ASSESSMENT OF STUDENT-CREATED VIDEOS AS AN ALTERNATE LABORATORY ASSIGNMENT AND DESIGN AND IMPLEMENTATION OF CLASSROOM ACTIVITIES DESIGNED TO IMPROVE STUDENT RETENTION AND LEARNING

by

MITZY ANN ERDMANN

JOE L. MARCH, ADVISOR
JACQUELINE NIKLES
TRACY P. HAMILTON
CRAIG P. MCCLURE
LEE MEADOWS

A DISSERTATION

Submitted to the graduate faculty of The University of Alabama at Birmingham, in partial fulfillment of the requirements for the degree of Doctor of Philosophy

BIRMINGHAM, ALABAMA

OCTOBER, 2015
ASSESSMENT OF STUDENT-CREATED VIDEOS AS AN ALTERNATE LABORATORY ASSIGNMENT AND DESIGN AND IMPLEMENTATION OF CLASSROOM ACTIVITIES DESIGNED TO IMPROVE STUDENT RETENTION AND LEARNING

MITZY ANN ERDMANN

DEPARTMENT OF CHEMISTRY

ABSTRACT

This dissertation presents three educationally based research projects and describes how they are related. The first portion of this manuscript describes the development of an alternate assessment for the general chemistry laboratory that harnessed both the availability of and interest in using smart phone technology in an educational setting. Student-created technique videos were implemented into the general chemistry laboratory curriculum in order to asynchronously monitor student use of standard laboratory equipment. A feasibility study was performed first, which showed that students were able to create videos that showed themselves performing standard laboratory techniques. Teaching assistants reported being able to easily access these videos and stated that the video quality was sufficient to allow asynchronous monitoring of technique. This study led to a full-scale research project, which showed overwhelmingly that there was a statistically significant difference between students who created a technique video that detailed the use of a Mohr pipet and those who did not
create such a video in being able to report the correct volume contained in graduated glassware on both a written final exam and a laboratory practical. Those that created a video reported the correct number of significant figures and manipulated the pipet correctly at a much higher rate than those students who did not create a video. The second portion of the manuscript describes the development and implementation of a laboratory exercise that informed students on the best practices of data handling and notebook keeping. This activity also introduced students to some of the ethical considerations that scientists encounter when recording and working with data. The last piece presented in this manuscript details the development of online instructional materials for the general chemistry laboratory. These materials were designed to offer identical instruction to all students using known best practices regarding both general education and online content delivery. Student opinion of the beginning phases of this project, and how they will develop the next steps and future directions, are also presented.
DEDICATION

All of the work presented here was possible because of an amazing support system. To my parents, you have made too many contributions to list here, so I will simply say “thank you”. My curiosity and desire to teach started with you, and ultimately this dissertation is as much yours as it is mine. To my husband Nathan, thank you for your patience. This was a long road, and I appreciate you walking beside me and pushing me forward when necessary. I also appreciate your feedback and bluntness throughout the years – you considered me a peer long before I actually was and your faith in me did not go unnoticed. To my kiddos, Langley and Landon, you kept me smiling when things got stressful. I hope that someday my contributions to education are used in your classrooms, and that you proudly smile and think, “my mom did that!” Lastly, to Mr. Jones, you made chemistry exciting and attainable, and this all started with you. Your students owe you a debt of gratitude too large to fathom. The world lost the most brilliant, sarcastic, challenging, encouraging, and student-centered chemistry educator much too soon. You were influential to me beyond measure and are truly missed. I still owe you $10 for betting against myself, and I promise to pay that forward.
ACKNOWLEDGEMENTS

I do not have words sufficient to thank my research mentor for his support and guidance during my career at UAB. Dr. March, you have been equal parts laid back, pushy, hands-off, hands-on, supportive, and maddening, and all together a perfect advisor. You are an inspiration to other educators, and your influence reaches further than I think you realize. It’s been fun, Boss. Thanks again.

I would also like to thank the members of my committee, Drs. Nikles, Hamilton, McClure and Meadows. I am aware that serving on a committee is a commitment, and I appreciate that each of you dedicated your time to support and challenge me in your own ways. Each of you played a unique role, and I truly feel that your input made for exceptional training.

To the staff of the Graduate School, I thank you for providing excellent professional development opportunities and for allowing me a chance to encourage my peers who are part of the CIRTL network. It has been a pleasure working with you, I wish The School continued success in the future.

Lastly, thanks, Dr. Graves, for taking a flyer on me years ago. I truly hope that I have meant as much to the Chemistry Department as it has meant to me.
Without your faith in me, I would have not have been able to help develop the chemistry education concentration in the department, and I will not soon forget that.
An Introduction To Statistics Used In The Behavioral Sciences ...........26
Overview Of The Dissertation Research ..............................................32
Research Questions ............................................................................33
Methodology .......................................................................................33
  Producing the Student-Created Technique Videos ..........................34
  Accessing and Grading the Technique Videos .................................38
  Formative Assessment of Student Opinion of the Technique Videos ...39
Initial Conclusions from Phase I ......................................................44

III. VIDEO REPORTS AS A NOVEL ALTERNATE ASSESSMENT IN THE UNDERGRADUATE CHEMISTRY LABORATORY .................47

IV. A LABORATORY ACTIVITY ON THE ETHICAL DATA REPORTING AND MAINTENANCE OF A LABORATORY NOTEBOOK THROUGH SIMPLE pH MEASUREMENTS .........................................................81

V. ONLINE CONTENT DELIVERY IN THE GENERAL CHEMISTRY LABORATORY .................................................................98
  Introduction ......................................................................................98
  Motivation And Formative Assessment ..........................................101
  Formative Survey Analysis ..............................................................109
  Design And Implementation Of Instructional Videos ......................113
  Assessment Of The First Generation Videos ..................................116
  Changes Implemented At The Midterm ..........................................131
  Initial Conclusions ........................................................................135

VI. FUTURE DIRECTIONS ..................................................................137
  Further Assessment Of Instructional Videos ....................................138
  Strengthening the Weaknesses Regarding the Use of Instructional Videos .................................................................140
  Challenge Videos ..........................................................................142
  Online Courses .............................................................................144
  Professional Development ...............................................................145

REFERENCES ....................................................................................147
APPENDIX
A Appendices Related to Chapter II .........................................................157
C Supplemental Material Submitted to J. Chem. Ed. .........................186
D Appendices Related to Chapter V .......................................................193
LIST OF TABLES

Table                                      Page

CHAPTER II

2.1 Select Student Response Items from the Fall 2011 and Spring 2012 End-of-Term Surveys .................................................................40

2.2 Test Items and Coding Criteria: Phase I .........................................................42

CHAPTER III

3.1 McNemar’s Chi Square analysis within groups for the Pre-, Post- and Final Examination data points.........................................................67

CHAPTER V

5.1 Fall 2014 End of Term Select Survey Items and Response Summary ....108

5.2 Spring 2015 Midterm Select Survey Items and Response Summary.......117

5.3 Response to Survey Item Probing Vocabulary in the Videos...............126

5.4 Sample statements from the free-response spring 2015 midterm prompt.................................................................................................128

5.5 Negative comments given to the free-response prompt.........................130
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter I</td>
<td></td>
</tr>
<tr>
<td>1.1 A pictorial interpretation of the main focus areas of SoTL and how they fit together to maximize student learning.</td>
<td>5</td>
</tr>
<tr>
<td>Chapter II</td>
<td></td>
</tr>
<tr>
<td>2.1 An example of a 2x2 contingency table used in calculating the chi-square statistic</td>
<td>31</td>
</tr>
<tr>
<td>2.2 Screen-shots from the first-term of student-created videos</td>
<td>38</td>
</tr>
<tr>
<td>2.3 Comparison of student performance on coded items pre- and post-implementation of the video assignment</td>
<td>43</td>
</tr>
<tr>
<td>Chapter III</td>
<td></td>
</tr>
<tr>
<td>3.1 Project Timeline</td>
<td>59</td>
</tr>
<tr>
<td>Box 1 Pre-test item and coding criteria</td>
<td>61</td>
</tr>
<tr>
<td>Box 2 Post-test and final exam items and coding criteria</td>
<td>62</td>
</tr>
<tr>
<td>3.2 The number of students who answered incorrectly on the pretest but correctly on a subsequent test</td>
<td>68</td>
</tr>
<tr>
<td>3.3 Comparison of student performance on all of the test items analyzed</td>
<td>69</td>
</tr>
<tr>
<td>Chapter IV</td>
<td></td>
</tr>
<tr>
<td>4.1 Example Student Notebook</td>
<td>90</td>
</tr>
<tr>
<td>Box 1 Representative post-activity discussion topics</td>
<td>92</td>
</tr>
</tbody>
</table>
CHAPTER V

5.1 Sample first-generation technique video ..............................................................115
5.2 Student Attitude Towards Vocabulary Used in the Videos .................................127
5.3 Background and calculation video shots ...............................................................132
5.4 Examples of second generation videos ...............................................................134

CHAPTER VI

6.1 Experimental design to measure effectiveness of challenge videos ..............144
CHAPTER I

THE ARGUMENT FOR THE SCHOLARSHIP OF TEACHING AND LEARNING AND DISCIPLINE BASED EDUCATION RESEARCH

PREFACE

Faculty are teachers. Even most faculty whose primary focus is research have some teaching requirement as service to their department. Those that are not required to spend time in the classroom teach their graduate students and post-doctoral associates in the research setting. Many of them do an excellent job in this role, but the act of teaching is not enough to engage students and create meaningful, lasting learning. To do the latter, we must study what works for our students both from the extant literature and by careful reflection of new strategies put in place in their own classrooms. For instance, a few questions faculty may ask themselves while developing and teaching a course include what are the most effective methods for content delivery, what tools can we create to aid in learning, why are the methods and tools useful? When we attempt to answer the last question, the why, we are attempting to determine “what works”. To do this effectively we need to turn to research methods to find
an answer. The research here follows the same process that finding an answer in traditional research such as bench chemistry would entail; we pose a problem, devise a way to study that problem in an attempt to find an answer, and analyze collected data to determine if the desired outcomes were met. Education research has slightly different end-goals than bench-science, but the steps of scientific inquiry, specifically those of stringent method, data analysis, and broader applicability all parallel those of traditional research.

In recent years, more people have begun to accept that carefully designed and implemented education studies should be considered scholarly research. The importance of this scholarship to national goals (such as preparation of a capable STEM workforce and development of a scientifically literate populace) has caused many groups to elevate its importance and attempt to make research on education as valuable to institutions of higher learning as traditional research. This scholarship takes many forms, and practitioners of education research will often self-identify within two major classifications: the Scholarship of Teaching and Learning (SoTL) and Discipline Based Education Research (DBER). There is considerable overlap between these fields, but it is important that the distinction between these two scholarly activities be clearly defined.
THE SCHOLARSHIP OF TEACHING AND LEARNING (SoTL) AND DISCIPLINE BASED EDUCATION RESEARCH (DBER)

Scholarship of Teaching and Learning (SoTL) is a broad term that describes scholarly work performed by teaching faculty regarding what impact materials and methods implemented in their classrooms have on student learning. SoTL projects range in breadth, but in general they describe the implementation and analysis of materials and methods to a specific set of circumstances. These projects may apply more broadly to other situations, but they are not required to in order to be considered SoTL. Any individual who wishes to qualitatively or quantitatively measure the impact of a teaching practice on their students can perform SoTL work. The field is inviting to all levels of faculty from all disciplines, and the prevalence of SoTL projects has increased in recent years.

Though the term scholarship of teaching has only been commonly used for about 20 years, literature that can be classified under the heading SoTL has been published for decades (McKinney, 2004). The term SoTL and the generally accepted definition of the practice was published by Boyer (1990), but many publications about related concepts appeared in the years before his work. For example, Shulman had previously highlighted the phrase pedagogical content knowledge (1987) and Pellino, Blackburn, and Brober discussed the scholarship of
pedagogy in their work on multiple forms of scholarship (1984). More recently, scholars have attempted to clearly define what is meant by SoTL. A definition that aligns with the goals of the work described in this dissertation frames SoTL as “viewing the work of the classroom as a site for inquiry, asking and answering questions about students’ learning in ways that can improve one’s own classroom and also advance the larger profession of teaching” (Huber & Hutching, 2005).

The past decade has seen tremendous growth regarding interest in teaching and learning. McKinney cites four compelling reasons why major change is taking place in higher education: (1) the “knowledge explosion”, (2) growing diversity in the preparation and expectations of college students, (3) political and public pressure to bring about major reform in education at all levels, and (4) the leadership of national foundations dedicated to the advancement of teaching. For the changes to have a positive impact, they should be data-driven and both draw from the extant literature and have the potential to build upon it (2007).

Rice argued that the scholarship of teaching as three main areas of focus; investigation of the synoptic capacity of our students, development of pedagogical content, and review and assessment of what we know about learning (1991). None of these categories are mutually exclusive but rather work
synchronously. For example, we need to study what we know about learning before developing materials so there is maximum benefit to the students who interact with them. Steps should be taken to ensure that the developed materials offer students a view of how this piece of the puzzle fits into the larger picture. Study and implementation of these research areas leads to more meaningful learning for our students. Figure 1.1 depicts the three focus areas and shows how they work together.

![Figure 1.1 A pictorial interpretation of the main focus areas of SoTL and how they fit together to maximize student learning (Rice, 1991).](image)

The knowledge explosion has forced academia to alter the goals of higher education. A language shift from “how much” students learn to “how well” they learn has taken place, and the “process” of learning is viewed as equally as important as the “product” submitted (McKinney, 2007). Instructional methods that actively engage students in their own learning have begun to replace the
lecture, an archaic practice that at one time was the sole method for content delivery (Huber & Hutching, 2005). This change in focus has not been haphazard. It has taken place as a result of the careful study of the factors that influence education. This study must continue to grow if the goals of higher education intend to grow with it.

The increase in the number of traditional researchers who consider educational research a scholarly activity has increased as a result of vocal advocates for SoTL. Goldsmid and Wilson attempted to bridge the divide between researchers and educators by addressing the similarities of and standards for both research and teaching, arguing that “collaborative inquiry is at the heart of both activities” (1980). Cross argued that change in education will come as a result of scholarly research on teaching when she stated: “What is needed if higher education is to move toward our goal of maximizing student learning is a new breed of college teacher that we shall call a Classroom Researcher” (1986). Since these definitions were published, an ever increasing number of faculty have worked to integrate classroom research into their personal development.

The boom in SoTL research has led to the development of a vast store of resources for its practitioners. National organizations dedicated to the advancement of scholarship have been developed (i.e., The Carnegie Foundation
for the Advancement of Teaching – CFAT and The International Society for the Advancement of Teaching and Learning - ISSOTL). There are numerous conferences focusing on dissemination of SoTL findings held locally, regionally, nationally and internationally each year. Extant literature on best practices in education are abundant, and professional organizations are showing interest in SoTL work by supporting new publications (McKinney, 2007).

A number of faculty handbooks from secondary institutions encourage their instructors to include SoTL work in their professional portfolios, and many campuses have developed centers to facilitate integration of SoTL activities into faculty development (Scholarship of Teaching and Learning, 2015, SOTL Program, 2015). This increased emphasis on creating a professoriate who is informed in the best practices of classroom management and instruction makes it an exciting time to be a Classroom Researcher, as published findings are being reviewed and implemented as never before.

The emergence of SoTL followed Boyer’s 1990 paper in which he defined the term scholarship. In this seminal work he stated the definition of “scholarship” in terms of the four ways in which it is demonstrated: discovery, teaching, application, and integration (1990). This definition not only helped to elevate SoTL work, it also helped to define the difference between practitioners of SoTL and DBER. SoTL work is done by those who perform scholarly work to
apply best practices to their classroom, and thus SoTL has limited broad applicability. DBER researchers create materials and assessments and disseminate results that are intended to apply not only to other classrooms in their disciplines, but to other STEM fields. This broad applicability is the key difference between the two disciplines, and is main criteria a faculty member would use to assign their work to either one.

As defined by the National Research Council’s (NRC) Report on Discipline-Based Education Research, the goals and DBER are to: (1) understand how people learn the concepts, practices and ways of thinking of science and engineering, (2) understand the nature and development of expertise in a discipline, (3) help identify and measure appropriate learning objectives and instructional approaches that advance students toward those objectives, (4) contribute to the knowledge base in a way that can guide the translation of DBER findings to classroom practice, and (5) identify approaches to make science and engineering education broad and inclusive. The report goes further to explain that DBER scholars conduct valuable studies on both basic and applied research. Such research combines expert knowledge of a science or engineering discipline, the challenges of learning and teaching in that discipline, and the science of teaching and learning in general (Singer, Nielsen, & Schweingruber, 2012).
CHEMISTRY EDUCATION RESEARCH (CER)

As stated by Taber, the development of any field is iterative, and as such the current state of Chemistry Education Research (CER) has been built upon the foundations of SoTL (2012). CER is, however, an arm of DBER and as such follows a stringent set of goals its practitioners must meet.

Chemistry Education Research (CER) has a long history dating back to the 1920’s when concerns surrounding undergraduate chemistry education were first voiced. At that time, the systematic study and subsequent dissemination of how students of chemistry learn and the best practices to reach them began to be published in the pedagogical journal of the field, *The Journal of Chemical Education*. Purdue University established the first departmental division devoted to chemical education in 1991 (Bodner, 2011). The first doctoral CER degrees were awarded in the 1990s at Purdue University, the University of Oklahoma, and the University of Northern Colorado. Tenure was given to the first CER faculty during the same time frame (Singer et al., 2012).

The American Chemical Society (ACS), the world’s largest scientific society, has recognized CER in its Statement on Scholarship since 2000. The ACS has an active and supportive Division of Chemical Education, established in 1994, that hosts its own Biennial Conference on Chemical Education (BCCE) in addition to the robust education related symposia offered at the semi-annual
National Conferences. Recently, the ACS has developed the American Association of Chemistry Teachers (AACT) to provide additional support and resources to chemical educators at all levels. Such vast resources make chemistry a robust field of DBER (Overview of CER, 2015).

A number of institutions of higher learning offer advanced degrees in CER. The Bretz CER Group at Miami Ohio, who maintains a webpage of resources for the CER community, lists 60 active CER faculty mentors in 26 Ph.D. granting departments and 7 departments that grant a Master’s level degree (Bretz, 2015).

CER degree programs generally follow a different model than traditional education programs. A student of CER completes the same departmental graduation requirements as students of any other division of chemistry (for instance, entrance exams, courses, qualifying and oral examinations, and a defense of the dissertation). Students of CER not only conduct research in both their primary discipline but are also required to complete some variety of bench-chemistry work. The latter component varies by institution and can range from developing new teaching resources for an upper-level laboratory to pure bench-chemistry (synthesis and characterization). In either case, the purpose of the bench requirement is to create a chemistry professoriate who is well versed in
both the literature on teaching and learning and is also familiar with specific chemistry content\(^1\) (A. Brandriet, 2013).

Chemical education research combines the theories, experimental designs, and tools of several disciplines, and as such is often misunderstood with the field of chemistry (D. M. Bunce & Cole, 2008). However, CER involves the application of the process of scientific inquiry just as any other scientific discipline does. This process includes “moving inductively from observations to a hypothesis and then moving deductively from the hypothesis to its logical implications”. In general, information obtained from the physical sciences through the process of scientific inquiry is accepted as published, as bench work is generally viewed as reliable and valid. Knowledge gained as a result of educational research, on the other hand, is often considered suspect because of the limitations of inquiry in the behavioral sciences. These limitations include the complexity of human subjects, difficulty in observation, difficulty in replication, interactions of the observer and the subjects, difficulties in control, and problems of measurement (Metz, 1994).

\(^1\) The bench-work for fulfillment of this requirement was performed previously at the graduate level at the University of Nebraska Lincoln. The graduate committee approved credit for work included in the publication (Schuetz, Erdmann, Day, Clark, & Belot, 2004) in 2011.
BRANCHES OF CHEMISTRY EDUCATION RESEARCH

To increase the validity of published research in chemical education, a task force was formed to develop guidelines for what should be considered CER. Their recommendations were based on Boyer’s definition of scholarship, and divided CER into four main lines: the scholarships of (1) teaching, (2) discovery, (3) integration, and (4) application.

Chemistry educators integrate the findings of CER into their teaching. They are aware of the needs of their audience, and with knowledge of the literature are able to tailor their lessons to meet these needs. Investigators of the Scholarship of Teaching use their own classrooms to implement the results of research carried out by colleagues. They also adopt and adapt reported practices, and subsequently report relevant findings of the adaptation back to the community. They create activities, demonstrations and texts that are applicable to multiple institutions and contribute to the education of thousands of students.

The Scholarship of Discovery utilizes carefully controlled experiments when possible, and seeks to make observations in the moment when limitations on the ability to manipulate human beings is a factor. Chemistry educators develop new teaching materials and evaluate their impact. This evaluation is accompanied by a carefully thought out experimental design. Such designs use data collection
methods that are both quantitative (i.e., coding of student work samples) and qualitative (i.e., observation of reaction to a situation).

Research that generates or refines learning theories is considered to be Scholarship of Integration. Much of CER informs theories in other disciplines, and vice versa. A best practice in the chemistry teaching laboratory could likely also be a best practice in a physics or biology teaching laboratory. These best practices are built on theories guided by cognitive science. Though these theories stem from other areas of research, CER contributes to their elaboration and refinement.

Lastly, course improvements, curricular reform and implementation of instructional innovations that are accompanied by careful collection of data are known to fall under the Scholarship of Application. In short, the scholarship of application is applied research. Emphasis in this category is placed on comprehension, visualization, the construction of ideas, and other processes required to fully understand chemistry. Scholars of this sub-discipline have the opportunity to benefit society by translating chemistry knowledge into terms that can be understood by the general public (D. Bunce, Gabel, Herron, & Jones, 1994).
THE DISSERTATION AS AN EXAMPLE OF CHEMISTRY EDUCATION

RESEARCH

The main work presented in the dissertation, the development, implementation, and assessment of the effectiveness of student-created technique videos, is a broad project that falls into multiple categories of CER work. The project was based on extant literature on the use of video as an instructional tool and the future of cellular phones in the classroom, and as such demonstrates the scholarship of teaching. Assessment of student learning followed an experimental design that sought to limit the impact of human subjects but also relied heavily on observation, as described by the scholarship of discovery. The materials created can be considered course improvements that were implemented alongside careful data collection and as such can be considered as scholarship of application. The smaller project described in chapter 4 describes the initial development of a laboratory activity that was later adapted and prepared for publication. This is an example of the scholarship of teaching.
CHAPTER II

FORMATIVE ASSESSMENT OF LABORATORY VIDEOS AS AN
ALTERNATE ASSESSMENT IN THE GENERAL CHEMISTRY
LABORATORY

INTRODUCTION

“… nor can verbal instruction teach that perfection of manipulation which is only to be gained by constant operation; but there is so much that can be taught, so much that can be suggested by such instruction....” –Michael Faraday (Faraday, 1827)

The Role of the Laboratory in Chemical Education

Laboratory technique has been central to chemistry instruction since Faraday’s 1827 publication Chemical Manipulation. In it Faraday described the physical requirements of the laboratory, including the manipulation of apparatus and the benefits of practice, and argued their crucial role in producing viable students of chemistry. The text was published to bridge the gap between theory and practice in the field of chemistry by elevating practice beyond that of a laborious activity for the technician. Faraday was a skilled experimenter and felt that the deficiency in technically astute chemists could be alleviated by providing sufficient hands-on instruction in the laboratory. Such a text had not been
previously published, and its introduction to the literature changed the landscape of chemical education. It helped to reinforce the laboratory as a teaching tool and emphasized the importance that proper technique plays in the sciences. Faraday emphasized that the central element in learning was experiential practice (DeMeo, 2001).

The laboratory experience has a long history that has included many curricular revisions since Faraday’s text. Most approaches to the general chemistry laboratory, even in its infancy, have worked to balance training students in proper technique and the development of critical thinking skills (Lloyd, 1992). Textbook authors Smith and Hall supported instructional approaches that reinforced technique through repeated manipulation of equipment (1902). Reports that credit experiential laboratory learning as a tool to increase retention for students who enroll in a laboratory and lecture course concurrently date back as early as 1924 (Bowers, 1924). Despite early publications that praised the hands-on nature of laboratory learning, increased enrollment at universities and decreased economic viability following World War I brought the role of the laboratory into question, and its importance to student learning began to be critically assessed (Barger, 1935; Lucasse, 1928; Noll, 1929; Payne, 1932a, 1932b, 1932c; H. R. Smith, 1926b). Though a number of studies showed that less expensive lecture demonstrations were equally as effective as individually performed experiments (Noll, 1929; Payne, 1932c), others strongly supported the inclusion of individually performed experiments in the curriculum. Smith found
that students who completed individual experiments scored higher on standardized exams than their counterparts (1926a). Schlesinger believed that individually performed experiments provided training in observation, developed self-confidence, and improved analytical reasoning abilities that could not be accomplished by lecture demonstration alone (1935). As the shift in instruction in the chemistry classroom moved from descriptive inorganic chemistry towards the study of chemical principles, individually performed experiments became the accepted practice (Lloyd, 1992). This approach ensured that all students were exposed to the required technique.

The teaching and assessment of technique has varied as much as the laboratory curriculum. Instructors have often dedicated a portion of a student’s grade to technique as measured by the student’s accuracy and precision (DeMeo, 2001), but safeguards to assure that students can correctly use the equipment necessary for data collection are not always in place. Early publications indicate that instructors held the view that reading detailed procedures while manipulating a laboratory tool would lead to becoming proficient with a technique (Scott, 1918; A. Smith & Hall, 1902; Willard, 1928). Even early texts provided visualizations to accompany the written procedures to increase recognition of the instruments being used (Francis, 1850). Dechsri, et al. found that students who use a manual that contains both written instruction and visual cues gained higher scores on measures of psychomotor skills than students whose manual contained no images (Dechsri, Jones, & Heikkinen, 1997). Still
images, though helpful in recognizing equipment, are still a poor substitute for witnessing the equipment in use.

Practice and repetition, or learning by doing, has long been the standard form of instruction regarding technique. Many laboratory courses and manuals require students to perform practice trials in order to become proficient in a technique prior to beginning data collection (Beasley & Heikkinen, 1983). A similar approach devotes entire laboratory periods early in the term for development of technical skills that will be used in subsequent activities (Bramstedt, Korfmacher, & Layloff, 1972; Fleming, 1995). These and other instances have shown that instruction alone is not enough to create students who retain manipulative skills. To master a technique, the instruction must be followed by practice.

The Use of Technology in the Chemistry Laboratory

Technology has been introduced to the teaching laboratory to assist instruction as advances have become available. In the 1960’s, tape players were placed near laboratory equipment to provide individualized direction to students and allow instructors additional time to answer questions (Lagowski, 1966). The advent of computers saw increased implementation of instructional technologies. Computer assisted pre-laboratory instructional programs help to ensure that students are prepared prior to walking into the laboratory (Kolodny & Bayly, 1983; Lagowski, 1989). Computers have assisted instruction during class
by reinforcing procedures or certain skills (Cavin, Cavin, & Lagowski, 1978; Moore, Smith, & Avner, 1980), and to allow rapid data collection and analysis (Amend, Furstenau, Howald, Ivey, & Tucker, 1990; Amend, Furstenau, & Tucker, 1990; Davis, Corey, & Macero, 1973).

Simulations have effectively substituted for physical activities when reactions have been too complex, hazardous or expensive to carry out individually (Jackman, Moellenbem, & Brabson, 1987). More recent technological advances have also worked their way into the classroom. Derting and Cox used a tablet PC to introduce pen-based technology to their organic course (2008). Online video tutorials have been introduced to the undergraduate analytical course to increase learning of difficult concepts. He, et al. used a pre-post experimental design to compare homework and exam scores between semesters when traditional lecture was utilized and those that followed the implementation of online tutorial videos. Exposure to the video tutorials led to significant learning gains on questions related to the content in the videos (He, Swenson, & Lents, 2012).

**Video Instruction in the Chemistry Laboratory**

The evolution of video instruction in the laboratory has paralleled that of technology. Short video clips were first recorded as early as the 1960s and delivered to students by videocassette or scheduled campus viewings (Barnard, Bertraut, & O’Connor, 1968; Barnard & O’Connor, 1968; Barnard, 1968). Closed-
circuit television was used in the 1960’s to broadcast demonstrations of experiments and procedures, pre-laboratory lectures, and special instructions to multiple sections of laboratories simultaneously at McMaster University (Humphreys & Tomlinson, 1969). Classroom overcrowding was alleviated at Michigan State University by having students complete activities involving both live, individually preformed experiments and recorded film-simulated experiments on alternating weeks (Brubaker, Schwendeman, & McQuarrie, 1964). Since that time, delivery of content via video has been used successfully in chemistry courses for training (Pantaleo, 1975) and demonstration (Fortman & Battino, 1990).

