BRIDGING BIOLOGY LECTURES AND LABS THROUGH HIGHER-ORDER THINKING

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ABSTRACT

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This research investigates the perceptions of biology lectures and labs according to the SETGO program students. Beliefs about the integration of biology lectures and labs, and whether biology labs cause students to use higher-order thinking skills will also be assessed in this research. There has been a push in recent years to reform traditional biology lab methods to be more inquiry-based to develop students’ higher-order thinking skills. Biology lectures and labs should also have a sense of connectivity. Students should not feel like they are in two different classes when go between lab and lecture. Therefore, the students were asked how important it was for their biology lecture’s content to be related to their lab’s activities. Students identified that it was extremely important to have their lectures and lab linked. They also explained that their labs were not causing them to use higher-order thinking skills.
Dedicated to:

My Family, Friends & Every Teacher I had

Without you I would not be who I am today.
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CHAPTER I
INTRODUCTION

Laboratory activities are an important component to college biology courses. Students are expected to incorporate what they learn in their lectures to facilitate their thinking in lab activities that would be homologous to the content (McComas, 2005). However, there are many times where students find themselves asking the questions: “Why are we doing this?” and “What was the point of this lab?” A major portion of labs used in biology classes are much like cookbook recipes (McComas, 2005), meaning students follow the procedures step by step without doing much thinking for themselves. Upon completion of the labs, the students have not really learned anything much about the topic they are covering or about doing real science. They have just gone through the motions of completing an experiment. There may be guiding questions pertaining to the biological content along the way, but those are easily looked up via the lab introduction and the lab exercise itself is virtually meaningless as a tool for learning.

In an ideal biology laboratory and lecture combination, students would learn the pertinent information in lecture then apply that knowledge in a laboratory that focused on the same topic. In the lab, students would be given the materials that they needed in order to create and design their own experiments, such as real scientists would do. I am an advocate of students knowing how to do science instead of just learning about science. The higher order thinking processes the students would develop and exhibit during lab would allow students to make a real-life connection to the content learned in lecture (Raghubir, 1979). This practical outcome would likely eliminate questions such as, “What is the point in learning any of this?”

Throughout traditional school science, I found myself and my classmates asking critical questions such as those listed above for almost every biology lab. I observed this lack of connectedness between lecture and laboratory activities even throughout my college career as a
biological science major. Even for the short time as a substitute teacher, I noticed this sort of disconnect between the course content, and how the students just go step by step without using higher order thinking skills. It seems like labs are more of a chore than a learning experience for many students. The students who do excel in relating lab material to the content learned in lecture also seem to achieve a higher rate of success within the course (Cavana & Leonard, 1985; McComas, 2005).

There has been research focused on what lab methods are used in the biological sciences, assessment of students in labs, different learning tools used in labs, and even the motivation levels of students that are taking lab courses that are associated with a biology class. However, there is minimal research on what labs best help students bridge the gap between lab activities and lecture content. In recent years, there has been a push for biological science labs to be more inquiry-based instead of the cookbook or structured approach (McComas, 2005). The step-by-step labs that guide students through the whole lab process can characterize cookbook labs; the students simply follow the procedure word for word without deviating from it. This call for a reform in pedagogy, from a cookbook approach to an open-ended, inquiry-based approach, is a major focus for national educators in science (Basey, Mendelow, & Ramos, 2000; National Research Council, 1996; National Science Foundation, 1996). The inquiry-based approach contrasts the more traditional content-based approach, where labs have the primary aim of facilitating students’ understanding of principles covered in lecture (Basey et al., 2000; Sunberg and Moncada, 1994). Content-based lab curricula enhance lectures by providing students with a multitude of learning experiences, such as demonstrations, kits and manipulatives, computer simulations, discussions and debates, field trips, writing and speaking projects, in addition to a limited use of inquiry activities (Basey et al., 2000). There are some inquiry-based labs that follow a guided inquiry in which the instructor maintains control over the topic and procedures
used by the students. Although the content-based labs described here seem best practice, they do not always require the students to use their higher-order thinking skills. The content-based labs are more typical of high school lab work than college level lab work, but they are still a common practice throughout many universities and community colleges.

