

Use of Google Docs as Learning Aid in Biological Laboratory Application

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by:

Cameron W. Habib

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Approved by:

Dr. Michael Buckholt
Department of Biology and Biotechnology
Worcester Polytechnic Institute

Dr. Jill Rulfs
Department of Biology and Biotechnology
Worcester Polytechnic Institute

0.1 – Abstract

The use of data collection and live display is an invaluable tool in learning environments. Current technological standards for data collection are often expensive, complex, and lack a high degree of flexibility. The need arises for the development of a cost effective and flexible system that can be implemented in a wide range of environments and maintained with basic technological skills. We propose the implementation of a Google Docs system, developed and supported by Google, Inc. We show that the Google Docs system is superior, both in ease of use and features, to the current standard of the CPS system, as sold by eInstruction. We recommend the implementation of this system in both biological laboratory and other learning environments, both as a replacement for previous systems, as well as a newly implemented technology.

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1.0 – Background

1.1 – Use of Data Collection and Presentation

The use of statistics and data analysis is an important and integral part of any scientific setting, in particular biological applications. The larger the data set, the greater the accuracy of that set¹.

Statistical tests remain a necessity to determine the accuracy and validity of that data, both for the use of experimental determinations, as well as for use in reporting of those determinations.

An issue exists, however, in teaching laboratory settings. Due to limited time and resources, it is often difficult to obtain the data set size necessary to obtain meaningful and useful results. As such, it is often necessary to pool and combine the data from the class, creating a more reliable data set. This data can then be distributed to the involved students, increasing the number of statistical analysis able to be performed and the accuracy of their results.

The collection of data distributed in a live manor also allows for the error analysis and comparison of results. While predesigned labs often do result in the predicted outcomes, the learning curve associated with unknown procedures for students, and variations due to changes beyond control, can lead to errors. The real-time distribution of data obtained from multiple separate groups allow each individual to insure their results are in line with expected results. The entering of data, leading to its viewing and reading, also allows for enhanced comprehension and learning of that material².

1.2 – CPS Clicker System

The existing standard for many universities and learning institutes is that of the Classroom Performance System, otherwise known as CPS clickers. The CPS clicker system is a system

marketed and sold by eInstruction³. The system consists of student or institution purchased remote “clickers” utilized for the input of data, receiver utilized to communicate with the clickers, and a software interface to communicate with the receiver. The entire system is proprietary, and requires the use of the eInstruction devices. While various forms and additions to the software can be acquired, they must be done so from the developer, and are unable to be tailored or altered in any significant manner. The use of the clickers also requires a paid registration fee, of which a yearly or lifetime registration period may be selected.

The closed and controlled nature of the proprietary system insures these devices are designed and tested together. This insures a high level of compatibility and performance otherwise difficult to obtain. However, these benefits come at a price. Because the system is proprietary, specific hardware and software must be used, decreasing the flexibility of the system. Flexibility manifests itself, both in terms of the pricing of the equipment, as well as the capabilities of the equipment. The purchasing institute is at the whim of the developing company; should a product offer too much or too little in the terms of features, they are unable to change the package to suit their needs and instead must change their needs to suit the package. While problems are less likely in such a proprietary system, when a problem does arise, the lack of transparency and working understanding of the system often lead to issues that cannot be self-rectified. Such problems often require dedicated IT staff or assistance from the developer.

1.3 – Google Docs System

Google Docs is a suite of online applications with spreadsheet, word processing, and presentation tools, deployed and supported by Google, Inc⁴. While Google is a for profit company, the suite is offered at no cost to any freely registered user or guest thereof. Based heavily on current office suite standards, the use of all applications is largely similar to products

such as Microsoft Office or OpenOffice, allowing an almost seamless transition. Initially developed by exterior companies later acquired by Google, each application has received a constant stream of revisions and feature additions, to its current day feature heavy form. Each application is hosted and run exclusively from the Google serves. Access and subsequent operations requires only a terminal with capable internet connection and browser. At this time, virtually all web devices, including iPod Touches, iPads, and computers up to several years in age all qualify as meeting the minimum requirements.

