INVESTIGATING THE IMPACT OF A LABORATORY SKILLS CHECKLIST ON STUDENT ENGAGEMENT IN BIOLOGY

by

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INTRODUCTION AND BACKGROUND

For the past fourteen years I have taught introductory biology at Mount Vernon High School. Mount Vernon High School serves an interesting conglomeration of students. At a glance, the student body appears to be homogeneous but upon closer inspection one discovers disparate economic backgrounds and points of view. Our high school is fairly large, 1200 students in a small town of 16,000 people and approximately 44% of our students are on free or reduced lunch (of those, most are on free lunch). Many families in our community hold extremely fundamental religious convictions that are juxtaposed against others who live in a small college town that is socially progressive.

During the 2010-2011 school year I taught 94 students in four sections of biology, an introductory college preparatory course. Traditionally, my students have enjoyed lab activities and experiments, and I enjoy providing my students with “hands on” scientific opportunities. Furthermore, lab activities are conducted with safety as a primary concern requiring that student conduct and behavior be carefully monitored thereby promoting an environment that is both safe and conducive to learning. In spite of providing an atmosphere that would encourage learning first hand, observations have led me to suspect that many students are overly reliant on their lab partners to complete a lab. While one student is diligently trying to learn new skills, the less engaged partner provides company or “moral support”. The following question is a result of this observation: Is there a way to encourage all students to participate more fully in learning lab skills thereby stimulating a more focused approach to biology labs?

One goal in this action research study was to generate a more attentive and purposeful attitude in students during biology laboratory activities. The second goal of this study was to enhance learning during laboratory exercises. If this study succeeds in improving student focus and engagement during labs then the potential for student learning should also improve. Hence, a positive outcome of the first goal will be essential to the outcome of the second goal. In this action research, a laboratory skills checklist (LSC) will be implemented as a formative assessment to be monitored by both students and teacher. The laboratory skills checklist is a formative assessment developed by the New York State Education Department that has been modified to fit specific tasks (Doran et. al., 2002). The ideal result of this implement is to transition students from merely enjoying "hands on" activities to becoming active partners with their teacher in monitoring their progress and learning during labs.

The significance of the study was threefold. The first benefit was to help improve the effectiveness of laboratory exercises by increasing student focus and engagement. Secondly, students should benefit by acquiring new lab skills and techniques for tracking their personal progress in the acquisition of science skills. A third benefit of this study was to provide a tangible tool to improve communication between the student and teacher. As communication improves, the student teacher relationship can begin to change. The literature supports the evolving role of teachers from judge to guide (Tomlinson, 2007), as student self-assessment and self-monitoring enhances the development of metacognitive capabilities (Hofstein & Lunetta, 2002).

The lab skills checklist provides students with an opportunity not only to plan for success in acquiring skills but also to review past accomplishments. By actively monitoring their progress, students should be encouraged to apply greater effort during lab activities. In summary, the three significant benefits to students and teacher are to increase student engagement, track student progress in attaining lab skills and improve classroom communication. The interplay of these three benefits should have a positive impact on student learning.

There is potential for this study to have a broader impact on science curriculum at Mt. Vernon High School (MVHS) and perhaps even in the district. Two colleagues have expressed an interest in this study and will consider implementing a lab skills checklist in their own biology classes. Furthermore, the performance assessment used in conjunction with the skills list has potential to be used as a critical part of an assessment for Flexible Credit. The Ohio Department of Education (ODE) recently instituted a requirement for schools to provide students an option to test out of an introductory class. The requirement called Flexible Credit; is an assessment for students to obtain credit. Every school must develop their own protocol or assessment for Flexible Credit. Because laboratory experiences play a critical role in biology, our department agrees that a performance assessment should be required along with a more traditional summative assessment for every student who wants flexible credit. MVHS colleagues have taken a critical look at the lab skills checklist and developed a related performance assessment as part of our summative assessment to meet the recent ODE requirement. In summary, if our department values these interventions, other districts could adopt them as well. Furthermore, lab skills checklists could be developed for and utilized by elementary and middle school science classes in our district as a means to ensure that individual students are in fact learning grade appropriate lab skills. Years ago, our district adopted state standards for teaching science concepts at appropriate grade levels, the use of a lab skills checklist is a logical extension of those standards. This intervention will allow our district to monitor students' acquisition of science skills that build in complexity over time. This scaffolding of techniques and skills should better prepare our students to learn new skills and technologies in the future.

While striving to address the initial problem of student focus and engagement during lab activities, a primary question for action research developed:

- What will be the impact of a laboratory skills checklist on student engagement in an introductory biology class?

Secondary questions are as follows:

- What will be the impact of a laboratory skills checklist on student understanding in an introductory biology class?
- How will a lab skills checklist effect communication between students and teacher?
- What will be the effects of a lab skills checklist on students of varied achievement levels?
- How will a biology teacher be impacted by the use of a lab skills checklist?

CONCEPTUAL FRAMEWORK

This Action Research (AR) will study the effects of a Laboratory Skills Checklist (LSC) on student engagement and learning in an introductory high school biology class. The primary questions are: What impact would the Lab Skills Checklist have on the acquisition of lab skills and student attitude during lab activities? How will the LSC impact communication between the student and teacher? The students identify a level of accomplishment for each laboratory skill (needs improvement, proficient, and exemplary) allowing the teacher to better determine student readiness for a performance assessment. A significant goal of student-focused assessment, such as the LSC, is the development within students of a sense of active participation in acquiring scientific skills. The LSC may be a valuable tool to enable significant student engagement during labs and improve student /teacher communication.

The implementation of the "lab skills checklist" (LSC) used in this action research has been influenced by the work of Carol Ann Tomlinson. Tomlinson's "ten understandings" (Tomlinson, 2007, p. 9) contributed to her "evolution from seeing teaching as a job to seeing teaching as a science-informed art that has become a passion" (Tomlinson, 2007, p. 9). One of the major changes in her thinking was to view assessment not as a way of judging her students but as a way to guide them. Her philosophy regarding assessment evolved, as she saw assessment become a tool to provide information rather than grades. Hence her clever name for the assessments she relies upon, not "formative assessments" or "summative assessments", but "informative assessments" (Tomlinson, 2007, p. 10).

Peggy Watterson (2007) uses a rubric for student self-assessment that is similar to the LSC. Watterson has found that frequent assessments "improve communication about learning and understanding through simple mechanisms for student self-assessment" (Watterson, 2007, p. 1). Watterson's rubric for student self-assessment is similar to the LSC in that it allows students to rate their levels of understanding on a topic; but it is different from the LSC in two ways. Watterson's rubric has a broad application of uses in the classroom whereas the Lab Skills Checklist (LSC) is specific to lab experiences. The LSC also allows assessment from teacher and student, which involves communication in both directions. The basic philosophy is similar in that both types of assessments are designed to improve communication and instruction. Watterson recommends that teachers state goals clearly and succinctly, which aligns with this action research, as clearly stated goals are a central feature of the LSC. Along with encouraging teachers to assess often, Watterson also extols the virtues of letting "students see growth in their own understanding " (Watterson, 2007, p. 2) and to "chart individual student progress" (Watterson, 2007, p. 3). The LSC has the potential to accomplish both of Watterson's recommendations by enabling students to track their progress over time.

> "Metacognition refers to one's knowledge concerning one's own cognitive processes or anything related to them, e.g., the learning-relevant properties of information or data. For example, I am engaging in metacognition if I notice that I am having more trouble learning A than B; if it strikes me that I should double check C before accepting it as fact." (Flavell, 1976, p. 232).

The work of Flavell (1976) is commonly cited in educational studies and articles. Flavell has encouraged educators and psychologists to explore the intrinsic mechanisms of learning, and to understand that learning will occur when people actively engage in their thinking processes. The LSC provides students with a set of concrete goals which encourage self-assessment and self-monitoring of the students' personal progress. The terms cognitive and metacognitive may be distinguished further; wherein the first requires the execution of a thinking task while the second requires planning how to do the thinking task (Sungur, 2007). "Therefore, cognitive strategies are used to achieve cognitive progress, whereas metacognitive strategies are used to monitor it" (Flavell, 1992; Sungur, 2007, p.316). Use of the LSC provides students with an opportunity not only to plan for success in acquiring skills but also to review their past accomplishments. In the metacognitive process of actively monitoring their lab progress, students should be encouraged to apply greater effort during lab activities.

In an attempt to determine what factors motivate students to apply strategies and effort towards learning, Semra Sungur (2007) used the Motivated Strategies for Learning Questionnaire (MSQL), which was made by Pintrich, Smith, Garcia and Mckeachie in 1991 (Sungur, 2007). The use of this questionnaire could provide teachers with insights regarding why some students try and others don't as they face similar challenges. This study was intriguing because the questionnaire proved to be a reliable gauge of important motivational factors such as students' goal orientation, effort regulation and self-efficacy (Sungur, 2007). Because many science teachers are puzzled by the lack of effort or motivation displayed by some of their students this study could have importance for action researchers who seek to inspire science students to greater engagement.

The results from the MSLQ allowed the author to develop a concept map of "the relationships among motivational beliefs, metacognitive strategy use, and effort regulation in science courses" (Sungur, 2007, p. 323). In the data analysis Sungur (2007) quantified the values of the relationships and made final recommendations that are straight-forward and affirming. Her "study's findings suggest that teachers should create learning environments and activities that promote students' beliefs that their abilities to learn can be improved through effort and experience" (Sungur, 2007, p. 323). Additional support for the use of a lab skills checklist can be gleaned from the author's conclusions that students' motivational beliefs can be impacted when "students' progress in a particular area [are] emphasized and specific suggestions [are] made for improvement, stressing connections between past efforts and past accomplishments" (Sungur, 2007, p. 324).