Purpose of Study

The purpose of this study was to gain information on how students perceive their biology classes and the labs associated with them. Along with investigating these perceptions, the beliefs about how connected biology labs and lectures are will be assessed. Learning more about the beliefs and perceptions of biology labs and lectures can better inform educators of the biology disciplines on how students learn and integrate the respective lab and lecture content. Ultimately, at the end of a biology lab activity and lecture session the students should know exactly why they did what they did in lab, and how it relates to their lecture content.

Research Questions

The essential questions for this study involve the students’ perceptions of biology lectures, their beliefs on the integration of biology labs and lectures, and whether or not they use higher order thinking skills. The specific research questions are stated below:

1. What are students’ perceptions of biology lectures and biology labs?
2. What are students’ beliefs about the integration of biology lectures and labs?
3. Are the lab methods being used in biology classes causing students to use higher-order thinking skills?

Significance of Study

Findings from this study will potentially have numerous and positive implications for biological science classes of all types. The same principles can even be extrapolated to many of the other core science classes that have laboratory activities associated with them. Teachers of
the science disciplines will be able to effectively create lab activities to better engage students to promote higher order thinking. The research will also be useful to curriculum developers to implement laboratory strategies to go along with the course lecture content. Most importantly, the students will be more actively engaged in lab activities and as a result, will achieve better grades in their science classes.

Summary of Chapters

The following chapters include the review of literature, the methods section, results, and the conclusions. Chapter two entails the review of literature based upon the academic findings of the experts within the field of teaching biology classes. Major findings from the literature in chapter two encompass traditional lab methods, inquiry-based lab methods, virtual lab technology, lab-based case studies, the integration of lab and lecture, and perceptions about biology labs and lectures. Chapter three provides details about the research methodologies used in this study. It describes the quantitative survey used, the qualitative interview questions, and how the data will be analyzed. Chapter four contains the results section. The results section contains the analysis for the quantitative and qualitative data that was collected. Lastly, chapter five contains the interpretations of the data through a discussion of the findings, conclusions and implications of the findings, and any recommendations for future research on the topic.

Definition of Terms

Higher-order thinking- involves the learning of complex judgmental skills such as critical thinking and problem solving. Higher order thinking is more difficult to learn or teach but is also more valuable because such skills are more likely to be usable in novel situations (i.e., situations other than those in which the skill was learned).

Inquiry- seeking knowledge or information by questioning.
Cookbook lab experiments- biology lab experiments that are characterized by giving step-by-step instructions to complete the lab.

Beliefs- the students’ opinions or convictions of biology lectures and labs that are not immediately susceptible to rigorous proof.

Perceptions- the immediate insight or understanding of students’ biology lectures and labs.

SETGO- a collaborative venture in which Bowling Green State University and Owens Community College partner with each other to increase the number of students graduating with associates and bachelors degrees in the STEM fields - science, technology, engineering and math.
CHAPTER II

LITERATURE REVIEW

Information found in the literature will facilitate the research of how students perceive biology lecture in labs and whether or not higher-order thinking was being used in their biology labs. Some biology classes are set up in a way that the material covered in lecture does not match up with the topics covered in lab. Therefore, it is important to identify the lab methods professors use, if students are using the lecture content to help them complete lab assignments, if the lab methods being used are causing students to use their higher-order thinking skills, and student perceptions of labs.

Lab Methods Used in College Biology Courses

Traditional Labs

The so-called cookbook labs often represent traditional labs, where students follow step-by-step instructions to complete the lab. Although it is important in science for students to learn how to follow directions, offering only cookbook labs limits students’ access to exploration (Peters, 2005). Evidence has shown that throughout cookbook labs students do not see the big concept that the lab is trying to convey, because they read each step discretely and do not connect the steps to see the bigger intention of the laboratory experience (Peters, 2005). Relevant research studies performed by Germann, Haskins, and Auls (1996) indicate that cookbook-like activities often short circuit opportunities to stimulate thinking by students, and that students have difficulty constructing meaning from cookbook labs. However, they indicate that inquiry-based labs require ongoing intellectual engagement of the students.