Of the many features offered by the suite, collaboration is among the most unique. Through the use of a series of user lists and permissions, as well as built in application functionality, each application is able to support multiuser editing. Applications, such as the spreadsheet, allow live editing of a document for up to fifty users at one time. Modifications are synchronized live with the Google servers and distributed to all terminals and accounts with access to the document. Forms can also be used, to input data from a static HTML source. Currently functionality of this method limits forms to single sessions, and as such, data cannot be edited or revisited by the use of forms. Documents can be uploaded and downloaded in a variety of formats, including Microsoft Excel, Word, and PowerPoint, Adobe PDF, and various other open source formats.

1.4 – Other Data Sharing Systems

Other systems are available, however, many of them exhibit a wide range of flaws. Various proprietary systems exist, almost all failing for the same reasons as the CPS system. High cost, difficulty to run, and lack of flexibility are features of almost all proprietary data collection systems. Various open source projects, free to obtain and use, are available in various forms and from various locations, however, their lack of support both in feature sets and software bug

correction, make them a secondary choice. The Google Docs system remains the best choice for a low cost high option data collection system.

1.5 – Implementation of Data Collection System

Due to the need for data collection in all levels of education, it becomes necessary to develop a system which may be implemented in a wide range of environments which including varying degrees of technical and financial abilities. The current use of the CPS system employed by numerous institutes is a costly and resource intensive system, which many are unable to obtain. The use of the Google Docs system however, is a low cost and low maintenance system, able to be deployed and run by even those with limited IT experience. The Google Docs system also improves on many of the CPS system issues, including flexibility and customization.

The Google Docs system not only has the ability to be implemented in various institutes lacking the capabilities necessary for the CPS system, but environments where the CPS system may not be appropriate. The CPS system is heavily limited to strictly numeric input. Because not all data collection is numeric in nature, a large restriction on where the system can and cannot be used is created. The Google Docs system, both with the spreadsheet and word processes capabilities, allows for any form of data, text and numeric, to be inputted and used. This makes the system applicable, not only for use in a laboratory, but in various other situations, such as a literature or arts application as well.

2.0 – Materials and Methods

2.1 – Google Docs Accounts Creation

An Apple Mac Pro with sufficient and capable internet connection, running internet browser Safari v4.0 was obtained. A new browser window was opened and navigated to the Google site address: <http://mail.google.com>. A link

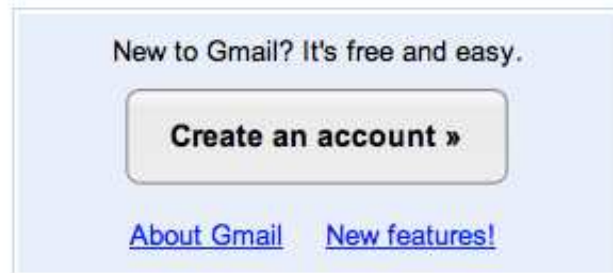


Figure 1: Google Signup Screenshot. Screen shot of page at <http://mail.google.com> used to create account for the use of Google Docs.

forwarding to a page for account creation was selected and opened (Fig. 1). Because no school sourced email accounts were available, a Google sourced account was necessary for access to the Google Docs system. Should a school sourced account have been available, a Google Docs account could have been used, requiring less information, and allowing for a less comprehensive access to many unneeded Google services. The institute name was used for both the “First name”

and “Last name” fields. A study of the class structure and schedule yielded seven separate sections. As such, seven separate accounts were created, each corresponding to a different section. Account user names were named with the institutes name, followed by the department code, followed by the section number (Table 1).

| Section # | Section Time / Date | Account Name |
|-----------|---------------------|--------------|
| 1 | Tuesday | WPI.BB01 |
| 2 | Wednesday AM | WPI.BB02 |
| 3 | Wednesday Afternoon | WPI.BB03 |
| 4 | Wednesday PM | WPI.BB04 |
| 5 | Thursday AM | WPI.BB05 |
| 6 | Thursday Afternoon | WPI.BB06 |
| 7 | Friday | WPI.BB07 |

Table 1: Account Creation. Naming nomenclature, and section association of accounts created for the use of the Google Docs system.

A “secrete question” and associated answer were selected in the event that access to the

account should become lost and the password is required to be reset. A private use school sourced email was entered for the “Recovery email,” used for delivery of any necessary notifications or messages, primarily ones pertaining to password resets. Remaining fields were filled out accordingly, and the account created.