In summary, the research indicates that the LSC may provide a tangible tool to help students function "metacognitively" by planning, monitoring and assessing their laboratory skills. Furthermore, the LSC provides a record of the students' past accomplishments as well as specific goals for future endeavors. A tool that motivates students to employ metacognitive strategies will help develop students' abilities to "learn how to learn" (Sungur, 2007, p. 315).

Formative assessments "measure the intermediary results of the learning process so as to give the students individual feedback about their progress as well as the necessary efforts for future success" (Stern, 2009, p. 210). The LSC can bridge a communication gap between the student and the teacher, as this type of formative assessment will "inform the teacher about the effects of the instruction and how it might be improved" (Stern, 2009, p.210). As a communication tool, the LSC meets the criteria suggested by Tanner and Allen that a classroom assessment "should be designed to be useful to both the instructor and the students" (Tanner & Allen, 2004, p.70). The use of intermediate evidence of student progress contrasts sharply with the more traditional summative assessments, which merely "inform students of a final judgment of their learning" (Tanner and Allen, 2004, p.69).

The LSC, used as a student-focused assessment has the potential to change the role of the teacher from judge to guide (Tomlinson, 2007). Such a role change for the teacher would necessitate the student becoming an active participant in the acquisition of science lab skills. "This difference in viewing both the teacher and student as actively engaged in the learning process necessitates new ways of conceptualizing both instruction and assessment" (Goubeaud, 2009, p.237). Many authors appear to agree with Goubeaud, who asserts "formative assessment lends itself to a process where students are active participants" (Goubeaud, 2009, p.239). Research suggests that a lab skills checklist (LSC) may hold the necessary attributes to encourage student engagement and participation in the acquisition of new skills.

Two different research articles provided information on how to collect and analyze data. Melanie Pickens, a high school science teacher, and Charles Eick, an Auburn University professor coauthored the article with the most relevant methods of data collection to this action research. Their study focused on the motivational techniques of two teachers of differently tracked high school science classes (Pickens & Eick, 2009). The study was also concerned with the response of the teachers' students to their motivational techniques. Their data collection consisted of several different types of information. One type of data collection involved taped interviews with the two teachers concerning the methods they use to motivate students. For a second type of data, one of the authors took field notes during numerous (7 to 8) observations of the teachers at work with their classes. "The purpose of these observations was to explore specific teaching strategies stated by the teachers and to observe the actual actions of the teachers and their impact on students' achievement-oriented behavior" (Pickens & Eick, 2009, p.352). The method of data collection described by Pickens and Eick relates to this action research because of the authors' attention to the degree of student engagement in the lesson (Pickens & Eick, 2009). The action research study described in this paper is focused on student engagement, during labs rather than during lessons. Using an unbiased observer to record student actions to determine the extent of engagement during labs could provide a significant data source for action research. The authors' also used debriefing and member checking with the subjects of their research to allow the participants a chance to view the data before sharing it more publically (Mills, 2007, p.86).

An additional data technique used by the authors was a Likert-type survey that "covered student views about motivation and learning, motivation in science class, and specific motivational strategies that emerged in their current science class" (Pickens & Eick, 2009, p.353). Finally, they concluded their semester long study with a focus-group interview of the two teachers together to "further discern teacher perceptions on motivation" (Pickens & Eick, 2009, p.353). These data collection techniques demonstrate useful methods to be utilized within an action research.

Pickens and Eick (2009) employed useful data analysis in their report. The authors examined their individual teacher interview data for patterns that could be placed in categories and used as headings in their matrixes. One technique in their data analysis was to take categories from individual teacher interviews to make a student survey of the motivational themes. Extracting themes or categories from one data source to embed in another data source allowed corroboration of the two different sources. Results indicate that some themes present in student interview data can be used to develop student surveys or vice versa. This permits the action researcher to compare different sources of feedback regarding student opinion on the lab skills checklist.

In summary, research articles inspired deeper thinking and planning as the nascent researcher commenced action research. Additionally, they provided a working model for the novice teacher researcher to organize their methodology and data collection and analysis.

David Henderson and Darrell Fisher (1998) used an instrument called the Science Laboratory Environment Inventory (SLEI) to assess “senior science students’ perceptions of aspects of their laboratory learning environment” (Henderson & Fisher, 1998, p. 1). The SLEI questionnaire was developed by Fraser, McRobbie and Giddings in 1993 and has been taken by thousands of science students around the world (Henderson & Fisher, 1998). The SLEI measures student attitude regarding five different “scales” or categories. For example, one scale is “student cohesiveness”, which is described as the “extent to which students know, help and are supportive of one another” (Henderson & Fisher, 1998, p. 4). Student cohesiveness or cooperative behaviors during labs showed a strong association with positive student attitudes (Henderson & Fisher, 1998). Another scale or category is integration, which is described as the “extent to which the laboratory activities are integrated with non-laboratory and theory classes” (Henderson, & Fisher, 1998, p. 5). The questionnaire uses a Likert-style ranking for the students to state how much or how often the particular practice or category takes place in their science laboratory. In addition, student outcomes were measured for inquiry skills and attitude. With these findings, the authors suggest a "strong association between the integration of practical and theory work and cognitive outcomes…indicating that biology teachers who integrate theory with practical [lab] work in their teaching are more likely to have higher achieving students in their classes" (Henderson & Fisher, 1998, p. 3).

The Henderson and Fisher study revealed two specific areas where a teacher may positively influence students' attitudes towards lab work. As previously noted, the study revealed a strong connection between cooperative behaviors and positive student attitudes. Improvement of the social atmosphere in the laboratory may motivate students toward greater effort in the lab and possibly greater achievement in science. The study also suggests that relating or integrating classroom work into lab work is another stimulus for positive student attitudes towards lab activities (Henderson & Fisher, 1998). In summary, through collaboration in labs, this research study provides supporting suggestions to improve student engagement during lab activities.

Avi Hofstein and Vincent Lunetta (2002) have engaged in a comprehensive analytical review of science research involving the function of the science laboratory in introductory science education, covering two decades of work, beginning in 1982. In the section titled "Goals", they suggest ways to support student learning that may be achieved by the intervention of the LSC. "To guide teaching and learning, it is very important for both teacher and students to be explicit about the general and specific purposes of what they are doing in the classroom" (Hofstein & Lunetta, 2002, p. 38). The authors' review of the research also supports the use of goals as "the most important bases for assessment" (Hofstein & Lunetta, 2002, p. 38). Furthermore, Hofstein and Lunetta cite studies which indicate that a lack of performance assessments has had a negative impact on science education (Bryce & Robertson, 1985; Lazarowitz & Tamir, 1994; Hofstein & Lunetta, 2002). The authors' emphasize that the "assessments of students' performance and understanding associated with the science laboratory should be an integral part of the laboratory work of teachers and students" (Hofstein & Lunetta, 2002, p. 42).

Although much of the authors' review of the research into science laboratory instruction laments the absence of inquiry and scaffolding of concepts, they end their review with several positive notes that have particular significance to this action research.

- "School laboratory activities have special potential as media for learning that can promote important science learning outcomes for students
- Students' perceptions and behaviors in the science laboratory are greatly influenced by teachers' expectations and assessment practices…and
- Teachers need ways to find out what their students are thinking and learning in the science laboratory and classroom" (Hofstein & Lunetta, 2002, p. 49).

The lab skills checklist will clearly define goals and expectations while simultaneously stimulating communication between teacher and students. The study by Hofstein and Lunetta provides evidence to support the use of a lab skills checklist as the primary instrument in action research.

One of the most significant literature references used for this AR studying the effects of laboratory skills checklist on student engagement, came from *The Science Educators' Guide to Laboratory Assessment* (Doran et. al., 2002). This book was instrumental in presenting the concept of using assessments to promote “student learning by providing feedback to students” (Doran et. al., 2002, p. 10). The text encourages teachers to modify and adapt the science skills checklist to fit specific tasks or goals, stating, “these lists should be treated as a resource of ideas” (Doran et. al., 2002, p. 49). The idea of using an assessment as a feedback mechanism is not unique to one author, Angello and Cross also extol the virtues of formative assessments as an essential form of communication between teacher and students. “When teachers and learners both receive regular feedback on student learning throughout the course, there are likely to be fewer surprises at semester’s end” (Angello & Cross, 1993, p. 26).

The literature review supports the use of a lab skills checklist as a worthwhile instrument for action research. Many reference articles reinforce themes that direct this action research such as the importance of explicitly stated goals (Watterson 2007); and the importance of clearly stating expectations, which emphasizes the need for clarity of purpose in the science lab (Hofstein & Lunetta, 2002). Another directional theme is the emphasis on tracking student progress (Watterson, 2007; Sungur, 2007). In addition, Tomlinson’s recommendation that the teacher become a guide for students rather than a judge supports the value of student self-assessment and self-monitoring in developing metacognitive capabilities (Tomlinson, 2002; Hofstein & Lunetta, 2002). A final theme worth restating is the importance of improved communication between student and teacher, which allows both individuals to work together toward improved student learning.

The laboratory skills checklist should provide substantial data for all the above-mentioned themes: clearly stated goals, tracking student progress, supporting student self-assessment and improving dialogue between the student and teacher.