Video-based content has been developed for courses throughout the chemistry curriculum, including general (Amaral, Shank, Shibley, & Shibley, 2013; Revell, 2014), organic (Browne & Auclair, 1998), and upper division courses (Fitzgerald & Li, 2015; Rouda, 1973; K. R. Williams, 1989). Videos, alongside computer-assisted instruction and a detailed laboratory manual, were used at the University of Michigan in the 1980’s to decrease operating expenses associated with the laboratories (Rasmussen, Hough, & Kozma, 1980). Benedict and Pence implemented a series of student-created videos and accompanying handouts that could be accessed via a smart phone that could read a 2D barcode. Here upper level students served as the instructors, creating instructional videos depicting proper use of instrumentation. Students that had accessed the barcodes reported
that having a video that could be accessed in real time made it easier to visualize the task at hand (Benedict & Pence, 2012).

As the role of video has developed, the “flipped” classroom has become more commonplace. By flipping their classroom, the instructor provides content to students outside of class meetings so that time spent together can be used for practice of concepts and ideas. This model is particularly well suited to the laboratory environment, which is hands-on in nature. As early as the 80’s, instructors were able to develop and deliver high-quality pre-laboratory instruction electronically (March, Moore, & Jacobsen, 2000; Winberg & Berg, 2007). Several studies have shown that pre-laboratory videos improve laboratory techniques and retention of content information (Erdmann & March, 2014b; Jenkinson & Fraiman, 1999).

Despite the technological advances the laboratory has witnessed, Bauer warned against over implementation of “black boxes” (computers) at the risk of reducing the number of scientifically literate students of chemistry (1990). Care should be taken to ensure that technology is implemented in such a way that the student can interact with it. In this way the technology can better serve as a teaching instrument and not just a source of information.
Cellular Phones as Teaching Tools

The increase in popularity of social media outlets such as Facebook, YouTube, and Twitter, along with personal electronic devices such as tablets and smart phones, offer instructors an interesting opportunity to integrate technologies that students regularly interact with into their classrooms. The current generation of learners has technologies available to them that no other generation has had before, and they are not only willing, but expect to use them in their education. Key among these technologies is the personal cellular phone. An ever increasing number of personal phones are manufactured annually, and their prevalence is so commonplace that it is assumed most students own a phone.

Cellular phones were identified as one of six emerging technology for teaching and learning in the 2012 Horizon report, and one of only two technologies they believed had a year or less to adoption. This annual report, a collaboration of the New Media Consortium Horizon Project and the EDUCAUSE Learning Initiative, identifies and recognizes technologies likely to have a large impact over the following five years in education around the globe. The 2012 report claimed that mobile apps and tablet computing would see mainstream use in teaching, learning, and creative inquiry within a year. The reports’ findings state students expect that they will be able to learn on these devices whenever and wherever they may be. Smart phones, and their available mobile apps in particular, allow for creation and composition and for integration
of created course materials with social media outlets (Johnson, Adams, & Cummins, 2012). Smart phone use was also investigated by the Pew Research Center. Their April 2015 report states that 65% of all Americans own a smart phone, up from 35% in the spring of 2011. Among adults ages 18-29, 85% own a smart phone and 15% claim it is their sole means of accessing the internet (Pew Research Center, 2015). Mobile phones were proposed to have a greater impact on chemical education than the personal computer (A. J. Williams & Pence, 2011). The prevalence and wide ranging capabilities of these devices allows them to offer ample opportunities for application in the classroom.

Those few students without a smart phone generally have some type of cellular phone. Even the most low-tech of these devices is capable of capturing video. In the case of many smart phones, that video can be edited directly on the device. When direct editing is not possible, it is generally quite easy to offload footage from the phone onto a personal computer either by connecting the phone to the computer, accessing the memory on the phone itself, or through wireless data transfer. As mentioned earlier, video has seen growth in education has it has evolved. The use of video capable phones to film course-related assignments is one of the next steps in this evolution.
Addressing a Void in the Literature on Video Assessments

Though there is ample literature that shows video can be used effectively to enhance learning in a variety of chemistry laboratory related content-delivery situations, the chemical education literature has relatively few examples of student-produced videos at the general chemistry level. Multimedia laboratory reports have been reported, and findings from their use show that students are willing to complete assignments that lie outside the traditional means of student assessment such as quizzes, reports, and exams (Jenkinson & Fraiman, 1999). Students who created videos as part of their biochemistry curriculum were more engaged and played a more active part in their own learning. Digital video assignments were required in the biochemistry course as a means to produce reusable peer-researched, -designed, and -created learning resources. These videos were created in small groups, and students reported having a higher opinion of working in groups when there was a creative element included in the course requirements (Ryan, 2013). Lancaster challenged his students to move beyond merely giving presentations to creating a series of vignettes (short interactive highlights of screencasts). The vignettes were created by students for use by their peers as review for a final exam. Students used Camtasia to make short review presentations that were collected in a portfolio that could be reviewed as needed by the students. Lancaster attributed the high number of passing marks on the exam to the creation of the vignettes (2014). The positive impact of having students create videos that they themselves are in has been
reported. Blonder, *et al.*, showed that having student teachers record themselves instructing has been shown to increase their self-efficacy (Blonder et al., 2013). Multiple studies have shown that the impact of a video is increased when a student sees themselves performing a task and that retention of the details of the task is higher than when a video of someone else is shown (Hirschel, Yamamoto, & Lee, 2012). These reports all highlight the positive impact that student-created video can have on learning, but instances of their use in large-enrollment general chemistry courses was absent from the literature.

We sought to determine if including student-created video assignments as a course requirement in the general chemistry laboratory was feasible, and if so, if they had an impact on learning that made them beneficial to the student. Creation of the videos would follow instruction from a teaching assistant and would allow for practice and repetition. Creating a video would allow students to create a permanent record of themselves performing a technique. This record could not only be used by them for review, but could be used by others in the future for initial instruction. Thus, this project integrates the best practices of demonstration and practice for mastery of technique with an alternate form of assessment that is created on an emerging device.
AN INTRODUCTION TO STATISTICS USED IN THE BEHAVIORAL SCIENCES

Quantifying study results in the behavioral sciences is often complicated by human subjects. Gauging opinion is difficult, as the response data is not represented by real numbers but rather by a sliding scale that lacks distribution. Survey data, Likert-type scales in particular (defined below), pose problems in analysis because each individual completing the survey may interpret the meaning of the categories given, and therefore their spacing, differently. Coding student work samples is often more quantifiable, but still poses problems when the researcher makes an incorrect assumption about the scale of the data. It is crucial to report study findings in the correct way, and to do that requires an understanding of the different types of data, statistics, and statistical tests, along with the limitations of each.

Data is often presented in terms of both descriptive and inferential statistics. The former takes raw scores and summarizes them into a form that is more manageable. In interval and ratio scale data, which most data from traditional research falls under, the number scale and resulting data points are ordered and all intervals are of identical size and spacing (i.e., they are real numbers). The appropriate descriptive statistics in these cases would be the average and standard deviation. This approach is also commonly used to report
Likert-type survey results, though it is in error. As mentioned, each individual that completes the survey may read the meaning of the category differently. This means that though the categories can be ordered and numerical values can be assigned to them, the categories are not necessarily equally spaced from each other. Individual responses are merely assigned to a group and therefore are only represented by the number, the number itself has no meaning in terms of the response. It is therefore inappropriate to calculate and average and standard deviation for ordinal data, and counts (and resulting percentages) should be used instead. The best methods to report descriptive statistics visually would be through tables and charts. The median and mode can be reported for a numerical description of an ordinal data set.

Inferential statistics make generalization about the populations from which study samples were selected. These generalizations do not come without limitation. Population samples, even those selected randomly, provide only limited information about the population they arise from. They are generally representative, but they are not expected to give a perfectly accurate picture of the entire population. The discrepancy between the sample and the population is known as sampling error. This sampling error can be minimized, often to the point where it can be removed from calculations, by increasing the number of data points. Surveying the majority of a population allows us to make better
generalizations regarding the remaining individuals in that population.

Similarly, if multiple populations are being sampled, working to create large, even participant pools will aid in comparison between populations.

Interval and ratio data, whose population distribution can be studied because of the equal spacing of the intervals between data points, fall into the broad category of parametric statistics. The z-score, t-test and ANOVA analysis commonly reported throughout the literature are examples of parametric statistics. Since these tests are calculated using averages and standard deviation, they are inappropriate for use in reporting ordinal data. These data are tabulated using frequencies, and fall under the umbrella of non-parametric statistics. The chi-square statistic ($\chi^2$), the most commonly reported non-parametric statistic, uses sample data to evaluate hypotheses and the proportions or relationships that exist within populations. A limitation of most non-parametric statistical tests is that they do not state hypotheses in terms of a specific parameter, and they make few if any assumptions about the population distribution (Gravetter & Wallnau, 2009). However, if the data set used to calculate these statistics is sufficiently large, inferences from the data set to the general population can be made and considered valid (Sullivan & Artino, 2013).

The Likert and Likert-type scales are commonly used in survey research to measure respondents’ attitudes by asking the extent to which their attitude or
opinion falls within one of the stated categories. The term Likert scale refers to the original 5-point scale that included the categories Strongly Approve, Approve, Undecided, Disapprove, and Strongly Disapprove published by Likert (1932). Any variation on this theme, such as changing the number of categories or the category descriptions, is better referred to as a Likert-type scale (Clason & Dormody, 1994). Another key difference in reporting these two items is that Likert aggregated all items in his questionnaire and reported the results as a whole. When survey items are reported separately, it is best to state that the analysis has been completed on a Likert-type scale (Boone & Boone, 2012).

Since Likert-scale data only imply a “greater-than” relationship and in no way quantitate how much greater than, descriptive statistics used to report findings include the median and mode for describing central tendency and frequencies for variability. Inferential reporting appropriate for Likert-type data is mostly commonly done by reporting the chi-square value for the data set (Boone & Boone, 2012), though it has been reported that in the case of extremely large data sets, the use of parametric statistical tests is permissible (Sullivan & Artino, 2013).

Quantification of learning-gains is often done by analyzing student work samples after an intervention. These samples are generally coded by one or more researchers to fall into one or more categories (correct/incorrect,
acceptable/unacceptable, etc.). This coding process, even when done with the strictest of coding criteria, assigns the work sample to a category similar to those of Likert-type data. The chi-square statistic is, therefore, also appropriate in this case, and is the method chosen for this dissertation.

The chi-square statistic compares observed data with data one would expect to obtain as it relates to a specific hypothesis. The statistic compares the counts of occurrences of each variable within each category in a contingency table in order to determine if there is a significant difference between the categories (see Figure 2.1 below). The chi-square statistic is not reliable if the expected count in any cell is less than 5 and should not be used in such cases (Gravetter & Wallnau, 2009). A variation of the chi-square statistic, McNemar’s chi-square, is used in pre-/post-test design to compare data points within a group and determine whether a significant change has occurred between the number of students whose scores have increased, decreased or remained unchanged (Elliot & Woodward, 2007). A cautionary note on interpreting chi-square values: it is valid to use them on large sample sizes to say that a change has occurred, but they should not be taken so far as to imply the scale of that change. Additionally, one must look back to the data set to determine the direction of the change, as the value of $\chi^2$ does not imply directionality.
Figure 2.1. An example of a 2x2 contingency table used in calculating the chi-square statistic.

<table>
<thead>
<tr>
<th></th>
<th>Variable 1</th>
<th>Variable 2</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1</td>
<td>a</td>
<td>b</td>
<td>a + b</td>
</tr>
<tr>
<td>Category 2</td>
<td>c</td>
<td>d</td>
<td>c + d</td>
</tr>
<tr>
<td>TOTALS</td>
<td>a + c</td>
<td>b + d</td>
<td>a + b + c + d = N</td>
</tr>
</tbody>
</table>

Examples of reporting the chi-square statistic in the literature are too numerous to list. A few brief examples that are similar to the analyses performed later in this dissertation are presented here. Williams, et al., recently published work in which drawings submitted by students were given a coded score prior to data analysis. Analysis and reporting of the results of the coding were done using the chi-square value (L. C. Williams, Underwood, Klymkowsky, & Cooper, 2015). Another study reported using chi-square to investigate the distribution of consistent and inconsistent student responses to the Redox Concept Inventory, which measures symbolic and particulate understanding of redox reactions (A. R. Brandriet & Bretz, 2014). Gordus conducted a study in which freshman quantitative analysis students were required to read the volume in two burets to the hundredths place. The individual values and the difference between the two values were recorded for each student. The statistically significant difference between these data sets was reported using the chi-square value (1987). McNemar’s chi-square was used to determine significance in a
longitudinal study of the effectiveness of a nanotechnology laboratory (Sadik, Noah, Okello, & Sun, 2014).

OVERVIEW OF THE DISSERTATION RESEARCH

Student-created technique videos were introduced to the general chemistry laboratory in the Summer 2011 term. Students created two videos, one detailing the use of a Mohr pipet and a second, separate video that detailed the use of an analytical balance. Students recorded their videos on devices they owned prior to enrollment (cell phones or digital cameras) and edited footage outside of class using free software (iMovie, Windows Movie Maker). The small enrollment of the summer section allowed for retooling of the rubrics and tutorials related to the assignment that were provided to both students and teaching assistants. Formative assessment showed that students were able to record and edit video and had positive feelings towards the video assignment. Teaching assistants reported being able to successfully asynchronously monitor student technique. This initial formative assessment, which can best be classified as SoTL work, was performed in order to allow for future implementation of an experimental design that would be stringent enough to elevate the work from SoTL to DBER. Thus, this piece is important in understanding the background for the project.
RESEARCH QUESTIONS

Research Question 1: Will groups of 3-4 general chemistry students be able to create and edit videos?

Research Question 2: Can student-created technique videos be used to asynchronously monitor student use of standard laboratory equipment?

Research Question 3: Are the rubrics prepared useful for students in regards to creating a useful educational product?

METHODOLOGY

Producing the Student-Created Technique Videos

Instructor to student ratios and variations in teaching assistant confidence and ability to offer effective instruction make it difficult to ensure that all students enrolled in CH116 are proficient with laboratory equipment during the regularly scheduled class time. Student-created technique videos were conceived in an effort to help to alleviate this problem, as they could capture student technique and allow for asynchronous monitoring by teaching assistants. This student assessment would not be effective if the overwhelming majority of the students were not able to meet the equipment and editing requirements of the assignment, however. To determine whether students could create videos within their laboratory groups of 3-4 students, the video assignments were implemented in the summer 2011 term. The small enrollment of the summer term kept initial
data collection to an easily manageable level. The decreased number of students made use of open ended response items on the end of term survey feasible. A decreased number of students also meant that, should the video assignment have a negative impact on student experience and/or learning, a minimum number of students would be adversely affected. The videos were added to the course as additional assignments for the summer term; the traditional weekly pre-laboratory quizzes and post-activity reports that were assigned in previous semesters were still the main source of assessment for the term.

The initial implementation required creation of two videos; one that required students demonstrate proper use of a Mohr pipet and a second that required demonstration of the proper use of an analytical balance. Both videos were recorded in groups of 3-4 students on existing technologies (cellular phones, digital cameras, tablets, etc.). To help students see the importance of mastering the chosen techniques, these videos were recorded the second week of the term, and accompanied the completion of the Density and Graphing and Sugar Solutions activities. The Density and Graphing activity required that students determine the density of water using an analytical balance and multiple pieces of glassware, depict their data graphically, and interpret these graphs to determine which piece of glassware offered the most accurate measurements. The Sugar Solutions activity built upon this idea by requiring students to create a series of dilutions from a stock sugar solution using the most accurate glassware from the Density activity. Both of these exercises had been part of the curriculum
for many years prior to the video assignments. Thus, prior to video production students had received demonstrations on the equipment from their teaching assistants and had ample opportunity for practice with the apparatus prior to filming.

Students were instructed to review the tutorials available online through the course management website (BlackBoard Learn). These materials included sample videos that illustrated use of the equipment, a video-shooting guide which offered helpful tips to create the best video possible (Appendix A.1), and a detailed grading rubric that students and teaching assistants could both use to assess the video (Appendix A.2). Students were also highly encouraged to come to lab with a script prepared to facilitate speedy filming and reduce unusable footage they would need to discard later.

The provided rubric detailed the minimum requirements that students must meet. These included the requirement that each student in the group must be seen completing the required task so that each student’s technique could be assessed separately. The rubric contained detailed information that outlined each individual point that was to be included from each group. An explanation of the steps taken to use the equipment in question was to accompany at least one of the demonstrations (though it was specifically mentioned that it did not need to accompany all of them). Students were instructed that they could either audibly recite the steps or they could include subtitles from the editing software of their
choice. In addition to the technical focus, students were asked to explain some theoretical aspect associated with the use of the equipment.

For the use of the pipet, student groups were asked to explain in detail why a meniscus occurs in cylindrical glassware and how to read a meniscus. For the use of the balance, student groups were asked to explain where the error in the readout of the balance lies and what steps you can take to minimize the error present in a mass measurement. In contrast to the technical portion of the video, the theoretical portion needed to occur only once, and any of the students could provide the explanation. Though students were not expected to submit movie-quality video, the focus of the assignment was on assessing student technique which required some clarity in filming. To encourage students to submit a product that easily facilitated monitoring technique, points were designated for video quality. The points were minimal to emphasize that the assignment measured the content of the video and not the production of the video itself. Bonus points were offered to those students who obviously put forth a great deal of effort while editing or took the time to produce an entertaining (including humorous) video. Bonus points were only assigned if the video met 85% of the requirements on the rubric.

The videos were designed to be edited in groups, but as footage was generally on a single individual’s device and editing was performed outside of class, this was difficult to monitor. The majority of students who owned their own computer had access to either iMovie (Macintosh systems) or Windows
Movie Maker (Windows systems) through their operating software. Those students who did not have a personal computer were instructed to contact the staff of the digital media studies department, who could grant them access to more professional editing tools. It was made clear that this was not a necessary step in completing the assignment as the focus was on the monitoring of technique. Students were required to select only one student from their group to submit their edited video via BlackBoardLearn. A number of students submitted an actual video file on their first submission, many of which were incompatible with the computer the teaching assistant was grading the videos on. Because of this, all groups were directed to upload their video to YouTube and provide a link to the upload via BlackBoard Learn. This eliminated incompatibility issues, and those students who did not wish to have their video made public in the YouTube search engine could simply utilize YouTube’s “unlisted” option. This option allowed only individuals who had the direct link to access the video. The majority of the students chose not to use this option and made their videos public, however. Figure 2.2 shows a variety of screen shots from the videos.
Figure 2.2. Screen-shots from the first-term of student-created videos. Clockwise from top left: a) A student demonstrates bringing the meniscus to eye level; b) A student obtains the mass of a sample on an analytical balance; c) A group illustrates data that should be collected when using a Mohr pipet; d) A student records data for mass.

Accessing and Grading the Technique Videos

Teaching assistants accessed links to the student videos from the instructor interface in BlackBoard Learn. The rubric used for this term did not place a time limit on the videos and a number of them were quite lengthy. Most students groups created videos that were near 5 minutes each, so length of grading was equivalent or less than that for a written assignment. Teaching
assistants used the same rubric that students were given access to when grading the videos. Groups that earned less than 80% of the points available on the grading rubric were required to produce a second video that corrected any and all points missed on the rubric. These groups were given 1 week to reshoot, edit, and submit a second attempt. Those students who earned at least 80% of the points on their first attempt were offered the choice of creating a second video or keeping their score. Most student groups chose to reshoot and earn the additional points.

**Formative Assessment of Student Opinion of the Technique Videos**

A survey was administered to all students enrolled in CH116 at the end of the Summer 2011 term prior to administration of the final exam. The survey included 4 open ended items, and as such was meant only to inform the creation of a Likert-type survey for future semesters. Questions presented on the survey and select representative student responses are presented in Appendix A.3. The common themes that arose from the Summer 2011 survey gave rise to a Likert-type survey given to CH116 students in Fall 2011 and to both CH116 and CH118 students in Spring 2012. This survey contained demographic items, 5 Likert items, and 3 free response items. Students were provided a printed copy of the informed consent form (“Erdmann M. A. and March J. L., (2011), Institutional Review Board for Human Use Protocol Number E141008003, UAB IRB Office,” 2011) and were informed that participation in the form of completing the survey
would have no bearing on their final grade, positive or negative. IRB Approval is presented as Appendix A.4. Of the 53 students enrolled, 39 (74%) completed the survey. A summary of student responses to the Likert items is present in Table 2.1 below (additional survey items and aggregated responses are presented in Appendix A.5). In general, student response to the project was positive, with the hands-on creative nature of the assessment being the high point of the assignment, based on students’ free responses.

**Table 2.1. Select Student Response Items from the Fall 2011 and Spring 2012 End-of-Term Surveys**

Responses to the Likert-scale items presented as counts and percentages (i.e., 54 (44.6)).

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>No Opinion</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I found it easy to record the video on my cell phone.</td>
<td>12 (30.8)</td>
<td>9 (23.1)</td>
<td>11 (28.2)</td>
<td>2 (5.1)</td>
<td>5 (12.8)</td>
</tr>
<tr>
<td>I found it easy to edit the video.</td>
<td>2 (5.1)</td>
<td>7 (17.9)</td>
<td>11 (28.2)</td>
<td>12 (30.8)</td>
<td>6 (15.4)</td>
</tr>
<tr>
<td>I liked the video reports better than the written reports.</td>
<td>6 (15.4)</td>
<td>7 (17.9)</td>
<td>6 (15.4)</td>
<td>9 (23.1)</td>
<td>11 (28.2)</td>
</tr>
<tr>
<td>It was easy to turn in my assignments in BlackBoard.</td>
<td>10 (25.6)</td>
<td>8 (20.5)</td>
<td>8 (20.5)</td>
<td>8 (20.5)</td>
<td>5 (12.8)</td>
</tr>
<tr>
<td>I feel that I will review my videos to refresh my lab technique in later courses.</td>
<td>1 (2.6)</td>
<td>8 (20.5)</td>
<td>7 (17.9)</td>
<td>10 (25.6)</td>
<td>13 (33.3)</td>
</tr>
</tbody>
</table>

To determine whether the video project had an impact on student learning, similar short essay questions were placed on the written final in both the Spring 2011 (pre-implementation) and Summer 2011 (post-implementation) semesters. Two items related to the techniques recorded in the video were monitored; the first involved reporting the correct number of significant figures
for a volume of liquid in a cylinder (i.e., reading a meniscus) and the second involved the preparation of a series of dilutions (i.e., using a balance and a Mohr pipet). Table 2.2 below details the items and the coding criteria that were used to assess student performance. Figure 2.3 shows the percentage of students who fell into coding categories for both the significant figure and solution preparation items. Responses to the significant figure items from the Spring 2011 final, Summer 2011 quiz (administered prior to the Density activity) and Summer 2011 final were given a coded score of 1, 2 or 3. Coding criteria are presented in Table 2.2 below. Students were assigned a code of 0, 1, 2, 3, or 4 for their response to the solution preparation item on both the Spring 2011 final and the Summer 2011 final. Coding criteria are again presented in Table 2.2.
Table 2.2. Test Items and Coding criteria.
Test items and coding criteria for both items reviewed as formative assessment of the impact of student created technique videos.

**Item 1 (Significant Figures):** What value should be reported for the volume shown in the cylinder? Your answer must be to the correct number of significant figures for any credit.

<table>
<thead>
<tr>
<th>Coding of 1</th>
<th>Coding of 2</th>
<th>Coding of 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorrect number of significant figures</td>
<td>Correct number of significant figures but unreasonable second digit</td>
<td>Correct number of significant figures and reasonable second digit</td>
</tr>
</tbody>
</table>

**Item 2 (Solution Preparation):** Describe, in detail, the steps needed to produce a series of solutions from solid CuSO₄*5H₂O for use in plotting a calibration curve. Be sure to include reasons for choosing any specific glassware, as well as any special comments that need to be made about the use of said glassware. Also include any tips for data collection and graphing.

<table>
<thead>
<tr>
<th>Coding of 0</th>
<th>Coding of 1</th>
<th>Coding of 2</th>
<th>Coding of 3</th>
<th>Coding of 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>The question was not answered</td>
<td>None of the criteria above were CLEARLY met or implied</td>
<td>1-2 criteria below were CLEARLY met and/or others were implied</td>
<td>3-4 criteria below were CLEARLY met and/or others were implied</td>
<td>5-6 criteria below were CLEARLY met</td>
</tr>
</tbody>
</table>

**Necessary Criteria:**
A  Student mentions obtaining the mass of the compound  
B  Student mentions volumetric glassware, and at least briefly mentions how to use the glassware  
C  Student mentions that a stock solution must be made  
D  Student mentions that dilutions should be made from the stock solution  
E  Student mentions graphing Abs vs. conc  
F  Student includes equations to be used \( M_1V_1 = M_2V_2, A = Elc \)
Figure 2.3. Comparison of student performance on coded items pre- and post-implementation of the video assignment. a) Graph of coded grades received by students on the Spring 2011 Final, Summer 2011 Pre-lab Quiz and the Summer 2011 Final. See Table 2 for test item and coding information. B) Graph of coded grades received by students on Spring 2011 and Summer 2011 Finals. See Table 2 for test item and coding information.
The collection of student response data was done primarily to determine if the videos had a negative effect on student performance. A significant increase in student performance was not expected at this time as the instruction regarding the videos had yet to be maximized. Analysis of student response data confirmed this expectation. The number of incorrect (codes 1 and 2) and correct (code 3) remained relatively unchanged between the Spring 2011 to the Summer 2011 final exams. Chi-square calculations returned a value of $\chi^2 = 1.01$ ($p = 0.315$), which is not significant at the 95% confidence interval. Similarly, the solution preparation exam item saw a non significant change in the number of responses considered unacceptable (codes 0, 1, 2) and acceptable (codes 3 and 4) ($\chi^2 = 0.355$, $p = 0.551$). These student achievement results and the generally positive response to the video assignment led to videos being a permanent fixture of the general chemistry sequence.

**INITIAL CONCLUSIONS FROM PHASE I**

The results of the formative evaluation of the video project were quite positive. This portion of the study was designed to determine feasibility, and the research questions developed for this phase reflected that design. All of the research questions, as well as some additional points that came up during this initial phase were all determined to be not only feasible, but in some cases easier than the existing assessment methods currently in place.
We first sought to determine if groups of 3-4 general chemistry students would be able to create and edit videos on devices they already owned during regularly scheduled laboratory time. The answer was a resounding yes. During the three semesters, only a handful of student groups were without an individual that owned an acceptable device. This was taken care of by simply asking for a volunteer with a device to change groups for the week. In the end, no student groups were unable to create videos due to a lack of equipment. Students were also able to offload their footage, edit it, and upload a finished product to YouTube successfully after sufficient practice.

We also wanted to know if the student-created technique videos could be used to asynchronously monitor student use of standard laboratory equipment. Teaching assistants, the author included, were able to access the videos quickly and easily via the learning management website. In most cases, the footage provided by students groups in the first drafts of their videos were sufficient to allow monitoring of technique and even offered clear enough detail that it was possible to read volumes in glassware and data collected in notebooks. Feedback provided from teaching assistants during staff meetings indicated that the videos were useful for showing proper technique, and a number of teaching assistants voiced the opinion that their students were more equipped to use the equipment in subsequent weeks than they had been in previous semesters. Teaching assistants also volunteered that the videos were easy to grade, and generally took
less time than the written reports that were also assigned to students during these terms.

Lastly, we wanted to determine whether students and teaching assistants felt the rubrics that were developed for the project were useful in regards to explaining assignment requirements. Teaching assistants provided informal feedback that the goals set forth by the authors were clear to them as a result of the rubric. Students also reported that they felt they were made aware of the requirements and knew what the teaching assistant would be looking for in terms of grading because the same rubric was given to both students and teaching assistants.

This initial work, which was formative and not meant to inform conclusions of the actual research project, is an example of the planning that must go into a carefully designed educational-based research experiment. More than a year was spent developing, implementing, and revising teaching tools prior to data collection. This also clearly illustrates how SoTL and DBER work are closely related. Phase I, which was largely qualitative in nature, lacked the rigor required to be considered DBER work. However, if the study had stopped at Phase I, a novel assessment (that later would prove to be beneficial in student learning) was developed and offered to students. The study did go on to investigate learning gains, and did so in such a way that built upon the formative SoTL and elevated it to DBER.
CHAPTER III

VIDEO REPORTS AS A NOVEL ALTERNATE ASSESSMENT IN THE UNDERGRADUATE CHEMISTRY LABORATORY

by

MITZY A. ERDMANN AND JOE L. MARCH

Chemistry Education Research and Practice, 2014, 15, 650-657

Copyright 2014 by M. A. Erdmann and J.L. March

Reproduced from Chemistry Education Research and Practice with permission from The Royal Society of Chemistry. Format adapted for dissertation
FORWARD

The work presented in this chapter was performed in order to quantify the impact of student-created technique videos on the retention of students in the general chemistry laboratory. This paper, published in Chemical Education Research and Practice in 2014, details the experimental design, implementation of the assessment, and data collection that followed the formative work presented in Chapter 2. Supplemental Information provided to the journal for electronic publication is presented in Appendix B.