2.2 – Folder and Document Structure

Because each section possessed it’s own username and password, a folder was created to correspond to each section. Using the pre-existing lab protocol and questions, spread sheets were created for each of the necessary labs. Spread sheets were created utilizing the on screen Google Docs tools. Various colors and column widths / numbers were used depending the question asked (Fig. 2). Eight copies of each spread sheet were created, one placed in a master

| Document Name |
|-----------------|
| BB2903_Tue_Lab1 |
| BB2903_Tue_Lab2 |
| BB2903_Tue_Lab3 |
| BB2903_Tue_Lab4 |
| BB2903_Tue_Lab5 |

Table 2: Document nomenclature. Naming scheme used for data spreadsheets.

folder for later use as a template, with the remaining seven named and placed according to their section. Spread sheets were named such that the lab course number followed by the section time

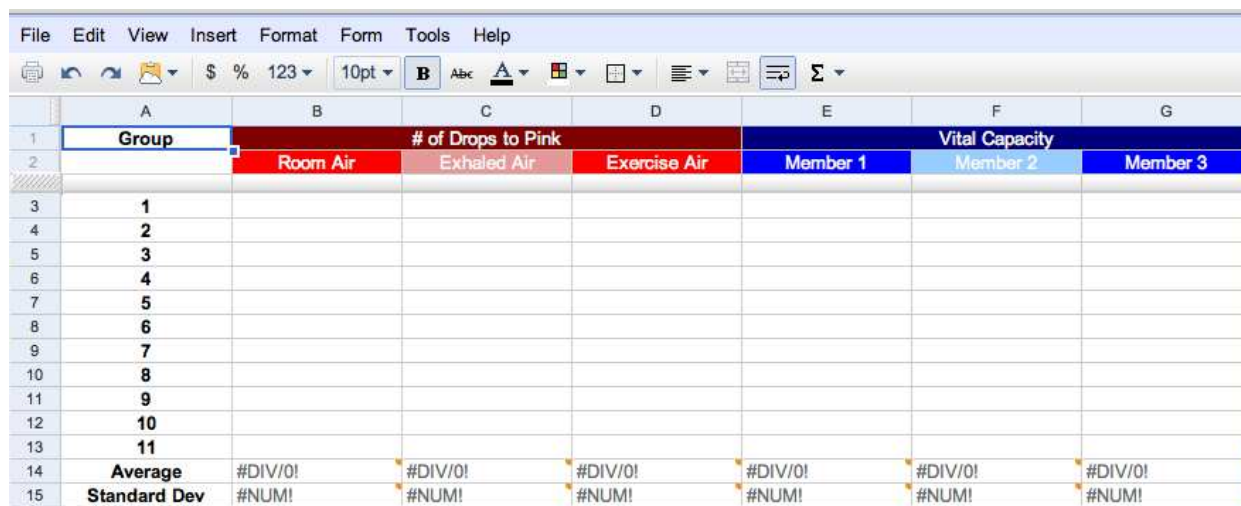
| | A | B | C | D | E |
|---|--------------|------------------------|-------------|-------------|-------------|
| 1 | Group | % Budding Yeast | | | |
| 2 | | T=0 | T=30 | T=60 | T=90 |
| 3 | 1 | | | | |

Figure 2: Spreadsheet Data Entry. Example screenshot of data entry, as taken from BB2903_Tue_Lab1. Cell for student data entry highlighted in blue.

(Table 2). Following the creation and placement of all sheets, each folder was selected and shared with the associated section via the “Share this folder” link. Each folder was also shared with the lab administrators, as to allow them access to recorded data for distribution and presentation.

2.3 – Terminal Administration

A computer lab, in this case a biological laboratory, consisting of an appropriate number of computer terminals was obtained. It was insured that each computer has an operational and sufficient internet connection as well as internet browser. Each computer was also assigned a numeric identity, ranging from one to the maximum number of terminals in the lab. Each student was provided a set of instructions on the access of the Google Docs account (Supplement 1). Students were instructed to navigate to the Google Docs home page (<http://docs.google.com>), enter the appropriate username and password for their section, open the appropriate lab document, fill out the corresponding questions, and properly exit the document. While in session, each section would feature the use of a projector displaying a session of the document in use (Fig. 3). This would be in tangent to the terminals in operation for each student.