METHODOLOGY

The Action Research described in this paper took place over several months during a unit on the cell. The methodology for this project received an exemption by Montana State University's Institutional Review Board, and compliance for working with human subjects was maintained. Implementation of the treatment, a lab skills checklist (Appendix A), began in November 2010 and concluded on January 31, 2011 with a post treatment microscope performance assessment (Appendix D). Pre treatment surveys and interviews were conducted in November and post treatment data collection was completed in mid March 2011. Stronger conclusions could have been drawn from this study if additional treatments had been conducted.

Before the treatment was implemented, all my students were given a copy of the Lab Skills Checklist and asked to complete a survey (Appendix B), regarding their opinion on potential benefits of the treatment. The pre treatment survey was conducted to determine student attitude toward the treatment. While 89 students took the pre treatment survey, a sample of convenience considering classroom grades of twelve students who participated in a pre treatment interview (Appendix C). The results of these two instruments indicated that the treatment would be a new experience for the students. Additionally, data from both pretreatment instruments provided a baseline of student opinion on the potential effects of a lab skills checklist to compare with post treatment opinions.

The primary treatment in this AR was the biology laboratory skills checklist (Appendix A) adapted from the New York State Department of Education (Doran et. al., 2002, p. 47). During interviews conducted with last school year's students, I learned that only one student (who moved from Pennsylvania) had previous experience with a lab skills checklist, or taken a performance assessment. The performance assessment on Cell Size and Microscope Use (Appendix D) was also adapted from the New York State Department of Education (Doran et. al., 2002, p. 87-89). The treatment and one of the primary instruments of this action research should be deemed reliable because they have been used by NYSDE for a number of years and also were peer reviewed by the *Science Educator's Guide to Laboratory Assessment*, (Doran et, al., 2002). Additionally, these instruments are valid, to biology instruction and may be implemented by two of my colleagues next school year. One of my colleagues planned to implement the performance assessment this past school year but ran out of time. The primary treatment was implemented over six lab periods throughout the unit of the cell and was compared to student scores on the associated performance assessment.

As a result of interviews with last year's students, I was persuaded to use the lab skills checklist as a form of communication rather than an evaluation. The lab skills checklist (LSC) allows students to indicate one of three levels of achievement for each listed skill. The three levels of achievement are: NI (needs improvement), P (proficient) and Ex (exemplary). Instead of merely checking a level of accomplishment, students were encouraged to indicate the date of their self- assessment. The use of dates instead of checkmarks provides a history of the students' progress. The LSC was stored in the classroom to provide a feedback mechanism between the students and the teacher. If for example, a student was not able to focus the microscope in high power, they indicated NI on their list; I knew whom to help during the next microscope lab. Because the checklist was not scored for a grade, instances of dishonesty with the students' self-evaluations were expected to be rare. If many students indicated NI, I offered additional instruction on that particular skill to the whole class. The expectation of a post treatment performance assessment, on microscope skills was expected to motivate each student to hone their personal microscope skills rather than rely on their lab partner.

One goal of the students' self- assessments on the LSC was to provide information on student readiness for the microscope performance assessment. On at least one occasion students were given an extra period to practice their skills. In an early survey, one student volunteered "sometimes I don't ask questions in class so this [the lab skills checklist] will help." A significant factor in this treatment was that it allowed a comfortable venue for shy students to request help.

Students were instructed on general use of the microscope earlier in the school year. Four microscope lab days were planned during our unit on the cell. Because of student responses on the LSC, two additional lab periods were provided for practice and assistance with the microscope labs. The lab procedure titled, Viewing Cells with a Light Microscope & Estimating Cell Size (Appendix H) gave detailed instructions for the students to follow. Students were asked to assess their microscope skills on the LSC after each of the four lab periods. During each of the labs, I wrote observations and notes, recording levels of student engagement, as well as provided assistance with focusing and adjusting microscopes. After each lab, I tabulated the number of students who marked NI (needs improvement) for a skill and based on those numbers, decided whether or not to review.

Table 1, summarizes all the data sources used to evaluate each of the research questions investigated in this study. Although it is not listed in Table 1, the treatment itself also functioned as a data instrument.

Table 1
Data Triangulation Matrix

	Data Sources				
Data Collection Matrix	**Surveys**	**Interview**	**Observations & notes**	**Class & test grades**	**Performance Assessment**
Research Questions					
1. What is the impact of a laboratory skills checklist on student engagement in an intro biology class?	✓	✓	✓	✓	✓
2. What is the impact of a laboratory skills checklist on student understanding?	✓	✓	✓	✓	✓
3. How will lab skills checklist effect communication between students' and teacher?	✓	✓	✓		
4. How will a lab skills checklist impact students of different abilities?	✓	✓	✓	✓	✓
5. How will a biology lab skills checklist impact a science teacher?		✓	✓	✓	

All data sources in Table 1 were used to evaluate the primary question: What will be the impact of a laboratory skills checklist on student engagement in an introductory biology class? The performance assessment (Appendix D) provided objective data to corroborate with the empirical data from class grades. Multiple lines of quantitative data from the performance assessment, test and class grades provided an objective comparison to qualitative evidence drawn from interviews, and field observations.

A secondary question, what is the impact of a laboratory skills checklist on student understanding, was also analyzed with different forms of data. Surveys will allow the tabulation of student opinion and can be compared with the more qualitative student interviews. My field observations and notes added to the qualitative analysis of this question and were compared with empirical data from student grades.

To determine the effects of a lab skills checklist on communication between students and teacher, analysis of qualitative data was compared with data from the LSC. Other qualitative data sources were used to evaluate the effects of the checklist as a form of communication. Student interviews were analyzed with survey data, while my personal reflections and journal entries provided another significant data piece about the effectiveness of the checklist in student/teacher communication.

My fourth question, how will a lab sills checklist impact students of varied ability in biology was measured by comparing all data sources and especially cross checking the sources with lab scores and grades. A student sample of convenience considering grades was established for the pre and post treatment interviews to determine if students of varied abilities were impacted differently by the treatment.

My fifth and final question was answered late in the action research: How will a biology lab skills checklist impact a science teacher? My own impressions of the implementation from my observations and notes provided subjective data. Student opinion of the treatment's impact on my teaching added another perspective.

DATA AND ANALYSIS

The action research implementing a lab skills checklist produced data from both qualitative and quantitative sources. To determine the effects of a lab skills checklist on student engagement in biology, several forms of data were collected prior to treatment and after treatment. In this section, pre and post treatment surveys and interviews are compared and analyzed with post treatment performance assessments. Additionally, teacher observations are compared with student data. The following findings could have been strengthened with addition of more treatments in a variety of different labs.

An anonymous survey was conducted with 91 biology students early in the school year (Appendix B) and followed by the smaller sample of student interviews (Appendix C). These pre treatment data sources were conducted to ascertain students' perspectives on lab work in general and specifically how a lab skills checklist, (Appendix A) might affect their lab experiences. The treatment, a lab skills checklist, was implemented in early November coinciding with a unit on the cell and more frequent use of the microscope.

Table 2 contains summarized data from a pretreatment survey given to all four biology classes. Most of the students are sophomores but twelve are freshmen. The freshmen demonstrated a high level of proficiency in science during middle school and therefore have taken an accelerated science track. Along with discovering if any students had prior experiences with a lab skills checklist, one could also examine student opinion on the potential benefits of using a checklist. The results of the pretreatment survey are in Table 2 below.

Table 2
Pretreatment Survey (*N*=91)

Question	**Positive response**	**Negative response**
Used lab skills checklist before	9	83
Potential to help you	78	4 no, 5 unsure
Check any potential benefits		
a. Keeps student on track	60	Na
b. Communication w/teacher	69	Na
c. Way to request help	71	Na
d. Other	14 wrote additional benefit	
Indicate reason checklist may not benefit you	13 wrote additional positive statement	14 wrote a reason they would not benefit

The pretreatment survey data indicated that 86% of the students saw potential for the lab skills checklist to aid in student / teacher communication. This was a positive indicator from the students that they would use the checklist as a communication tool. An important goal of the study was to create a feedback mechanism to improve communication. Realization of this goal would help the teacher determine students' skill levels prior to assessments. The positive student opinion prior to treatment caused me to infer that the treatment would significantly improve communication and aid in assessment preparedness.

Table 3 contains summarized data from the pretreatment interviews. The pre treatment interview shows a strong correlation with the pre treatment survey. Both data tables indicate that the majority of students believe the lab skills checklist will benefit them in some way. Additionally, of the nine of eleven students interviewed, 82% believed the lab skills checklist would encourage greater focus during labs.

Table 3
Pretreatment Interview (*N*=13)

Questions	**Response**			**Response**		
Enjoyed science classes	11 yes			2 no		
Favorite class	4 science 5 math			3 other		
Enjoy & remember lab activities	7 yes			3 depends on partner, 3 don't remember		
Benefits of working w/partners & lab groups	10 help with understanding			4 help with work		
Challenge of working w/partners & lab groups	1 disagree-ments	3 too pushy	4 too lazy	2 sharing supplies	2 getting off track	2 too slow
Wish you could work lab independently	2 Yes	7 sometimes		1 no		
Will checklist encourage peers to be more independent in lab	3 Yes	1 sometimes		2 no	1 not every week	1 depends if they care
Will checklist cause you to be more focused in lab	9 yes			2 no		
Will checklist cause your peers to be more focused in lab	3 yes	4 yes, if they are tested		4 yes for some students & no for other students		

Only two of the interviewed students said they would not benefit from the treatment. Both interviewees reasoned that they are already focused and on task during labs. They are coded as students B-0 and B-13 both are motivated science students who expressed an interest in pursuing science in the future. B-13 explained, "I am already well aware of my personal science skills but some other people could use looking at this now and then." Other motivated students like B-12 felt they personally might benefit from the skills checklist "if I forget to do something, it's right here. It reminds you of stuff and also [it will] force me to learn more because I will want to do the best I can on it so I will try to really learn it rather than skim through."