VIDEO REPORTS AS A NOVEL ALTERNATE ASSESSMENT IN THE UNDERGRADUATE CHEMISTRY LABORATORY

ABSTRACT

The increased use of video capable cellular phones to document everyday life presents educators with an exciting opportunity to extend this capability into the introductory laboratory. The study assessed whether students enrolled in a southeastern U.S. university’s first-year laboratory course retained technical information at a higher rate after creating a technique video. These videos were created on hand-held video
capable devices that students owned prior to enrolling in the course, eliminating additional cost to students. Pre-/post-test analysis (N=509) was performed to determine short- and long-term learning gains regarding reporting the volume of graduated glassware to the proper number of significant figures. Though both groups used various graduated glassware throughout the term, chi-square analysis showed that students who created a video detailing use of a Mohr pipet reported the volume of graduated glassware correctly on the final exam and laboratory practical at a significantly higher rate than those students who received only verbal instruction on the technique.

**INTRODUCTION**

Laboratory instruction has been considered an essential component of chemistry instruction since 1927 (DeMeo, 2001). The goals for general chemistry laboratory courses are generally a balance between training students in proper laboratory techniques and the development of research (critical thinking) skills (Lloyd, 1992). Even courses that are focused on critical thinking skills require students to take measurements in order to collect data that will allow them to draw accurate conclusions. While proper technique is implied and often demonstrated in these approaches,
there is opportunity for error to be introduced the first time a student performs a technique.

The explosion of social media in the past 5 years including Facebook, YouTube, and Twitter, along with the development of personal electronic devices, has resulted in a generation that has new and different technology available for use in their own learning than previous generations. Personal phones are widely popular and a large number of devices are manufactured and purchased annually (Global Mobile Statistics, 2013). Williams and Pence propose that the use of cellular phones or portable devices will impact chemical education (and society) in greater ways than the introduction of the personal computer (Williams & Pence, 2011). Additionally, the Horizon Report, an annual report that summarizes research and discussion on current issues in technology and education from publications and the internet, recognized cellular phones as an emerging technology for teaching and learning because of these wide ranging capabilities including video capture and data transfer. (Johnson et al., 2011).

A survey of currently available cellular phones shows that even the most low-tech of these devices is capable of capturing video. This video can be transferred as a data file by either docking the phone with a
computer, accessing an internal memory card, or through wireless data transfer. For those students who do not own an adequate phone or have difficulty transferring data from its storage device, inexpensive point and shoot cameras are an easy and readily available option. Our institution offers students video equipment on short-term loan, though no student in the study took advantage of this opportunity.

Technology has long been a part of the chemistry laboratory curriculum (March et al., 2000; Winberg & Berg, 2007). Specifically, video technology has been used for everything from training (Pantaleo, 1975) and demonstrations (Fortman & Battino, 1990) to self-reflection (Veal et al., 2009). Videos have been used extensively for in-laboratory instruction for a variety of chemistry courses, including upper level courses in physical (Rouda, 1973) and analytical chemistry (Williams, 1989). Searches through YouTube’s internal search engine for standard laboratory techniques result in a number of useful tutorial videos (MIT, 2013; ChemLab, 2013). These videos are largely instructor/institution produced, with little to no student involvement. Instructor-produced pre-laboratory videos are a valuable asset in the classroom and have been shown to improve laboratory techniques and retention of information (DeMeo, 2001).
Despite this literature demonstrating the effectiveness of instructor-generated videos as a teaching and learning tool, the chemical education literature provides only a few descriptions of student-generated videos. Initial studies involving multimedia laboratory reports indicate that students are willing to report their results via less conventional means (Jenkinson & Fraiman, 1999). Student-authored videos on biochemistry topics were used in a second year undergraduate course to engage students in their own learning (Ryan, 2013). This study found that the students were more engaged in their own learning, perceived deeper learning, and enjoyed working in groups. Lancaster describes the effectiveness of student authored vignettes where students use Camtasia Studio to prepare short review presentations on topics required on a final examination (Lancaster, 2014). Passing marks suggest a positive relationship between the introduction of the vignettes and the passing rate. A conference paper describes how student-generated videos allow the instructor to identify student’s knowledge gaps and misconceptions (Niemczik et al, 2013). An additional paper shows that having teachers (as students in a professional development program) prepare videos improves their self-efficacy (Blonder et al, 2013). These results are consistent with observations in disciplines outside of chemistry (Hirschel et al., 2012;
McCullagh, 2012) where the impact of the video is increased when the student reviews themselves performing the task. Thus, student-created videos have been shown to have positive effects on student learning, but none of these studies have focused on laboratory techniques or instruction.

**CONTEXT AND RATIONALE FOR THIS STUDY**

Students’ ability to correctly report significant figures when reading a meniscus has traditionally been poor at the authors’ institution. Analysis of laboratory final exams collected over a number of semesters indicate that students have difficulty understanding the need to estimate between the graduations (only 30% of students report the volume using the proper significant figures on final examinations). The frequent use of laboratory glassware that requires such a skill offered an opportunity to relate a laboratory technique with the creation of technique videos. Moreover, these videos could be created alongside laboratory activities that were already a part of the curriculum. The introductory exercise in our laboratory sequence requires students to develop an experimental procedure to determine the density of an unknown liquid (guidelines are provided and the instructor demonstrates the use of the equipment, but a detailed step-by-step procedure is not presented to students). The expected
procedure requires the transfer of the liquid using glassware that has
graduated volumetric marks and a mass measurement using an electronic
balance. The glassware provided includes a 10-mL Mohr pipet, a 100-mL
graduated cylinder, and a beaker. Class data and discussion of standard
deviation and error analysis is expected to lead students to select the pipet
when transferring small volumes of liquid. Because of this, the proper use
of the Mohr pipet was chosen as the first video topic.

THE RESEARCH QUESTION

The work presented in this paper seeks to determine whether the
data support the hypothesis that students who create a video detailing the
proper use of a Mohr pipet as part of a laboratory exercise report a volume
accurately and to the correct number of significant figures more frequently
than students who complete the same laboratory exercise without
preparing the pipet video (having prepared a video on using a balance
instead).

METHODS

To answer the research question, we integrated the creation of
videos into the existing laboratory curriculum and used a pre-/post-test
research design to analyze how students reported the significant figures
associated with reading a volume. Assessment items were included on written quizzes or exams and direct observation made during a laboratory practical. All students enrolled in the course participated in the study. Informed consent was explained to all participants, though signed forms were not collected in an effort to maintain anonymity. Students were assigned to either the balance video (control) group or pipet video (experimental) group based on lab section. Test items and observation rubrics were collected and coded and statistical analysis was performed.

**Formative Surveys**

A formative survey was developed to identify possible barriers to implementing a video requirement in the laboratory. All students enrolled in the introductory course during the summer 2011, fall 2011 and spring 2012 semesters were asked to complete a formative survey related to the availability of video cameras and their perceived self-efficacy with video capture, editing, and transferring (N=799). Students completing the formative survey are not included in the current study because we did not wish to place a graded requirement in the syllabus that could not be completed by a significant number of students. These surveys were collected after informed consent was given. Students were also asked to
indicate their preference for video assignments over more traditional assignments (written reports, exams, etc.). The results of these surveys indicated that the students were willing and able to prepare videos as part of the course requirements. Survey items and results can be found in the supplementary information. (see Appendix I)

Subjects

Data were collected in the fall 2012 semester at a public university in the southeastern United States. All students in the study were enrolled in the first part of a two-term introductory chemistry laboratory sequence. The majority of students (95%) enrolled were STEM or pre-health majors. The course is a stand-alone laboratory course requiring students to master both conceptual and technical items. Students are not required to be co-registered in a lecture course, but most (98%) are co-registered for or have completed the corresponding first semester lecture. Students were instructed to prepare for the laboratory activities by reviewing a laboratory manual custom-published by the authors (March, 2012) and by reviewing texts and online resources associated with a list of suggested topics. The laboratory met for a three-hour block once-a-week twelve weeks of a fifteen-week semester†. In the fall of 2012, 16 sections were offered with an
initial enrollment of 619 students (5.5% of the university student body). Each section has 39:2 student to instructor ratio. All sections were led by at least one graduate teaching assistant, and occasionally upper-level undergraduate students who had performed exceptionally well in the laboratory were assigned to assist as the second instructor. Only those students completing all components of the study (pre-test, post-test, written final exam, and laboratory practical exam) were included in the final analysis. Of the 619 students initially enrolled, 509 were present for all four of these testing periods.

Both the control and experimental groups created a video during the same week of the study during their scheduled laboratory period, but the technique chosen to be described differed between the groups. The videos were not stand-alone assignments, and both of the video topics chosen were necessary to complete the laboratory assignment for the week. Despite the creation of the video, students in both groups were expected to use the equipment the same number of times throughout the semester. The 16 sections offered in fall 2012 were divided into two groups; 9 sections were in the control group (N=276) which created an analytical balance video and 7 sections were in the treatment group (N=233) which created a Mohr pipet video. Group assignments were made on the basis of the
day/time that the laboratory section met, so students were not able to choose the content of the video they recorded. Assigning treatment/control on the basis of the day/time of the week resulted in some teaching assistants leading both groups.

**Video Production and Submission**

Detailed grading rubrics, video recording, and editing tutorials were provided to students via the course management website at the start of the term (see Appendices II and III). Students were instructed to review these materials as their pre-laboratory assignment in the week prior to video production. Student groups created videos in parallel to a standard laboratory exercise, and the creation of the video was presented to students as a complementary activity to the standard laboratory assignment. The laboratory exercise required students to determine the density of an aqueous solution using an analytical balance and volumetric glassware; including a Mohr pipet. The assignment offered an equipment list to students but did not give them explicit instruction on determining the density. Videos were recorded in groups of 3-4 students. Though formation of laboratory groups is at the discretion of the TAs, the majority of students are allowed to choose their laboratory partners. Each student had to
perform the technique and it had to be obvious that each student was present in the video (i.e., simply showing the students’ hand was not sufficient). Make-up periods were provided in the event that students later realized they needed additional footage. Editing requirements were minimal, but time limits were placed on the video both to avoid lengthy segments where students are simply standing around and to limit the amount of time teaching assistants spent grading videos. Students were instructed to perform any edits outside of class time, and they had two weeks to edit the first version of their video. (Figure 1)

![Figure 3.1. Project timeline. The 15-week fall 2012 semester indicating key events relative to the project.](image)

Students published their videos to YouTube. Students that did not wish to make their video public were instructed to choose YouTube’s ‘unlisted’ option, which allows the video to be published but only those individuals with a link directly to the videos are able to view it. We did accommodate a student that was concerned with privacy issues by viewing
the video from a personal laptop during office hours. YouTube was selected as a submission platform because it converts a large number of file types to a player that our teaching assistants were familiar with and offers help with file types and uploading. Thus, teaching assistants did not have to learn how to use multiple video players. Videos were graded by one of the section’s teaching assistants the week after submission. Feedback was provided to the students during the next laboratory meeting via a scored rubric. Students submitting a video with gross technical errors received a rubric with additional written comments from their TA and were encouraged to edit their video, reshooting if necessary, and to submit it for re-grading.

Test Items

A pre-test was administered as a single item (Box 1) on a five-question pre-laboratory quiz during week 2, the week that the pipet was used for the first time (Figure 1). Students were provided information in the laboratory manual related to the meniscus, graduations, and estimation, but the quiz was administered prior to the pre-laboratory lecture or demonstration. Students were given 10 minutes to complete the quiz.
Box 1. Pre-test item and coding criteria.

Two post-tests were administered to measure short- and long-term learning gains. The short-term post-test was given in week 4 (two weeks after treatment). The post-test item was included as a single item on a multi-item pre-laboratory activity quiz (Box 2, Post-test Item). Again, students were given 10 minutes to complete the entire quiz. Longer-term gains were measured as a single item on the written final exam (Box 2, Final Examination Item) and direct observation as part of a laboratory practical exam in week 15 (thirteen weeks after treatment). Students were instructed to review both the laboratory manual and their notes to prepare for both the written exam and practical exam. All students completed the written exam prior to starting the practical exam.
Box 2. Post-test and final exam items and coding criteria. The same image was presented for both prompts.

For the laboratory practical exam, students were instructed that they would need to determine the density of a solution and provide data concerning both the accuracy and precision of their measurements. They were not allowed to bring their notebook or other notes. Stations were set up to mimic the week 2 density determination activity and included a balance, a 10-mL Mohr pipet, a 100-mL graduated cylinder, and beakers. Each laboratory section had outside proctors (also known as supervisors or monitors), who had been trained to monitor technique through a series of training videos. Proctors were not placed in observation positions until their scores on training videos met calibrated scores established by three different instructors. Proctors were assigned to laboratory sections, but were not told which video the students had prepared. These proctors used a rubric to monitor whether students chose to use the Mohr pipet and
whether they used whatever glassware they chose and the balance correctly. Students were given a worksheet on which they recorded data and performed calculations. Proper use of significant figures was based on the data recorded on the student worksheet and the observation of the proctors. All laboratory practical exam materials can be found in Appendix IV of the supplementary information.

DATA COLLECTION AND ANALYSIS

Written quizzes and the written final exam were administered and collected by the teaching assistants for the individual laboratory sections. Materials were scanned into PDF form by the teaching assistants and sent to the authors before being graded. Electronic copies of all test items were stored in a password protected folder. Each student was given an alphanumeric code so that individual student progress could be followed. Student data presented here was collected under the guidance of the University’s Institutional Review Board for Human Use (Erdmann, 2011).

For the pre- and post-test, each response was coded using a 2/1/0 score. As the task required in the pre- and post-test items differed slightly, the skills required in each item were classified according to a revised Bloom’s Taxonomy domains: (2) Remember and Apply/Analyze, (1)
Remember, and (0) Incorrect (other responses) (Anderson et al, 2001; Krathwohl, 2002). As part of the practical, selecting the most accurate glassware (the Mohr pipet) and reporting the proper number of significant figures was scored as (2) used the pipet and recorded the volume to 2 decimal places or (1) used the pipet recorded the volume incorrectly (incorrect number of significant figures or the beginning/final meniscus was outside the graduation marks) or (0) used the incorrect glassware.

Each student enrolled in the course was expected to spend similar time on task and as such both the control and experimental groups were expected to show improvement in reporting the proper number of significant figures. Thus, McNemar’s chi square and odds ratios were calculated within each group to evaluate any differences in performance within the groups. This statistic is commonly used in pre-/post-test design to compare and determine significance between the number of students whose scores have increased, decreased or remained the same (Elliott & Woodward, 2007). Between groups analysis was analyzed using chi-square ($\chi^2$) determinations between the pre-/post-test, pre-test/written final exam, and post-test/written final exam. The chi-square statistic was selected since this statistic uses the frequency data from a sample to evaluate the relationship between the variables in a population and is the one of the
most common nonparametric statistical values (Gravetter & Wallnau, 2009). Chi-square calculations were performed using a 3x2 contingency table to assess whether the increase in number of students that use the pipet and record the proper number of significant figures was different between the groups as a result of the treatment. Due to the size of the data pool and the degrees of freedom, minimal requirements for all cells of the contingency tables were met and the correction for continuity was not necessary and thus ignored. Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS version 20 for Windows). Tabulated statistical data can be found in the Supplementary Information (see Appendices V, VI, and VII).

Key points regarding data collection along the semester are presented in the timeline shown in Figure 1. During week 2, the pre-test was administered prior to all students filming videos detailing the use of either a Mohr pipet or an analytical balance. The post-test was administered during week 4, after students had edited and submitted the first draft of their videos. The longitudinal post-test data point (the written final exam) was administered the last week of the semester (week 15) along with the practical examination.
Of the 10 labs performed during the course, 8 of them required estimating the last decimal place when reading a volume. Mohr pipets were used to transfer solutions 3 of the 10 weeks, but students also used burets (2 of 10 weeks) or graduated cylinders (at least 5 of 10 weeks) throughout the course. Teaching assistants demonstrated the proper use of each piece of glassware at least once during the term, though the rigor in the presentation admittedly varied among TAs. The large sample size is expected to address this variable treatment.

RESULTS AND DISCUSSION

Between group analysis of the pre-test results from the balance/pipet groups show that there is no significant difference ($\chi^2=0.6051, p=0.739$) in prior knowledge of volume measurements or significant figures between the two groups, and corrections for *a priori* knowledge were not performed. As both groups performed identical tasks throughout the semester, it is not surprising that within group analysis indicate that both groups showed improved performance on the post-test and the final exam. The post-test odds ratios (OR) (Table 1) indicate that the preparation of the pipet video does have some influence on the experimental group’s performance even though the percent correct is similar. Students who created a pipet video
were 4.6-fold more likely (McNemar’s $\chi^2=43.2$) to increase their performance between the pre-test and post-test while students who created a balance video are only 2.6-fold more likely (McNemar’s $\chi^2=25.3$). It is important to note that the difference between the two ORs does not indicate the magnitude of this influence (i.e., it is not a doubling effect).

The influence of the pipet video is tempered between the post-test and the written final examination (OR=2.6, McNemar’s $\chi^2=13.3$ (pipet) and OR=3.1, McNemar’s $\chi^2=23.3$ (balance)). These odds ratios indicate that the number of students providing correct answers increased for both groups by the end of the semester. This observation is not unexpected since both groups used graduated glassware throughout the semester.

<table>
<thead>
<tr>
<th>Study Period</th>
<th>Statistical Test</th>
<th>Pipet Group (N=233)</th>
<th>Balance Group (N=276)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test to Post-test</td>
<td>McNemar’s $\chi^2=43.2$</td>
<td>4.6</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>Odds Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test to Final</td>
<td>McNemar’s $\chi^2=82.6$</td>
<td>11.1</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td>Odds Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-test to Final</td>
<td>McNemar’s $\chi^2=13.3$</td>
<td>2.6</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td>Odds Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test to Practical</td>
<td>McNemar’s $\chi^2=21.3$</td>
<td>2.5</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Odds Ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final to Practical</td>
<td>McNemar’s $\chi^2=31.6$</td>
<td>5.1</td>
<td>36.0</td>
</tr>
</tbody>
</table>

Table 3.1. McNemar’s Chi Square analysis within groups for the Pre-, Post- and Final Examination data points. All probabilities are statistically significant at the 99% confidence interval ($p<0.01$).
Figure 2 shows the number of students who were able to improve their performance from an incorrect to a correct answer between the pretest and subsequent tests (i.e., the number of students who fell into the ‘no/yes’ category in the McNemar’s chi-square table).

![Comparison of students' improvement between test periods](image)

**Figure 3.2.** The number of students who answered incorrectly on the pretest but correctly on a subsequent test. All results are statistically significant, but the increase in correct answers between the pre-test and practical are particularly striking.

Between group analyses of short-term learning gains showed that creation of a technique video had a marginal effect on student performance on the post-test. The $\chi^2$ statistic of 3.29 ($p=0.193$) implies that there is a little over an 80% chance that the videos led to an increase in student performance on the post-test. However, given that this assessment method appeals to a group of learners that is often overlooked in the chemistry laboratory environment (i.e., bodily/kinesthetic learners) (Gardner, 1983),
the positive correlation between assessment and learning gains provides opportunities for further studies that include learning style preferences as another variable.

![Graph](image)

**Figure 3.3.** Comparison of student performance on all of the test items analyzed. Statistically significant differences are starred. Particular attention should be paid to the results of the practical.

Additional between group analyses show that the pipet group answered the assessment item correctly on the written final exam at a higher rate the balance group (81% versus 72%, $\chi^2=9.78$, $p=0.008$). Though this finding is encouraging, the performance on the laboratory practical exam is the important observation. The item on the written final exam was similar to the post-test item, so responses on the written final exam could be influenced by the availability of the graded quiz as a study guide. During the practical exam, students in the pipet group used a Mohr pipet
to transfer the solution at a higher rate (91%) than those students in the balance group (75%) ($\chi^2=50.53$, $p<0.001$). Thus, though both groups spent the same amount of time using the pipet earlier in the term to determine the density, those students that made a pipet video selected the intended piece of glassware at a significantly higher rate. Additionally, students who used the Mohr pipet for volume determination also reported the correct significant digits at a much higher rate in the pipet group (74%) than the balance group (46%) ($\chi^2=34.77$, $p<0.001$), indicating that creation of the video leads to an increase in proper application of the techniques the video details.

In addition to the data collected regarding significant figures related to volume, items were included on the pre- and post-tests probing students’ familiarity with the significant figures associated with the analytical balance. As with the volume data, no differences in a priori knowledge were found between the groups. Additionally, there was no significant difference in growth between the groups on items related to using an analytical balance, which is likely attributed to the fact that the balances in question do not require estimation on the students’ part as the mass readout is digital.
Though the majority of student groups submitting videos were able to successfully demonstrate proper technique with their initial submission, a potential limitation of the results lies in requiring these groups to re-shoot their videos or portions of video when gross technical errors were observed. The collection of this additional footage requires additional practice with the pipet that students in the control (balance) group would not have performed and time on task between the groups is not equivalent. The improved performance on the practical may be attributed to the instructor’s feedback and student corrective action, and not simply from making the video. However, asynchronous monitoring is not possible without the video, so this corrective action would likely not ever have occurred. Thus, there could be an indirect benefit from the video preparation.

**IMPLICATIONS FOR PRACTICE**

The results of this study can be useful in many classroom situations. Using student-created videos offers an improved method for monitoring student technique by moving from a synchronous to an asynchronous evaluation model, and has uses in large-enrolment courses and distance-learning environments.
Student-created video assessments offer instructors the ability to observe technique and offer critique asynchronously, thus ensuring that the instructor can observe and provide feedback to all students in the laboratory. Jones et al state that feedback can be seen as ‘the end of a cycle of learning and the beginning of the next’ and describe a method of assessment using screen capture digital video to provide feedback (Jones et al., 2012). In this method, students receive instructor feedback on their assignments via short screen capture videos created by the instructor. Thus, videos could be potentially useful in large enrolment laboratory courses, with the additional benefit of requiring equipment that the student already owns and software that can be obtained free of charge.

Many laboratory course designs require students to perform tasks in small groups. One potential problem in any such cooperative learning setting is that of the ‘hitch hiker’, or the individuals who defer to the ‘good’ student to complete the work (Cooper, 1995). In the laboratory, this hitch hiker problem often leads to the most technically astute member of the group taking responsibility for the majority of the data collection. Ensuring student involvement and equal participation among all group members in the laboratory is difficult due to the extent of the observation of the group required. This difficulty is exacerbated when graduate teaching assistants
are responsible since they have limited experience with classroom management. The use of video could potentially be used to address the “hitch hiker” issue. Requiring all students to be seen in the video requires a minimum level of participation that is often difficult to monitor in a normal classroom environment.

An exciting potential application of student-created videos is in the distance-learning laboratory course setting. At the author’s institution and others, enrolment is ever increasing while infrastructure remains largely unchanged. This phenomenon has led a number of institutions to increase their offerings of online courses (Phipps, 2013). Despite these growing pains, the contentious issue of the laboratory experience remains one of the largest obstacles to implementing online chemistry courses (Pienta, 2013). Safety, expense, retention and academic rigor further complicate the online laboratory course environment (Casanova et al, 2006; Hoole and Sithambaraesian, 2003; Patterson, 2000; Boschmann, 2003). Provided safety precautions are in place, video reports may have value in distance learning environments where the instructor is not physically present, as they provide an active learning method of assessment. Instructors of these courses could ensure that off campus students are performing their own experiments by requiring them to create videos of themselves safely
performing laboratory activities. In this model, the student-created video would be used for more than just analysing technique, it would be used to ensure students are individually performing their tasks. In this way instructors could monitor that the technical aspect of the laboratory experience is met. The author’s data, specifically the high chi squared value associated with the application of technique, imply that creating a video could lead to increased retention and more meaningful learning in the online laboratory setting, thus alleviating some of the academic rigor concerns.

This study also allows us to consider the development of a list of techniques that could be included in a student’s personal electronic library for use in other laboratory courses or in the research laboratory. These techniques could be as simple as the proper use of a piece of glassware or much more technical, such as the use of a HPLC. A number of techniques and instruments are common across scientific fields, and these videos on these techniques could be retrieved from the student’s e-portfolio when needed.
CONCLUSIONS

Student-created technique videos were successfully integrated into the general chemistry laboratory curriculum as an alternate assessment. Formative surveys indicate that students are able to create and edit videos with little difficulty. Though the project required additional training of teaching assistants and the occasional need to address the hitch hiker problem (Cooper, 1995), the videos proved to be a worthwhile addition to the laboratory course. The short- and long-term measurements indicate an increase in students’ ability to correctly report a volume to the correct number of significant figures after having prepared a video describing the proper technique. These results suggest that instructors can consider the use of video laboratory reports to improve retention of proper laboratory technique. Further studies should probe whether the important step in the learning gain is the preparation of the video or the process of reviewing oneself in the video after its preparation.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Michele Foreman for the excellent video tutorials that she created for this project and Dr. Julia Austin for graciously agreeing to review this paper. Special thanks also go
out to the teaching assistants of the course for their patience and assistance
during the course of the study.

NOTES

Department of Chemistry, University of Alabama at Birmingham,
Birmingham, Alabama 35205, United States.

† Laboratory courses met only during the 5 day weeks of the semester.
Students were not asked to meet during holiday weeks or during the week of
final exams.
AFTERWORD

The work presented in Chapter III would not have been possible without the formative planning and development described in Chapter II. These two chapters combine to offer both faculty and graduate students an introduction to the various scales of education based research. Smaller scale projects, such as the materials development and revision that accompanied Phase I, can be implemented to determine if a particular practice is useful for a select group of students. Additionally, this work can be taken further and quantified in some way (in our case the quantification took the form of learning gains within a pre-/post-test design) and made available to others for implementation in their own classroom. I feel that these two chapters accurately depict both SoTL and DBER work, and I hope that they invite others to join the education research community and share the positive changes they have made in their own classrooms.
REFERENCES


CHAPTER IV

A LABORATORY ACTIVITY ON THE ETHICAL DATA REPORTING AND MAINTENANCE OF A LABORATORY NOTEBOOK THROUGH SIMPLE pH MEASUREMENTS

by

MITZY A. ERDMANN and JOE L. MARCH

Submitted to The Journal of Chemical Education

Format adapted for dissertation
FORWARD

The material presented in this chapter describes a classroom activity that was developed to emphasize the importance of proper notebook keeping in the laboratory setting. The activity was initially developed as a fulfillment of a course requirement for the GRD 715, Preparing TAs to be Effective Teachers, course. It introduces students to proper data collection, and facilitates a discussion on ethical data reporting. Supplemental Information provided to the journal for electronic publication is presented in Appendix C.

A LABORATORY ACTIVITY ON THE ETHICAL DATA REPORTING AND MAINTENANCE OF A LABORATORY NOTEBOOK THROUGH SIMPLE pH MEASUREMENTS

ABSTRACT

Sample handling and laboratory notebook maintenance are necessary skills, but can seem abstract if not presented to students in context. An introductory exercise focusing on proper sample handling, data collection and laboratory notebook keeping for the general chemistry laboratory was developed to emphasize the importance of keeping an accurate notebook. The exercise requires minimum technique or prior knowledge, and as such provides students
a comfortable introduction to the college laboratory setting. Details of the activity, including preparation, background, procedure and post-activity instruction are provided. Alternative uses and application of the activity are also proposed.

GRAPHICAL ABSTRACT

INTRODUCTION

We describe here an initial exercise for the introductory chemistry laboratory. This activity serves as an ice-breaker for students to meet their new laboratory partners, and has two main instructional purposes:

(1) Provide students a foundation for proper notebook keeping

(2) Introduce students to some of the ethical dilemmas of data collection and handling.
The activity is designed to introduce students to their laboratory environment, and as such is brief and requires minimal skill in the laboratory or *a priori* knowledge. Students test the pH of various samples using inexpensive pH test strips. This simple technique allows students to focus their efforts on the collection of data without being distracted by more involved techniques. This activity was developed and initially performed in a college-based introductory chemistry setting, but is easily adaptable for use with secondary school students.

Laboratory instruction has long been considered a crucial part of general chemistry education.\textsuperscript{1–4} Documentation supporting the importance of a well-kept laboratory notebook first appeared in The Journal as a five-part symposium in 1933.\textsuperscript{5–9} Many published manuals discuss the importance of the laboratory notebook, but provide fill-in-the-blank data sheets. These data sheets imply that a laboratory notebook is not expected or used in conjunction with the manual. Discovery or guided-inquiry-based manuals sometimes provide an introduction to the scientific notebook, but do not present activities specifically designed to experience the value of a well-documented experiment.\textsuperscript{10,11} This void in instruction can leave students unsure of themselves in the laboratory setting and may open the door for ethical issues associated with mis-interpreted or incomplete data.
Prior authors have theorized that if emphasis is placed on the laboratory notebook, students may see it as a valuable part of the learning process\textsuperscript{12}, but that merely giving student guidelines and expecting them to excel is rarely sufficient\textsuperscript{13}. The activity described here seeks to narrow this gap in instruction and place an emphasis on proper record keeping. The laboratory exercise provides students an opportunity to learn to keep a notebook during a low-stakes data collection assignment. The activity also provides laboratory instructors the opportunity to introduce students to the ethical dilemmas of poorly collected or missing data through actual data collected by the entire laboratory section.