Another study conducted by Russell and French (2001) examines the effects of lab structure on student achievement and attitude toward science. In this study, students were enrolled in traditional cookbook laboratories for the first three semesters. An inquiry-based lab
replaced cookbook labs in the fourth semester, where students examined a weekly question by developing and testing their own hypotheses. Data was analyzed under three specific areas relative to the lab models: the effect of gender, the effect of attitude, and the effect of content knowledge. It was found that females spent less time than males talking about the lab activity in cookbook and inquiry labs. However, females were more likely to talk about the lab and be more active with the experiment in the inquiry labs. Results based on attitude showed that in traditional labs, students who have positive attitudes toward biology are more active and students with lower attitudes toward biology show less active participation. In the inquiry-based labs, students showed active learning in all aspects of the lab. The effects on content knowledge between traditional versus inquiry-based labs resulted in students that were normally lower scoring taking on more responsibilities in inquiry-based labs. Russell and French (2001) conclude that inquiry-based labs may increase the active participation of female students and result in higher achievement for students, because opportunities to handle data and manipulate experiments are greater than in traditional, cookbook approaches.

**Inquiry-Based Labs**

Inquiry-based labs can be characterized by a wide range of labs that lie on a continuum of practices from *confirmation* to *guided inquiry* (Huziak, 2003). *Conformational inquiry* labs are the most closely related to traditional lab activities where students know the correct answers to manipulate their data to fit what they are supposed to achieve. *Structured inquiry* provides students with the tools and questions they need to complete the lab, but do not provide the answers. *Guided inquiry* is a process where the students are given a specific question, but the students are often responsible for coming up with their own procedure. Huziak (2003) also explained *coupled inquiry* where the labs are a combination of guided inquiry and open-ended
Open-ended inquiry is when students choose their own research question, design their own procedure, and collect their own data.

The downside of labs that are solely inquiry-based according to Sundberg and Moncada (1994) is that the students’ exposure to major biological principles may be limited (Basey et al., 2000). Even though the activities of science inquiry require more time to cover the same content, research has indicated that an inquiry approach to teaching may be well worth the cost in reduced content, because it may improve student outcomes (Basey et al., 2000; Ebert-May, Brewer, & Allred, 1997; Sundberg and Moncada, 1994;). In addition, Sundberg, Dini, and Li (1994) showed that a reduction in the content addressed in biology lectures for non-science majors improved student-learning outcomes, compared to the increased content addressed in the biology lecture for science majors. However, it can be argued that the difference between majors and non-majors in this sample have different interests and motivations toward biology. Therefore, it would make sense that the non-science majors would do better with less content to learn. Russell and French (2002) found that inquiry-based active laboratories improved student participation, raised academic achievement, and enhanced attitudes toward biology. While all higher education science instructors are aware that inquiry-based learning is time consuming and resource-intensive, a current innovation is to blend hands-on and online learning environments using the benefit of modern technologies to improve practice (Garrison and Kanuka, 2004; Toth, Morrow, & Ludvico, 2009).

Madhuri and Broussard’s (2008) research findings outline the positives and negatives of inquiry-based labs in a college developmental biology course. The authors noted that in order for students to be equipped with twenty-first century scientific research skills, the students must combine scientific knowledge, experimental design, quantitative analysis, and communication skills in order to be successful. Therefore, they wanted to integrate experimental analysis into
the lecture and laboratory to provide the students with an inquiry-based foundation. Upon completion of the course (a sample of 14 students), a survey was given to the students to find out what they thought of the inquiry-based approach to lab and lecture. Five of the students wrote that the inquiry-based format enabled them to learn more about experimental techniques, seven of the students wrote that the inquiry-based format made the lab more interesting, only one student did not enjoy the open-ended nature of the lab. However, three of the students wrote that the inquiry-based nature of the labs translated into more trial and error and increased stress when experiments were unsuccessful. When asked if the concepts in the lecture were easier to understand after they had the opportunity to work on them in the lab setting: seven of the students felt all concepts in the course were reinforced or easier to learn because of the lab experience, five of the students felt some concepts were reinforced or easier to learn, the other two students felt that only one of the concepts was easier to learn or reinforced because of the lab experience. The researchers finally noted that even though it was a challenge getting the students accustomed to the inquiry-based curriculum, the students exceeded their expectations with higher levels of motivation to learn, increased investment in the topics learned, and the development of the skills in the process of science.