Of the thirteen students interviewed only two said they do not generally enjoy science classes. B10-C6 hasn't "really enjoyed science, but 5th grade was probably the easiest" science class and therefore his favorite. B10-C6 doesn't remember doing labs until last year when he was "stuck with people who had really, really bad grades and if I didn't pay attention we didn't know what to do and we would fail" the lab. Even though he has had bad group experiences he still would "not really" prefer to work independently. He further notes that "if people are on topic, it makes it much easier" to complete labs. It was a common theme throughout the interviews that the quality of lab partners determines the quality of a lab experience. The other student who does not enjoy science, B10-C7, seemed to contradict herself when we began discussing labs, "I've done a lot of labs and I love doing labs! It just depends on which group you get in and who doesn't want to do it." Her comment regarding lab group or partners determining the degree of enjoyment or satisfaction with labs ran through many conversations. Student B-8 is different from B10-C7 because science is his favorite class; he "likes to learn about life and stuff." But he voiced a similar frustration when he said "I like to work with a group [but] I hate it when someone just sits there." These comments indicate that an individual's focus is only one positive component toward improved student engagement during labs. Lab partners and lab groups play a significant role in the success or failure of an individual's effort during lab experiences.

Table 3 contrasts the benefits and challenges of working with a group or partner. Whether they are motivated students or not, all of the interviewees appreciate the advantages of a partner or group for helping with understanding and/or with the hands on work of setting up and cleaning up labs. B10-C7 likes "that one other person to make sure you are doing it right and share ideas and stuff." But everyone was also able to site at least one challenge like B-9 who said that "If you want to do something [by yourself in lab] you might have to let someone else do it." Or even more challenging than sharing supplies is when a partner works at a different pace. B3-C2 says he "sometimes wishes to work alone if a partner moves too slowly." B13-C3 has found that some partners require a lot of help and that "having to explain everything, while it may be useful to them, it slows me down. I like working with people who are at my same pace. We can help each other." Still she likes to compare other student's answers to her notes and then she can "form my own conclusion." Overall, even the motivated students do not prefer to work independently all the time.

A majority of the motivated students saw a potential benefit to using the lab skills checklist but they were doubtful that their less serious counter parts would become more engaged. B-8 said, "with me it will help show what I need to do and I think it will help with others." But, he warned, "some people if they're used to just sitting there, then…" he ended with a shrug of his shoulders and a shake of his head. So I pressed a little further, "what if they know there will also be a performance assessment?" "Then, they might" he said, but he looked dubious.

Observation notes describe B-7 as an overly enthusiastic, somewhat boisterous student during labs, B10-C6 was a part of his group early in the treatment and they struggled to stay on task. During the pretreatment interview, B-7 expressed a strong desire to perform well in science and lab work and to his credit admitted that one of his challenges with group work is “not talking about other things besides science.” He thought the lab skills checklist would help him “because it will tell me what I need to work on and stuff like that.” With regards to his peers he said it “depends on the person because some people do it [lab work] and don’t even care and other people, they really try. I’m pretty sure that most people will want to do it cause you gotta get good grades.” One goal of the treatment was to influence easily distracted students like B-7 to stay on task during labs.

In summary, most pre treatment interviews indicated that students saw potential benefits for themselves when using the lab skills checklist. Some interviewees were less certain their peers would be motivated to focus as a result of the skills checklist. Interestingly, students that were targeted in my observations as a distraction during labs believed they would be motivated to achieve by the skills checklist and/or the performance assessment. B10-C6 is just such a student who agreed that the performance assessment would motivate him, “Yeah, I’d be studying. But, there are always people who just don’t care and they won’t do it anyways.” Student B12-C4 is an accomplished student and his final thought on the potential of the lab skills checklist was that “we will all be more focused if you want to succeed in this class.” Pre treatment data suggested the lab skills checklist and /or the performance assessment had the potential to motivate students towards greater engagement and focus during laboratory activities.

Approximately two months after the LSC was implemented, the Microscope Performance Assessment (Appendix D) was administered late in January to gauge students skills attained during microscopy labs. The performance assessment provided empirical data to compare with pre and post treatment surveys and interviews about the effects of the lab skills checklist on student engagement during microscope labs.

Separation of the interviewed student data from total student data allows a closer investigation of the pros and cons of the lab skills checklist. Table 4 below illustrates the various grade levels of the interviewed sample.

Table 4
Comparison of assessment scores and regular test scores of interviewed students (*N*=12)

Name-ID	Post treatment assessment score	Opinion of the LSC	Regular Test average	Average overall grade
B7	4/10	No help	D+	C+
B10-C7	5/10	Helped	D+	B-
B9	9/10	Helped	D+	C
B10-C6	5/10	No help	C-	C+
B5	7/10	Helped	C+	C+
B0-C8	6/10	No help	C+	B
B-11	8/10	Helped	B-	B-
B3-C1	10/10	Helped	B	A-
B13-C3	8/10	Yes / no	B+	A
B12-C4	7/10	Helped	A-	A-
B3-C2	9/10	Helped	A	A
B15-C5	9/10	Helped	A	A

Table 4 above shows the grade stratification of the interviewed students. While three students maintained that the lab skills checklist was not helpful in preparation for the post treatment assessment; eight students claimed the LSC was beneficial. One of the twelve students was equivocal in her opinion of the LSC. Overall the small, stratified group of students' opinion supports the use of a lab skills checklist in preparation for a performance assessment. While it would have been interesting to gain further insight of

B7's attitude toward the post treatment assessment, he was angry and uncooperative and refused to be interviewed.

Survey and interview data lend additional perspective to the impact of the lab skills checklist. More equivocal results were obtained when probing into the thoughts and feelings of the interviewed students. B10-C6, a student who lacks focus in labs, might have benefited from the LSC but he checked exemplary for every microscope skill on the LSC. Still, when asked if his test score (5/10) was a surprise; he said he was surprised that he "didn't get a zero. I thought I was prepared for it. I wasn't." When asked if the lab skills checklist was helpful to him he guaranteed, "the majority of students just checked the top one [exemplary] so that they don't have to stay after school." His comment was contradictory to classroom policy and indicated a lack of regard for the purpose of the lab skills checklist; further underscoring the challenge in motivating disengaged students. While the LSC failed to improve communication and engagement for B10-C6, some of his classmates disagreed with his assessment of the treatment.

Student B10-C7 is a classmate of B10-C6 who also performed poorly on both the non-treatment and post treatment performance assessments. In spite of B10-C7's low score, she had a different perspective from her classmate. She attributed her low performance score to test anxiety, "I pretty much freaked out when I got it. I do that a lot". Although she did not perform well on the post treatment assessment, she "thought [the lab skills checklist] was really helpful just because I knew what was going to be there and I could work on what I needed to do." When asked how other members of her lab group responded to the LSC, she "felt like they knew what [to do] because it's in order so they were focused more and not off topic." Student B10-C7 strives to do well in labs and utilize the tools provided by her teacher. B10-C7 often achieves poor test scores, but they are not a result of distracted behavior or lack of motivation.

During microscope labs I observed students' attitude and behavior, and in my notes designated each interviewed student a level of engagement. In order to objectively measure student engagement, the following four levels were assigned a numerical value. Scores were based on four levels of engagement: Fully on task = 3; Mostly on task = 2; partially on task = 1; mostly off task = 0. The interviewed students were observed in labs before treatment and during treatment. The following table compares the average level of student engagement during labs with their performance assessment scores.

Table 5
Level of engagement during labs before treatment and during treatment (*N*=12)

Student ID	Engagement before	Engagement during	Post treatment assessment score
B7	1	1	4/10
B10-C7	3	3	5/10
B9	1.5	2	9/10
B10-C6	1.5	2	5/10
B5	2	2.5	7/10
B0-C8	1.5	1.5	6/10
B11	3	3	8/10
B3-C1	3	3	10/10
B13-C3	3	3	8/10
B12-C4	2.5	3	7/10
B3-C2	3	3	9/10
B15-C5	3	3	9/10
Average	2.25	2.5	

Table 5 shows that the interviewed students improved their level of engagement during lab while the treatment was in use. On a scale of zero to three, the average level of engagement was 2.5 during the treatment compared with 2.25 before the treatment.