The importance of introducing students to scientific ethics is well represented in the literature. Case studies are commonly used as a framework for delivery of ethics related content.\textsuperscript{14–16} Gillette described a writing assignment designed to introduce freshman chemistry majors to scientific ethics\textsuperscript{17} and Kandel used a similar approach\textsuperscript{18}. Kovac argues that students will best learn scientific ethics when they are introduced to ethical questions through realistic situations.\textsuperscript{19} The described activity is a simple approach to utilizing actual data points that students collect, and provides discussion topics that frequently arise in the laboratory.
The data mentioned above takes the guise of determining the water quality of a set of samples. Water quality was chosen as the introductory topic to create a real-world connection for students. The Cahaba River, which is located near the university, is well known to those from the area as a major drinking water source. Nitrogen content is presented as a pollutant that can enter river systems through both treated and untreated waste water. We tie nitrogen concentration to ammonia, which can easily be tested with inexpensive pH strips. Students are introduced to the concept of pH and the relationship between ammonia content and pH is generally described (as ammonia content increases a solution will become more basic and thus will have a higher pH).

ABOUT THE ACTIVITY

Laboratory Manual Write-up

Background material relating the goal of the experiment and general scientific terms are presented in the student laboratory manual. This material introduces students to a number of general scientific terms (quantitative vs. qualitative, etc.) and contains a narrative explaining how water quality can vary across different types of water samples (tap or drinking, waste and river). Students are given a list of materials available to them and asked to predict the steps they would need to take in order to label three samples as either tap, river
or waste water. However, in the spirit of a guided inquiry activity, minimal instructions are included regarding the specific data to collect or how to organize the information.

**Materials**

Prior to beginning the activity, students collect a sample set of solutions, pH strips, a wash bottle, a waste beaker, and glass stir rods. As performed at the authors’ institution, the sample set was comprised of three dilute ammonia solutions that gave distinctly different colors on the pH strips. These solutions had concentrations of 0.00625 M (~pH of 8), 0.0125 M (~pH of 9) and 1.0 M (~pH of 10) ammonia. The solutions were kept in storage vials that had been labeled with both an identification number and a concentration. Thirteen solution sets were prepared for each section of 39 students; eight sets were labeled with the correct concentration, and five sets had the concentrations purposely mislabeled (a detailed labeling scheme is presented in the supporting information). Unknown samples are prepared from the same three stock solutions by labeling the containers A, B, or C. Additional sample preparation notes can be found in the Supporting Information.
Pre-Activity Instruction

Pre-activity instruction given by the TA includes a review of the background information presented in the lab manual, how to properly use the pH strips, and the relevance of properly obtaining water quality measurements. Students are instructed to consider how pH may be affected by nitrogen content (i.e., ammonia concentration) and given the concentrations of the three solutions they will test. They are then asked to predict which order the concentration of the solutions (tap, river, or waste water) should be placed to demonstrate an increase in pH. In order not to reveal the ethical twist of the activity (i.e., the samples may be mislabeled), the pre-activity lecture details the general laboratory ideas presented in the laboratory manual.

The pre-activity lecture introduces students to proper record keeping in a scientific notebook, including such items as recording sample labels and taking measurements in triplicate. Laboratory instructors demonstrate how to properly test the pH of a solution using a glass stir rod and pH strips (i.e., the pH strip should not be dipped directly into the solution). The safe handling of dilute ammonia solutions is also be emphasized. Since some solutions are mislabeled, students are told at the beginning of the exercise to treat all solutions as if they were 1.0 M ammonia solution; avoiding contact with the skin and working in a well-ventilated area.
Student Workflow

Each student group (3-4 students per group) collects a sample set of solutions from the laboratory instructor. Each member of the group is required to determine the approximate pH of each of the three samples using the pH indicator strips. The accuracy of pH values taken from pH test strips is expected to be poor, so there is often wide variation regarding assigned pH even within each group. Each group is required to reach a consensus pH value for each solution to be reported to the entire class.

Once pH values are reported to the class (typically on the whiteboard), the laboratory instructor reviews the reported values with each group and assigns the group one of 3 unknown samples to test. Students follow the same pH test procedure with their unknown, assigning the unknown one of the concentrations on the labeled samples. The unknowns are assigned such that there are enough groups testing the same unknown and at least one group will incorrectly report the concentration due to observing mislabeled knowns. Once each group reaches a consensus on the concentration of their unknown, they record their concentration on the whiteboard and the post-activity discussion begins.
Figure 4.1. Example Student Notebook. (a) Example student notebook showing group data. The notebook includes collected data for the pH of the three labeled samples and the unknown ‘A’. When there was disagreement among the group, a consensus value was agreed upon. (b) Example student notebook showing compiled class data. The table shows the data for lab groups that tested unknown ‘A’. The mis-labeling of the samples becomes apparent when reviewing class data.

Post-Activity Discussion

When all laboratory groups have collected their data, all students in the laboratory assemble and participate in a post-activity discussion. In general, students quickly see that there are a number of discrepancies among the data and immediately assume that some of their peers performed the lab incorrectly (this inevitably initiates cross-talk among lab groups and serves as an engaging way for students to introduce themselves). Laboratory instructors use the reported results to facilitate conversation regarding data collection and reporting. The activity was introduced to our curriculum in the Fall of 2011, and has been run multiple times a year since then. Similar discussion topics have arisen with each
group that has undergone the exercise. Examples of the typical topics that arise after review of compiled data are presented in Box 1.

The activity was included as part of our curriculum to provide our students with a basic understanding of the ethics associated with data recording and reporting. Assessment of the impact on student learning has not been undertaken, but a review of in-class assignments completed by students following the post-activity discussion indicate that the activity is positively received. When asked what the “take-home message” of the activity was, typical student responses indicate their TA had emphasized the importance of sample handling, data collection and reporting, and that there are negative implications if record keeping procedures are not adequately followed. TAs have provided informal feedback that the activity has led to greater interaction amongst student laboratory groups and the class as a whole early in the semester. TAs have also indicated that they enjoy teaching this activity as it benefits from assertive instruction and provides the students an excellent introduction to the teaching style of their TA on the first day of the course.
### Box 1. Representative Post-Activity Discussion topics

**Sample labeling and data handling.** A number of student groups will not have written down the three digit code on the labeled sample vial or the identity of the unknown (A, B or C). Instructors should mention that without properly identifying the samples used during an experiment, it is not possible to repeat the experiment with any success.

**Error among class data.** Students should be polled whether they feel it is reasonable to use data collected from many different people or if it is better to average results from the same experimenter. Instructors should take the opportunity to discuss the error among the class data in terms of variation in technical ability among the members of the laboratory and tie this into the poll results.

**Pressure to conform to reported results.** Many students who feel they are unprepared for techniques required of them in the laboratory may feel the need to change their results to conform to the rest of their group. The instructor should point out that while it may be necessary to re-test a result, it is unethical of your group to force you to change your results.

**Ethics of reporting data you know to be incorrect.** Students should be polled to determine their comfort level with reporting data they know to be incorrect. In the class discussion, instructors should identify the social implications of reporting incorrect data.

**Recognizing patterns in data.** Compiled student group data can be used to point out where a pattern in the general data fail. This can help students in future situations when they are attempting to determine the appropriateness of a data point.

**Proper use of significant digits.** An excellent opportunity to tie the pre- and post-activity lectures together is in the reporting of significant figures. Many students are unaware of how to properly report qualitative data. If students report pH values to the tenths place, these values can be used to discuss the importance of significant figures.

---

**Box 1.** Representative post-activity discussion topics that routinely present themselves following review of compiled class data. Suggestions for leading class discussions on these points is also presented.

### Alternate use of the activity

Instructors who may be uncomfortable knowingly deceiving their students may be interested in an alternate approach to performing this activity.

Sample preparation, materials, and student data collection are identical. Instead of students being unaware of the mislabeling of samples, students can alternatively be told some of the labels are incorrect and that they are required to create an experimental plan that allows them to correctly identify the incorrect labels. Many of the talking points presented in Box 1 still apply to this approach.
SUMMARY

This paper discusses an introductory chemistry laboratory activity that details proper sample handling, data collection and notebook keeping. The activity engages students and requires them to work in groups to collect data with little stress, as the technical demands and prior knowledge required to complete the assignment are minimal. Discussion of sample labeling and the ethical issues involved in poor data collection offer students an opportunity to start the semester on good footing. Both graduate and undergraduate TAs have successfully led this activity for 8 semesters with minimal training. Though formal assessment of impact on student learning has not been conducted, the activity has been well received by students as gauged through personal interactions, and participation in the post-activity discussion among students enrolled in all laboratory sections that the author has taught have been high. Teaching assistants have reported that students appear to have a more sound understanding of proper notebook keeping after completing the activity. The authors feel that this activity offers instructors in a wide variety of educational situations an easy and effective way to introduce data collection ethics into their courses.
SAFETY

It is important that all students follow standard laboratory safety protocol when completing this activity. Ammonia may be fatal if ingested, inhaled or absorbed through the skin at high concentration. Solutions of ammonia may also cause irritation to the eyes and respiratory system and may cause burns if contact is made with the skin. Ammonia is considered dangerous for aquatic wildlife and the environment in even low concentrations and should be disposed of carefully. Care must be taken when handling ammonia solutions of any concentration. While safety glasses should be worn throughout the experiment, additional PPE should not be necessary with such dilute solutions.

ASSOCIATED CONTENT

Supporting Information

Detailed instructor notes on preparing for and carrying out this activity, the experimental outline provided to students in the laboratory manual, the pre-activity quiz, and the post-activity assignment are all available via the Internet. (They can be found in Appendix 4).
ACKNOWLEDGMENTS

We thank both the Department of Chemistry and the Graduate School at the University of Alabama at Birmingham. Special thanks go directly to Nancy Abney and Julia Austin for teaching GRD 715 in which this activity was a course requirement, and to both Su Xu and Reza Farasat, who helped in creating the supplemental materials used as part of the first iteration of the GRD 715 requirement. We also send our heartfelt gratitude to our teaching assistants for their dedication in teaching this and all other activities for the department and for their patient and diligent collection of student work samples for the authors. This lab was written with funding from the Council of Graduate Schools/Office of Research Integrity of the DHHS, “Embedding Ethical Decision-making in the Curriculum of Graduate Students at the University of Alabama at Birmingham (UAB)”, Bryan D. Noe (P.I.), Jeffrey A. Engler (co-P.I.), 10/1/08 – 10/30/10. This grant funds ethics education projects for graduate students in the biomedical and behavioral sciences.
REFERENCES


CHAPTER V

ONLINE CONTENT DELIVERY IN THE GENERAL CHEMISTRY LABORATORY

INTRODUCTION

Laboratory curriculum has evolved throughout the years, with the trend moving towards the more inquiry-based approaches of learning-cycle generated activities such as POGIL (Hanson & Wolfskill, 2000; Hockings, DeAngelis, & Frey, 2008) and the Science Writing Heuristic (Burke, Greenbowe, & Hand, 2006; Greenbowe, Poock, Burke, & Hand, 2007). Learning-cycle based activities require students to explore, invent and apply information to solve a problem, and avoids providing specific instructions or identifying the solution to the problem (Spencer, 1999). These techniques have been shown to be more effective than traditional techniques when successfully implemented. However, instructors must be comfortable delivering content and facilitating discussion in order to be successful. Thus, results in many studies are confounded by instructor effects. Instructors set the tone and norms of behavior for a course (Pollock, Finkelstein, & Kost, 2007), and a weak instructor will have difficulty creating a comfortable,
safe learning environment for their students. Confidence and interest in teaching is crucial to successful implementation and instructor effects limit their broader use in many cases.

Minimization of the instructor effect can be addressed with additional training, but a more modern approach that eliminates the effects of instructors that have no desire to improve their skills is to increase the use of the internet to deliver pre-laboratory content. Video, text, animations, and self-assessment pieces are delivered on-demand and allow students to study required material at their own pace. The delivery of a common set of materials across multiple sections sets the tone for expectations, and these expectations are recognized by both the students and the teaching assistants.

The delivery of pre-laboratory instruction via video or DVDs is not new (Pantaleo, 1975; Phipps, 2013), but this type of delivery has been expanded as the concept of a “flipped” classroom is discussed in more venues. The flipped classroom is largely defined as a course in which the instruction is provided outside of class time (usually online via video) so time in class can be spent on inquiry-based activities and problem solving. The call for an increased use of the flipped classroom approach is one well suited to the laboratory due to the hands-on nature of the environment (Teo, Tan, Yan, Teo, & Yeo, 2014).
Despite the increased practice of online delivery, little has been done to ensure that the content delivered via video is an engaging experience. Review of videos related to laboratory instruction range from talking-head lectures to voice-over-PowerPoint slides. There are little or no elements of an active learning classroom in these videos. This observation is likely a function of the medium and the amount of time required to storyboard, capture footage, and edit the product.

To eliminate this time drain, some online courses use existing instructional materials, both amateur and professionally produced. However, use of video produced outside of the home institution decreases student satisfaction and performance when compared to videos where students can tell it was produced for them and include the instructor or at a minimum branding that is associated with their home institution (Chang & Smith, 2008; Noel-Levitz, 2014). Increased interaction between students and the instructor in online courses, including recorded interactions, increases student engagement in the online environment (Veletsianos, 2010). Creating videos that are clearly branded by the students’ university and recorded with familiar settings and staff could increase the connection that exists between students and their instructors in the traditional setting (Hibbert, 2014).
MOTIVATION AND FORMATIVE ASSESSMENT

The role of video in education has many exciting potential applications, including to deliver content, to assess student performance, and to help alleviate overcrowding as enrollment increases exceed the rate of construction of new facilities. The work presented in Chapters 2 and 3 showed that students who were required to film themselves performing and explaining how to use a piece of equipment were significantly more likely to use that equipment correctly in a laboratory practical setting (Erdmann & March, 2014b). The data and formative research shows that teaching assistants can assess technique asynchronously and that students retain the important aspects of a laboratory technique at a much higher rate. Though these findings have important implications related to teaching laboratory technique, focusing all of the students’ efforts on creating technique videos would take away from the writing and critical thinking skills that are widely seen as essential goals for the laboratory course. This led us to investigate another exciting potential application mentioned above: creating instructional videos that would deliver high-quality, uniform instruction to all students in CH116.

The main goals behind creating online instructional videos were to provide uniform instruction to all enrolled students, including technical details, safety concerns, and disposal instructions. We also felt that if a series of well
thought-out, peer reviewed, and vetted videos were available to both students and teaching assistants, that both graduate and undergraduate staff would be exposed to best-practices of instruction that will be valuable to them later in their career. Another chief goal of the project was to work towards shortening the time students spent in the laboratory completing the weekly activities. As enrollment at the University has increased, it has become increasingly difficult to ensure that all students desiring to enroll in CH116 in their first term on campus are able to do so. Creating a series of online videos could shorten time spent in the laboratory while still providing high-quality instruction without eliminating the presence of the inquiry-based ideals many of the activities are built upon. This would allow us to offer two-hour versus three-hour sections of the laboratory, subsequently increasing the number of sections we are able to offer without requiring additional staff coverage. This would ultimately allow more students to enroll in their first term and stay on track for a timely graduation.

Though shortening the time spent physically in the laboratory was a goal of this project, the primary focus was to offer all enrolled students identical instruction. Multiple factors influenced this instructional move, the most obvious being the varied experience, ability, and motivation to teach across the large population of teaching assistants used in the general chemistry course. Both graduate and undergraduate student teaching assistants are utilized in the
general chemistry laboratory sequence. In general, the graduate student is seen as the head instructor in the room (as instructed by the coordinator at the beginning of the term). It is not always the case that the graduate student is the strongest instructor in the room, however, and because of this necessary division of responsibilities the undergraduate student often defers to the graduate student.

Another limitation of the staff is their familiarity with inquiry or learning cycle based approaches to instruction. These methods generally leave one or more aspects of the lab open-ended so that students must develop their own unique solution to obtaining the answer to the problem. Their solution is not always correct, though, and learning-cycle approaches require a good deal of trial and error from students. Often students struggle and are visibly frustrated when they realize their proposed solution was incorrect and that they must develop a new one. An instructor who is not familiar with this approach to learning (which includes the majority of the teaching assistants used in general chemistry as they have had no formal education based training), can become uncomfortable. This could happen for a number of reasons, including the facts that the teaching assistant is not comfortable answering questions as they arise and students can sometimes transfer their frustration with the activity to the teaching assistant.
Pre-term teaching assistant training focuses largely on the student-instructor interactions that arise in a teaching setting. Because of time limitations and lack of sufficient background in learning theory, training specific to inquiry in the classroom is avoided during these initial training sessions. Weekly staff meetings during the term are used to iterate the purpose of each activity and to instruct teaching assistants to avoid offering step-by-step instruction to their students. Detailed examples of pre-laboratory lectures that complement the learning-cycle approach are offered to teaching assistants as part of these weekly meetings by either more experienced teaching assistants or the laboratory coordinator. Despite this learning-cycle specific training, teaching assistants in large part continue to provide students step-by-step instruction and thus derail the instructional approach.

Offering all students instructional materials that are created by experienced graduate students and faculty who are well-versed in learning-cycle based teaching can help to maximize the use of inquiry in the lab. By creating videos using the same best practices that were used in offering teaching assistants the pre-laboratory lecture in weekly meetings ensures that students are still required to develop their own solutions to solve a problem. The role of the teaching assistant as a facilitator is still very much present, but as they are also required to view the videos as part of their pre-laboratory preparation, they are
able to witness best practices in teaching first-hand. This theory has been confirmed qualitatively as teaching assistants have commented that they better understand why more direction was not offered in the manual.

Formative surveys used in previous terms to explore whether students could prepare videos also included items that gauged student interest in viewing video instruction. Students reported that they would be willing to take other courses that offered video instruction or required video assignments. Students indicated they felt positive about receiving video instruction, and either had already or would not be opposed to taking a course with a strong online component. These results led us to rethink the way information regarding the weekly laboratory activities was delivered to our students.

Formative assessment was conducted prior to implementation of the video instruction project in the form of a student-opinion survey administered to all CH116 students at the conclusion of the Fall 2014 term. The survey was administered via Canvas as an ungraded survey with submissions kept anonymous. Students were informed that completion of the survey was voluntary and that their decision whether or not to participate would have no bearing on their final grade. Informed consent was provided to students as the first item of the survey, as approved by UAB’s IRB (Erdmann & March, 2014a). Informed consent is included as Appendix 5.1.
The survey contained 24 items presented to students as individual 4-point Likert-type prompts. A four point scale that avoided the middle or “no opinion” option was used to remove ambiguity in responses to the items and to facilitate easy dissemination of results (the highest two categories would be considered “positive” responses and the lowest two considered “negative responses”). The Likert-type options provided to students varied from prompt to prompt to better describe what was being measured by the individual item and were presented to students in order as multiple choice responses.

Participation in the survey was solicited via email from all students enrolled in CH116 following the last class meeting of the semester. One hundred twenty-one students (18% of the 664 enrolled students) confirmed their desire to participate by answering “I agree” to the informed consent item. In addition, 2 students agreed to participate but failed to respond to any additional items, 3 students did not agree to participate and 4 students ignored this item entirely. The responses of these 9 students are not included in totals. Demographic information or details regarding the teaching assistant, section, or grade expected in the course was not collected, so it is difficult to ascertain whether the teaching assistant or student performance in the course weighed on the student responses. Survey results were intended to serve as a baseline for comparison in later terms. A summative table of all survey items and responses from the 121 students that
complete the majority of the survey is presented in Appendix 5.2. Items of
significant interest here are presented in Table 5.1
<table>
<thead>
<tr>
<th>Fall 2014 End of Term Select Survey Items and Response Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Table 5.1 – Fall 2014 End of Term Select Survey Items and Response Summary</strong></td>
</tr>
<tr>
<td>Likert-type items included on the Fall 2014 End of Term survey are presented under the corresponding Likert-type categories to reduce space requirements and redundancy. Items are numbered in order of placement on the survey to provide an idea of sequence. Response data is presented as totals and percentages (i.e., 54 (44.6)).</td>
</tr>
</tbody>
</table>
The Fall 2014 survey contained items regarding teaching assistant effectiveness, but it was designed largely as a feasibility study. The survey included items that would later allow us to compare the perception of students when their instruction given by a teaching assistant versus when their instruction is provided online.

**FORMATIVE SURVEY ANALYSIS**

Pre-laboratory instruction typically contains a minimum of 6 essential components: Introduction to the broad purpose of the lab, chemical concepts, technique descriptions, safety, disposal, and expectations for reporting. Thus, the Fall 2014 survey contained a number of questions that detailed teaching assistant behaviors as they pertained to the pre-laboratory lectures, which would be replaced if instructional videos were created. The following essential components were not addressed by the survey: (1) introduction to the purpose of the lab, (2) the chemical concepts or (3) the expectations for reporting. We omitted the three mentioned categories as they are covered in some detail in the required laboratory manual and were not an intended focus of the initial videos. Instead, the survey focused primarily on (1) technical descriptions, (2) safety information, and (3) disposal instructions. Elaboration of the survey items presented in Table 5.1 follows.
The clarity of the pre lab instruction was assessed by asking whether the teaching assistant presented the material for that activity in a clear and concise manner. Students responded positively to this query nearly 88% of the time. Another probe detailing whether students felt that their teaching assistant’s pre-laboratory lectures were organized and easy to follow had a nearly identical response (89% positive). Thus, the majority of the students report they are satisfied with their teaching assistant’s instruction. However, this question does not explore how day of the week, time of day, the laboratory setting, use of the white-board or whether language barriers affects student perception of their instructor.

When asked if they felt that pre-laboratory lectures were a good use of class time, 85% either completely or mostly agreed. This large percentage implies that students desire additional instruction over what is provided in their laboratory manual alone to be comfortable performing laboratory activities. Interestingly, though students felt their teaching assistant was clear in their presentation and that the lectures were worth class time, the percentage of positive responses to the query “In general, did you feel prepared to perform the lab activity following your TA’s pre-lab lecture” fell to 57%. Items to probe what type of information students would like presented to them were not included on the survey.
Many of our students are unfamiliar with the equipment found in our laboratory prior to its first required use. As such, sufficient instruction on use of laboratory apparatus by the teaching assistant is essential. Two items were designed to gauge whether teaching assistants were providing sufficient instruction on use of laboratory equipment. The first, “How often did your TA demonstrate the proper use of lab equipment being used for the first time this semester?” elicited a 91% positive response. The second item, “How often did your TA repeat a demonstration for more difficult to use equipment (pipet, buret, etc.)?” only received 77% positive responses. This implies that teaching assistants are aware students require technique instruction, but that some of them fail to provide reinforcement. Teaching assistants were not asked to provide explanations as to their motivations for choosing to (or not to) provide reinforcement of techniques.

Personal safety and proper disposal instructions are crucial to providing a safe learning environment for all individuals present. However, these items are easy to overlook when background and technical information has already made for a lengthy pre-laboratory lecture. When asked how often their teaching assistant provided specific safety instructions in regards to the chemicals being used that week during the pre-laboratory lecture, 92% responded that they were given instruction at least some of the time. A similar percentage of students, 96%,
agreed or completely agreed that their teaching assistant provided weekly disposal instructions at least some of the time. The high percentage of positive responses to these two items are encouraging, but the seriousness of safety and disposal still warrant additional attention.

The survey contained a number of items geared towards assessing student familiarity and attitude towards online instruction. While the goal of the project was to move all of the pre-laboratory components to the learning management system, including the pre-laboratory quizzes, only two items focusing on video instruction are of interest here. Surprisingly, only 47% of students completely or mostly agreed that they had previously been required to view videos as a course requirement. With the current push towards online course offerings nationwide, it was expected that this percentage would be much higher. In contrast, the percentage of positive responses increased to 62% when students were asked if videos would be a useful way to deliver content in CH116. This implied that, while students were not currently being asked to view videos for their courses, they were not only open to the idea, but felt that it would be helpful to them.
DESIGN AND IMPLEMENTATION OF INSTRUCTIONAL VIDEOS

Rarely are two sections taught by the same two teaching assistants, and even though graduate teaching assistants teach more than one section, they are not always the most effective instructor of the pair. This leads to a different pre-laboratory lecture for most sections being taught. Variation among teaching assistants in both desire to teach and ability to conduct an effective lecture resulted in a student population that is not homogeneously prepared. To allow all enrolled students the same opportunities for preparation and learning, pre-laboratory instructional videos were introduced to all enrolled CH116 students in the Spring 2015 semester. These videos were produced in-house, showing familiar settings and equipment (campus, the general chemistry laboratory and instrumentation room) and with UAB branding to create a sense of personalization. A consistent team of personnel was used so students would be able to further identify with the instruction. Videos were purposely kept under 10 minutes, both to minimize time spent producing the video and the maximize retention by keeping the videos within the length of the average student’s attention span. The scripts used for narration of the videos were initially written either by an experienced undergraduate or graduate teaching assistant, and all were edited by the laboratory coordinator. This system of checks and balances
assured that the content presented and language used for that presentation would deliver quality instruction.

Semesters in which instructional changes are introduced are often learning opportunities, and this project was no different. The videos created for activities performed early in the term focused almost solely on the technique necessary to successfully complete data collection. They featured 1-3 actors who performed the experiments just as the students would. We wanted to maintain the guided-inquiry nature of the printed materials, and as such videos did not show step-by-step protocols. Instead, these videos focused on the major goals of the activity, providing a list of objectives and a brief (minimal) explanation of the background necessary to succeed on the pre-laboratory quiz. All glassware that was being used for the first time during the term was explained in great detail to increase students' comfort level upon arriving in the laboratory. Experimental procedures that students should already be familiar with were mentioned in subsequent weeks, with separate technique videos being made for multi-step or difficult to use equipment. Emphasis was placed on specific safety hazards and disposal instructions for the week.

Videos were uploaded to YouTube and distributed to students via the external URL option in Canvas. To ensure DSS compliance, closed captioning for the hearing impaired was added to the videos through YouTube. Modules
containing the pre-laboratory video and a weekly quiz were built for each weekly activity, and modules were set up to ensure that students had to, at a minimum, load the video before being granted access to the quiz.

Figure 5.1 – Sample first-generation technique video. This portion of video was designed to familiarize students with the spectrophotometer prior to using it in a laboratory activity. It was available to them later in the semester when the instrument was used again.

The weekly quizzes, which were built in, administered through, and graded by Canvas, mimicked those that had been given on paper in the laboratory in previous terms. The wording on a number of the items included in the quizzes was made to parallel the wording in the videos in an effort to directly tie the instructional videos to an assessment piece.
ASSESSMENT OF THE FIRST GENERATION VIDEOS

To ascertain if the effort put into creating the instructional videos was worthwhile to those enrolled, student-opinion surveys were issued to students via Canvas at the midterm. As with the formative assessment, students were informed that participation was voluntary and only those students who agreed to the informed consent item were included in final totals. One hundred sixty-nine students completed the survey, and 166 response sets were included in the analysis.

The survey contained 63 total items grouped into 9 categories of probes, one stand-alone item, and 1 free-response prompt that requested constructive feedback regarding the videos. Responses to all of the Likert-type items are tabulated and presented in Appendix 5.3. Select items that are directly related to the perceived success of the instructional video project are presented in Table 5.2.
<table>
<thead>
<tr>
<th><strong>Spring 2015 Midterm Select Survey Items and Response Summary</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In general, I feel prepared to perform the lab activity after watching that week’s video.</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>In general, the material in the video is well organized and easy to follow.</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>I feel that the videos adequately demonstrate proper use of lab equipment that is being used for the first time this semester.</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>I feel that the recorded videos are a useful way to deliver course content in 116.</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>The videos mention specific safety concerns in regards to chemicals being used that week.</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>The videos instruct me in proper disposal of chemicals.</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>I feel that the videos deliver pre-lab content at least as well as my TA would.</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>I feel that the information provided in the videos allows all students to receive identical instruction.</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Most Weeks</strong></td>
</tr>
<tr>
<td><strong>I watch the entire video from beginning to end.</strong></td>
</tr>
<tr>
<td><strong>I use a search engine (i.e., Google) to look up key terms.</strong></td>
</tr>
<tr>
<td><strong>I take notes from the video WITHOUT it paused.</strong></td>
</tr>
<tr>
<td><strong>I take notes from the video WITH it paused.</strong></td>
</tr>
<tr>
<td><strong>I take notes from the lab manual.</strong></td>
</tr>
<tr>
<td><strong>I re-watch the video or parts of the video.</strong></td>
</tr>
</tbody>
</table>

**Table 5.2 – Spring 2015 Midterm Select Survey Items and Response Summary**
Response data for Likert-type items included on the Spring 2015 midterm survey are presented as totals and percentages (i.e., 32 (19.3)).
Probes designed to parallel a number of items from the Fall 2014 were placed on the survey administered in the Spring. As question format was altered from Fall to Spring to reduce the time spent completing the survey, the wording of these items was changed slightly. Change in the number of responses can still serve as a qualitative formative assessment, but care should be taken not to make direct statistical comparisons between the response sets in many cases. Both sets of survey responses serve the intended role of informing the staff in charge of video creation in regards to impact of videos on student learning.