The image shows a screenshot of a Microsoft Excel spreadsheet. The spreadsheet has a menu bar at the top with 'File', 'Edit', 'View', 'Insert', 'Format', 'Form', 'Tools', and 'Help'. Below the menu bar is a toolbar with various icons for formatting and data manipulation. The spreadsheet itself has columns labeled A through G and rows numbered 1 through 15. The data is organized into a table with headers and data rows. The headers are: Row 1: 'Group' (A), '# of Drops to Pink' (C), and 'Vital Capacity' (E-G). Row 2: 'Room Air' (B), 'Exhaled Air' (C), 'Exercise Air' (D), 'Member 1' (E), 'Member 2' (F), and 'Member 3' (G). The data rows (3-13) contain numbers 1 through 11 in column A. The summary rows (14-15) contain 'Average' and 'Standard Dev' in column A, and error messages like '#DIV/0!' and '#NUM!' in columns B through G.

| | A | B | C | D | E | F | G |
|----|--------------|----------|--------------------|--------------|----------------|----------|----------|
| 1 | Group | | # of Drops to Pink | | Vital Capacity | | |
| 2 | | Room Air | Exhaled Air | Exercise Air | Member 1 | Member 2 | Member 3 |
| 3 | 1 | | | | | | |
| 4 | 2 | | | | | | |
| 5 | 3 | | | | | | |
| 6 | 4 | | | | | | |
| 7 | 5 | | | | | | |
| 8 | 6 | | | | | | |
| 9 | 7 | | | | | | |
| 10 | 8 | | | | | | |
| 11 | 9 | | | | | | |
| 12 | 10 | | | | | | |
| 13 | 11 | | | | | | |
| 14 | Average | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! | #DIV/0! |
| 15 | Standard Dev | #NUM! | #NUM! | #NUM! | #NUM! | #NUM! | #NUM! |

Figure 2: Spreadsheet presentation screen. Example presentation screen shown via projection for viewing by students as taken from BB2903_Tue_Lab5.

2.4 – Student Survey

Following a seven week term use of the data collection system, a survey was administered to assess the effectiveness and usability of the system. A total of eleven questions were asked, three of which allowed for open essay type responses, two of which allowed or yes / no responses, and six of which utilized a Likert scale (Table 3). All questions, except for the essay, allowed for the answer of “Not applicable.” Questions number 2, 4, and 5 also prompted students to answer “Not applicable” should they have answered “No” to question 1. Survey was administered via the Blackboard classroom management software suite used at the institute. Students were offered a limited number of bonus points following the completion of the survey.

| Question # | Answer Form | Question |
|------------|--------------|--|
| 1 | Yes / no | Have you taken a biology lab (BB 2901-BB 2904) before in which the CPS clickers were used to gather class data for display and statistics? |
| 2 | Likert scale | If you answered yes to question 1 please indicate your level of agreement with the following statement: I found the CPS system easy to use for data entry and display. |
| 3 | Likert scale | Please indicate your level of agreement with the following statement: I found the Google Docs system easy to use for data entry and display. |
| 4 | Likert scale | If you answered yes to question 1 please indicate your level of agreement with the following statement: The Google Docs system was easier to use than the CPS system. |
| 5 | Likert scale | If you answered yes to question 1 please indicate your level of agreement with the following statement: The CPS system was easier to use than the Google Doc system. |
| 6 | Likert scale | Please indicate your level of agreement with the following statement: I think collecting and displaying group data in real time is useful in lab. |
| 7 | Yes / no | Did you take advantage of the chat feature of Google Docs? |
| 8 | Likert scale | Please indicate your level of agreement with the following statement: I think the chat feature would be useful if more groups utilized it? |
| 9 | Essay | Did you have any issues with the Google Docs system? If so, how could they be resolved? |
| 10 | Essay | Are there any improvements or changes you were like to see? |
| 11 | Essay | Other comments / suggestions? |

Table 3: Student Survey Questionnaire. Questions used in survey to students eliciting responses from experiences with the Google Docs system.

3.0 – Results

3.1 – Participation Level

A total of 83 participants completed the survey. Data was compiled via the Blackboard application and entered into a spreadsheet format. Participants completed all questions, except one subject who failed to provide an answer for question number 6.

3.2 – Student Background

The system and subsequent survey were deployed in the third term of a four-term entry-level bio offering. Although it is assumed that students begin with the initial course, each is designed so that students may

enter in at any term in the program. It was therefore necessary to determine the number

of students that had been exposed to the previous method of data collection, the CPS clicker system. A question was posed asking if the participant had previous experience with the CPS clicker system. Results indicated a nearly even distribution, 50.6% having previous and 49.4% lacking previous experience with CPS clickers (Fig. 4).