**Virtual Laboratories**

Virtual lab environments are another possible lab techniques available, and they are certainly finding their way into the mainstream. Virtual laboratories are software tools that allow the user to conduct the same scientific inquiry afforded by hands-on investigation but at a reduced expense, with increased safety, and within the time constraints of higher education classrooms (Toth et al., 2009). Virtual labs would certainly target the population of students that are using distance education as their form of learning and obtaining information. For many years, distance education research has seen a significant difference between achievement in
traditional classroom classes and achievement in online classes (Annetta, Klesath, & Meyer, 2009). With the pervasiveness of synchronous environments and the interactive nature of web 2.0, indicators of learning such as engagement, immersion, and presence are shedding light on the relative effectiveness of teaching online. Another major benefit of virtual lab technology is that students can repeat experiments many times over and receive feedback from the online learning program at no extra cost to the university for staffing or materials (Cobb, Heaney, Corcoran, & Henderson-Begg, 2009). Although one can argue that there is no replacement for the experiences a student receives in a bench lab, a student might be able to learn more from a virtual lab if it is properly designed and developed than other online animations or activities that are less immersive (Annetta, et al., 2009).

Further research suggests that virtual labs were able to specifically document the level of presence and immersion by the students (Annetta, et al., 2009). The three main learning objectives that were identified for this lab was to determine habitats of particular species of insects, to visually identify common insects of North Carolina, and to know the taxonomic classification for and among insect species and groups. They used the Presence and Immersive Tendency Questionnaire (PITQ) that was developed by the U.S. military to measure presence and immersion. Their results yielded that there was an overall significant correlation between immersion and presence, which supports the idea that students felt a sense of presence, but also felt a high level of immersion in the virtual lab. Their results imply that students’ engagement in virtual laboratories may be an effective supplement for traditional labs, and thus a good indicator for achievement.

Laboratory-Based Case Studies

Another lab technique that is described in the literature is laboratory-based case studies. Lab-based case studies are an innovative lab method that introduces students to a real life case
study. The students then design a lab experiment or a series of experiments to solve the particular problem or case. In another effort to try to avoid the cookbook lab approach, case-based laboratories challenge students to develop, as much as possible, their own experimental procedures, and to think about and interpret the significance of the result they obtain (Dinan, 2005). These types of labs are certainly an inventive way to get away from the classical lab-type setting which asks the students very little, except that they do exactly what the text directs them to do. Laboratory-based case studies are similar to those used in science classrooms but differ in that they are designed to engage students in a problem that has an experimental solution. The following key elements are what make up a well designed laboratory case study: (1) it should tell a story that is interesting and relevant to the audience, (2) it should pose a challenging problem for the students to solve experimentally, (3) it should, as far as possible, allow the students to work in teams to design appropriate experiments with minimal faculty guidance to solve the experimental problem, (4) it should be brief, and (5) it should require a report written in a narrative style. This lab technique is very much like an inquiry-based lab, but it does not require the lengthy time commitment for each lab. Case-based labs also provide for a real-life application in which the students can identify with. Most importantly, a well-designed laboratory case should give students a feeling of ownership for the experimental approach they design. Moreover, they require critical thinking in addition to “technique-based” laboratory skills and involve students in meaningful ways that conventional laboratories all too often do not.

An interesting example of implementation of lab-based case studies was researched in the biotechnology field to try to improve higher-order thinking skills among their 200 non-science major students (Dori, Tal, and Tsushu, 2003). The major goal of this study was to improve students’ higher-order thinking skills and to improve scientific literacy in a social perspective based upon lab-based case studies. Upon examining the pre- and posttest data, Dori et al. (2003)
found that there was a significant improvement from the to the posttest. This shows that lab-based case studies are an effective tool to improve higher-order thinking skills and learning.

