through shortcuts and pages.

Suggested Solution:

Lock the ability to reorganize applications on iPads so there is a clear and consistent pattern of organization when students attempt to find an application for class or an assignment.

C. Problem 3:

There was a problem with students quickly accessing the LMS. The students were often required to type a zip code, then select their school from a list within the zipcode. Often they also had to type their log in information (sometimes username, other times email). Logging into the LMS often required several minutes of class time.

Suggested Solution:

The LMS should utilize locational services, allowing for a GPS position to identify which school the student is attempting to gain access to. Log in information should remain static, and not vary between username and email. By implementing these small changes a student may gain access to their course material in a fraction of the time.

D. Problem 4:

There were problems with the organization of course on the LMS. Course material was located in the main area of the course page once a student was able to access it. However, assignments, readings, homework, and workbook pages are all intertwined in a list of material.

Suggested Solution:

Organizing course material under headings may allow students access to course material in a faster, more direct manner. Students would be required to read less on the course page if they knew the type of assignment they were attempting to access.

While an LMS can provide immediate remote access to student's course materials, interfaces for can be difficult to navigate. As shown above, even simple experiments to determine the usability of the interface throughout a learning managements system, with a variety of different level students can resolve some of the issues students may have (Nakamichi et al, 2006).

One of the significant components of a usable LMS is to deliver an atmosphere that enables learning and instruction without restricting users of their time due to attempting navigation, lack of ability to utilize the system, or distance from a campus (Epping, 2010). Students utilizing an LMS should easily be able to learn and adapt to the features provide, in a timely manner (Stuikyr et al, 2006). Usability has become a significant concern for electronic learning and LMS advancement. Problems within the LMS design will decrease a user's satisfaction when attempting to navigate and operate the system's features (Inversini et al, 2006).

5.3 Phase 3: Task 1

It became apparent during this phase of the testing that users were unable to access their LMS account in a quick and efficient manner. Prior to inputting their username and password, students are required to type in their zip code, and select their school from a list associated with that zip code. In this specific school district, users were tested in an elementary school that was named after the same individual the high school was named after. This problem mirrored the problems observed during the cognitive walkthrough in phase 2 of the project.

A. Problem 1:

The students often encountered a requirement to input their zip code. Using a zip code input to narrow school selection works fairly well in suburban and rural areas. When applied in urban landscapes, a zip code method may inconvenience the user, particularly if there are multiple schools within the district.

B. Problem 2:

There was often confusion with the school selection after narrowing the school search using zip codes. Schools with similar names may confuse users upon selection. Approximately 30% of participants selected the incorrect school when attempting to select their correct school.

Suggested Solution:

Remove the zip code and school list feature from the school selection during the log in process. In this specific situation, the technology is site specific and remains at the school. If locational services are applied to the LMS, users would already be assigned to the school they are in when attempting to log into their account. If schools are conjoined, or on the same campus, a list feature would suffice and the list would be substantially shorter and cause fewer errors.

5.4 Phase 3: Task 2

Students are required to use a dropdown menu from the interface navigation bar under “Courses” to select and access a specified course. As is shown in Figure 3, “Courses” is located between the “Home” and “Groups” menu items. The “Course” dropdown menu holds several options including “6TH Grade ELA: Section 1, 2, & 3”, “6TH library instructor name”, “Instructor name Math: 16-17”, etc.

A. Problem 1:

The navigation bar choices are vague and misleading the option “Groups” located next to “Courses” may be misconstrued by users as an option to select a particular class.

Suggested Solution:

Change “Courses” to “Classes”. “Classes” is more of a convention in casual language used within the school classroom. Users should be able to correlate their physical class to their digital LMS with “Class” better than “Course”.

B. Problem 2:

Selections in “Courses” dropdown menu are not direct enough. The user has to read an instructor’s last name and “6TH” before their class title in 3 of the 5 options on Figure 3.

Suggested Solution:

Place the class type at the beginning of the title.

Example: Change “6TH Grade ELA: Section 1, 2, & 3” to “ELA Section 1-3: 6th Grade”

As was previously noted, the majority of research conducted on LMSs do not include many studies at elementary school levels. However, the limited research that has been undertaken involving school-related LMSs show how student-learning practices can change as a result of the opportunities provided on the LMS platform (Snodin, 2013). Even with the extensive extent of high level implementation of LMSs in many countries, the majority of application is within higher education institutions (Piña, 2013). This means that many of the terms and nomenclature from higher education setting have carried through into the LMS used in school settings. Addressing this to make the products more suitable for school students would improve the use of these systems in these settings.