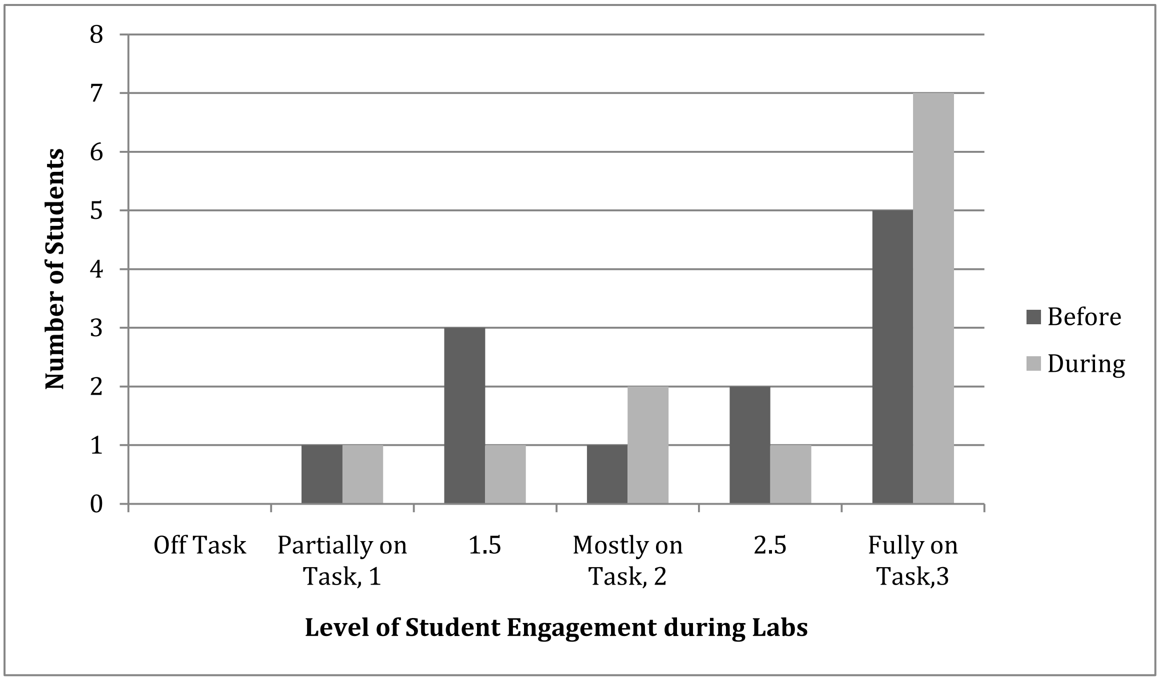

Figure 1. Comparison of students' level of engagement during labs before and during the treatment (*N*=12).

Teacher observations were quantified to compare improvement in student's engagement during labs seen in Figure 1 above. Figure 1 shows that student engagement improved with the use of the LSC. My observations and notes showed that more students were cross- checking lab procedures with the LSC to better prepare for their performance assessment.

Although one would expect high achieving students to perform well on assessments with or without special treatments, many in this group appreciated the lab skills checklist as a tool to monitor their progress. Several of the high achieving students believed the LSC helped them to prepare for the performance assessment. B3-C2 said "it really pinpoints what you need to know, what other stuff you don't really need to focus on. It's more fine tuning what you need." He had marked proficient on focusing in high power "so every other microscope lab we had that made me really practice it." He used the LSC to identify a skill that needed more practice and was motivated in each successive lab to improve that skill. Another motivated student found the LSC helpful for herself and her lab partners; B3-C1said that the LSC helped her group to focus on a task. "If they… check something that they didn't understand, they would ask help from me and I would help them." If more lab groups used their lab skills checklist this effectively the treatment might have had a more positive impact on the performance assessment grades.

One of the "A" students was more ambivalent about the lab skills checklist. B13-C3 suggested that because "humans sort of overestimate themselves sometimes…it might help if there is a double check to make sure what we put down as our opinion is what we really can do." B13-C3 concerns for quality lab work were easily resolved when we found a good partner for her earlier in the school year. She felt the LSC was probably more valuable to other partners at her lab table than it was for B13-C3 who had a really good partner, "we can see how we are doing [without a LSC]." The importance of a high quality lab partner has been a constant concern of interviewed students throughout this study.

Table 6 below summarizes student opinion post treatment and post performance assessment. A Likert style survey was conducted after sharing class results from the performance assessment. Students' lab skills checklist, performance assessment and graded rubric were returned to purview. In addition to their individual assessments, class results of the assessment (Appendix J) were projected on a screen so they could compare their scores with the class data. Students were asked to look over their assessments and the class data (Appendix J) as they completed the survey.

Table 6
Post treatment and post performance assessment survey data (*N*=89)

Questions:	Strongly disagree	Disagree	Agree	Strongly agree
1. My score was about what I expected	7	27	37	18
% students	38%		62%	
2. My score was close to the class average	10	43	24	12
% students	59%		41%	
3. I felt prepared for the micro. assessment	4	19	45	21
% students	26%		74%	
4. I used the lab skills checklist to indicate that I need more time on a skill	5	35	44	5
% students	45%		55%	
5. The lab skills checklist was NOT helpful in preparation for micro. assessment	15	42	26	5
% students	64%		35%	
6. The Lab skills checklist would be more helpful if it were revised	10	46	23	4
% students	63%		30%	

The post treatment survey, Table 6, indicates that 74% of students felt prepared for the microscope test. While this survey data appears to corroborate with the 74% who passed the microscope assessment, 10% of the passing students only scored 6/10 while 64% attained the median score of 7/10 or higher. Also, only 62% of the students attained the score they were expecting to achieve on the microscope test indicating that while 74% felt prepared and 74% passed, approximately 38% scored lower or higher than they had expected. This data indicates that although many interviewed students felt the lab skills checklist helped improve student performance in lab assessments surveyed student expectations and student achievement were not tightly corroborated. Some of the interviewed students indicated that they expected higher or lower scores than they achieved. B3-C-2 got a 9/10 on his microscope performance assessment but indicated on his survey that he should have gotten a 10/10.

Table 7 below compares student responses from their pre treatment surveys to their post treatment surveys and to student data from the lab skills checklist.

Table 7
Comparison of Student responses to Pre and Post Treatment Surveys and the LSC (*N*=89)

	Pre Treatment Survey	Post Treatment Survey	Data from LSC
The LSC will be a way to ask for help	78%		
The LSC was helpful		64%	
I used the LSC to request help		55%	
Students who indicated NI, needs improvement			39%

Table 7 above, shows that 78% of students surveyed prior to treatment indicated the LSC would be a way to ask for help. In the post treatment survey 64% indicated the lab skills checklist helped them prepare for the microscope performance assessment. Although the majority of students, 64%, found the treatment helpful in preparation for their performance assessment, there was a notable decline from their more positive pretreatment survey. An interesting discrepancy was found by comparing data from the treatment, the lab skills checklist and the post treatment survey. In the post treatment survey, 55% of students agreed that they used the LSC to indicate that they needed more time to practice a skill, but in reviewing the lab skill checklists, only 39% of students had actually checked Needs Improvement over the two month period of use. It was surprising to see such a weak correlation between these factors since the students were given their own LSC to review while they completed the post treatment survey. Evidently, there was some confusion for some students about the skill levels on the LSC.

When asked for suggested revisions to the LSC, one student recommended using other words to indicate skill levels like basic, good and excellent, instead of NI (needs improvement), proficient, and exemplary. Perhaps further clarification from the teacher regarding the use of the lab skills checklist could increase corroboration between those who actually checked needs improvement and those who merely thought they had.

Figure 2 below, explores the correlation between the microscope performance assessment and student assessed lab skills checklist. Question 10, calculate the length of one onion skin cell, was the most frequently missed of questions on the microscope assessment. Determining the size of microscopic specimens was task # 5 on the lab skills checklist that would address student readiness for question 10.

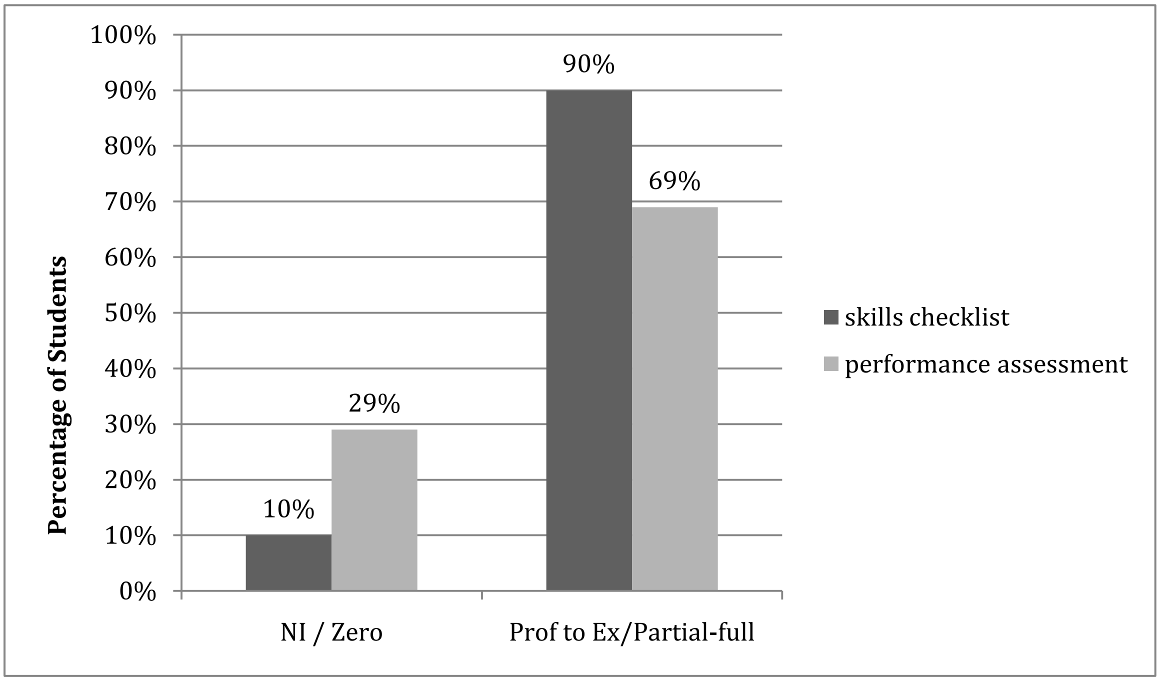

Figure 2. Comparison of lab skills checklist with performance assessment question #10; calculate the size of a cell, (*N*=89).