Integration of Lab and Lecture

Another way to promote student learning is through the integration of lab and lecture, which is referred to as the seamless biology curriculum. The goal of seamless biology curriculum is to engage students in research and lab activities while applying concepts immediately after they were discussed as a means to develop scientific process skills, promote conceptual understanding, and increase motivation toward biology (Burrowes & Nazario, 2008). Basically, the way the seamless biology curriculum works is when students learn about a certain topic; they perform an experiment about that respected topic right after it is discussed. For example, shortly after talking about homeostasis in zoology, students proceed to measure the metabolic rate of ectotherms versus endotherms under different thermal regimes, using respirometers, oxygen concentration sensors, and graphing calculators. Through the seamless biology curriculum model, students are taking what they had just learned and applied it to a practical lab experiment to further their knowledge and understanding of the content. There are times when students do not make the link between lecture content and lab material, but this model can potentially eliminate students’ misconceptions of labs not relating to what they are being taught in lecture. In this manner, science is taught the way that it is done: by inquiry, observation, and experimentation (Burrowes & Nazario, 2008; Lawson, 1999). In traditional labs, students usually have to wait a few days or maybe up to a week to apply what they have learned from lecture to the laboratory since college biology labs usually only meet once a week. The integration of guided observations, dissections, experimental activities, and corresponding reporting of their findings through graphs and data tables were an important component of the
seamless biology curriculum to encourage development of scientific process skills among students (Burrowes & Nazario, 2008).

In addition, Burrowes and Nazario (2008) found that all students who took a seamless biology curriculum class commented that they enjoyed working in cooperative groups, because it increased their motivation to come to class, allowed them to learn from their peers, and fostered good relationships. Results on student learning showed that the seamless biology curriculum was more effective than traditional, non-integrative curricula at engaging students in the process of science, and improving learning while developing scientific process skills. In addition, students in the course expressed that they enjoyed the integration of laboratory activities with the discussion of theoretical content in the same setting (Burrowes & Nazario, 2008). The seamless biology curriculum approach seems to be a clear model for college biology lab reform, but a downside may be that the integration of lecture and lab would take too long for the typical 50-minute class period.

Students’ Perceptions and Beliefs Toward Science

Perceptions and beliefs are often viewed as one of the same term. However, they can be defined as two distinctly separate entities. Perceptions are the immediate insight or understanding of something. Research done by Johnston and McAllister (2008) investigates students’ perceptions of learning anatomy and physiology. More specifically, they tested whether or not students’ perceptions increased with the use of virtual simulations for laboratory learning. Results from this study suggest that one of the best motivators may be hands-on interaction with real material, which enables students to engage with, understand, and then apply knowledge acquired in alternative contexts. In turn, these motivators acted as a vehicle to increase student perception of the lab. They were able to conclude that the relevance of knowledge being learned is paramount in students’ perception of its importance.
Beliefs are the opinions or convictions that are not immediately susceptible to rigorous proof. Research done by Perkins, Adams, Pollock, Finkelstein, and Wieman (2004) correlates students’ beliefs with their learning in a physics class. They examine the influence of teaching practices on student beliefs, the relationship between the students’ beliefs about physics and their decisions about which physics course to take and whether to continue on in physics, and the relationship between student beliefs about physics and their conceptual learning in the physics course. Results found that students with higher conceptual gains tend to have more favorable beliefs, and that students in the lowest conceptual gain category tend to regress in beliefs. It was also noticed that students who come into a course with favorable beliefs are more likely to achieve high learning gains (Perkins et al., 2004). These data are consistent with the idea that beliefs are a factor in student learning.

Summary

There has been an extensive amount of research on the educational reform of traditional labs to inquiry-based labs. Research that provides information on the effect of cookbook labs on student learning has started to make science education researchers create more innovative labs that encompass the needs of today’s biology students. For example, the inquiry-based labs allow students to come up with their own ways of performing lab experiments, which in turn, increases the level of higher-order thinking done by the students. Virtual lab technology is also becoming more prominent in the classroom with the influences of new technologies. Students would have the ability to manipulate lab experiments in an easy and timely fashion with virtual lab technology. Laboratory-based case studies are another lab method that increases students’ level of thinking by having them solve a real life problem by performing an experiment or a series of experiments. Lastly, the seamless biology curriculum is a way of integrating lab and lecture to ensure that students are making the appropriate connections and linkages between the two areas.
All of the lab methods that have been mentioned have shown increases in student performance and higher-order thinking according to the relevant research.