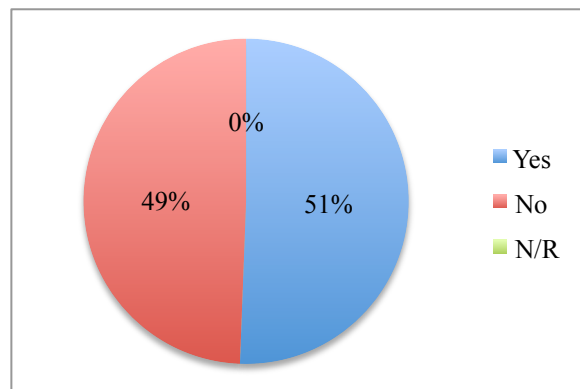


Figure 3: Question #1 Survey Results.

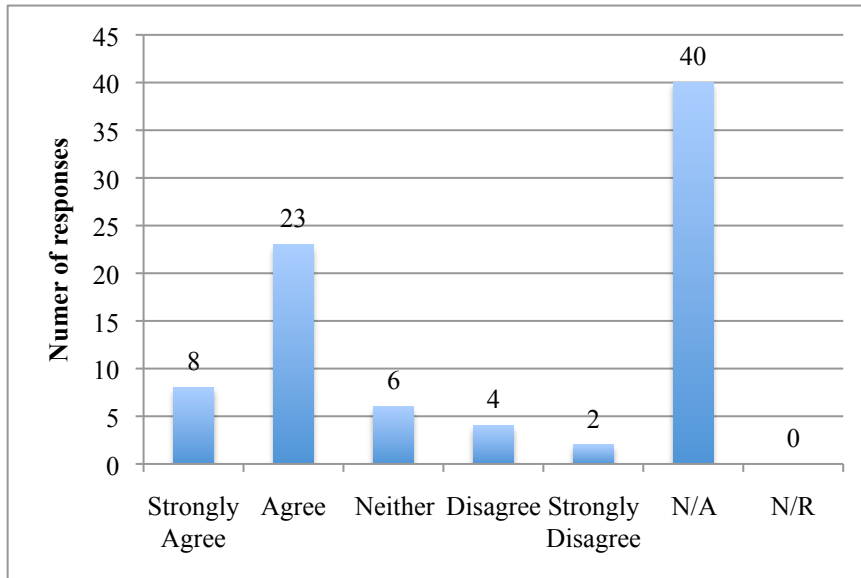


Figure 4: Question #2 Survey Results.

In order to assess any pre-existing notions in relation to the previous data collection method based on the population of participants that had experience, participants were asked if they believed the CPS clicker system was an easy to use method of

data collection and display. 37.3% of participants agreed or strongly agreed that the system was easy to use while only 7.2% disagreed with the statement (Fig. 5). 48.2% of participants reported that the question was not applicable to them, a value in line with that expected from results obtained through Question 1.

3.3 – Comparison to CPS clicker system

In order to determine the ease of use of the Google Docs

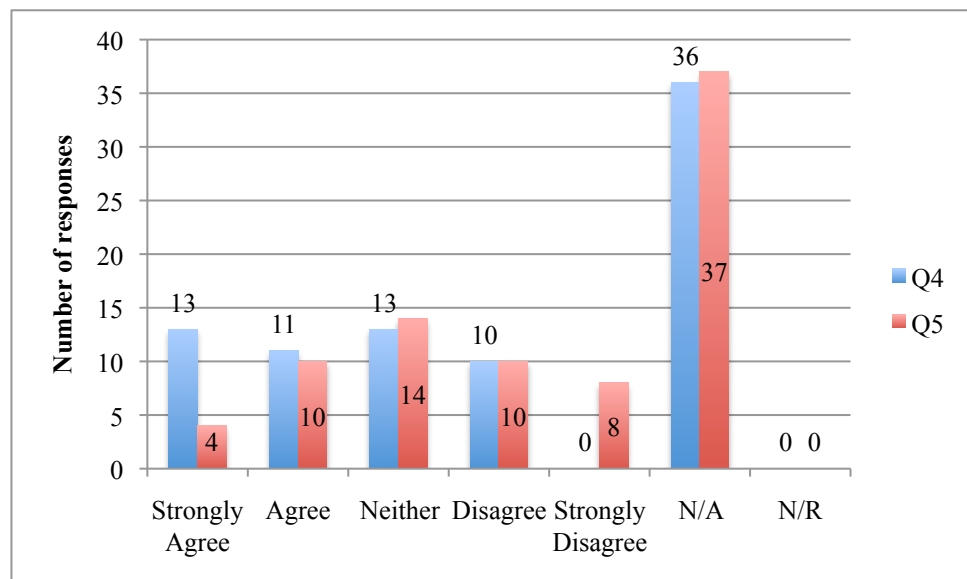


Figure 5: Question #4 & 5 Survey Results.