When asked if students felt generally prepared to complete the laboratory activity after viewing the week’s video, 90% of students completely or mostly agreed with the prompt. This is an increase in positive responses over the 57% who stated they felt very or somewhat prepared at the conclusion of their teaching assistants lecture. While the majority of students seemed content with their instructor’s presentations, enrolled students seem to prefer the video instruction. This is particularly compelling when one considers that students in the trailing semester course were comfortable after watching the videos. Typically these students perform at a slightly lower level than those students who take the courses in sequence. The perceived quality of the instruction in the video was not assessed in this or any probe.
Videos presented to students at the beginning of the term provided prompts that are expected to promote thought leading to experimental design and background to better facilitate the guided-inquiry nature of our assignments. Care was taken to avoid providing step by step instruction of the protocol for that week’s activity. The majority of students, 85%, felt that the material in the video was well-organized and easy to follow. Learning-cycle based instructional approaches are sometimes frustrating and overwhelming to students who are unable to fill in gaps because they are unfamiliar the background or techniques required of the activity. The fact that there was a very slight decrease from the 89% of fall survey respondents who felt their teaching assistant was well organized is encouraging, as it implies recorded instruction can be presented in a manner that parallels inquiry based learning. Though these percentages are qualitative at best, it is likely that statistical analysis would reveal a lack of significance in the difference of the values.

To determine if students felt the videos allowed them to view the experimental steps clearly, we asked them to report whether they were able to witness demonstration of proper technique regarding equipment used for the first time that week. Ninety percent of students positively reported that the manner in which the videos were shot allowed them to view the steps clearly. This is only slightly higher than the 87% that positively responded to the similar
teaching assistant prompt in the Fall term. Both of these percentages are indicative of a ceiling effect. Thus, the delivery of the pre-laboratory instruction by video appears to do no harm.

We were interested in whether or not students routinely reviewed the videos during the laboratory period to reinforce concepts or techniques. All teaching assistants indicated that they observed students’ reviewing the videos in the laboratory, and those teaching assistants that specifically mentioned review of the videos at some point in the term indicated that their students routinely reviewed the videos during class time. We did not investigate whether the videos were useful in reinforcing techniques that had been used at least once during the term as we did with the Fall 2014 survey. This was omitted because students were directed to review the previous video if equipment was being used again.

One of the motives for ensuring uniform instruction was that all students would be made aware of the safety and disposal information for the week. The wording of the items from survey to survey makes a comparison of the two instructional techniques a bit problematic, as the fall term used the prompt “How often did your TA demonstrate the proper use of lab equipment being used for the first time this semester?” and categories Most Weeks, Sometimes, Rarely, Never. This is in contrast to the prompt presented in Table 5.2 for the Spring
term. Here it is more reasonable to compare the first category from the Fall, Most Weeks, with the two positive categories from the Spring. Students reported being presented receiving safety instructions most weeks 70% of the time during the Fall term. This falls well short of the 94% who completely or mostly agreed that the video provided weekly safety details. Similarly, when asked if they received instruction on proper disposal of chemicals from their teaching assistants, 63% of students enrolled in the Fall chose the Most Weeks category while 95% of students agreed they were given instruction on disposal weekly from the videos. Given the importance of safety and chemical disposal, these response results are a valid argument for increasing the use of online videos.

Spring term students who had access to the videos responded positively that it was a useful way to deliver CH116 course content 80% of the time. It is encouraging that students who were given access to the videos think highly of them. This implies that the majority of the students felt comfortable with the instruction they were receiving, even if was not presented in person by their teaching assistant. There were no specific items presented in the survey that allowed students to elaborate on why they may have responded negatively to this prompt.

Students were asked to report what type of device they generally viewed the videos on, and 8% stated they used either a smart phone or a public
computer or laptop. This is in stark contrast to the 86% that watch them on a private computer or laptop. It was initially surprising a minority of students were using their phones to view the videos. However, since the videos deliver content that pertains directly to a pre-laboratory quiz that is also delivered via Canvas, it is most likely that students view the videos on a computer because Canvas is difficult to maneuver on a hand-held device. Viewing them on a computer allows the student to move directly from the video to the quiz and minimize the number of sessions needed to prepare for the laboratory session. It is possible that lack of access is responsible for a portion of the negative responses.

It is difficult to ascertain why students responded negatively to whether online instruction is useful in CH116 as the survey lacked items to clearly indicate what they did not like about the method. Reviewing student responses to the free-response items indicated that students felt the videos were lacking in instruction on background material and calculations, which could in part be responsible for the 15% of students who felt negatively towards the content delivery method.

Students were asked whether they felt the videos presented material as well as their teaching assistant would. Seventy-four percent of students agreed with the prompt that the videos were comparable to a teaching assistant. Though
the majority of students in CH116 in the Spring term are taking it for the first time, there are a number of students who have participated in at least part of the course earlier in their career. There were no items that sought to determine whether these students could speak from experience and provide a direct comparison. Placing such an item on the survey could potentially allow for identification of the student responding which would violate the conditions of the IRB approval.

Students were asked whether they felt the videos allowed all students to receive identical instruction. Absolutely no students completely disagreed with this statement and only 5% of students responded negatively at all. Accounting for the percentage of students who failed to respond at all, a 91% positive response is very exciting. It shows that students feel the coordinators of the laboratory courses are working to ensure that all students are treated in the same manner.

The responses detailed above validated the usefulness of the instructional videos. As the videos presented technical steps and material presented in the videos, students were aware that they should be used as a study tool. To help us better understand how students interacted with the videos, one of the survey’s 9 item groups contained probes that asked students to indicate how often they
used the videos to prepare their pre-laboratory notes. In this way we could
determine if the videos helped students prepare for the weekly laboratory quiz.
The videos had been kept under 10 minutes to facilitate watching them straight
through. To gauge whether the short time-frame was accomplishing this goal,
students were asked how often they watched the video from beginning to end.
Eighty-six percent of students reported that they watched the video from
beginning to end most weeks, and 78% claimed that they would re-watch all or
part of the video most of the time. Teaching assistants confirmed this by
reporting in weekly staff meetings that students would routinely view the videos
on a device during the laboratory period.

The narrations in the videos were recorded at a conversational pace,
which is faster than most students can take notes. One advantage of video
instruction is that students can pace it to their own learning style by pausing the
video when needed. Two items were placed on the survey to determine how
students took notes while watching the video: The first asked how often they
took notes without stopping to pause and the second asked how often they took
notes with the video paused. Only 8% reported that they attempted to take notes
from the video without pausing it, and 87% claimed that they paused the video
to facilitate notetaking at least sometimes. Some of those students who
sometimes paused the video were stopping to use a search engine, such as
Google, to look up key terms (64%). These responses indicate that students interact at least in small part with the videos. This increased interaction of pausing, taking notes, and returning to watch and then re-watch the video is expected to be associated with increased performance and retention of information and warrants further study.

Elimination of the written laboratory manual is not a goal of this project, and a number of the questions on weekly quizzes come from material from the text. To determine whether students were using their notebook in addition to watching the videos, students were asked whether they took notes from their laboratory manual. Unfortunately, only 41% of students stated that they took notes from the manual itself most weeks. This implies that the majority of students had moved completely away from the manual as a source of information. This finding led to verbal reminders placed in all videos after the midterm that quiz items would also come from the information provided in the notebook.

It is sometimes difficult to ascertain whether material is being presented to students using language they feel is accessible to them. To give an idea of content delivery from the videos, students were asked how complex the vocabulary in the video was in relation to their level of understanding (Table 5.3). The percentage of students responding to each category is also shown below in
Figure 5.2. The A very small percentage of students (7%) felt that the vocabulary was too complex and that they understood very little. Over half of the students (54%) felt that the vocabulary was acceptable and that they understood everything. Another 33% of students stated that the videos contained some complex language, but that they understood most of what was being said. The results of this item indicated that the videos being created were addressing the majority of the population at a level they could easily understand. Students were not uncomfortable with the complexity of the language, and while this does not indicate learning is taking place, it does indicate that the language presented in the videos avoids placing undo stress on students.

Table 5.3 Response to Survey Item Probing Vocabulary in the Videos

<table>
<thead>
<tr>
<th>The vocabulary use in the video was....</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Complex, I understood very little</td>
<td>12 (7.2)</td>
</tr>
<tr>
<td>Complex, I understood most</td>
<td>55 (33.1)</td>
</tr>
<tr>
<td>Acceptable, I understood everything</td>
<td>89 (53.6)</td>
</tr>
<tr>
<td>Too simple, I understood, but it was over simplified</td>
<td>3 (1.8)</td>
</tr>
<tr>
<td>No Response</td>
<td>7 (4.2)</td>
</tr>
</tbody>
</table>
Figure 5.2. Student Attitude Towards Vocabulary Used in the Videos. The majority of students (54%) reported that the material presented in the videos was done with vocabulary that they could easily understand. An additional 33% understood most of the material presented.

A total of 148 students provided a response to the open-ended item that completed the survey. A sampling of student responses that directly addressed concerns regarding student opinion of the video are presented below in Table 5.4. Student responses were grouped based on whether they were positive, negative, or neutral towards the videos. Thirty-one students (20.9%) provided responses that were completely positive and provided no criticism or suggestions for improvement. An additional 40 students (27.0%) voiced approval of the videos but urged that additional items be emphasized. The largest set of responses (66, or 44.6%) provided suggestions with no clear indication whether they were for or against use of instructional videos in the course. Eight students (5.4%) felt negatively towards the videos provided to them. The remaining three
(2.0%) responses had no connection to video instruction and were not considered as part of this analysis.

**Table 5.4 – Sample Statements from the Free-Response Spring 2015 Midterm prompt.**

<table>
<thead>
<tr>
<th>Prompt: Please offer constructive feedback that would improve the pre-laboratory videos. Please keep this civil and limit your responses to video content/style and avoid leaving comments about the actors in the video or chemistry department staff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I really enjoy the lab videos. The equations are hard to do on the quiz because they are not explained well in the video. Other than that I love the videos and they are very helpful.</td>
</tr>
<tr>
<td>b. Good format overall, just feel that since the lab can be taken separately from the lecture, a little more background information would be welcome.</td>
</tr>
<tr>
<td>c. Sometimes the videos can be too long and cause me to lose interest.</td>
</tr>
<tr>
<td>d. I would find it more helpful to include more shots of the minimum required information (tables, graphs) that I would need in my notebook to make recording the data easier.</td>
</tr>
<tr>
<td>e. The videos overall are very beneficial for all types of learners. The only thing that I would suggest changing is the person speaking on the videos. It gets the students attention when they can see different people.</td>
</tr>
<tr>
<td>f. I think the videos are extremely helpful versus and instructor trying to explain procedures and equipment because, with the video, you can pause it and play it back as many times as you want</td>
</tr>
<tr>
<td>g. I think the videos are a good tool to standardize the information being delivered to all classes</td>
</tr>
</tbody>
</table>

The student responses highlighted above not only addressed staff concerns, they are also representative of the majority of student responses.

Overall, the responses to the mid-term survey led us to conclude that students felt positively towards online instruction and appreciated that all enrolled students received an identical pre-laboratory “lecture”. However, responses also indicated that a number of students were struggling to complete the calculations associated with the lab, as numerous free-response items requested additional time be spent on calculations (42 (28%) students mentioned either “math” or
“calculation) (Table 5.4, comment a) and background information (20 (14%) students mentioned “background”, “information”, “purpose” and/or “objective”)(comment b). Length of the video was mentioned (comment c), but the number of students who indicated that they were too long was roughly equal to the number that requested they be lengthened. Responses requesting additional footage depicting proper notebook keeping (comment d) were given 12 (8%) times. Comments directed at staff in the videos (comment e) were given minimal times and were generally positive, though a few students requested seeing more actors used. Comments f and g above will not be elaborated on, but were included in the table as they provided unsolicited comments that addressed some of our goals regarding video instruction.

It should be noted that negative comments were avoided in Table 5.4 because those few that were given by students failed to provide constructive suggestions or requested that we provided step by step instructions that would work against the learning-cycle approach of the activities. Though they will not be included in the discussion below, they are included here in Table 5.5 to provide a complete picture of student opinion to the videos.
### Table 5.5 – Negative Comments Given to the Free-Response Prompt

<table>
<thead>
<tr>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>I really think the videos do not explain in depth the complete procedure. The TAs are not exactly as helpful as I expected them to be. They are also vague with their help. I would prefer for the TA to explain the procedure in class than watch videos.</td>
</tr>
<tr>
<td>The videos do not work.</td>
</tr>
<tr>
<td>I do not find learning at home useful!</td>
</tr>
<tr>
<td>The pre-lab videos do not give us enough information for us to be prepared for lab.</td>
</tr>
<tr>
<td>With the exception of the milk lab, I feel that the videos do not successfully convey all of the info that is needed to comple[te] the lab each week.</td>
</tr>
<tr>
<td>I would love to have an actual teacher in the lab course. The TA has terrible English skills and is impossible to understand. The videos do nothing to help me understand the calculations or science involved in these experiments. I am a 4.0 student currently with a C in lab. I am very disappointed in this class. I will strongly consider taking Chemistry 2 at another college.</td>
</tr>
<tr>
<td>The videos were fine, but I did not like watching videos for a lab.</td>
</tr>
<tr>
<td>Often times the information in the quiz did not reflect the information given in the lab videos or lab manuals, this needs to change. I spent an abundance of time making sure I knew every detail in the video and the manual and I would still end up doing poorly on the lab quizzes</td>
</tr>
</tbody>
</table>

A number of the comments in Table 5.5 pertain to the role of the teaching assistant in the classroom. As mentioned, one goal of the videos was to minimize the instructor effect that accompanies multiple-section, large enrollment courses. The videos have, in fact, met this goal, but some may be concerned that an increased role of video instruction will lead to a decreased role of teaching assistant instruction (and subsequently training). To ensure that teaching assistants are still responsible to interact with their students in an instructional capacity, they have been instructed to reiterate particularly difficult concepts or techniques prior to the activity. They are also still responsible for interacting and
communicating with students during class time, and they still grade weekly assignments, the videos, a lengthy midterm report, and the final exam. The key components of training in instruction are still in place despite the addition of the videos. This can help to enhance the learning experience for both the students and teaching assistants.

**CHANGES IMPLEMENTED AT THE MIDTERM**

The midterm survey reinforced the usefulness of video instruction, but also clearly indicated that students perceived there was room for improvement. The main themes that arose from the free-response comments were addressed in videos created after the midterm. Focusing solely on the technique used in the weekly activities was creating a student population who felt they could perform the needed task but did not have much of an idea why they were doing it and had even less of an idea how to deal with the data that resulted from the task. Background and calculations needed to be presented to students, but we did not want to increase the length of the video. In order to address the issue of lengthy videos (Table 5.4, comment c) and maintain the existing “under 10 minute” time frame, separate background videos were made for laboratory activities performed after the mid-term.
The background videos were voice-over-PowerPoint slides, as shown in Figure 5.3, and provided an explanation of the objectives for the activity, background necessary for a basic understanding of the principles behind the laboratory, and detail on calculations necessary to complete data analysis. The discussion surrounding the calculations was done in a way that addressed the material that students needed to collect based on the variables in the equations they were using that week. A running list of key terms was placed on the right third of the screen to emphasize key ideas and variables to collect data for.

Canvas modules were modified to require students to load both the background and technique videos prior to being granted access to the quiz.

![Figure 5.3 – Background and Calculation Video Shots](image)

Screen shots of the background (a) and calculation (b) portions of the Acid Content in Soda instructional video. This shows that the calculations were described in terms of the equations used. You can also see the running Key Ideas list that built up during the video.

The background video avoided providing data tables for students due to the manner in which the calculations were described. Items of particular interest in data collection were emphasized in the list of key terms. The technique video
featured footage of the actors taking measurements in a data-table in their
notebook. This approach allowed us to include sample notebook pages for
students while keeping the guided-inquiry approach of the activities.

Additionally, the number of actors featured in the technique videos was
expanded to include an increased number of teaching assistants and staff.

The initial videos were well-received, but the camera used to record the
experimental technique lacked sophistication and often could not process frames
fast enough to reduce motion blur. A faster, higher-resolution Sony full-HD
camera was purchased, and the production quality of the videos was increased
to provide students with a more professional end product.

The model of separate background and technique videos was maintained.
The voice-over PowerPoint was replaced with live-narration in front of a chalk-
board style background, shown in Figure 5.4. To strengthen the institutional
presence of the videos, on-screen face-time with the actor was increased and
university branding was used. One actor dedicated to providing background and
calculation instruction throughout the term and another dedicated to describing
proper technique, safety and disposal for the week was used to provide
continuity of instruction. Additional staff was utilized in technique videos.
Figure 5.4 – Examples of the Second Generation videos
Images from the Chemical Equilibrium and LeChatelier’s Principle activity show
the actor-over-greenscreen model that was adopted. The green screen gives a
professional look while allowing images and equations to be shown on screen
with the actor.

The Spring midterm survey showed that the majority of students pause
the videos to take notes. To facilitate this process, visual cues were embedded
into the videos to assist students in identifying key concepts and ideas. Two sets
of visual cues were used, one a subtle pencil point and the second a more
obvious text box instructing students to take note of what was just said. Data
collection as to the effectiveness of either or both of the visual cues on written
pre-laboratory preparation is currently underway. The placement and length of
the cues is identical between the two videos, as is the instruction itself. Data
collection is being completed as part of a treatment/treatment experimental
design. The choice to avoid using a control group, which would have received no
visual cue at all, was made to ensure that all students receiving the instructional videos would receive some instruction on what was important to include in their notes. The limitations of not having a true control group for comparison were outweighed by the potential instructional benefit to the student.

**INITIAL CONCLUSIONS**

Instructor-created instructional videos have allowed us to offer uniform instruction to all students enrolled in our general chemistry laboratory courses. The instructor effect that is so often present when instructors of various backgrounds are placed in a multiple-section course, such this sequence, has been minimized, and students have acknowledged that they feel all enrolled students are treated fairly. The videos offer a means of ensuring everyone is made aware of important safety and disposal information. They allow students to review the material presented at their own pace and as many times as needed. Closed captioning both allows us to tailor instruction to our hearing impaired students and gives all students the chance to annotate their laboratory notebook from a script. Creating high-quality instructional videos is a large task, and requires facilities, equipment and a dedicated staff, but the rewards to both instructor and student greatly outweigh these drawbacks.
A major limitation of this initial work is the lack of an adequate assessment piece to allow for dissemination. This is not uncommon in formative SoTL work, but for the videos to be elevated to a product that can be shared with others (i.e., to move the project forward to DBER work), further study of their benefits to students is required. Though the student survey was carefully thought out and distributed in such a way to address a variety of students, it should still be considered formative. Additional feedback from students should be obtained, including which aspects of the videos they felt were most useful. A comparison of student learning gains between semesters when no videos were offered and those when videos (both first and second generation) should be performed. Additional assessment pieces, including a careful study of the reduction of time spent in lab, teaching assistant opinion of the videos as they relate to both student instruction and their own professional training, and the applicability of the materials to an online learning environment, should also be undergone. The formative work done during the initial three semesters will help to create a meaningful and valid experimental design that will allow us to speak to the usefulness and broad applicability of the videos as teaching tools.
CHAPTER VI

FUTURE DIRECTIONS

The studies that we have done regarding video use in student learning show that they have utility in multiple facets of laboratory instruction. We have seen the success of student-created videos as an assessment and the wide acceptance of instructional videos as a content-delivery tool. The resources we have built as these projects have developed open the door for further development of video-based teaching tools. The future of instruction is grounded in technology, and a better understanding of the elements of video that make it compelling for student learning is necessary to create the most useful product possible. Maximizing interaction between the student and the video instruction by increasing the prevalence of learning-cycle activities will lead to more meaningful learning. Implementation of both of these concepts will increase the validity and effectiveness of online courses.
Further Assessment of Instructional Videos

As mentioned in previous chapters, dissemination of the video project will be most meaningful if we are able to determine that they benefit student learning in a positive way. One way to come to this determination is to investigate if the videos, specifically if visual cues imbedded in the videos, lead to an increase in positive student behaviors. The Spring midterm survey suggested that the majority of students pause the videos to take notes. However, it is not clear what notes they are recording or what level of detail they are using to make annotations. It is also unclear what actually prompts a students to take notes. As there is a desire to increase interaction between the students and the video, which we hope will in turn lead more students to take notes during the video presentation, visual cues were embedded into the videos to assist students in identifying key concepts and ideas and to prompt them to include these concepts in their notebook. Two sets of visual cues were used, one a pencil icon and the second a text box instructing students to take note of what was just presented. Data collection as to the effectiveness of either or both of the visual cues on written pre-laboratory preparation is currently underway. The placement and length of the cues is identical between the two videos, as is the instruction itself. Data collection is being completed as part of a treatment/treatment experimental design. The choice to avoid using a control group, which would have received no
would receive some instruction on what was important to include in their notes. The limitations of not having a true control group for comparison were outweighed by the potential instructional benefit to the student. The results of this analysis will inform the community on the effectiveness of visual prompts in instructional videos, and will lead to production of instructional content that increases student interaction by encouraging engagement with the course material.

Data collection regarding the time spent in the laboratory after the implementation of the videos should be undergone. This data would allow for determination of whether moving the majority of the pre-laboratory instruction and requiring the pre-laboratory quizzes be completed prior to attending the laboratory have worked to shorten the laboratory period sufficiently to allow for two-hour periods and thus additional section offerings. If it has not, this data would drive the revision of the current activities (and/or the development of new ones) that would fit into this window. Shortening the laboratory period would allow increased access to the course for UAB students.
Strengthening the Weaknesses Regarding the Use of Instructional Videos

The instructional videos implemented are well thought-of among students. However, additional vetting and revision is necessary to maximize both instruction and learning. Additional peer-review should be undergone, including from undergraduates enrolled in the course, teaching assistants, the laboratory coordinator, and additional department staff. This additional vetting would eliminate miswording, and the inclusion of faculty who instruct upper division courses would help to ensure that instruction provided to students in CH116 parallels the theories and skills they will need later in their studies.

The greatest strength of the videos is the minimization of the instructor effect in the classroom. Unfortunately this could also be seen as their greatest weakness, as it takes a large portion of the responsibility for instruction away from the teaching assistant. Leading inquiry-based activities is difficult for some teaching assistants for a variety of reasons; they want to speed things along in their laboratory, they are uncomfortable watching their students struggle, they have a desire for to be well-liked by their students, or they just do not have an understanding of the benefits of inquiry-based learning. Additional training, specifically on the best practices of inquiry (and teaching in general) could be offered to the teaching assistants so they better understand what is expected of them in regards to the activities. Increased emphasis can be placed on reiteration
of difficult topics presented in the videos prior to the beginning of an activity, which would help develop both communication and instructional skills. For those students who are less comfortable with their ability to direct instruction, “scripts”, which include prompts to spark discussion, could be written by the coordinator and distributed in the form of a teaching assistant manual.

Teaching assistants may be more likely to play a direct role in their students’ education if they are made aware of their strengths and weaknesses as instructors. Historically, teaching assistants have had very little feedback in the form of surveys from students or constructive criticism from instructors. The absence of a feedback loop, and subsequent consequences if minimum requirements are not met, have led some teaching assistants to skate by as instructors. Middle- and end-of-term surveys could be implemented to allow teaching assistants insight into the view students have of them in the classroom. Items could be directed towards communication skills, organization, and grading. The middle-term survey could be used to immediately implement changes in the teaching assistant behavior. These surveys are admittedly not directly related to the implementation of the instruction videos, but could improve the laboratory experience for both the teaching assistant and the students.
The actors in the videos are often recognized by students as they move around campus. Particularly good-natured students have even asked the actors to sign their laboratory manuals or take a picture with them. While this is light-hearted and silly, it indicates that the students who view the videos see the actors as legitimate instructors who deliver content. Expanding the cast of actors to include teaching assistants could increase how their students perceive their authority. For those particularly interested in teaching in the long term, video projects, including writing scripts, starring in, and editing videos could be assigned to allow them an increased role in the instructional process. These changes could help to elevate the role of the instructor in the eyes of their students and would also help teaching assistants have a better understanding of the work that goes into creating instructional materials.

**Challenge videos**

Video instruction is a useful tool, but without meaningful interaction between the student and the material, the effectiveness of the instruction comes into question. “Challenge Videos”, which will follow the learning cycle approach of exploring material, inventing a solution, and applying information to solve a problem. Modules will be designed to improve students’ understanding of the course content and the scientific process by utilizing the learning cycle with a
“challenge video, assessment, explanation video” design. The modules will be created that include (1) a video that provides background on a topic and introduces a “model” for exploration of problem, (2) an assessment to determine whether students can invent a solution and apply it to the problem, and (3) a second video that provides at least one possible solution to the exploration. These materials will provide high-quality, inquiry-based instruction and are anticipated to lead to better retention of course content.

The interactive nature of the proposed videos will emphasize the importance of inquiry in science and will access of higher order thinking skills. Attainment of the goal will be realized by developing the necessary video modules and then assessing their effectiveness on retention of course content. To determine whether the newly created learning tools are successful, we will implement a Pre-/Post-Test experimental design. Finally, to ensure that the impact of the work is maximized within the STEM community, we will disseminate our work via the traditional routes.
Figure 6.1 – Experimental Design to Measure Effectiveness of Challenge Videos

This figure details the pre-/post-experimental design, as well as the data collection/analysis points associated with the study of how effective the challenge videos are to create meaningful learning for students.

Online Courses

Understanding the correlation between the stylistic elements and content of instructional videos and student performance will provide the community data that will ensure identical, effective instruction is offered to every student, whether they are physically present in the classroom or not. On many campuses including ours, enrollment has increased while available facilities have remained unchanged in recent years. One current push to alleviate these growing pains is to increase the number of courses that are offered online (Pienta, 2013). The instructional materials and relevant findings gained as part of the instructional
video project will allow us to create online chemistry courses at this institution. Online instructional content will be built on the extant literature to inform programs that seek to offer online laboratory (Casanova, Civelli, Kimbrough, Heath, & Reeves, 2006; Phipps, 2013). Online courses will extend the reach of the university, offering opportunities to individuals who otherwise might not be able to take chemistry courses. This increased outreach is an exciting opportunity to increase interest in chemistry at UAB, and carefully designed research studies surrounding the online course will inform the community of the best practices of online chemistry education.

**Professional Development**

The recent increase in the acceptance of education based research as an important and valid area of focus is due not only to an increase in the rigor of the discipline (as evidenced by the goals for DBER research set forth by the NRC (Singer et al., 2012), but also because of dissemination and opportunities for professional development. My goal as a member of both the SoTL and CER communities is to educate others in teaching fields on the importance of educational research and to work with them to develop materials and assessment methods to quantitate work they have done in their own classroom. I have already been given the opportunity to do this as an instructor for the Graduate School at UAB. I hope to be able to continue educating graduate students about
implementing SoTL work into their teaching assistant experiences. I would also invite the opportunity to train and work with faculty on the assessment and dissemination of course improvements implemented in their classroom. The text provided in this dissertation has offered examples of both small- and large-scale projects, and relates them successfully to SoTL and DBER work, respectfully. I hope that members of the community will find these examples helpful to them in their own teaching.
REFERENCES


Benedict, L., & Pence, H. E. (2012). Teaching Chemistry Using Student-Created Videos and Photo Blogs Accessed with Smartphones and Two-Dimensional


Bodner, G. M. (2011). The development of research in chemical education as a field of study, (765), 16–21.


APPENDIX A.1 – Video Shooting Guide Offered to Students Through the LMS to help them create a useful video product.

Chemistry Video—Filming Guidelines
Consumer-level digital video cameras, digital still cameras, and phones have the capability to record video and audio at a quality to satisfy this assignment. You want to make sure the device you choose has the following recording capability:

- Record for at least 3 minutes long at a take or shot
- Record video AND audio
- Can export the recording to a computer for basic editing

Workflow:

- Understand the lab assignment and write a brief script or outline of what you will say. Three minute time length.
- Rehearse your script.
- Make sure all your lab items are prepared and in reach
- Analyze your location for light and sound
- Set up the camera and do a run-through:
  - Can you see the presenter and the lab equipment clearly? Do they fill up most of the frame? If not, reframe the shot by moving in closer or zooming in.
  - Can you hear the presenter speaking? Play back your rehearsal recording and if you cannot hear, move the camera and internal microphone closer.
- Film the entire lab start to finish in a wide shot
- Re-shoot the elements of the lab that are most technical in close-up. When you edit, you can cut in these close up shots to point out the specific techniques you are describing.
- Export the footage to your computer and use editing software to cut a three-minute video from your footage. Most computers come loaded with Windows Moviemaker or Apple iMovie.
- Export you finished video and upload to YouTube
- Link your YouTube video to your class Blackboard Learn site

Composition
The goal of this assignment is to demonstrate your master of chemistry lab techniques. You need to make sure your work fills the frame of the video. If the camera is too far away, you and your work will be too small to assess for a grade. Use the compositional frame well and think about filling the space.
Always shoot so that your frame is horizontal (longest part of the rectangle is horizontal)!