5.5 Phase 3: Task 3

In this task, the users were required to search through a list of documents for a specified assignment that was previously completed in the curriculum. Once located, a user had to then select "View Assessment", regardless if there is a single assessment or multiple attempts. Then, users were provided with their submission with an assessment.

A. Problem 1:

Within the LMS, the class list of documents are not organized by type. This requires the user to go item-by-item through the list to locate their desired material.

Suggested Solution:

The LMS should allow instructors to organize their documents into sections on their class pages. Although it was mentioned that the instructor could create subfolders to allow organization of materials, that would require the user to implement another click to access that material. By providing users sections like "Assignments", "Readings", and "Homework", users would be able to read a concise section to access their material, rather than seeking through the entire class curriculum.

B. Problem 2:

The "View Assessment" ability is not optimized for user performance: If a user has completed an assignment and they would like to view it, they are required to do the following task flow:

Select "Courses" > Select the Class > Select the assignment > Select "View Assessment"

Approximately 30% of participants clicked and scrolled throughout the submission details before selecting "View Assessment". Regardless if there is one submission or multiple submissions, a list is still shown.

Suggested Solution:

If an assignment is no longer collecting attempts, a user should not be required to select a single submission from a list of a single submission. The LMS should automatically direct the user to their single submission. Otherwise, a list holding two or more submissions is an efficient method.

Within the list, selecting to view an assessment should be expanded to the entire line, not just a small clickable area on the right hand side of the item.

As stated by Mandel (1997), navigational controls within the platform of the LMS allow students to control their way around the interface. If properly organized, the LMS should empower students, users, or lecturers to remember information while utilizing the system. The small changes proposed above should lead to an improved interface for all student users.

5.6 Phase 3: Task 4

For this task, users were asked to verbalize their assessment score assigned by their instructor. Figure 9 shows the location of the assessment score, placed at the top right-hand corner of the assessment window.

A. Problem:

Participants sought out their assessment score in multiple locations, as can be seen from the eye-tracking data in Figure 10. Assessment scores are not labeled in a clear location that is easily accessible for users to review. Figure 10 shows that users tend to scroll up and down the entirety of the assignment page seeking their grade.

Suggested Solution:

Move the user's submission grade to be directly next to the name of the assignment or place it in the area where the assignment assessment is being displayed for user feedback.

Ghoniemy and Fahmy (2010) identified that a simple LMS user interface should be implemented to promote fluent interaction between instructors, students, and systems. As is demonstrated by the problem identified above, the student use of the LMS to find their grade is restricted by the student's perceptual and cognitive abilities (Thuseethan, 2014). By applying usability standards to an existing LMS, improvements can be made to enhance the learning experience for users in addition to their academic performance (Tselios et al, 2008).

5.7 Phase 3: Task 5

Finally, the users were asked to log out of the LMS. Users were not given information pertaining to the location of the logout button.

A. Problem:

Users were unable to easily locate the logout button. Currently, the LMS requires a user to click the downward pointing arrow in the top-right corner to reveal a dropdown menu holding the logout button.

Suggested Solution:
Remove the logout button from the dropdown menu and make it available throughout the interface, prominently on the navigation bar.

In order to improve the usability of a LMS, human computer interaction standards can be implemented to play a key role in obtaining an improved user performance (Sung and Mayer, 2012). De Lera et al (2010) mention research in this field that offers substantial insight for technology usability and attentiveness to the user's needs for the design element of human computer interaction.

6. Conclusion

The literature reviewed indicates that technology is successful when it is implicated to education in a way that allows for students to benefit and increase their learning potential. To do so, instructors must be not only well versed in the material, but also in the way technology is utilized to enhance education experiences. Studies have shown that students can be distracted by technology if it is not employed into the curriculum in a way which runs homogenously with studies and instructor capabilities. Research to educate instructors how to become fluent with technology and understand its capabilities is essential to continue to develop education with modern tools. Without proper training, a student's capabilities are limited by their educators. Comparison of training techniques for faculty is advised to develop an optimal technique that will better enable educators.

The study, although small in scale, also shows the necessity to have technology be as simple and concise as possible, applying standard HCI and usability improvements – specifically in this instance of the LMS. Location services have been shown to decrease the amount of time needed to log into the LMS, and simplify its procedures. By instating such tools to an interface for education, students are enabled to access their information more quickly, and minimize frustration with the system. More research is required to further analyze and compare the success rate of individuals using improved interfaces, to individuals using current interfaces. Future development of research in this field calls for larger participant groups sampling various components of a LMS redesigned to improve task completion time and usability.

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