system, as compared to the previous system, participants with CPS system experience were asked to compare the CPS system to the Google Docs system. Two inverted questions were asked to allow for a comparison. Participants were then probed for their belief that the Google Docs system was easier to use than the CPS clicker system (Fig. 3: Q4). Subsequently, participants first asked for their belief that the CPS clicker system was easier than the Google Docs system (Fig. 3: Q5). The results indicated that 28.8% of participants agreed or strongly agreed that the Google Docs system was easier in use than the CPS system, while only 16.8% agreed or strongly agreed that the CPS system was easier in use than the Google Docs system.

3.4 – General Opinion

All participants, including both those with and without prior experience with the previous CPS system, were probed for opinion of the new Google Docs system. Participants were first asked if they agreed with the statement that the Google Docs system was easy to use. The results indicate that 84.3% agreed or strongly agreed that the system was easy to use, while only 6% disagreed or

strongly disagreed (Fig. 4).

Participants were then asked if they felt the use of live data collection and display in lab was useful. The results indicate that 89.2%

agree or strongly

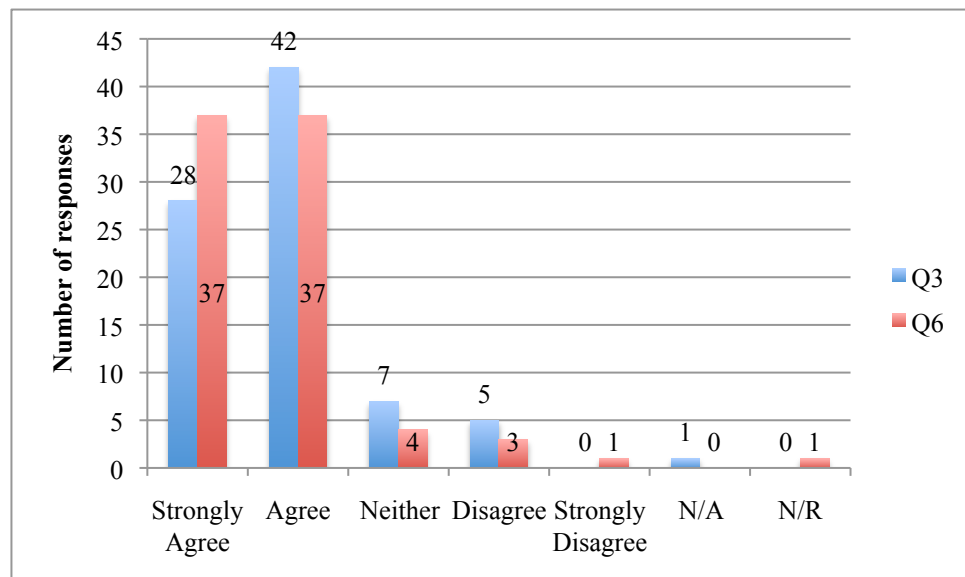


Figure 6: Question #3 & 6 Survey Results.

agree, while only 4.8% disagreed or strongly disagreed.

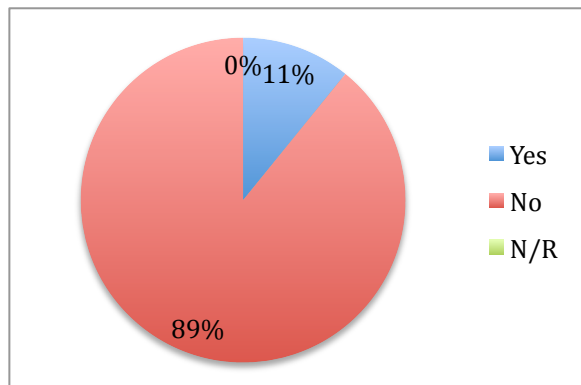


Figure 7: Question #7 Survey Results

3.5 – Additional Use of Features

One feature of the Google Docs system of interest for future use was that of the chat. Participants were probed as to the usefulness and usability of this feature in lab. Participants were first asked if they had used the chat feature. The

results indicated that only 11% had utilized this feature, with 88% responding that they had not (Fig. 5). Participants were then asked that, should the chat feature have been used by more groups, would it become useful. The results indicated 49.4% of participants agreed or strongly agreed, while 10.8% disagreed or strongly disagreed (Fig. 6).