Your Widest Shot:
- The lab presenter occupies almost entire top to bottom of frame.
- Her arm and balance occupy almost entire length (left to right) of frame.
- You will shoot your entire lab start-to-finish in this framing.

Close up Shots:
- For the more technical elements, shoot in close up. You can drop in these close-up shots in the editing.
- You will shoot these select close-ups after you have shot the entire lab in wide shot.

You want to minimize your time editing, so make sure you have a start-to-finish take of your entire lab that can used as the main narrative of your finished video. You can cut away to a close-up shot to illustrate a certain point or cut way to a different take to hide a mistake or omission. You do not want to be in a position where you have to piece the lab together after the fact with bits and pieces of random shots.

Audio
The microphones on consumer cameras and phones are designed to be close. Try to shoot within conversational distance for clear audio (~3-5 feet). Listen to a rehearsal recording to make sure your audio is clear. If you are too far away, move closer. If the background noise is too loud or distracting, move to a quieter place or wait until the room is less crowded.

If your audio is not clear, you may have the option of recording a voiceover track separately which you can add in to your edited video. In your editing software, you will have the option to delete your audio track recorded in the lab and you can insert your new voiceover recording.
Lighting
Make sure your image is well-lit so that you can clearly see your presenter and the lab equipment. If you are in a dark or dim area, move to a brighter area. Do not shoot with a bright window behind you. You will look silhouetted because the camera cannot compensate for the bright sunlight coming in behind you. Film with the window behind you, or move to a more interior location in the room.

Steadiness
Holding a small camera or phone steady is difficult to do. If you do not have a tripod, use a stack of books to prop the camera up or brace your arm against a wall or table or even bending it to brace against your body to minimize camera motion.

Editing
Transfer your footage to a computer and open your video editing software (for many of you, Windows Moviemaker or iMovie). Select your best start to finish take and lay that clip down in your movie sequence. You can add your close up shots when appropriate: the rule of thumb is SEE and SAY. When the lab presenter SAYS something, you can cut to your close-up so that we can SEE it. When the presenter moves on to the next point, the close up shot can end. You do not need to fade or dissolve to and from these cuts.

Troubleshooting: If your recorded audio is unusable, you can separately edit the audio and video from your clips. You are able to keep your video track and delete the audio track. You can record a new audio voiceover track from your script, import it into the computer and lay it down under your video picture.

You are welcome to add text or fades to black at the beginning or end of the video, but do not exceed three minutes.

When you are done, you will export your video in one of the accepted YouTube formats (.mov, .wav., .mp4, for example) to prepare for upload.

Examples of successful videos:
2. http://www.youtube.com/watch?v=3wOPthcJkRg&feature=related

160
Uploading Movie to YouTube

(1) To upload a movie to YouTube, you must have both a YouTube account and a Google account:
   a. to create an account, click the Create Account link at the top of the home page (www.youtube.com) and follow the given instructions
   b. if you already have a YouTube account, sign in with your username and password
(2) click on the Upload link in the top right-hand corner of any YouTube page
(3) click the yellow Upload video button to browse for the video file of interest; select the file you want to upload and click “Open”
(4) while the video file is uploading, enter as much information about your video as possible into the relevant fields (including Title, Description, Tags, and Category)
(5) click the “Save changes” button to save your updates
(6) the web address of your uploaded video will be displayed at the top of the screen; remember to take note of this!

Uploading YouTube Videos to UAB Blackboard Learn

(1) using your BlazerID and password, login to the UAB Blackboard Learn website at https://cms.blazernet.uab.edu/cgi-bin/bb9login
(2) under “My Courses”, click on the link for your section of CH116
(3) click on the Assignments button in the Course Menu, located on the left-hand side of the screen
(4) click on the particular assignment for which you are submitting a video
(5) an Upload Assignment form will appear; make sure that the Text Editor button is switched “on”
(6) to upload YouTube video(s) to the assignment, click on the “Add Mashup” button in the Text Editor menu bar
(7) a drop-down menu will appear; select “YouTube Video”
(8) a pop-up menu will appear that enables you to search YouTube for your video:
   a. it is recommended that you search for your video using the “Exact Phrase” option
b. the matching video(s) will be displayed; click on the “Select” button for the video to be uploaded

(9) a new window entitled **Create Mashup Item** will appear:
   a. the video can be displayed as a thumbnail, a text link, or an embedded video; the choice is up to the student
   b. under **Mashup Options**, select “Show YouTube URL” and “Show YouTube Information”
   c. to preview the mashup item, click on “Preview”
   d. to attach the video to the assignment, click on “Submit”
   e. the video should now appear in the **Upload Assignment** form under “Assignment Materials”
(10) finally, click the green “Submit” button to send the assignment in for grading
APPENDIX A.2 – First Version of the Video Grading Rubrics (Summer 2011)

Balance Video Grading Rubric (15 total points):

Lab Group Members:___________________________________________________________

TAs: The video should fall into one category under each of the following headings. Choose the category you feel best describes the submitted video. Items that have and underlined require every piece mentioned in the item.

---

**(2 pts possible) General video quality:**

**(2 pts)** The video was shot in a manner that allows for clear observation of measured values, all close ups of notebooks and meniscus allow the viewer to read results, and explanations or definitions are audible.

**(1 pt)** The students can all be seen performing the procedure (or the audio provides a reasonable description), but the video was not shot in a manner to allow the viewer to determine the accuracy of any measurements.

**(0 pts)** The video does not allow for any determination of how the measurements were made.

---

**(5 pts possible) Technique:**

**(5 pts)** Each student in the group can be seen taring the balance, obtaining the mass of their weighing vessel, adding sample away from the balance, and obtaining the mass of the weighing vessel and sample together. All of the previous, as well as what data must be recorded to obtain mass of sample, must be accompanied with explanations.

**(3 pts)** Each student in the group can be seen performing the majority of the steps adequately, but not all of them. All of the previous must be accompanied with explanations.

**(1 pt)** Each student in the group can be seen performing the majority of the steps adequately, but not all of them. Also, the previous items are not accompanied with explanations.

**(0 pts)** The entire group is not seen in the video.

---

**(2 pt possible) Uncertainty question**

(completed as a group, once per video)

**(2 pt)** The students describe where the uncertainty of the balance lies and describe that external effects cause the readout to shift. A description of what steps can be taken to minimize this effect are also described.

**(1 pt)** The students mention the uncertainty and its effect on the readout, but fail to offer explanation of why this happens.

**(0 pts)** This question is not addressed in the video.

---

**(2 pts possible) Consistently using the same balance**

(completed as a group, once per video)

**(2 pt)** The students mention that it is important to consistently used the same balance throughout an entire experiment and provide sufficient example to support their claim.

**(1 pt)** The students mention that they should use the same balance through an experiment, but fail to explain why.

**(0 pts)** This question is not addressed in the video.

---

**(2 pts possible) Notebook:**

**(2 pts)** The notebook is clearly shown in the video and includes: a 'named' or labeled sample, data for initial and final masses, and all decimals given by the balance have been recorded.

**(1 pt)** The notebook is shown in the video, but data for initial and final mass are not shown or all decimals given by the balance have not been recorded.

**(0 pts)** The notebook is not shown at all in the video or is shown in a way that makes it difficult to determine what was recorded.

---

**(2 pts possible) Usefulness:**

**(2 pts)** The video is an excellent resource (all technical steps are present and correct) and could be used in the future as a teaching tool.

**(1 pt)** The video had limited use in the future due to significant errors in technique and/or description. It is evident that students had only a limited grasp of the concepts at hand.

**(0 pts)** The video will have no future use and should not be used as a review of technique.

---

**(15 pts possible) Overall Grade**

(10 of 15 points required to earn extra credit)
Titration Video Grading Rubric (15 total points):

Lab Group Members:__________________________________________________________

TAs: The video should fall into one category under each of the following headings. Choose the category you feel best describes the submitted video. Items that have **and** underlined require every piece mentioned in the item.

___ (2 pts possible) General video quality:
____ (2 pts) The video was shot in a manner that allows for clear observation of measured values, all close ups of notebooks and meniscus allow the viewer to read results, **and** explanations or definitions are audible.  
____ (1 pt) The students can all be seen performing the procedure (or the audio provides a reasonable description), but the video was not shot in a manner to allow the viewer to determine the accuracy of any measurements. 
____ (0 pts) The video does not allow for any determination of how the measurements were made.

___ (2 pts possible) Definition of titration:
(Completed as a group, once per video.)
____ (2 pts) The students describe why titrations are performed, what data you need to know before beginning a titration, what data should be collected to determine the unknown variable, **and** they give an explanation of how to read a volume (to the correct number of decimal places).  
____ (1 pt) The students adequately describe why a titration is performed but fail to mention data or the students fail to mention why a titration is performed but mention the data that must be collected. 
____ (0 pts) The above information is not mentioned in the video.

___ (2 pts possible) Definition of Priming (cleaning) the Buret (Note: the actual action doesn’t need to be included in the video and explanation may be included as a group, once per video.)
____ (2 pts) The students mention that the pipette was rinsed with water and solution 3x each before use. 
____ (1 pt) The students mention that the pipette needs to be cleaned prior to use but do not give details how. 
____ (0 pts) Priming is not mentioned in the video.

___ (5 pts possible) Technique:
____ (5 pts) Each student in the group can be seen determining the initial volume, properly releasing a volume, swirling the reaction vessel, **and** determining the final volume. The end point reached must be a light pink color. All of the previous must be accompanied with explanations.
____ (3 pts) Each student in the group can be seen releasing a volume and swirling the reaction vessel, but it is difficult to determine whether the students are determining the initial and final volumes. **And/or** the end point reached is a dark pink color. 
____ (1 pt) Each student in the group can be seen releasing a volume and swirling the reaction vessel, but it is difficult to determine whether the students are determining the initial and final volumes. And/or the end point reached is a dark pink color.
____ (0 pts) The entire group is not seen in the video.

___ (2 pts possible) Notebook:
____ (2 pts) The notebook is clearly shown in the video and includes: a ‘named’ or labeled sample, data for initial and final volumes of a labeled titrant, **and** all volume data is recorded to two decimal places. 
____ (1 pt) The notebook is shown in the video, but data for initial and final volume are not shown or the data is not recorded to two decimal places. 
____ (0 pts) The notebook is not shown at all in the video or is shown in a way that makes it difficult to determine what was recorded.

___ (2 pts possible) Usefulness:
____ (2 pts) The video is an excellent resource and could be used in the future as a teaching tool. 
____ (1 pt) The video had limited use in the future due to significant errors in technique and/or description. It is evident that students had only a limited grasp of the concepts at hand. 
____ (0 pts) The video will have no future use and should not be used as a review of technique.

___ (15 pts possible) Overall Grade  
(10 of 15 points required to earn extra credit)
Chromatography Video Grading Rubric (15 total points):

Lab Group Members:________________________________________________________________________

TAs: The video should fall into one category under each of the following headings. Choose the category you feel best describes the submitted video. Items that have and underlined require every piece mentioned in the item.

___ (2 pts possible) General video quality:
___(2 pts) The video was shot in a manner that allows for clear observation of measured values, all close ups of notebooks and meniscus allow the viewer to read results, and explanations or definitions are audible.
___(1 pt) The students can all be seen performing the procedure (or the audio provides a reasonable description), but the video was not shot in a manner to allow the viewer to determine the accuracy of any measurements.
___(0 pts) The video does not allow for any determination of how the measurements were made.

___ (2 pts possible) Definition of chromatography: (Completed as a group, once per video.)
___(2 pts) The students describe the usefulness of the chromatography and explain what is happening on a molecular level. Descriptions of the polarities of the dyes, mobile phases and stationary phases are given. An explanation of the difference in separation between different plates is also given.
___(1 pt) The students do not provide sufficient explanation for all of the above items.
___(0 pts) The meniscus is not mentioned in the video.

___ (4 pts possible) Notebook/Data collection:
___(4 pts) The notebook and plate are clearly shown in the video and include: a reference guide to the sample spotting on the TLC plates, an indication of where the solvent front ended, measurements of each spot on the plate, a clear measurement of the distance the solvent traveled, and all Rf data is collected and calculated to the correct number of decimal places.
___(2 pt) The notebook and plate are shown in the video, but only 3-4 of the above criteria were met.
___(0 pts) The notebook is not shown at all in the video, or 2 or fewer of the criteria were met, or is shown in a way that makes it difficult to determine what was recorded.

___ (5 pts possible) Technique:
___(5 pts) Each student in the group can be seen spotting a plate, placing the plate in a beaker large enough that it will not curl, and taking measurements for Rf values. All plates were removed from the chambers free the solvent reached the top of the plates. Sufficient separation can be seen between the spots and the solvent front. All of the previous must be accompanied with explanations.
___(3 pts) Students can be seen performing some but not all of the necessary procedure. All plates were removed from the chambers free the solvent reached the top of the plates. Sufficient separation can be seen between the spots and the solvent front. All of the previous must be accompanied with explanations.
___(1 pt) Students can be seen performing some but not all of the necessary procedure, and the solvent either traveled to the top of the plate or insufficient separation was recorded. Also, the previous items are not accompanied with explanations.
___(0 pts) The entire group is not seen in the video.

___ (2 pts possible) Usefulness:
___(2 pts) The video is an excellent resource and could be used in the future as a teaching tool.
___(1 pt) The video had limited use in the future due to significant errors in technique and/or description. It is evident that students had only a limited grasp of the concepts at hand.
___(0 pts) The video will have no future use and should not be used as a review of technique.

___ (15 pts possible) Overall Grade
(10 of 15 points required to earn extra credit)
Pipette Video Grading Rubric (15 total points):

Lab Group Members:___________________________________________________________

TAs: The video should fall into one category under each of the following headings. Choose the category you feel best describes the submitted video. Items that have **and** underlined require every piece mentioned in the item.

___ (2 pts possible) General video quality:
__(2 pts) The video was shot in a manner that allows for clear observation of measured values, all close ups of notebooks and meniscus allow the viewer to read results, and explanations or definitions are audible.
__(1 pt) The students can all be seen performing the procedure (or the audio provides a reasonable description), but the video was not shot in a manner to allow the viewer to determine the accuracy of any measurements.
__(0 pts) The video does not allow for any determination of how the measurements were made.

___ (2 pts possible) Definitions of meniscus:
(Completed as a group, once per video.)
__(2 pts) The students describe what a meniscus is, why a meniscus occurs, gives an explanation of how to read a volume (the bottom of the meniscus), and provides an example of a meniscus with their pipette (a detailed drawing may also be included).
__(1 pt) The students adequately describe how to read a meniscus but fail to provide an example (or the video is shot in a manner that does not allow the viewer to read it) or the students provide a visible example but lack a detailed definition.
__(0 pts) The meniscus is not mentioned in the video.

___ (2 pts possible) Definitions of Priming (cleaning) the Pipette (Note: the actual action doesn’t need to be included in the video and explanation may be included as a group, once per video.)
__(2 pts) The students mention that the pipette was rinsed with water and solution 3x each before use.
__(1 pt) The students mention that the pipette needs to be cleaned prior to use but do not give details how.
__(0 pts) Priming is not mentioned in the video.

___ (5 pts possible) Technique:
__(5 pts) Each student in the group can be seen drawing up a volume, determining the initial volume, transferring from the pipette to the reaction vessel properly, and determining the final volume. All of the previous must be accompanied with explanations.
__(3 pts) Each student in the group can be seen drawing up a volume and transferring to the reaction vessel, but it is difficult to determine whether the students are determining the initial and final volumes. All of the previous must be accompanied with explanations.
__(1 pt) Each student in the group can be seen drawing up a volume and transferring to the reaction vessel, but it is difficult to determine whether the students are determining the initial and final volumes. Also, the previous items are not accompanied with explanations.
__(0 pts) The entire group is not seen in the video.

___ (2 pts possible) Notebook:
__(2 pts) The notebook is clearly shown in the video and includes: a ‘named’ or labeled sample, data for initial and final volumes, and all volume data is recorded to two decimal places.
__(1 pt) The notebook is shown in the video, but data for initial and final volume are not shown or the data is not recorded to two decimal places.
__(0 pts) The notebook is not shown at all in the video or is shown in a way that makes it difficult to determine what was recorded.

___ (2 pts possible) Usefulness:
__(2 pts) The video is an excellent resource and could be used in the future as a teaching tool.
__(1 pt) The video had limited use in the future due to significant errors in technique and/or description. It is evident that students had only a limited grasp of the concepts at hand.
__(0 pts) The video will have no future use and should not be used as a review of technique.

___ (15 pts possible) Overall Grade
(10 of 15 points required to earn extra credit)
APPENDIX A.3 – Questions Presented to students on the Summer 2011 Free Response Survey and Select Representative Responses.

1. What were the strengths of the student-created video assessment?
   Fun and hands-on; different than normal labs, but still a learning experience.
   Had to understand the concepts more.
   They were more interesting as they were more interactive.
   Interesting new take on lab reports.
   Created unity amongst the group.
   Forced us all to try the technique.

2. What were the weaknesses of the student-created video assessment?
   Did not have any editing experience.
   Cell phone video was poor – led to poor product.
   The lab was loud during recording – had to add subtitles.
   I’m camera shy – this made me uncomfortable.
   Tough to schedule the group for editing/reshoot.

3. Would you be willing to take other courses that required video assignments?
   Yes (56%)
   Maybe (3%)
   No (33%)
   No Response (8%)

4. What, if any, tutorials would have been helpful in creating and/or editing your videos?
   The tutorials already provided were helpful.
   More examples of videos.
   How to write a script.
UAB's Institutional Review Boards for Human Use (IRBs) have an approved Federalwide Assurance with the Office for Human Research Protections (CHRP). The Assurance number is FWA00005960 and it expires on September 29, 2013. The UAB IRBs are also in compliance with 21 CFR Parts 50 and 56.

Principal Investigator: ERDMANN, MITZY
Co-Investigator(s):
Protocol Number: E110697002
Protocol Title: Student Produced Laboratory Videos: Creating a Personal How-To Library of Laboratory Techniques

The above project was reviewed on 7/11/11. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services. This project qualifies as an exemption as defined in 45CF46.101, paragraph .

This project received EXEMPT review.
IRB Approval Date: 7/11/11
Date IRB Approval Issued: 7/11/11

Marilyn Doss, M.A.
Vice Chair of the Institutional Review Board for Human Use (IRB)

Investigators please note:

IRB approval is given for one year unless otherwise noted. For projects subject to annual review research activities may not continue past the one year anniversary of the IRB approval date.

Any modifications in the study methodology, protocol and/or consent form must be submitted for review and approval to the IRB prior to implementation.

Adverse Events and/or unanticipated risks to subjects or others at UAB or other participating institutions must be reported promptly to the IRB.
CONSENT TO PARTICIPATE IN AN EDUCATION STUDY

You are invited to participate in a study conducted by Mitzy Erdmann, Dr. Joe March, and Christine Pressey of the Chemistry Department at The University of Alabama at Birmingham (UAB). We aim to learn the value of student-created video assignments as an alternative assessment in the general chemistry laboratory. You were selected as a possible participant in this study because of your current enrollment in Chemistry 116.

Should you choose to participate, you will be asked to complete two surveys, one at the onset of the course, and a final one at the completion of the course. The surveys will be brief and should take no more than 15 minutes of your time for each one as they will be given during class. These surveys will seek to determine your familiarity with cell phone video capture and digital video editing technologies, as well as your opinions of the effectiveness and educational value of the video lab report assignments. All survey responses will be anonymous, and honest and open answers to any questions presented on the surveys will not adversely affect your final grade in Chemistry 116.

This education study poses no physical or emotional risk to you as the voluntary participant, and participation should not inconvenience you in any way, as surveys will be issued during your scheduled laboratory time. There will be no monetary requirement on your part, nor will you be compensated for participating in the study.

Any information that is obtained in connection with this study will not be identifiable with you and will remain confidential. If you give us your permission by completing the opinion survey, we plan to disclose results in the form of statistical data published in scholarly educational journals. Data will also be collected from required course assignments such as reports, quizzes, videos, or final exams and is exempt from obtaining consent. Again, this data will be disclosed in the form of statistical data published in scholarly journals and will be done so anonymously and in aggregate.

Your decision whether or not to participate will not prejudice your future relations with the Chemistry Department or UAB in any way. If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time without penalty. The Institutional Review Board for Human Use of UAB has reviewed and approved the present research.

If you have any questions, please ask us. If you have any additional questions later, Mitzy Erdmann (205-934-7300, merdmann@uab.edu) will be happy to answer them. Questions regarding the rights of research subjects may be directed to UAB’s Institutional Review Board of Human Use, 205-934-3789.

You are being given this copy of this form to keep.

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE. YOUR COMPLETION OF THE SURVEY INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE IN OUR EDUCATIONAL STUDY, HAVING READ THE INFORMATION PROVIDED ABOVE.
APPENDIX A.5 – Aggregated Responses to the Likert-Type Surveys Given to CH116 Students in Fall 2011 and CH116 and CH118 Students in Spring 2012. Responses are presented as percentages, and grouped into positive (completely agree and agree), neutral, and negative (disagree and completely disagree).

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strong Agree or Agree</th>
<th>No Opinion</th>
<th>Disagree or Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I found it easy to record the video on my cell phone/camera/iPad</td>
<td>72.2</td>
<td>11.2</td>
<td>16.0</td>
</tr>
<tr>
<td>After practice, I found it easy to edit the videos.</td>
<td>55.3</td>
<td>23.8</td>
<td>20.8</td>
</tr>
<tr>
<td>I reviewed the rubrics provided in BBL in preparation for recording the videos.</td>
<td>73.3</td>
<td>12.4</td>
<td>14.3</td>
</tr>
<tr>
<td>The rubrics were easy to follow.</td>
<td>71.8</td>
<td>15.4</td>
<td>12.7</td>
</tr>
<tr>
<td>I knew what the TA would be grading for because of the rubrics.</td>
<td>83.7</td>
<td>6.7</td>
<td>9.1</td>
</tr>
<tr>
<td>I felt my grades on the videos were as good or better than those on the written reports.</td>
<td>64.6</td>
<td>19.2</td>
<td>11.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Response</th>
<th>Response</th>
<th>Response</th>
<th>Response</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which device did you find it easiest to use to record your video?</td>
<td>Cell Phone 54</td>
<td>Camera 34</td>
<td>iPad (Tablet) 6</td>
<td>Other Device 4</td>
</tr>
<tr>
<td>Which, if any, of the following software did you use to edit your videos?</td>
<td>Movie Maker 43</td>
<td>iMovie 31</td>
<td>YouTube 6</td>
<td>Other Software 17</td>
</tr>
<tr>
<td>Which, if any, of the following tutorials available on BBL did you use to create or edit your videos?</td>
<td>Movie Maker Tutorial 17</td>
<td>iMovie Tutorial 12</td>
<td>Uploading your videos to YouTube tutorial 27</td>
<td>Chemistry Video Shooting Guide 20%</td>
</tr>
</tbody>
</table>

170
APPENDIX B

SUPPLEMENTAL MATERIAL PUBLISHED BY THE JOURNAL
CHEMICAL EDUCATION RESEARCH AND PRACTICE
**SI Table 1.** Formative survey items and rate of student response (given in %). Surveys were collected over two semesters (Fall 2011 and Spring 2012). All students enrolled in the first semester general chemistry laboratory were asked to participate in Fall 2011 and all students enrolled in both semesters of the general chemistry laboratory sequence participated in Spring 2012. Survey completion was performed at the close of the term, was voluntary, and in no way affected students grades in the course.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>No Opinion</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I found it easy to record the video on my cell phone/camera/iPad.</td>
<td>34.70</td>
<td>38.81</td>
<td>10.05</td>
<td>6.39</td>
<td>9.13</td>
</tr>
<tr>
<td>After practice, I found it easy to edit the video.</td>
<td>20.09</td>
<td>32.42</td>
<td>26.94</td>
<td>13.24</td>
<td>7.31</td>
</tr>
<tr>
<td>I liked the video reports better than the written reports.</td>
<td>17.81</td>
<td>22.37</td>
<td>17.81</td>
<td>17.35</td>
<td>24.66</td>
</tr>
<tr>
<td>It was easy to turn in my assignments in BlackBoard Learn.</td>
<td>29.68</td>
<td>36.07</td>
<td>16.89</td>
<td>8.22</td>
<td>9.13</td>
</tr>
<tr>
<td>I feel that I will review my videos to refresh my technique in later courses.</td>
<td>8.68</td>
<td>9.59</td>
<td>26.03</td>
<td>26.03</td>
<td>29.68</td>
</tr>
<tr>
<td>I reviewed the rubrics provided in preparation for recording the videos.</td>
<td>31.51</td>
<td>42.92</td>
<td>11.42</td>
<td>4.57</td>
<td>9.59</td>
</tr>
<tr>
<td>The rubrics were easy to follow.</td>
<td>25.11</td>
<td>44.29</td>
<td>15.53</td>
<td>7.76</td>
<td>7.31</td>
</tr>
<tr>
<td>I knew what the TAs would be grading for because of the rubrics.</td>
<td>42.01</td>
<td>40.18</td>
<td>7.76</td>
<td>3.65</td>
<td>5.94</td>
</tr>
<tr>
<td>My grades on the videos were comparable to the written reports.</td>
<td>29.22</td>
<td>35.16</td>
<td>21.00</td>
<td>3.65</td>
<td>5.94</td>
</tr>
</tbody>
</table>
SI Table 2. Student response data for the pre-test, post-test, final examination, and laboratory practical. Counts were used in 2x2 contingency tables for within group analysis (McNemar’s $\chi^2$ values and Odds Ratios (OR)) to determine differences in student performance on the various test items.

<table>
<thead>
<tr>
<th></th>
<th>Pipet (N=233)</th>
<th>Balance (N=276)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre and post right (Yes/Yes)</td>
<td>82</td>
<td>91</td>
</tr>
<tr>
<td>Pre right, post wrong (Yes/No)</td>
<td>19</td>
<td>37</td>
</tr>
<tr>
<td>Pre wrong, post right (No/Yes)</td>
<td>88</td>
<td>96</td>
</tr>
<tr>
<td>Pre and post wrong (No/No)</td>
<td>44</td>
<td>52</td>
</tr>
<tr>
<td>McNemar’s $\chi^2$ (OR)</td>
<td>43.2 (4.6)</td>
<td>25.3 (2.6)</td>
</tr>
<tr>
<td>Pre and final right (Yes/Yes)</td>
<td>91</td>
<td>116</td>
</tr>
<tr>
<td>Pre right, final wrong (Yes/No)</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Pre wrong, final right (No/Yes)</td>
<td>111</td>
<td>118</td>
</tr>
<tr>
<td>Pre and final wrong (No/No)</td>
<td>21</td>
<td>30</td>
</tr>
<tr>
<td>McNemar’s $\chi^2$ (OR)</td>
<td>82.6 (11.1)</td>
<td>84.8 (9.8)</td>
</tr>
<tr>
<td>Post and final right (Yes/Yes)</td>
<td>150</td>
<td>165</td>
</tr>
<tr>
<td>Post right, final wrong (Yes/No)</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>Post wrong, final right (No/Yes)</td>
<td>52</td>
<td>69</td>
</tr>
<tr>
<td>Post and final wrong (No/No)</td>
<td>11</td>
<td>20</td>
</tr>
<tr>
<td>McNemar’s $\chi^2$ (OR)</td>
<td>13.3 (2.6)</td>
<td>23.3 (3.1)</td>
</tr>
<tr>
<td>Pre and practical right (Yes/Yes)</td>
<td>66</td>
<td>49</td>
</tr>
<tr>
<td>Pre right, practical wrong (Yes/No)</td>
<td>35</td>
<td>79</td>
</tr>
<tr>
<td>Pre wrong, practical right (No/Yes)</td>
<td>87</td>
<td>45</td>
</tr>
<tr>
<td>Pre and practical wrong (No/No)</td>
<td>45</td>
<td>103</td>
</tr>
<tr>
<td>McNemar’s $\chi^2$ (OR)</td>
<td>21.3 (2.5)</td>
<td>8.8 (0.6)</td>
</tr>
<tr>
<td>Practical and final right (Yes/Yes)</td>
<td>141</td>
<td>90</td>
</tr>
<tr>
<td>Pract right, final wrong (Yes/No)</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Pract wrong, final right (No/Yes)</td>
<td>61</td>
<td>144</td>
</tr>
<tr>
<td>Pract and final wrong (No/No)</td>
<td>19</td>
<td>38</td>
</tr>
<tr>
<td>McNemar’s $\chi^2$ (OR)</td>
<td>31.6 (5.1)</td>
<td>130.5 (36.0)</td>
</tr>
</tbody>
</table>
**SI Table 3.** Student response data for the pre-test, post-test, and final examination, presented in both counts and percentages (listed in parentheses). This data was used for between group analysis ($\chi^2$ values) to determine differences in student performance on the various test items.