Perceptions and beliefs of science classes were also recognized in the review of literature. An understanding of the difference between perceptions and beliefs aided the research when analyzing the results for research questions one and two. Many people believe that perception and beliefs are synonyms, but they have their own meanings within this research study.

The research that was done in this study will add to the current research by showing how students specifically bridge the gap between lab and lecture. It will also gauge the beliefs and perceptions of the students on biology lectures, biology labs, and the integration of biology lectures and labs. This research will also show whether some of these new practices are being put to use, and if the students believe they are using their higher-order thinking skills to complete their labs.

A mixed methods study was conducted by using quantitative surveys and qualitative interviews to research the essential questions that were stated in Chapter One. The perceptions of biology labs and lectures, and the beliefs about the integration of labs and lectures were assessed through the survey. Based upon interesting responses and findings, interview questions were constructed to further explain these questions along with researching the breadth of higher-order thinking skills used in biology labs.
CHAPTER III  
RESEARCH DESIGN AND METHODS  

Introduction  

Biology labs are an important component to any biology class. Therefore, it is important to research whether they are being properly integrated with the lecture, and if they are causing the students to use higher-order thinking skills. There are many inquiry-based labs that are challenging the traditional labs such as virtual labs, case-based labs, and by integrating the lab right into lecture. According to the literature, these new lab methods will raise students’ higher-order thinking skills, thus raising performance in the class.

Purpose and Research Questions  

The purpose of this study was to find out how students integrate their lab and lecture content in biology classes. Researching the use of higher-order thinking among students in biology labs was another purpose for this study. The essential questions and research questions that were the focus for this study were:

1. What are students’ perceptions of biology lectures and biology labs?
2. What are students’ beliefs about the integration of biology lectures and labs?
3. Are the lab methods being used in biology classes causing students to use higher-order thinking skills?

Research Design and Methodology  

Mixed Methods Rationale  

Mixed methods is a research approach that can be defined as the collection or analysis of both quantitative and qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and involve the integration of the data at one or more stages in the process of research (Hanson, Creswell, Plano-Clark, Petska, & Creswell,
Using both forms of data in educational research is valuable, because it allows researchers to simultaneously generalize results from a sample to a population and to gain deeper understanding of the phenomenon of interest. More specifically, for this study a quantitative survey will be administered to the participants then a follow-up interview following qualitative traditions will be conducted to extend the study’s results to gain insight as to why the participant chose a certain response (Glesne, 1999). The strength of using a mixed methods approach with the use of surveys and interviews, is that when the participant says, for example, that they “strongly agree” or “strongly disagree” on a statement we can probe them and get them to explain why they chose that particular statement (Glesne, 1999). Steps taken to further analyze the reasoning behind participants’ responses allowed for more detailed descriptions on a potentially important source of data.

A pragmatic paradigm would be appropriate for this study’s sequential explanatory design. Adherents to the pragmatic paradigm rarely concern themselves with ultimate conceptions of reality, preferring to deal with practical problems that confront them as educators and trainers (Reeves, 2006). The research traditions of the pragmatic paradigm are rooted in mixed methods research (Armitage, 2007). Pragmatism is not situated around social, but how to solve practical problems. In sequential explanatory designs, quantitative data are collected and analyzed, followed by the qualitative data (Hanson et al., 2005). According to Hanson et al. (2005), quantitative data are the primary source of data, and that the qualitative data are mainly used to supplement quantitative data. The data analysis stage of the sequential explanatory design is usually connected, and the integration of quantitative and qualitative data occurs at the interpretation stage and in the discussion. This design is particularly useful for explaining relationships and/or study findings, especially when they are unexpected (Hanson et al., 2005).
Survey Research Rationale

Survey research is a quantitative method of research that falls under the umbrella of descriptive research designs (Mertler, 2009). The purpose of descriptive research is to describe and make interpretations about the current status of individuals, objects, settings, conditions, or events (Mertler, 2009). This study used survey research as a foundation of responses to gain a broad perspective of biology labs and lectures. Survey research involves acquiring information from individuals representing one or more groups – perhaps about their opinions, attitudes, or characteristics – by specifically asking them questions and then tabulating their responses (Mertler, 2009). The ultimate goal of the survey research done in this study was to learn about the perceptions of biology students on how they learn in biology lectures and labs.