3.6 – Open Response Feedback

Participants were asked to provide feedback as to any improvements or issues with the Google Docs system. Several topics had a significant number of hits.

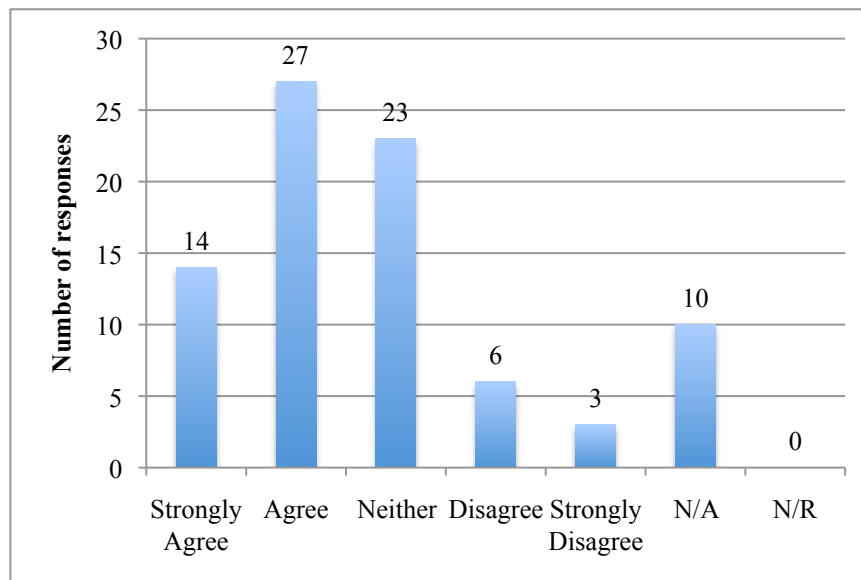


Figure 8: Question #8 Survey Results.

Participants commented on the security of the system, mentioning the fact that since the password is known to students, it could be altered in such a fashion as to prohibit access by other

students or faculty. Participants also commented on the method by which data was inputted into the spreadsheet, saying that it was at times confusing on where to place data, and the possibility of accidentally deleting or altering existing data. Comments were made as to connectivity issues of the computers used, as well as performance issues of the site itself. Participants with experience using the chat commented that it was difficult to determine the terminal using chat, as no unique identities existed.

3.7 – Survey Summary

Participants generally agreed that the Google Docs system was both easier to use than the CPS system, as well as an easy system in general to operate. They also believed that the use of a system, such as Google Docs, to collect and display data was generally helpful. Essay style feedback indicated a limited number of issues, many of which are minor in nature. These combined results would indicate that the Google Docs system was an overall successful implementation, and would most likely be well received by subsequent populations in similar environments.

4.0 – Discussion

4.1 – Result of Survey

It is important to consider previous systems in place when considering the Google Docs system. Previous experiences by students, negative in nature, may shy students away from the use of any data collection system, by way of association. Inversely, a positive experience may prepare and compel students in the use of such a system, as well as impart users with knowledge that may aid them in the use and operation of that system. As determined by the survey, the system was used by a generally equal number of new and veteran users. The users familiar with the CPS system had a general bias toward favoring the CPS system, and had no notable negative opinions of it. Should pre-existing negative opinions have existed, this could not have only impacted the student's opinions of the Google Docs system, but also influenced the opinion of other non-experienced users. When these same veteran users were asked for their opinion of the Google Docs system, as compared to the CPS system, their opinion was that the Google Docs system was an easier to use method for the collection of data than the CPS system. This shows that while CPS system is effective, the Google Docs is a positive improvement.

The population as a whole, including users with no CPS experience, also shared this opinion. Users indicated that the Google Docs system was both easy to use, as well as an effective method by which to display data. This fact shows that the use of the CPS system prior to that of the Google Docs system granted an insignificant amount of experience or knowledge with which to assist in the operation of the Google Docs system. It also showed that the use of such a system prior to that of the Google Docs had no substantial impact on the opinion on that system. This

allows Google Docs to be a suitable choice for both environments with no previous data collection system in place, as well as those with a working but inferior system in place.