<table>
<thead>
<tr>
<th>Table 1a. Student Response Data for the Pre-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Control (Balance)</td>
</tr>
<tr>
<td>Treat (Pipet)</td>
</tr>
<tr>
<td>$\chi^2 = 0.605$ ($p=0.739$)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 1b. Student Response Data for the Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Control (Balance)</td>
</tr>
<tr>
<td>Treat (Pipet)</td>
</tr>
<tr>
<td>$\chi^2 = 3.285$ ($p=0.193$)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 1c. Student Response Data for the Final Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Control (Balance)</td>
</tr>
<tr>
<td>Treat (Pipet)</td>
</tr>
<tr>
<td>$\chi^2 = 9.781$ ($p=0.008$)</td>
</tr>
</tbody>
</table>
**SI Figure 1.** Comparison of pre-test responses between the experimental and treatment groups.

**Student Response on Pre-Test**

<table>
<thead>
<tr>
<th>Coded response</th>
<th>Percentage of students reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Incorrect Response</td>
<td>60</td>
</tr>
<tr>
<td>Correct SF, Incorrect Vol</td>
<td>50</td>
</tr>
<tr>
<td>Correct SF, Correct Vol</td>
<td>40</td>
</tr>
</tbody>
</table>

**SI Figure 2.** Comparison of post-test responses between the pipet and balance groups.

**Student Response on Post-Test**

<table>
<thead>
<tr>
<th>Coded response</th>
<th>Percentage of students reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Incorrect Response</td>
<td>30</td>
</tr>
<tr>
<td>Correct SF, Incorrect Vol</td>
<td>20</td>
</tr>
<tr>
<td>Correct SF, Correct Vol</td>
<td>60</td>
</tr>
</tbody>
</table>
SI Figure 3. Comparison of final exam responses between the pipet and balance groups.

![Graph showing student response on final exam]

SI Table 4. Comparison of practical exam performance. Practical exam data was made through direct observation by trained proctors and by review of student data worksheets.

<table>
<thead>
<tr>
<th></th>
<th>Used the pipet and reported correct SF</th>
<th>Used the pipet but reported incorrect SF</th>
<th>Used any other glassware</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of students (%)</td>
<td># of students (%)</td>
<td># of students (%)</td>
</tr>
<tr>
<td>Pipet Group</td>
<td>156 (67)</td>
<td>56 (24)</td>
<td>21 (9)</td>
</tr>
<tr>
<td>Balance Group</td>
<td>94 (34)</td>
<td>113 (41)</td>
<td>69 (25)</td>
</tr>
</tbody>
</table>

$\chi^2 = 34.773 \ (p<0.001)$
SI Figure 4. Comparison of practical responses between the experimental and treatment groups.
Balance Video Grading Rubric (20 total points):

Lab Group Members:________________________________________________________________________

TAs: The video should fall into one category under each of the following headings. Choose the category you feel best describes the submitted video. Items that have and underlined require every piece mentioned in the item.

____ (2 pts possible) General video quality:
    ___(2 pts) The video was shot in a manner that allows for clear observation of measured values, all close ups of notebooks and balance readout allow the viewer to read results, and explanations or definitions are audible.
    ___(1 pt) The students can all be seen performing the procedure (or the audio provides a reasonable description), but the video was not shot in a manner to allow the viewer to determine the accuracy of any measurements.
    ___(0 pts) The video does not allow for any determination of how the measurements were made.

____ (8 pts possible) Technique:
    ___(8 pts) Each student in the group can be seen taring the balance, obtaining the mass of their watch glass, adding sample away from the balance, and obtaining the mass of the watch glass and sample together. All of the previous, as well as what data must be recorded to obtain mass of sample, must be accompanied with explanations.
    ___(4 pts) Each student in the group can be seen performing the majority of the steps adequately, but not all of them. All of the previous must be accompanied with explanations.
    ___(2 pts) Each student in the group can be seen performing the majority of the steps adequately, but not all of them. Also, the previous items are not accompanied with explanations.
    ___(0 pts) The entire group is not seen in the video.

____ (2 pts possible) Uncertainty question (completed as a group, once per video)
    ___(2 pts) The students describe where the uncertainty of the balance lies and describe that external effects cause the readout to shift. A description of what steps can be taken to minimize this effect are also described.
    ___(1 pt) The students mention the uncertainty and its effect on the readout, but fail to offer explanation of why this happens.
    ___(0 pts) This question is not addressed in the video.

____ (2 pts possible) Consistently using the same balance (completed as a group, once per video)
    ___(2 pts) The students mention that it is important to consistently used the same balance throughout an entire experiment and provide sufficient example to support their claim.
    ___(1 pt) The students mention that they should use the same balance through an experiment, but fail to explain why.
    ___(0 pts) This question is not addressed in the video.

____ (2 pts possible) Notebook:
    ___(2 pt) The notebook is clearly shown in the video and includes: a ‘named’ or labeled sample, data for initial and final masses, and all decimals given by the balance have been recorded.
    ___(1 pt) The notebook is shown in the video, but data for initial and final mass are not shown or all decimals given by the balance have not been recorded.
    ___(0 pts) The notebook is not shown at all in the video or is shown in a way that makes it difficult to determine what was recorded.

____ (4 pts possible) Usefulness:
    ___(4 pts) The video is an excellent resource and could be used in the future as a teaching tool.
    ___(2 pts) The video has limited use in the future due to significant errors in technique and/or description. It is evident that students had only a limited grasp of the concepts at hand.
    ___(0 pts) The video will have no future use and should not be used as a review of technique.

____ (20 pts possible) Overall Grade
(15 of 10 points required to earn extra credit)
Your video should be 5 minutes or less. Videos between 5 and 7 minutes will earn a 4 point deduction. Videos between 7 and 9 minutes will earn an 8 point deduction. Videos longer than 9 minutes will not be graded.
Pipette Video Grading Rubric (20 total points):

Lab Group Members:________________________________________________________________________

TAs: The video should fall into one category under each of the following headings. Choose the category you feel best describes the submitted video. Items that have and underlined require every piece mentioned in the item.

____ (2 pts possible) General video quality:
    ____ (2 pts) The video was shot in a manner that allows for clear observation of measured values, all close ups of notebooks and meniscus allow the viewer to view the results, and explanations or definitions are audible.
    ____ (1 pt) The students can all be seen performing the procedure (or the audio provides a reasonable description), but the video was not shot in a manner to allow the viewer to determine the accuracy of any measurements.
    ____ (0 pts) The video does not allow for any determination of how the measurements were made.

____ (2 pts possible) Definitions of meniscus: 
(Completed as a group, once per video.)
    ____ (2 pts) The students describe what a meniscus is, why a meniscus occurs, gives an explanation of how to read a volume (the bottom of the meniscus), and provides an example of a meniscus with their pipette (a detailed drawing may also be included).
    ____ (1 pt) The students adequately describe how to read a meniscus but fail to provide an example (or the video is shot in a manner that does not allow the viewer to read it) or the students provide a visible example but lack a detailed definition.
    ____ (0 pts) The meniscus is not mentioned in the video.

____ (2 pts possible) Definitions of Priming (cleaning) the Pipette (Note: the actual action doesn't need to be included in the video and explanation may be included as a group, once per video.)
    ____ (2 pts) The students mention that the pipette was rinsed with water and solution 3x each before use.
    ____ (1 pt) The students mention that the pipette needs to be cleaned prior to use but do not give details how.
    ____ (0 pts) Priming is not mentioned in the video.

____ (8 pts possible) Technique:
    ____ (8 pts) Each student in the group can be seen drawing up a volume, determining the initial volume, transferring from the pipette to the reaction vessel properly, and determining the final volume. All of the previous must be accompanied with explanations.
    ____ (4 pts) Each student in the group can be seen drawing up a volume and transferring to the reaction vessel, but it is difficult to determine whether the students are determining the initial and final volumes. All of the previous must be accompanied with explanations.
    ____ (2 pts) Each student in the group can be seen drawing up a volume and transferring to the reaction vessel, but it is difficult to determine whether the students are determining the initial and final volumes. Also, the previous items are not accompanied with explanations.
    ____ (0 pts) The entire group is not seen in the video.

____ (2 pts possible) Notebook:
    ____ (2 pts) The notebook is clearly shown in the video and includes: a named or labeled sample, data for initial and final volumes, and all volume data is recorded to two decimal places.
    ____ (1 pt) The notebook is shown in the video, but data for initial and final volume are not shown or the data is not recorded to two decimal places.
    ____ (0 pts) The notebook is not shown at all in the video or is shown in a way that makes it difficult to determine what was recorded.

____ (4 pts possible) Usefulness:
    ____ (4 pts) The video is an excellent resource and could be used in the future as a teaching tool.
    ____ (2 pts) The video will be useful to those who made it in the future, but will likely not be used as a teaching tool.
    ____ (0 pts) The video will have no future use and should not be used as a review of technique.

____ (20 pts possible) Overall Grade
(15 of 20 points required to earn extra credit)
Your video should be 5 minutes or less. Videos between 5 and 7 minutes will earn a 4 point deduction. Videos between 7 and 9 minutes will earn an 8 point deduction. Videos longer than 9 minutes will not be graded.
DOCUMENTS RELATED TO THE LABORATORY PRACTICAL

Instructions to Teaching Assistants

Primary responsibilities:

- Ensure each station is prepped prior to each session (see supply list below)
- Observe student technique
- Collect student worksheets and grading rubrics to be graded

Students should sign up for a session on the sign-up sheet posted on the door after finishing their written final. Sessions will begin promptly every twenty minutes. During these 20 minutes students will need to get set-up, collect all data they feel is necessary, and complete all calculations. **ABSOLUTELY NO EXTRA TIME WILL BE GIVEN DURING ANY SESSION.**

You will need to kick them out if they are not done.

Students are only allowed (1) a calculator and (2) a writing utensil with them at their station. Phones may not be used as calculators. Bookbags, notebooks, etc. should be left in the hallway, but if students do bring them in, please have them leave these under the whiteboard.

Each station should be given all of the following at the start of each session:

- Instructions with station number taped beside the balance
- Student worksheet
- Grading rubric (taped and folded)
- Labeled sample bottle
- Dry 50-mL beaker
- 2 dry 150-mL beakers
- Dry 100-mL graduated cylinder
- Dry 10-mL Mohr pipet
- Balance cleaning brush
- Weighing paper
- Paper Towels

Be sure to carefully keep time.

- Students should be given warning when there are 5 minutes and 2 minutes left in their session.
- Students should be given instructions to begin turning in their worksheets at the 2 minute warning.

Each proctor will have no less than 3 students to observe during each session. Use the provided rubric to assess student technique. The rubric should be easy enough to follow, but some things to keep in mind are:

- The entire practical is worth 35 points.
- The Technique Items (section 1) will be graded while students are in the lab. The Data Collection and Data Reporting Items will be graded by the section TAs once students have left.
- The first four rows of the grading rubric are redundant. Students who use a beaker or cylinder will lose 5 points automatically (line 1). Students who use the pipet should be graded based on lines 2-4.
- The correct number of decimal places (in Data Collection Items) should be graded based on the glassware they chose, whether it was correct or not. No double jeopardy, please.

DO NOT ACCEPT ANY PRACTICAL FROM A STUDENT WITHOUT CONFIRMING THE DATA THEY GRAPHED IS THEIR OWN!
Instructions to Students

Please sign up for a session on the sign-up sheet to the right of these instructions.

- Sessions will begin every twenty minutes, starting at the time indicated for each section in the chart below.
- During these 20 minutes you will need to get set-up, collect all data you feel is necessary, graph your results, and complete all calculations.
- You will be given a warning when five minutes are remaining for your session. At 2 minutes, you will be asked to begin cleaning and turning in your belongings.

- **NO NOTEBOOKS ARE ALLOWED IN THE PRACTICAL!**
- **ABSOLUTELY NO EXTRA TIME WILL BE GIVEN DURING ANY SESSION!**

<table>
<thead>
<tr>
<th>Section (meeting time)</th>
<th>Session 1</th>
<th>Session 2</th>
<th>Session 3</th>
<th>Session 4</th>
<th>Session 5</th>
<th>Session 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>5X (T 8:00)</td>
<td>9:00</td>
<td>9:20</td>
<td>9:40</td>
<td>10:00</td>
<td>10:20</td>
<td>10:40</td>
</tr>
<tr>
<td>J2 (T 11:00)</td>
<td>12:00</td>
<td>12:20</td>
<td>12:40</td>
<td>1:00</td>
<td>1:20</td>
<td>1:40</td>
</tr>
<tr>
<td>J3 (T 2:00)</td>
<td>3:00</td>
<td>3:20</td>
<td>3:40</td>
<td>4:00</td>
<td>4:20</td>
<td>4:40</td>
</tr>
<tr>
<td>N9 (T 5:00)</td>
<td>6:00</td>
<td>6:20</td>
<td>6:40</td>
<td>7:00</td>
<td>7:20</td>
<td>7:40</td>
</tr>
<tr>
<td>J7 (W 8:00)</td>
<td>9:00</td>
<td>9:20</td>
<td>9:40</td>
<td>10:00</td>
<td>10:20</td>
<td>10:40</td>
</tr>
<tr>
<td>2Q (W 2:30)</td>
<td>3:30</td>
<td>3:50</td>
<td>4:10</td>
<td>4:30</td>
<td>4:50</td>
<td>5:10</td>
</tr>
<tr>
<td>M2 (W 5:45)</td>
<td>6:45</td>
<td>7:05</td>
<td>7:25</td>
<td>7:45</td>
<td>8:05</td>
<td>8:25</td>
</tr>
<tr>
<td>Y3 (R 8:00)</td>
<td>9:00</td>
<td>9:20</td>
<td>9:40</td>
<td>10:00</td>
<td>10:20</td>
<td>10:40</td>
</tr>
<tr>
<td>M3 (R 11:00)</td>
<td>12:00</td>
<td>12:20</td>
<td>12:40</td>
<td>1:00</td>
<td>1:20</td>
<td>1:40</td>
</tr>
<tr>
<td>M4 (R 2:00)</td>
<td>3:00</td>
<td>3:20</td>
<td>3:40</td>
<td>4:00</td>
<td>4:20</td>
<td>4:40</td>
</tr>
<tr>
<td>Y6 (R 5:00)</td>
<td>6:00</td>
<td>6:20</td>
<td>6:40</td>
<td>7:00</td>
<td>7:20</td>
<td>7:40</td>
</tr>
<tr>
<td>P1 (F 8:00)</td>
<td>9:00</td>
<td>9:20</td>
<td>9:40</td>
<td>10:00</td>
<td>10:20</td>
<td>10:40</td>
</tr>
<tr>
<td>P3 (F 2:30)</td>
<td>3:30</td>
<td>3:50</td>
<td>4:10</td>
<td>4:30</td>
<td>4:50</td>
<td>5:10</td>
</tr>
</tbody>
</table>

You are only allowed (1) a calculator and (2) a writing utensil at your station.

Please do not bring anything else in the room with you, including your notebook or your phone. Phones may not be used as calculators and the time will be kept for you. Computers with graphing software will be provided. Please leave all items other than your calculator and writing utensil in the hallway.

No instruction will be given once you are in the room. Also, please be advised that proctors will not answer any questions during this practical. Follow the procedure below:

- Review your notebook pages regarding finding the density of a solution as well as the technique videos you created during the semester prior to your session. Please note that graphing software will be set up for you, so you will not need to know how to create the graph.
- Proceed directly to your assigned station and write your name on both the student worksheet and the grading rubric. **Do not begin data collection until you have given the proctor for your station the grading rubric.**
- Collect data to answer the problem given to you on the student worksheet.
- Complete all calculations on the student worksheet.
- Graph your results on one of the provided computers.
- Clean your station and turn in your worksheet to your proctor.
### TECHNICAL ITEMS

<table>
<thead>
<tr>
<th>Item</th>
<th>Always</th>
<th>Sometimes</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student uses the Mohr pipet.</td>
<td>5</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>The student avoids pipetting directly from the bottle.</td>
<td>1</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>The student reads the pipet at eye level.</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>The student stops draining the pipet with the meniscus in the graduations.</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Indicate choice of glassware if not pipet:

<table>
<thead>
<tr>
<th>Item</th>
<th>Always</th>
<th>Sometimes</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student avoids returning excess reagent to the bottle and disposes of it properly.</td>
<td>1</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>The student tares the balance before adding the weighing vessel.</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>The student uses an empty weighing vessel that fits inside the balance.</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>The student closes the balance doors when obtaining the mass (student should not lose points if there are not doors to close).</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>The student waits for the balance to equilibrate before recording the mass.</td>
<td>1</td>
<td>0.5</td>
<td>0</td>
</tr>
<tr>
<td>The student removes the weighing vessel from the balance to add sample.</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>The student maintains a clean workspace.</td>
<td>2</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

### DATA COLLECTION ITEMS

<table>
<thead>
<tr>
<th>Item</th>
<th>Always</th>
<th>Sometimes</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student records volume data to the correct number of decimal places for their glassware.</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>The student records all of the digits presented on the balance</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>The student uses the mass by difference method</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

### SAFETY

<table>
<thead>
<tr>
<th>Item</th>
<th>3 - Wore goggles and had on pants and proper shoes</th>
<th>2 - Wore goggles but had on shorts a/o sandals</th>
<th>0 - didn’t wear goggles and wore shorts a/o sandals</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student has taken appropriate safety precautions (goggles, pants, shoes, etc)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### DATA REPORTING ITEMS

<table>
<thead>
<tr>
<th>Item</th>
<th>3 points</th>
<th>2 points</th>
<th>1 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student’s average was within the following range:</td>
<td>10%</td>
<td>15%</td>
<td>20-40%</td>
</tr>
<tr>
<td>The student’s standard deviation was X% of their average:</td>
<td>10%</td>
<td>20%</td>
<td>30-50%</td>
</tr>
<tr>
<td>The student’s R² value was within the following range:</td>
<td>&gt;0.95</td>
<td>0.90-.9949</td>
<td>0.85-0.899</td>
</tr>
</tbody>
</table>

Proctor:___________________________________________________________
Determine the density of the provided solution using the MOST ACCURATE piece of glassware.
Refer to the instructions taped around your station if you need guidance. Complete all data collection and calculations on this sheet. You may use the back of this page if necessary. BE SURE TO CLEARLY LABEL DATA AND CALCULATIONS SO YOUR WORKSHEET WILL BE EASY TO GRADE!

Bottle ID__________ Density with precision (include units)_______________________________

Best fit equation__________________________________ R² value_______________________

Your instructor must verify that the data you graphed matches the data on this worksheet! Do not leave a computer without having your instructor initial that the data above has not been falsified.
Brief instructions and helpful tips

Station 1

Choose the piece of glassware that gives the most accurate results.

Collect data that will allow you to calculate the density of the provided solution.

Organize your data in a manner that the proctor can easily grade.

Record data to the proper number of significant figures.

Graph your results on one of the provided computers.

Record the results (including a rough sketch of your graph) on your worksheet.

Turn in your assignment and exit the room quietly.

Station 2

Choose the piece of glassware that gives the most accurate results.

Collect data that will allow you to calculate the density of the provided solution.

Organize your data in a manner that the proctor can easily grade.

Record data to the proper number of significant figures.

Graph your results on one of the provided computers.

Record the results (including a rough sketch of your graph) on your worksheet.

Turn in your assignment and exit the room quietly.
APPENDIX B.2 – Screenshot of permission statement from the Royal Society of Chemistry (Obtained through RightsLink).
APPENDIX C

SUPPLEMENTAL MATERIAL SUBMITTED TO THE JOURNAL OF CHEMICAL EDUCATION
Supporting Information

<table>
<thead>
<tr>
<th>Set</th>
<th>Actual Conc (M)</th>
<th>Actual Conc (M)</th>
<th>Actual Conc (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100s</td>
<td>0.00625</td>
<td>0.0125</td>
<td>1.0</td>
</tr>
<tr>
<td>300s</td>
<td>0.00625</td>
<td>0.0125</td>
<td>1.0</td>
</tr>
<tr>
<td>500s</td>
<td>0.00625</td>
<td>0.0125</td>
<td>1.0</td>
</tr>
<tr>
<td>700s</td>
<td>0.00625</td>
<td>0.0125</td>
<td>1.0</td>
</tr>
<tr>
<td>200s</td>
<td>1.0</td>
<td>0.00625</td>
<td>0.0125</td>
</tr>
<tr>
<td>400s</td>
<td>1.0</td>
<td>0.00625</td>
<td>0.0125</td>
</tr>
<tr>
<td>600s</td>
<td>0.0125</td>
<td>1.0</td>
<td>0.00625</td>
</tr>
<tr>
<td>800s</td>
<td>0.0125</td>
<td>1.0</td>
<td>0.00625</td>
</tr>
</tbody>
</table>

Table 1. Key for the labeling of sample sets. The three digit codes can be used to identify the actual concentration of the samples in the vial on the basis of the first digit. For safety reasons, a chart similar to this should be kept in the laboratory where the activity is being carried out.

The concentration of the unknown samples, labeled A, B or C, were varied along with the 'labeled' samples. The three known concentrations were divided evenly among all three unknowns.
Determination of the Nitrogen Concentration in Water Samples

Written by Mitzy Erdmann
© 2012, Department of Chemistry, University of Alabama at Birmingham

PRE-LAB INSTRUCTION

Identify and read background material in your textbook or other reference materials relating to: water quality, nitrogen concentration in water, affects of pollutants on plant and animal life.

In your manual:
You should take detailed notes on the background information you read. You should also outline the procedure you will use on your lab pages. You will be able to use any notes you take on your pre-lab quiz. Present these to your TA after completing your quiz.

You will need to bring:
This handout, your lab notebook, safety goggles

FOR YOUR SAFETY

Ammonia is a weak base, and therefore is harmful if it is ingested or contact is made with the skin. Flush skin that has been exposed to the reagent with water for at least 15 minutes. If ammonia is ingested, contact your TA who will seek help from poison control.

OBJECTIVES

After this laboratory you should be able to:
- Describe the steps necessary for a rudimentary determination of the ammonia content of water
- Describe the quality of various samples of water
- Understand the importance of sample handling and data collection

BACKGROUND

The term water quality refers to the physical, chemical and biological properties of a sample of water. In simple terms, it is a measure of the condition of that water sample relative to water that would be “safe”, or ideal for human consumption. The testing of the quality of various water samples, including tap, river/lake, and waste water are continuously carried out to ensure the safety of plant and animal life that depend on these water sources.

The Cahaba River, located just south of Birmingham, is the longest river in Alabama. It is a hugely bio-diverse river, and is home to more than 131 species of freshwater fishes (18 of which have been found in no other river system), 40 species of mussels, and 35 species of snails. Sixty-nine of these animal species are endangered¹. Due to the presence of diverse varied wildlife and the scenic nature of the area, the Cahaba River has been designated a National Wildlife Refuge².
Growth throughout Birmingham and the surrounding area have threatened the quality of the water that flows through the Cahaba River. Because it is a major source of drinking water for the city and a known recreation area, as well as home to the wildlife previously mentioned, the constant monitoring of pollutants in the river is necessary.

One pollutant commonly tested for is nitrogen, which commonly enters river and lakes through both treated and untreated waste water. A compound which is dissolved in a solvent is referred to as an analyte, and in this case nitrogen would be the analyte dissolved in the aqueous (or water based) solvent. Nitrogen is generally found in aqueous solutions in the form of nitrates, nitrites, ammonia and the ammonium ion, which can each be measured by various means.

Ideally, quantitative data, or data that allows for a definitive calculation of the exact concentration of an analyte, would be found in these situations. However, quantitative tests are often quite costly and sometimes unnecessary if water quality has not been adversely affected. In such cases, qualitative tests, or tests that allow for the collection of data that tells an individual whether or not an analyte is present (and sometimes can give a rough estimate of abundance) but does not give an exact value as to the concentration, is used as a first line of defense.

Test strips, such as those that can be used to test pH, are commonly used as a first step in determining the quality of a water sample. These strips are easy to both use and find, and they are similar to aquarium test strips sold at pet stores. An important distinction between the use of test strips at home and in the lab is that the home kits are designed for the strips to be completely submerged in the water. You will never want to do this in the lab. Drops of your solution should be brought to the pH test strip rather than the strip being placed in the solution. Solution can be easily transferred with a glass stirring rod. This will help you avoid contaminating your sample.

As this is your first day in lab, it is important that you become comfortable with keeping a laboratory notebook. Researchers, who keep notebooks daily, quickly learn that no detail is too small to record. Observations of all chemicals and materials used should be made. The identity of samples should be carefully recorded, and all data should be labeled and recorded in an orderly fashion (generally a table is best for this). If your group is instructed to perform multiple trials, you should clearly label who performed which trial. Throughout this semester you will be periodically graded on the quality of your notebook, so begin the semester strong by doing your best today.

**GENERAL PROCEDURE**

Your TA will pass out a series of labeled water samples to your group. Each set will contain one of each of the following samples: tap water, river water, and waste water.

To test the quality of the water samples, your group will be given standard pH test strips. Note that the label on the tube is used as the key. Each sample of water should be tested by each group member (for a total of three tests per sample or nine tests total). Record any data in your notebook.
After you have finished collecting data on the known samples, contact your TA. Upon successful completion of the first part of the lab, you will be asked to clean your area and will then be assigned an unknown sample to test. Unknowns will ALWAYS be tested in triplicate, so you should collect three data points for this sample as you did with the known solutions. Compare your unknown sample results with those of the knowns to determine the identity of the unknown. Upon completion of this portion of the experiment you will share your data with the class for comparison.

POST LAB ASSIGNMENT
Your TA will distribute an in-class assignment that must be completed before you leave the lab. All questions should be answered fully and thoughtfully. Shallow, flippant answers will not receive the same credit as well thought out ones. The entire assignment will be worth 10 points.

REFERENCES
In-Class Assignment (Determination of Nitrogen Content)

Name:__________________________________   Date:___________    Lab Section:_______

Data Set:__________________  Unknown:____________________

1. (a) (1 point) Your group should have taken three measurements for each of the labeled samples as well as for the unknown sample. Were all of these measurements in agreement? What identity did your group assign to the unknown?

(b) (1 point) The data collected today was qualitative. Had it been quantitative, what statistical value should you have calculated to determine the agreement of your measurements (hint: consult the appendices in the front of your notebook).

2. (1 point) What surprised you about the data from your class when it was compiled and viewed on the board? Knowing what you know now, what was the take-home message of this laboratory assignment?

3. (1 point) Consider for a moment that you are a research scientist preparing your own samples. What steps could you take to reduce the error associated with this experiment? What would be a consequence of this data set if these were real samples?

4. (3 points) Provide three concrete reasons why it is important to collect and record laboratory data carefully. Put some thought into this, shallow answers will not earn credit.
   1.
   2.
   3.

5. (3 points) You will need to turn in the yellow copy of your notebook from this lab. Staple it to this sheet.
In-Class Assignment Rubric (Determination of pH of water samples)

1. **(a) (1 point)** Your group should have taken three measurements for each of the labeled samples as well as for the unknown sample. Were all of these measurements in agreement? What identity did you group assign to the unknown?

<table>
<thead>
<tr>
<th>1 point</th>
<th>0.5 points</th>
<th>0 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>The groups’ data was in agreement and they were able to ID the unknown based on their data.</td>
<td>The groups’ data was not in agreement or they were unable to ID the unknown based on their data.</td>
<td>The question was not answered.</td>
</tr>
</tbody>
</table>

**b) (1 point)** The data collected today was qualitative. Had it been quantitative, what statistical value should you have calculated to determine the agreement of your measurements (hint: consult the appendices in the front of your notebook).

<table>
<thead>
<tr>
<th>1 point</th>
<th>0 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student mentions standard deviation.</td>
<td>The student does not answer the question or mentions anything other than standard deviation.</td>
</tr>
</tbody>
</table>

2. **(1 point)** What surprised you about the data from your class when it was compiled and viewed on the board? Knowing what you know now, what was the take-home message of this laboratory assignment?

<table>
<thead>
<tr>
<th>1 point</th>
<th>0.5 points</th>
<th>0 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>The students provides a viable reason for being surprised by the data and understands that proper data collection and notebook upkeep are necessary.</td>
<td>The student provides a weak but related reason for being surprised by the data or does not understand that proper data collection and notebook upkeep are necessary.</td>
<td>The question was not answered or the students provides an unrelated reason and lacks understanding.</td>
</tr>
</tbody>
</table>

3. **(1 point)** Consider for a moment that you are a research scientist preparing your own samples. What steps could you take to reduce the error associated with this experiment? What would be a consequence of this data set if these were real samples?