The data suggests that higher assessment scores could be attained if students recognized and indicated when they needed help. For example, Figure 2 illustrates that 29% of the students taking the performance assessment achieved a zero on question 10, calculate the length of on onion cell. However, on the lab skills checklist, only 10% of students indicated NI, needs improvement for determining the size of microscopic specimens. Figure 2 underlines the disparity between 69% of students who demonstrated proficiency at this skill, and the 90% who indicated they were proficient on their LSC.

While the pre treatment survey indicated that 76% of students thought the lab skills checklist would aid communication with the teacher, post treatment data suggests otherwise. The goal of improving communication between student and teacher did not succeed as well as the pre treatment survey predicted. This particular skill requires several steps, focusing the microscope, measuring with the scope and performing some math. Perhaps student self assessment is less accurate when a task requires more than one step.

Figure 3, below compares the students' self assessment on the lab skills checklist for identifying animal cell parts with #12 on the performance assessment; make a diagram of a cheek cell.

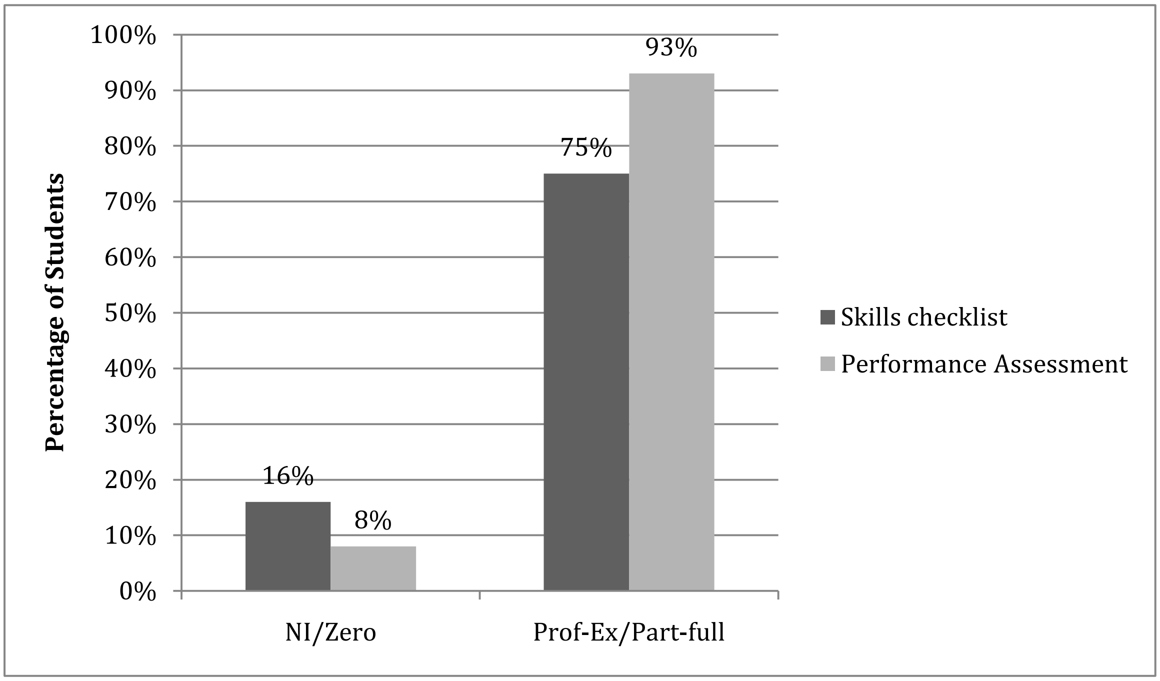

Figure 3. Comparison of performance assessment item 12; diagram a cheek cell, with skill assessment. (*N*=89)

Figure 3 casts a more favorable light on the success of the lab skills checklist. In this comparison between #12, diagram a cheek cell, on the performance assessment and a comparable task on the lab skills checklist, identify animal cell parts, students appeared not to overestimate their abilities. Seven students did not check this item on their skills list, which accounts for the percentage of students not adding to 100%. 16% indicated that they needed improvement and ultimately students performed well on this task in their performance assessment with 93% getting full or partial credit. Perhaps students more easily judge some skills than other skills. The completion of this task required fewer steps than estimating cell size thus allowing the majority of students to adequately judge their skill level. If more treatments had been implemented the effectiveness of student self assessment in multi step or single step skills might have been decided.

Overall, the data suggests the treatment does more good than harm for introductory biology students. Only 26% of students failed the post treatment assessment while 74% passed. A majority of surveyed students, 64%, believed the LSC helped them prepare for the performance assessment. With some refinements and more experience with the treatment, a lab skills checklist could become a valuable tool in laboratory experiences. For example, when reviewing the lab skill checklists, a teacher should be wary of a low achieving student marking exemplary on every self- assessment, as did B10-C6. Repeated implementation of an instrument should improve a teacher's ability to recognize a student who has marked high achievement merely to avoid teacher attention.

INTERPRETATION AND CONCLUSION

Early in my project I was gratified to see that most of my students had a positive attitude toward the lab skills checklist, 86% saw a potential benefit in the treatment. I believed their positive attitude improved the chances that the treatment would benefit my classes. Prior experiences have taught me that if students begin a new treatment with a positive attitude then the probability of success is greater. Ultimately this was true, post treatment surveys indicate that a majority of students (64%) felt the LSC was beneficial. While, disappointing to see a drop in pre and post opinion of the benefits to students, the majority considered the treatment helpful. Also, 74% of students passed the post treatment performance assessment and my observation notes indicated more focused student behavior during labs. The average level of student engagement increased from 2.25 before treatment to 2.5 during treatment, based on a scale of zero to three. The impact of the LSC on introductory biology students was positive as evidenced by improved student engagement.

The effect of the LSC on students of various levels was a concern early in the study. In the pre treatment survey, one student was concerned that if she would indicate needs improvement (NI) on the checklist, we wouldn't allow extra time. Another student indicated they were confident in their lab skills and worried about progressing too slowly. I was interested to determine from the interviews if other bright and motivated students were worried about slow progress because of the treatment. My observations and interviews indicated that the accomplished students tolerate extra review if their peers are not lazy. B-13 generously explained that even "if there are more people who are exemplary or proficient than NI then we could probably spare a period to go over the skills because it is all about teamwork, the group helping the whole." When students worked in a cooperative group, productivity and satisfaction both appeared to be higher. In such cases, good students were able to assist other students and maintain their personal standards of excellence. For example B3-C1, was able to score a perfect post treatment assessment and still assist students at her lab table.

B3-C1 held a high opinion of the treatment as indicated by her post treatment survey and interview. When asked for suggestions to improve the LSC she replied, "Honestly, I think it's good just the way it is. Because people just realize what they need to work on and what they're OK on. I think it's good how it is." She was able to utilize the treatment to identify goals and track her progress attaining the goals.

One of my secondary questions was to determine how the LSC affects students of various abilities. Results for less accomplished students were equivocal. Interestingly, 50% of the less accomplished students indicated the treatment was helpful while 50% stated they did not benefit from the treatment. My observations of these students' level of engagement recorded an improvement in the same students who felt the treatment was beneficial with one exception. My observations indicated an improvement in level of engagement from B10-C6, who did not have a high opinion of the LSC. This experience has taught me the value of double- checking students who indicate "exemplary" for all skills on their LSC if their assessment contradicts past performances.

Results of the lab skills checklist as a tool for improved communication were also equivocal. While 76% of students surveyed pre treatment believed the LSC would aid communication with the teacher, a comparison of performance assessment results with data from the LSC showed variable results. In the post treatment survey 55% of students said they used the LSC to ask for more practice time while data from the LSCs show only 39% of students indicated NI (needs improvement). If a question presented more than one step, the correlation between students indicating they need more time and those not performing well on that question was low (see Figure 1). If a question contained only one step, or task, then students' self assessment on the LSC correlated well with their performance assessment of said task (see Figure 2).

Perhaps communication can be improved with a simple revision of the LSC to "Needs more practice" rather than NI (needs improvement). One student surveyed revealed the potential confusion of the current system when he stated, "I'd like to be EX. [exemplary], not proficient before I take a test over a microscope." On his lab skills checklist, he had marked five skills as proficient and two as exemplary. Even though directions were repeatedly given for use of the LSC, and my observations indicate that said student struggles to pay attention, simple changes could improve the LSC as a feedback mechanism. I believe only two skill levels should be available for student self-assessment of each task on the LSC: “Needs more practice” and “Ready for the test”. With these simple revisions, the LSC could allow even the least attentive student to more accurately communicate with their teacher.

In summary, the lab skills checklist slightly improved student engagement in labs, allowed students to track their progress and had benefits for students of varying levels of achievement. While 50% of students who test at a C to D average felt the LSC was helpful, 83% of the A to B average students said the LSC was beneficial. One can infer that the A-B students appreciated the LSC because they routinely use tools that have the potential to improve their learning. As a communication tool, the LSC accurately informed the teacher of student readiness in skills that require one step and less accurately demonstrated student readiness for multi-step tasks. Furthermore, student surveys revealed that the LSC shows potential to improve as a communication tool with simple revisions.

VALUE

One significant impact on my teaching is that I will continue to implement the treatment allowing the collection of data from my students, to better direct my instructional practice. In the past I have tried a variety of new instruments to improve student experience but prior to my AR, I determined the effectiveness of those instruments intuitively. On each occasion that I shared data from the LSC or from performance assessment scores, students were very interested in the results. Stimulating a shared interest in results of a treatment could be a significant step in moving students from passive learners to "active participants in learning." In the future, I will avoid intuitive decisions about the effects of treatments, and will continue to collect and share with my students the results from qualitative and quantitative data.