Participants generally agreed, that while the chat feature of Google Docs was unused, the use of such a feature would be beneficial and welcomed. This is an important consideration when designing future implementations of Google Docs, due to the method in which the system must be put into place. It is also an important consideration when instructing the students, to place special emphasis on the presence and feature of chat. Because several participants reported a lack of awareness of the feature, a demonstration or assignment in the use of the chat may help to familiarize them with the feature.

4.2 – Issues and Problems

Several difficulties existed with the implementation of the Google Docs system. Because the system was hosted off premises, the performance and availability of the site was subject to external factors. As such, slow response times, down time, and connectivity problems were experienced at various times. These were due in part, both to issues with the Google servers, as well as the internet connection servicing the environment. Due to the wireless connectivity of the computer terminals, and the interference caused by infrastructure and lab equipment, connectivity issues to the network also existed.

The Google Docs system was designed to serve as a data collaboration system, not as a data input system. As such, each terminal is able to edit, and possibly delete, data entered by other terminals. This causes a problem for both intentional and accidental manipulation of data. The Google Docs does feature a forms function, however, this function does not allow data to be displayed in a live manor, nor does it allow data to be changed once it is input, disallowing it for

use in this application. Sheet protection is also available, however, it cannot be selectively applied to users, but only to the document as a whole, and is therefore also not applicable. This lack of protection created some confusion, as students were able to input data in any field in the document, the data would at times be entered into the incorrect field. Protection of all but the necessary fields would eliminate this problem.

Because each section consisted of just one username and password, all terminals were listed under the same name. While this caused no issues for the entering and sharing of data, it was problematic for the chat feature. Although each terminal was listed as a different color, the colors were dynamic in nature, and difficult to associate with a terminal. As such, students were unable to identify a chat log with a terminal user, making the chat in essence anonymous.

4.3 – Future Improvements

While the implementation of the Google Docs system was highly effective, there remains a great deal of room for improvement. Movement of the system to local servers from remote servers would allow for a more reliable and speedy access of data. This movement onto local servers would also allow integration into the pre-existing username and login system, allowing students to log in with their own credentials, rather than that provided by the lab section. This would also solve the issue of chat identities, as well as security of the system, since each user would be responsible for their own unique username and password. The connections could be hardwired instead of the wireless system used. Although the portability of the system would decrease, the reliability and speed would increase, creating a more useable overall experience.

A change in the terminal hardware could also be used. In the implementation, tabletop notebooks were used as the terminals. These are rather cumbersome, slow, and in many ways, overqualified

for use in the system. They have extremely limited portability, due to their power and connectivity requirements, and often times are a large source of issues. An alternative would be the use of an ultraportable, such as an Apple iPod Touch, iPad, or other similar device. These devices, using the built in web browser, could interface with the system and allow remote entry of data. Since these devices are designed to be portable in nature, they could be taken outside of the laboratory and used in external applications, such as field labs or field trips. Because they are also, in essences, a web-browsing device, the web experience and capabilities of the machine are typically much better suited for use in the Google Docs system.

4.4 – Final Considerations

In environments already using the CPS system or an equivalent, by transitioning to a Google Docs system, a large range of benefits are gained, including a reduction in operation cost and an increase in flexibility, allowing for attention to be applied elsewhere, increasing the overall quality of education. In environments without a preexisting data collection system, the implementation of one such as the Google Docs system allows for an enhanced learning experience by way of statistical analyses and simulation of real world data sharing practices. Google Docs has been shown to be a suitable for application in both of these situations, in terms of functionality and usability.

5.0 – References

¹ BENDAVID, A. (2007). A lot of randomness is hiding in accuracy *Engineering Applications of Artificial Intelligence*, 20(7), 875 <last_page> 885. doi:10.1016/j.engappai.2007.01.001

² *Can technology replace live preparations in student laboratories? -- modell 256 (6): 18 -- advances in physiology education* Retrieved 4/27/2010, 2010, from <http://advan.physiology.org/cgi/content/abstract/256/6/S18>

³ *eInstruction - products* Retrieved 4/27/2010, 2010, from <http://www.einstruction.com/products/index.html>

⁴ *Google documents - google docs help* Retrieved 4/27/2010, 2010, from <http://docs.google.com/support/bin/topic.py?hl=en&topic=15114>