<table>
<thead>
<tr>
<th>1 point</th>
<th>0.5 points</th>
<th>0 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student provides two viable steps for keeping data straight and mentions a danger to public welfare (or something similar) as a consequence.</td>
<td>The student provides less than two viable steps (or provides two weak ones) for keeping data straight or does not mention a danger to public welfare (or something similar) as a consequence.</td>
<td>The question was not answered or the student lacks understanding of the consequences.</td>
</tr>
</tbody>
</table>

4. **(3 points)** Provide three concrete reasons why it is important to collect and record laboratory data carefully. Put some thought into this, shallow answers will not earn credit.

<table>
<thead>
<tr>
<th>3 points</th>
<th>2 points</th>
<th>1 point</th>
<th>0 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student provides three concrete reasons why proper data handling is important.</td>
<td>The student provides 1-2 concrete (or 3 weak) reasons why data handling is important.</td>
<td>The student provides 1 concrete (or 1-2 weak) reasons why data handling is important.</td>
<td>The question was not answered.</td>
</tr>
</tbody>
</table>

5. **(3 points)** You will need to turn in the yellow copy of your notebook from this lab. Staple it to this sheet.

<table>
<thead>
<tr>
<th>3 points</th>
<th>2 points</th>
<th>1 point</th>
<th>0 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>All samples (labeled and unknown) are clearly labeled. Data is collected in a manner that TAs can quickly and easily read the yellow notebook pages. All trials are ID’d by who performed them.</td>
<td>Two of the three criteria to the left are met.</td>
<td>One of the criteria to the left are met.</td>
<td>The question was not answered.</td>
</tr>
</tbody>
</table>
APPENDIX D

APPENDICES RELATED TO CHAPTER V
Appendix 5.1 – IRB Approval and Informed Consent, Protocol Number E141008003
Informed consent statement included as the first item on the Canvas quiz:
This serves as an invitation to participate in an analysis by Mitzy Erdmann and Dr. Joe March of the Chemistry Department at the University of Alabama at Birmingham (UAB). Information provided by you, the student, will be used to determine whether pre-laboratory instruction in CH116 and/or CH118 can be successfully delivered via Canvas, the course LMS. You were selected as a possible participant in this analysis because of your current enrollment in CH116 or CH118.

Should you choose to participate, you will be asked to complete one survey at the completion of the course (during the week of the laboratory final). The survey will be brief and should take no more than 20-25 minutes of your time. Surveys will be administered via Canvas. These surveys will seek to determine your opinion on pre-laboratory instruction and to contrast the difference between content delivered in person and content delivered online. All survey responses will remain anonymous, and honest answers to any questions presented on the surveys will not adversely affect your final grade in CH116 or CH118.

This educational analysis poses no physical or emotional risk to you as the voluntary participant, and participation should not inconvenience you in any way. There will be no monetary requirement on your part, nor will you be compensated for participating in the analysis.

Any information that is obtained in connection with this analysis will not be identifiable with you and will remain confidential. Information will also be collected regarding final assigned grades. All information will be disclosed in the form of statistical data published in scholarly journals and will be done so anonymously and in aggregate (as counts or percentages).

Your decision whether or not to participate will not prejudice your future relations with the Chemistry Department or UAB in any way, nor will your final grade be affected. If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time without penalty. You may contact Mitzy Erdmann or Dr. Joe March to withdraw your consent.

If you have any questions, please ask. You may contact Mitzy Erdmann (205-934-7300, merdmann@uab.edu) or Dr. Joe March (205-934-8788, march@uab.edu).

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE. YOUR COMPLETION OF THE SURVEY INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE IN OUR EDUCATIONAL ANALYSIS, HAVING READ THE INFORMATION PROVIDED ABOVE.
Appendix 5.2 - Fall 2014 End of Term Survey Items and Response Summary

Likert-type items included on the Fall 2014 End of Term survey are presented under the corresponding Likert-type categories to reduce space requirements and redundancy. Items are numbered in order of placement on the survey to provide an idea of sequence. Response data is presented as totals and percentages (i.e., 54 (44.6)).

<table>
<thead>
<tr>
<th>Completely Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Completely Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. In general, my TA presented the material necessary to complete the laboratory activities in a clear and concise manner.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54 (44.6)</td>
<td>51 (42.1)</td>
<td>12 (9.9)</td>
<td>4 (3.3)</td>
</tr>
<tr>
<td>7. The pre-lab lectures were a good use of class time.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>62 (51.2)</td>
<td>41 (33.9)</td>
<td>9 (7.4)</td>
<td>9 (7.4)</td>
</tr>
<tr>
<td>8. In-class quizzes motivated me to review the experiment before arriving at the laboratory.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>57 (47.1)</td>
<td>38 (31.4)</td>
<td>13 (10.7)</td>
<td>13 (10.7)</td>
</tr>
<tr>
<td>9. My TA offered suggestions to our group on ways to work more efficiently.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>47 (38.8)</td>
<td>43 (35.5)</td>
<td>21 (17.4)</td>
<td>10 (8.3)</td>
</tr>
<tr>
<td>10. I feel that I would be motivated to prepare for lab if my time-on-task was better monitored.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 (19.0)</td>
<td>40 (33.1)</td>
<td>48 (39.7)</td>
<td>9 (7.4)</td>
</tr>
<tr>
<td>11. I have viewed videos as a course requirement for this or other classes.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 (15.7)</td>
<td>40 (33.1)</td>
<td>33 (27.3)</td>
<td>29 (24.0)</td>
</tr>
<tr>
<td>13. In general, were your TA’s pre-lab lectures organized and easy enough to follow?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 (23.1)</td>
<td>80 (66.1)</td>
<td>11 (9.1)</td>
<td>2 (1.7)</td>
</tr>
<tr>
<td>15. I feel that I would do better on the quiz if I could take it at my own pace.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35 (29.0)</td>
<td>49 (40.5)</td>
<td>33 (27.3)</td>
<td>4 (3.3)</td>
</tr>
<tr>
<td>16. I would prefer to take my pre-lab quiz online so I can have as much time as needed.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>63 (52.1)</td>
<td>37 (30.6)</td>
<td>12 (9.9)</td>
<td>9 (7.4)</td>
</tr>
<tr>
<td>17. I feel that my grade on an online quiz would be as good or better than my grades on the in-lab quizzes.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>78 (64.5)</td>
<td>34 (28.1)</td>
<td>6 (5.0)</td>
<td>3 (2.5)</td>
</tr>
<tr>
<td>18. I feel that recorded videos would be a useful way to deliver course content in CH116.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37 (30.6)</td>
<td>37 (30.6)</td>
<td>28 (23.1)</td>
<td>19 (15.7)</td>
</tr>
<tr>
<td>19. I feel that my TA was approachable for assistance in this course.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85 (70.2)</td>
<td>18 (14.9)</td>
<td>11 (9.1)</td>
<td>7 (5.8)</td>
</tr>
<tr>
<td>20. My TA was helpful during the lab period.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>79 (65.3)</td>
<td>28 (23.1)</td>
<td>8 (6.6)</td>
<td>6 (5.0)</td>
</tr>
<tr>
<td>21. My TA was knowledgeable about the course material.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>93 (76.9)</td>
<td>26 (21.5)</td>
<td>2 (1.7)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>22. My TA was able to manage the laboratory environment well.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85 (70.2)</td>
<td>28 (23.1)</td>
<td>6 (5.0)</td>
<td>2 (1.7)</td>
</tr>
<tr>
<td>23. My TA showed an interest in engaging students in their learning.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>61 (50.4)</td>
<td>37 (30.6)</td>
<td>18 (14.9)</td>
<td>5 (4.1)</td>
</tr>
<tr>
<td>24. I feel this course helped me to develop critical thinking skills.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 (33.1)</td>
<td>49 (40.5)</td>
<td>20 (16.5)</td>
<td>12 (9.9)</td>
</tr>
</tbody>
</table>
2. How often did your TA demonstrate the proper use of lab equipment being used for the first time this semester?

<table>
<thead>
<tr>
<th>Most Weeks</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>I don’t remember</th>
</tr>
</thead>
<tbody>
<tr>
<td>87 (71.9)</td>
<td>23 (19.0)</td>
<td>9 (7.4)</td>
<td>2 (1.7)</td>
</tr>
</tbody>
</table>

3. How often did your TA repeat a demonstration for more difficult to use equipment (pipet, buret, etc.)?

<table>
<thead>
<tr>
<th>Most Weeks</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>I don’t remember</th>
</tr>
</thead>
<tbody>
<tr>
<td>46 (38.0)</td>
<td>47 (38.8)</td>
<td>22 (18.2)</td>
<td>6 (5.0)</td>
</tr>
</tbody>
</table>

4. How often did your TA mention specific safety concerns in regards to chemicals being used that week during their prelab lecture?

<table>
<thead>
<tr>
<th>Most Weeks</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>I don’t remember</th>
</tr>
</thead>
<tbody>
<tr>
<td>85 (70.2)</td>
<td>26 (21.5)</td>
<td>8 (6.6)</td>
<td>2 (1.7)</td>
</tr>
</tbody>
</table>

5. How often did your TA instruct you in proper disposal of chemicals during the pre-lab lecture?

<table>
<thead>
<tr>
<th>Most Weeks</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>I don’t remember</th>
</tr>
</thead>
<tbody>
<tr>
<td>76 (62.8)</td>
<td>33 (27.27)</td>
<td>11 (9.09)</td>
<td>1 (0.8)</td>
</tr>
</tbody>
</table>

6. In general, did you feel prepared to perform the lab activity following your TA’s pre-lab lecture?

<table>
<thead>
<tr>
<th>Prepared</th>
<th>Very Prepared</th>
<th>Somewhat Prepared</th>
<th>Barely Prepared</th>
<th>Not at all Prepared</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 (7.4)</td>
<td>60 (49.6)</td>
<td>14 (11.6)</td>
<td>38 (31.4)</td>
<td></td>
</tr>
</tbody>
</table>

12. For your level of understanding, were your TA’s explanations too complicated, too simple, or just about right?

<table>
<thead>
<tr>
<th>Understanding</th>
<th>About Right</th>
<th>Mostly Okay</th>
<th>Too Complicated</th>
<th>Way Too Complicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>27 (22.3)</td>
<td>75 (62.0)</td>
<td>15 (12.4)</td>
<td>4 (3.3)</td>
<td></td>
</tr>
</tbody>
</table>

14. How often were you required to submit your weekly quiz before you were able to complete it?

<table>
<thead>
<tr>
<th>Time to Complete</th>
<th>I always had enough time</th>
<th>Most weeks I had enough time</th>
<th>I was able to finish three or four in time</th>
<th>I only finished one or two in time</th>
</tr>
</thead>
<tbody>
<tr>
<td>69 (57.0)</td>
<td>44 (36.4)</td>
<td>5 (4.1)</td>
<td>3 (2.5)</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix 5.3 - Spring 2015 Midterm Survey Items and Response Summary

Likert-type items included on the Spring 2015 End of Term survey are presented as grouped and presented to students. Response data is presented as totals and percentages (i.e., 54 (44.6)).

**Group 1:** The following items are designed to gauge your opinion on how well the videos prepare you for various aspects of the lab. Choose the appropriate response from the pulldown menus.

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Completely Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Completely Disagree</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>In general, I feel prepared to perform the lab activity after watching that week's video.</td>
<td>32 (19.3)</td>
<td>97 (58.4)</td>
<td>29 (17.5)</td>
<td>3 (1.8)</td>
<td>5 (3.0)</td>
</tr>
<tr>
<td>I feel that the videos adequately demonstrate proper use of lab equipment that is being used the first time this semester.</td>
<td>76 (45.8)</td>
<td>73 (44.0)</td>
<td>8 (4.8)</td>
<td>4 (2.4)</td>
<td>5 (3.0)</td>
</tr>
<tr>
<td>I feel the videos provide explanations that are just right for my level of understanding.</td>
<td>42 (25.3)</td>
<td>88 (53.0)</td>
<td>26 (15.7)</td>
<td>4 (2.4)</td>
<td>6 (3.6)</td>
</tr>
<tr>
<td>The videos mention specific safety concerns in regards to chemicals being used that week.</td>
<td>124 (74.7)</td>
<td>32 (19.3)</td>
<td>2 (1.2)</td>
<td>2 (1.2)</td>
<td>6 (3.6)</td>
</tr>
<tr>
<td>The videos instruct me in proper disposal of chemicals.</td>
<td>127 (76.5)</td>
<td>31 (18.7)</td>
<td>0 (0.0)</td>
<td>2 (1.2)</td>
<td>6 (3.6)</td>
</tr>
<tr>
<td>I feel that having to watch the videos online makes me prepare for lab further ahead of time then I would otherwise.</td>
<td>75 (45.2)</td>
<td>58 (34.9)</td>
<td>18 (10.8)</td>
<td>9 (5.4)</td>
<td>6 (3.6)</td>
</tr>
<tr>
<td>The videos offer suggestions to our group on ways to work more efficiently.</td>
<td>70 (42.2)</td>
<td>75 (45.2)</td>
<td>11 (6.6)</td>
<td>4 (2.4)</td>
<td>6 (3.6)</td>
</tr>
<tr>
<td>In general, the material in the video is well organized and easy to follow</td>
<td>52 (31.3)</td>
<td>89 (53.6)</td>
<td>15 (9.0)</td>
<td>4 (2.4)</td>
<td>6 (3.6)</td>
</tr>
<tr>
<td>I feel that the recorded videos are a useful way to deliver course content in 116</td>
<td>66 (39.8)</td>
<td>68 (41.0)</td>
<td>18 (10.8)</td>
<td>7 (4.2)</td>
<td>7 (4.2)</td>
</tr>
</tbody>
</table>

**Very Helpful
d | Mostly Helpful
d | A Little Helpful
d | Not helpful at All
d | No Response
d
| I feel that viewing the videos before lab is helpful. |                   |              |                 |                    |             |
**Group 2:** The following items are designed to determine which equipment students are familiar with when they enter the lab. Select the statement that represents how much the videos helped you to:

<table>
<thead>
<tr>
<th>Item</th>
<th>Very Helpful</th>
<th>Mostly Helpful</th>
<th>A Little Helpful</th>
<th>Not helpful at All</th>
<th>I Already knew what a … was</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognize the balance</td>
<td>72 (43.4)</td>
<td>24 (14.5)</td>
<td>17 (10.2)</td>
<td>1 (0.6)</td>
<td>45 (27.1)</td>
</tr>
<tr>
<td>Recognize a Mohr pipet</td>
<td>76 (45.8)</td>
<td>48 (28.9)</td>
<td>21 (12.7)</td>
<td>3 (1.8)</td>
<td>11 (6.6)</td>
</tr>
<tr>
<td>Recognize a Buchner funnel</td>
<td>88 (53.0)</td>
<td>41 (24.7)</td>
<td>19 (11.4)</td>
<td>4 (2.4)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>Recognize a pH paper</td>
<td>82 (49.4)</td>
<td>18 (10.8)</td>
<td>6 (3.6)</td>
<td>0 (0.0)</td>
<td>53 (31.9)</td>
</tr>
<tr>
<td>Recognize a volumetric flask</td>
<td>76 (45.8)</td>
<td>35 (21.1)</td>
<td>9 (5.4)</td>
<td>5 (3.0)</td>
<td>34 (20.5)</td>
</tr>
</tbody>
</table>

*All items in Group 2 had a no response rate of 7 (4.2).*

**Group 3:** The following items are designed to determine whether the videos were effective in demonstrating equipment technique. Select the statement that represents how much the videos helped you to:

<table>
<thead>
<tr>
<th>Item</th>
<th>Very Helpful</th>
<th>Mostly Helpful</th>
<th>A Little Helpful</th>
<th>Not helpful at All</th>
<th>I Already knew how to use…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use the balance</td>
<td>68 (41.0)</td>
<td>31 (18.7)</td>
<td>17 (10.2)</td>
<td>1 (0.6)</td>
<td>42 (25.3)</td>
</tr>
<tr>
<td>Use a Mohr pipet</td>
<td>80 (48.2)</td>
<td>47 (28.3)</td>
<td>21 (12.7)</td>
<td>2 (1.2)</td>
<td>9 (5.4)</td>
</tr>
<tr>
<td>Use a Buchner funnel</td>
<td>76 (45.8)</td>
<td>51 (30.7)</td>
<td>22 (13.3)</td>
<td>6 (3.6)</td>
<td>4 (2.4)</td>
</tr>
<tr>
<td>Use pH paper</td>
<td>82 (49.4)</td>
<td>18 (10.8)</td>
<td>9 (5.4)</td>
<td>0 (0.0)</td>
<td>50 (30.1)</td>
</tr>
<tr>
<td>Use a volumetric flask</td>
<td>68 (41.0)</td>
<td>41 (24.7)</td>
<td>14 (8.4)</td>
<td>4 (2.4)</td>
<td>32 (19.3)</td>
</tr>
</tbody>
</table>

*All items in Group 3 had a no response rate of 7 (4.2).*
Group 4: The following items are included so the authors of the videos can gain insight into how the lab TAs interact with students and the videos. Choose the appropriate response from the pulldown menus.

<table>
<thead>
<tr>
<th>Question</th>
<th>Most (almost all) Weeks</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>I don’t remember</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often does your TA refer to the videos as part of their prelab lecture?</td>
<td>67 (40.4)</td>
<td>53 (31.9)</td>
<td>27 (16.3)</td>
<td>12 (7.2)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>How often does your TA ask you to re-watch the videos when you ask a question during lab?</td>
<td>24 (14.5)</td>
<td>40 (24.1)</td>
<td>48 (28.9)</td>
<td>47 (28.3)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>How often does your TA present an additional pre-lab lecture that goes over the same material in the videos?</td>
<td>74 (44.6)</td>
<td>43 (25.9)</td>
<td>27 (16.3)</td>
<td>15 (9.0)</td>
<td>7 (4.2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Completely Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Completely Disagree</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>I wish my TA would present the same material that was presented in the videos during a prelab lecture.</td>
<td>65 (39.2)</td>
<td>57 (34.3)</td>
<td>22 (13.3)</td>
<td>15 (9.0)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>My TA seems to know what was covered in the video for that week.</td>
<td>78 (47.0)</td>
<td>60 (36.1)</td>
<td>14 (8.4)</td>
<td>7 (4.2)</td>
<td>7 (4.2)</td>
</tr>
</tbody>
</table>
**Group 5**: The following items will gauge your opinion of online learning and information delivery via video. Choose the appropriate response from the pulldown menus.

<table>
<thead>
<tr>
<th>Question</th>
<th>Completely Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Completely Disagree</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would like more classes to use videos to deliver course content.</td>
<td>57 (34.3)</td>
<td>52 (31.3)</td>
<td>30 (18.1)</td>
<td>20 (12.0)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>I prefer taking the pre-lab quizzes online instead of in class.</td>
<td>103 (62.0)</td>
<td>37 (22.3)</td>
<td>8 (4.8)</td>
<td>11 (6.6)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>I feel that the videos deliver pre-lab content at least as well as my TA would.</td>
<td>66 (39.8)</td>
<td>56 (33.7)</td>
<td>29 (17.5)</td>
<td>8 (4.8)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>I feel that the information provided in the videos allow all students to receive identical instruction.</td>
<td>93 (56.0)</td>
<td>58 (34.9)</td>
<td>8 (4.8)</td>
<td>0 (0.0)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>I feel that the videos are a useful way to deliver class content.</td>
<td>76 (45.8)</td>
<td>66 (39.8)</td>
<td>15 (9.0)</td>
<td>2 (1.2)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>I feel that having to take the quizzes online makes me prepare for lab further ahead of time than I would otherwise.</td>
<td>79 (47.6)</td>
<td>45 (27.1)</td>
<td>26 (15.7)</td>
<td>9 (5.4)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>I feel that I do better on the online quizzes because I can take them at my own pace.</td>
<td>77 (46.4)</td>
<td>47 (28.3)</td>
<td>18 (10.8)</td>
<td>17 (10.2)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>I feel that my grades on the online quizzes are as good or better than they would be if I took similar paper quizzes in the lab.</td>
<td>60 (36.1)</td>
<td>52 (31.3)</td>
<td>34 (20.5)</td>
<td>13 (7.8)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>I am able to view the audio/visual content included in the online quizzes.</td>
<td>108 (65.1)</td>
<td>39 (23.5)</td>
<td>10 (6.0)</td>
<td>2 (1.2)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>How frequently are you required to submit your weekly quiz before you are able to complete it?</td>
<td>79 (47.6)</td>
<td>22 (13.3)</td>
<td>20 (12.0)</td>
<td>38 (22.9)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>The vocabulary used in the video was</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very complex; I understood very little</td>
<td>12 (7.2)</td>
<td>55 (33.1)</td>
<td>89 (53.6)</td>
<td>3 (1.8)</td>
<td>7 (4.2)</td>
</tr>
<tr>
<td>Complex; I understood most</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceptable; I understood everything</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Too simple; I understood, but over-simplified</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Response</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Group 6:** The following items will determine how you interact with the videos and your laboratory notebook. Choose the appropriate response from the pulldown menus to indicate how often you do each of the following.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Most Weeks</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>Never</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete the &quot;In Your Notebook&quot; section in your manual before taking the quiz.</td>
<td>70 (42.2)</td>
<td>51 (30.7)</td>
<td>20 (12.0)</td>
<td>16 (9.6)</td>
<td>9 (5.4)</td>
</tr>
<tr>
<td>Watch the entire video from beginning to end.</td>
<td>142 (85.5)</td>
<td>12 (7.2)</td>
<td>3 (1.8)</td>
<td>0 (0.0)</td>
<td>9 (5.4)</td>
</tr>
<tr>
<td>Use a search engine (ie., Google) to look up key terms.</td>
<td>52 (31.3)</td>
<td>55 (33.1)</td>
<td>38 (22.9)</td>
<td>46 (27.7)</td>
<td>9 (5.4)</td>
</tr>
<tr>
<td>Take notes from the video without it paused.</td>
<td>13 (7.8)</td>
<td>43 (25.9)</td>
<td>6 (3.6)</td>
<td>7 (4.2)</td>
<td>9 (5.4)</td>
</tr>
<tr>
<td>Take notes from the video with it paused.</td>
<td>101 (60.8)</td>
<td>43 (25.9)</td>
<td>6 (3.6)</td>
<td>7 (4.2)</td>
<td>9 (5.4)</td>
</tr>
<tr>
<td>Take notes from the lab manual.</td>
<td>68 (41.0)</td>
<td>53 (31.9)</td>
<td>24 (14.5)</td>
<td>12 (7.2)</td>
<td>9 (5.4)</td>
</tr>
<tr>
<td>Re-watch the video or parts of the video.</td>
<td>129 (77.7)</td>
<td>24 (14.5)</td>
<td>2 (1.2)</td>
<td>2 (1.2)</td>
<td>9 (5.4)</td>
</tr>
<tr>
<td>Actively look at other tabs or windows while the video is playing.</td>
<td>12 (8.4)</td>
<td>21 (12.7)</td>
<td>57 (34.3)</td>
<td>65 (39.2)</td>
<td>9 (5.4)</td>
</tr>
</tbody>
</table>
Group 7: Share your thoughts on the content of the videos with the following items. Choose an option from the pulldown menus to indicate whether the videos should place more of an emphasis on each of the following aspects in order for the videos to successfully prepare your for the quiz and lab activity.

<table>
<thead>
<tr>
<th>Describe the amount of time spent on background/chemistry information in the videos.</th>
<th>There is TOO MUCH time spent on</th>
<th>There is THE RIGHT AMOUNT of time spent on</th>
<th>There is TOO LITTLE time spent on</th>
<th>I would prefer there NOT BE ANY time spent on</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 (3.6)</td>
<td>96 (57.8)</td>
<td>53 (31.9)</td>
<td>2 (1.2)</td>
<td>9 (5.4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Describe the amount of key terms and definitions in the videos.</th>
<th>3 (1.8)</th>
<th>96 (57.8)</th>
<th>56 (33.7)</th>
<th>2 (1.2)</th>
<th>9 (5.4)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Describe the amount of time spent on calculations in the videos.</th>
<th>3 (1.8)</th>
<th>42 (25.3)</th>
<th>110 (66.3)</th>
<th>2 (1.2)</th>
<th>9 (5.4)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Describe the amount of time spent on lab technique demos in the videos.</th>
<th>4 (2.4)</th>
<th>122 (73.5)</th>
<th>30 (18.1)</th>
<th>1 (0.6)</th>
<th>9 (5.4)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Describe the amount of time spent on lab equipment demos in the videos.</th>
<th>7 (4.2)</th>
<th>131 (78.9)</th>
<th>19 (11.4)</th>
<th>0 (0.0)</th>
<th>9 (5.4)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Describe the amount of time spent on lab safety in the videos.</th>
<th>31 (18.7)</th>
<th>121 (72.9)</th>
<th>3 (1.8)</th>
<th>2 (1.2)</th>
<th>9 (5.4)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Describe the amount of time spent on proper disposal procedures in the videos.</th>
<th>13 (7.8)</th>
<th>135 (81.3)</th>
<th>6 (3.6)</th>
<th>3 (1.8)</th>
<th>9 (5.4)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Describe the amount of time spent on sample notebook pages in the videos.</th>
<th>There are TOO MANY shots of sample notebooks</th>
<th>There are THE RIGHT AMOUNT of shots of sample notebooks</th>
<th>There are TOO FEW shots of sample notebooks</th>
<th>I would prefer to NEVER see shots of sample notebooks</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 (1.8)</td>
<td>55 (33.1)</td>
<td>97 (58.4)</td>
<td>2 (1.2)</td>
<td>9 (5.4)</td>
</tr>
</tbody>
</table>
**Group 8:** The following items will ask for your input on specific aspects of the videos the authors have created. Choose the appropriate response from the pulldown menus.

<table>
<thead>
<tr>
<th>Item</th>
<th>Completely Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Completely Disagree</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>The use of the split screen (PPT slide and Instructor) was distracting.</td>
<td>11 (6.6)</td>
<td>17 (10.2)</td>
<td>59 (35.5)</td>
<td>69 (41.6)</td>
<td>10 (6.0)</td>
</tr>
<tr>
<td>The use of humor (the limerick, action figures and dinosaurs) made the videos more entertaining.</td>
<td>48 (28.9)</td>
<td>56 (33.7)</td>
<td>25 (15.1)</td>
<td>28 (16.9)</td>
<td>9 (5.4)</td>
</tr>
<tr>
<td>I found the pencil pop-up to be useful in differentiating important info.</td>
<td>64 (38.6)</td>
<td>34 (20.5)</td>
<td>17 (10.2)</td>
<td>12 (7.2)</td>
<td>9 (5.4)</td>
</tr>
<tr>
<td>I found the text boxes that pop up from the bottom helpful in learning key terms.</td>
<td>75 (45.2)</td>
<td>68 (41.0)</td>
<td>13 (7.8)</td>
<td>1 (0.6)</td>
<td>9 (5.4)</td>
</tr>
<tr>
<td>The video of the actual lab equipment was close enough to the equipment I have to use that I could recognize it when I got to lab.</td>
<td>95 (57.2)</td>
<td>55 (33.1)</td>
<td>5 (3.0)</td>
<td>2 (1.2)</td>
<td>9 (5.4)</td>
</tr>
</tbody>
</table>
Group 9: The last set of questions will ask you to give your opinions on the videos as a whole. Choose the appropriate response from the pulldown menus.

<table>
<thead>
<tr>
<th>I prefer to have someone voice over PPT slides</th>
<th>I prefer not to have any text and just watch someone speaking</th>
<th>I prefer shots in the lab or primary visuals</th>
<th>I prefer some combination of these three</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 (10.8)</td>
<td>6 (3.6)</td>
<td>29 (17.5)</td>
<td>105 (63.3)</td>
<td>8 (4.8)</td>
</tr>
</tbody>
</table>

Which of these responses best describes what you would prefer from these videos in terms of style?

<table>
<thead>
<tr>
<th>The videos switch images often enough that they hold my attention.</th>
<th>Completely Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Completely Disagree</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 (42.2)</td>
<td>74 (44.6)</td>
<td>12 (7.2)</td>
<td>2 (1.2)</td>
<td>8 (4.8)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>In general, I find the videos interesting.</th>
<th>Completely Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Completely Disagree</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>48 (28.9)</td>
<td>76 (45.8)</td>
<td>26 (15.7)</td>
<td>8 (4.8)</td>
<td>8 (4.8)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>I would prefer one longer video as opposed to several shorter ones.</th>
<th>Completely Agree</th>
<th>Mostly Agree</th>
<th>Mostly Disagree</th>
<th>Completely Disagree</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>37 (22.3)</td>
<td>41 (24.7)</td>
<td>39 (23.5)</td>
<td>41 (24.7)</td>
<td>8 (4.8)</td>
<td></td>
</tr>
</tbody>
</table>

Stand Alone Item

<table>
<thead>
<tr>
<th>On what type of device do you USUALLY watch these videos?</th>
<th>Smart Phone</th>
<th>Tablet</th>
<th>Personal Computer</th>
<th>Public Computer</th>
<th>No Response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 (2.4)</td>
<td>4 (2.4)</td>
<td>143 (86.1)</td>
<td>7 (4.2)</td>
<td>8 (4.8)</td>
</tr>
</tbody>
</table>