For example, students' responses from last year's data strongly influenced the direction of my AR this year. In summary, the effect of being data driven in this study will have implications for my future students. As a result of this study I will continue to use a lab skills checklist and performance assessments.

Three notable results from this AR encourage me to implement the treatment again next school year. First, my data indicated that the treatment improved student engagement from 2.25 to 2.5 on a scale of zero to three. Second, as a communication tool, the LSC gave me concrete information about student readiness. One of my students confirmed that advantage to me when he said, "you can see, as a teacher whether or not they're getting it through that checklist." A third reason to implement the treatment again is that students were able to monitor and assess their own progress, allowing them to "see growth in their understanding" (Watterson, 2007, p. 2) and "chart their individual progress." (Watterson, 2007, p. 3). When questioned about extending the use of the LSC, one of my students replied, "that would be fine and in addition to helping each of us to stay on task, it would help also for us to see where we need to continue to learn more." In summary, the three significant benefits to the student and teacher were to increase student engagement, to track student progress in attaining lab skills and to improve classroom communication. The interplay of these three benefits should continue to have a positive impact on student learning.

Broader implications of this study are that my colleagues could choose to implement the treatment, a lab skills checklist. One of my colleagues planed to implement the microscope performance assessment (Appendix D), before the end of the 2011 school year, but time did not allow. A majority of post treatment surveyed students, 64%, felt they benefitted from the treatment. Additionally, high achieving students did not appear to be hampered by the treatment. If my colleagues' classes also experience an increased level of engagement during labs then the treatment could be implemented district wide.

Our district already ascribes to well- defined standards at each grade level for teaching scientific concepts. A logical extension of these standards would include lists of grade appropriate lab skills. If we implement this treatment in all the grade levels district wide, then student learning and engagement during lab activities would increase from lower grade levels to higher-grade levels. Such a scaffolding of skills and techniques could improve the overall quality of scientific understanding for Mount Vernon High School graduates.

This action research and specifically the student interviews have made me aware of the significant impact a lab partner has on even a motivated student. If I were to pursue a related yet different action research to improve laboratory experiences, I would investigate the possibility of improving collaborative efforts. The next step in this investigation would be to research the literature. In my literature review, I referred to the

Science Laboratory Environment Inventory (SLEI), which measured among other things, student cohesiveness. More studies of that type would direct the next AR. While my current treatment was to use a lab skills checklist, my data was influenced by social conditions during labs. When I asked one student how other lab partners responded to the treatment he replied, “it just depended on who they were with.” Many students preferred to work in a group and yet acknowledged that a bad partner can make for a bad lab experience.

During my AR, I addressed this adjacent issue by switching up lab groups and lab partners more often. If students didn’t feel stuck with a “slacker” and if unmotivated students couldn’t bully the same person into doing all the work, then the treatment and associated instruments had a better chance of improving student engagement and accomplishment. Results from this year’s study suggest that a next step in AR should promote student cohesiveness during collaborative efforts which could make further improvements in student engagement during labs.

While many challenges were faced in the quest to complete my first action research, I have learned through the process the value of initiating a more thoughtful research design. The lack of an adequate number of treatments diminished the value of my conclusions due to fewer comparisons that could be made from the data. The addition of lab skill checklists over a wider variety of science skills would improve the value of my data. Hence, the value of this study could have been improved if the conclusions were corroborated from multiple treatments.

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APPENDICES

APPENDIX A

BIOLOGY LABORATORY SKILLS CHECKLIST

Biology Laboratory Skills Checklist Name: ___________________

Teacher and student enter the date when a new level of skill is demonstrated.
NI: Needs Improvement; P: Proficient; Ex: Exemplary

1. Focus a compound light microscope in low power.

Student evaluation: NI ___________ P___________ Ex ___________
Teacher evaluation: NI ___________ P___________ Ex ___________

2. Focus a compound light microscope in medium power.

Student evaluation: NI ___________ P___________ Ex ___________
Teacher evaluation: NI ___________ P___________ Ex ___________

3. Focus a compound light microscope in high power.

Student evaluation: NI ___________ P___________ Ex ___________
Teacher evaluation: NI ___________ P___________ Ex ___________

4. Prepare wet mount slide and apply staining techniques.

Student evaluation: NI ___________ P___________ Ex ___________
Teacher evaluation: NI ___________ P___________ Ex ___________

5. Determine the size of microscopic specimens in micrometers (microns).

Student evaluation: NI ___________ P___________ Ex ___________
Teacher evaluation: NI ___________ P___________ Ex ___________

6. Identify plant cell parts under the compound light microscope.

Student evaluation: NI ___________ P___________ Ex ___________
Teacher evaluation: NI ___________ P___________ Ex ___________

7. Identify animal cell parts under the compound light microscope.

Student evaluation: NI ___________ P___________ Ex ___________
Teacher evaluation: NI ___________ P___________ Ex ___________

These skills will be followed by a ***performance assessment*** in December. Carefully consider your preparedness for all the skills listed above.

APPENDIX B

PRETREATMENT SURVEY/OPINION

Bio I Pre treatment Survey/Opinion ***Lab Skills Checklist***

Participation in this survey is voluntary and participation or non-participation will not affect your grade or class standing.

1. Have you used a Lab Skills checklist in a science class before?

2. If yes, in which science class?

3. Do you think the lab skills checklist has the potential to be helpful to you?

4. Indicate any of the following ways you might find the lab skills checklist to be helpful:

    a. Checklist keeps student on track for upcoming skills to learn

    b. Checklist provides a method for communicating with the teacher on my progress

    c. Checklist provides a way for me to ask for more help or time on a skill

    d. Other:

5. Indicate any reason you think the lab skills checklist will not be beneficial to you.

APPENDIX C

PRETREATMENT INTERVIEW

Pretreatment Interview

Participation in this interview is voluntary and participation or non-participation will not affect your grade or class standing.

Interview Prior to Treatment Student Name____________________ Date

Me to student: Hi! Thank you for participating in my interview today. Do you mind if I record our conversation? This will be a big help to me so I remember everything we discuss. I will be using our conversation in my research about lab skills checklist.

Q: Over the years, would you describe yourself as a person who enjoys science classes? If so, which classes have you enjoyed the most? Why has that been more interesting to you?

If not, are there some sciences you have liked more than others or some part of any of the sciences that you enjoy at least a little? What is your favorite topic in school? What about that subject do you enjoy the most? Why do you enjoy it so much?

Q: Do you typically enjoy lab activities? Why or why not? When do you remember your first time in doing lab activities? Can you tell me about those early lab experiences?

Q: Do you enjoy working with partners & lab groups? Why or why not? What is your biggest benefit from working with partners? What about the biggest challenge?

Q: When you are in science labs would you describe yourself as independent? Do you like to figure stuff out by yourself? If yes, do you sometimes wish you could do the lab alone? Or do you enjoy working in a group?

If you do not feel independent in lab, do you think your lab group helps you? Can you tell me some of the ways?

Q: If the lab skills checklist encourages you and your peers to be more independent in lab, will you benefit from that? If so, how? If not, why not?

Q: Do you think you will be more focused in labs as a result of the skills checklist? Why or why not? Can you give me an example?

Q: Do you think others in your lab group will be more focused as a result of the skills checklist? Why or why not? Can you give me an example?

APPENDIX D

MICROSCOPE SKILLS PERFORMANCE ASSESSMENT

Microscope Skills Assessment

Name:

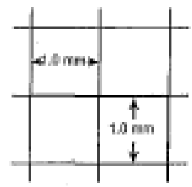
Station Z: Cell Size

TASK:
At this station you will measure the size of a microscope's field of view, estimate the size of a cell, and draw pictures of cells that you observe under the lowest and highest powers.

DIRECTIONS:

1 Pick up Slide A, hold it up to the light, and look at the squares.

2 Slide A is a prepared slide of a tiny piece of graph paper. The lines of the graph paper are all spaced 1.0 mm apart.

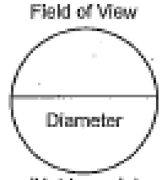


Graph Paper on Slide A
(Not to scale)

3 Place Slide A on the microscope stage and bring the graph paper into focus, using medium power.

4 When you look into the microscope, the whole area you see is called the "field of view." Knowing that the lines of the graph paper are 1.0 mm apart, estimate the diameter of medium power's field of view to the nearest 0.25 mm.

Field of View



(Not to scale)

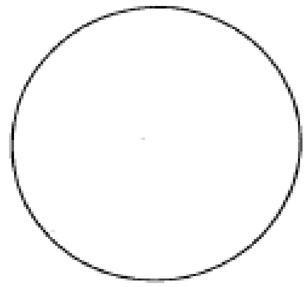
Estimated diameter of medium power's field of view: __________ mm

5 Return Slide A.

6 Place Slide B on the microscope and bring it into focus under medium power. Slide B is a piece of onion skin tissue that has been stained and mounted for viewing. See the diagram below for a sketch of what one cell might look like. The cell length has been labeled.

One Cell

7 Look closely at Slide B under the Med. power. Find one row of cells that goes across the middle of the field of view from one edge of the field of view to the other edge. These cells may go from side to side, from top to bottom, or diagonally across the diameter. In the circle at the right, carefully sketch only <u>one row</u> of cells whose lengths go across the field of view.



One Row of Cells Under Lowest Power

8 How many cells did you see under Med. power in the row that you drew above? _______ cells

9 In Step 4 on the previous page, you estimated the diameter of the medium power's field of view. Record that value again here: _______ mm

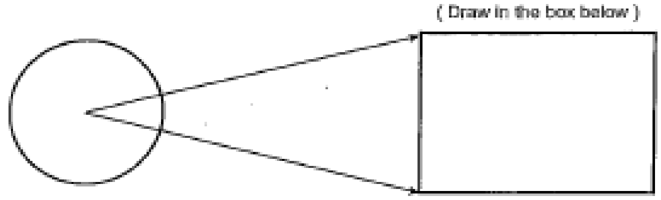
10 Based on the values you recorded in Steps 8 and 9, calculate the average length of <u>one</u> onion cell in your diagram to the nearest 0.1 mm. _______ mm/cell

Work Space

11 Return Slide B.

12 Place Slide C on the microscope stage. Bring Slide C into focus under the lowest power. Now bring the slide into focus under the highest power. In the box below, draw an enlarged view of one typical cell on this slide under the highest power. Your drawing should accurately show the shape and structures of the cell.

(Draw in the box below)



Field of View

Enlarged View of One Cell Under Highest Power

13 When you are finished, put the microscope back to the lowest power. Return all materials to their positions as shown on the Station Diagram.

STOP

APPENDIX E

MICROSCOPE ASSESSMENT SCORING RUBRIC

Performance Assessment Scoring Rubric Student: ______________________

Note: only tasks numbered 4., 8., 10., and 12., are scored for points.

Task & Criteria	possible points	awarded points
Total	8	_______________
4. Estimate the diameter of the field of view		_______________
Student estimates 1.25-1.75mm	2	
Estimates 1.00-1.24mm or 1.76-2.00mm	1	
Estimates less than 1, more than 2	0	
8. How many cells are in a row?	1	_______________
Student response matches student diagram in #7. (+- 1 cell)		
10. Calculate the length of one onion- skin cell.	3	_______________
Student shows work & correct approach and obtains correct solution by dividing value in # 9 by the value in #8.		

Allow 1 point if student shows correct work
Incorrect answer

Allow 1 point if student shows correct answer
but no work

Allow 1 point if student answers to nearest 0.1mm
Or zero

Sample:

mm/cells
1.5mm/5cells = 0.3 mm/cell

Task & Criteria	possible points	awarded points
12. Cheek Cell Diagram		
Shows correct cell shape & nucleus	2	_______________
Allow 1 point if student shows general outline of cell shape	1	_______________

APPENDIX F

POST TREATMENT SURVEY

Survey: Performance Assessment Name: ____________

Participation in this survey is voluntary and participation or non-participation will not affect your grade or class standing.

Please give your honest response to the following questions or statements regarding your experience with the Microscope Performance Assessment and the Lab Skills Checklist. <u>*Circle*</u> *the response that best indicates your agreement or disagreement with each statement.*

1. My overall score on the microscope test was about what I was expecting to achieve:

   1. Strongly disagree 2. Disagree 3. Agree 4. Strongly Agree

Explain:

2. My overall score on the microscope test was close to the class average.

   1. Strongly disagree 2. Disagree 3. Agree 4. Strongly Agree

Explain:

3. I felt prepared for the microscope test.

   1. Strongly disagree 2. Disagree 3. Agree 4. Strongly Agree

Explain:

Please take a minute to look at your Lab Skills Checklist before you respond to the following questions.

4. I used the Lab Skills Checklist to indicate to Mrs. Steen that I needed more time practicing a microscope skill

   1. Strongly disagree 2. Disagree 3. Agree 4. Strongly Agree

Explain:

5. The Lab Skills Checklist was NOT helpful in preparing me for the microscope test.

1. Strongly disagree   2. Disagree   3. Agree   4. Strongly Agree

Explain:

6. The Lab Skills Checklist would be more helpful to me if it were revised.

1. Strongly disagree   2. Disagree   3. Agree   4. Strongly Agree

Suggested changes to the Lab Skills Checklist:

7. How could you better prepare yourself for the Microscope Performance Assessment?

8. How could Mrs. Steen better prepare you for the Microscope Performance Assessment?

APPENDIX G

POST TREATMENT INTERVIEW

Post Treatment Interview Questions Name: ________________

Participation in this interview is voluntary and participation or non-participation will not affect your grade or class standing.

Thank you for taking time to meet with me today. This conversation will give me more qualitative data that I can use with the test and lab skills checklist data. With your permission, I will need to record our conversation to better relate the main points of our interview into my paper.

1. How did the microscope performance assessment go for you? Were there any surprises on the test?

2. Was the lab skills checklist helpful in any way?

3. Did it help you focus on specific tasks for the test?

4. What about your lab group – do you think the lab skills checklist helped group members to focus and prepare for the microscope performance assessment?

Any suggestions?

5. Overall, how have lab experiences been for you this year?

APPENDIX H

LAB: VIEWING CELLS WITH A LIGHT MICROSCOPE

Viewing Cells with a Light Microscope **Use Your Own Paper – Be Neat!**

Materials:

Microscope
Slides & cover slips
Clean flat toothpick
onion "skin"
Potato slice

Biological Stains:
methylene blue
lugol's solution (iodine)

Safety: Human epithelial cells*, *cheek cells* (the person who provides the cheek cells is the only one to handle the slide and that includes cleaning the slide. **Or *human epithelial cells* from the *wrist* – a little easier to prepare.

Procedure: Do steps 1 through 4. * Be careful with the scalpel! Get approval to move on to step 5 etc. See procedure for estimating cell size on the back →

1. Remove a small thin, transparent (clear) piece onion skin and place it on the center of a slide. Put a drop of water over the plant piece and cover with a cover slip.
2. With low power, look for the thinnest area of the leaf where you can see the cells most clearly. Change to high power and locate a single cell. Observe carefully: *estimate the size of the cells* & *draw a diagram of one cell labeling all visible cell parts*.
3. Carefully use a scalpel to cut a paper thin slice of potato. Place it on the center of a slide, add a drop of water and cover with a cover slip.
4. With low power, look for a thin area of the potato slice where you can see the cells most clearly. Change to high power and locate a single cell. Observe carefully and *draw a diagram of the cell labeling all visible cell parts*. Without lifting the cover slip, add a drop of iodine to the slide – Mrs. Steen will demonstrate the correct technique. (The small oval shaped organelles that are stained dark by the iodine are called leucoplasts. What nutrient do they function to store?)
5. Using a medicine dropper, place one drop of methylene blue on a slide. ***GENTLY*** rub the inside lining of your cheek with the flat edge of a toothpick. Mix the material on the toothpick in the drop of stain. Immediately dispose of the toothpick in the wastebasket. – Do Not leave used Toothpicks out!!
6. View under low power, moving the slide until you center a single cell in the field. Change to high power and observe the cell carefully. *Draw a diagram of the cell labeling all visible cell parts.*

7. Take a piece of sticky tape and stick it onto the inside of your wrist. Rub the tape so it sticks onto your wrist. Tear off from one corner quickly. Place the tape sticky side up onto the microscope slide. Add one drop of methylene blue onto the tape on the microscope slide and place a cover slip on top. Observe the slide using the 40x objective. Can you see any cells? *Increase magnification to high power & draw a diagram of the cell – label all visible structures*.

Analysis: (***Write complete sentences for all your answers***.)

1. What structure did you observe in both the potato and onion cells but not in the human cheek cells? What is its function?
2. Why was a biological stain used on the epithelial (cheek and wrist cells)?

APPENDIX I

ESTIMATING CELL SIZE

Estimating cell size:

Your ***field of view*** is the area that you see when you look through a microscope eyepiece.

Use the slide with graph paper to estimate the size of your field of view at low power (40x) and medium power (100x).

1. Each tiny square or lines on the graph paper is 1mm.
2. Count the number of millimeters (mm) you see across your microscope field of view in low power record this number on your paper. _________
3. Count the number of millimeters (mm) you see across your microscope field of view in medium power record this number on your paper. ____________
4. Why can't you measure the number of millimeters of your field of view when you are in high power?

5. Use the equation below to calculate the diameter of the high power field of view. ___________

Calculate the diameter of high power field of view:

$$\text{Diameter of High power} = \frac{\text{Magnification of low power}}{\text{Magnification of high power}} \times \text{diameter of low-power field of view}$$

Estimating cell size (*length* of cells) continued:

6. Focus in medium power to look at onion cells. Look at one row of cells that stretches across the diameter of the field of view, how many cells do you see in medium power in the row of cells? Record the number of cells in that row: ____________

7. Divide the estimated length of the field of view in medium power by the number of cells in the row of cells above. Show your math:

8. You have just calculated the length of one onion cell. ________________

APPENDIX J

MICROSCOPE PERFORMANCE ASSESSMENT DATA

Microscope Performance Assessment Data

All Class Totals n= 89 students
Maximum Possible 10pts Mean score: 7.2 Mode: 10

Scores	10	9	8	7	6	5	4	3	2
#students	21	15	8	13	9	12	4	6	1

Question by question analysis follows with the possible points for each question and the percentage of students attaining each score.

4. Estimate the diameter of the field of view

points	% of students
2 pt	53%
1pt	43%
0pt	4%

8. How many cells are in a row?

points	% of students
1pt	90%
0pt	10%

10. Calculate the length of one onion skin cell.

points	% of students
3 pt	57%
2pt	1%
1pt	11%
0pt	29%

12. Diagram of Cheek Cell

2pt	66%
1pt	27%
0pt	8%

14. Diagram of onion cell during metaphase.

2 pt	71%
1pt	11%
0pt	18%