Interview Research Rationale

Interviewing is one of the most common and powerful ways in which we try to understand our fellow human beings (Fontana & Frey, 2000). This study was designed to use the process of interviewing the participants to further investigate why they chose specific ratings in the survey, and to ask more in-depth questions on their biology lecture and lab experiences. There is an inherent faith that the interview results are trustworthy and accurate and that the relation of the interviewer to respondent that evolves in the interview process has not unduly biased the account (Fontana & Frey, 2000). Therefore, interviewing was a reliable way to accumulate the data needed for the respected research of this study.

Instrumentation and Procedures

Quantitative Instrumentation

Design of the Survey

The intention of the survey was to gain a quantitative overview of students’ perceptions on what helps students relate lab material to lecture content, what helps students relate lecture
content to lab activities, and general information on biology labs and lectures. The survey constructed for this research came from a variation of a survey that was created by Frantz, DeHaan, Demetrikopoulos, and Carruth (2006). Many of the original questions that were used in their study were eliminated or modified to fit the purposes of this research study. The survey was not pilot tested. However, each survey item is directly linked to one or more of the research questions.

**Structure of the Survey**

The survey that was administered consisted of 38 statements, based on a 4-point Likert Scale with a Not Applicable option. It consisted of a preliminary question, two sections of statements, and a demographics section. A preliminary question prompted the students to identify the most recent biology class they have taken, and this is the class that they were to think of when they were answering the survey statements. Section one of the survey consisted of 14 statements pertaining to the beliefs based on the biology lab and lecture that the student indicated in the preliminary question. For example, there were statements such as: *The lecture taught me to think through a problem or argument in biology, and the lab taught me to think through a problem or argument in biology.* Statements like: *I could predict what kinds of lab activities we were going to do in lab based on the lecture content we were covering,* were in section two of the survey. This section used these types of statements to gain insight on the students’ beliefs about the integration of biology labs and lectures. Lastly, the demographics section of the survey asked the sex, class rank, ethnicity, and the age of the participants. See Appendix A for the complete survey.

**Administration of the Survey**

The survey was administered at one of the students’ SETGO meetings. They were prompted to read through and sign the consent letter, agreeing to the terms of the research that
was being conducted. The consent letter can be viewed in Appendix B. The participants were
given approximately 15 minutes to respond to the survey questions. The surveys were then
collected and kept in a folder for safekeeping.

Qualitative Instrumentation

Design of the Interview

The intention of the student interview was to gain more information from the responses that were given on the surveys. Interviewing allows for the participants to expand on their thoughts, which they were not able to do with the quantitative survey. The answers provided in the interview also added to the reliability and the validity of the survey data. The students that were chosen to participate in the interview had the most interesting survey responses concerning biology lectures and labs. Meaning that they commonly strongly agreed or strongly disagreed with statements that the sample as a whole thought opposite of.

Structure of the Interview

The student interview consisted of 11 open-ended questions. Based on the survey results a variety of these 11 questions were selected to further understand specific survey responses. Some questions were changed or tailored according to interesting findings from the survey. For example, if a student responded to a statement that they strongly agreed or strongly disagreed with, an interview question was tailored ask the participant why they chose that particular response. Example interview questions from the unaltered interview template included: How do you bridge the gap between lab work and lecture, and what are some elements from lecture that helped you with lab activities? The complete list of unaltered interview questions can be viewed in Appendix C.
Administration of the Interview

Individual appointments were made for each student who was going to participate in the interview process. When the students arrived they were asked to sign a consent form indicating that they could be audio recorded during the interview. An explanation was given about the structure of the survey and how it reflected each person’s individual responses from their survey. The participants were read each interview question, and they responded accordingly. Upon completion of the interviews, the participants were thanked once again for participating in the research. Each audio file was then downloaded onto a password-protected computer for transcribing.

Data Collection and Sample

Participants

The sample for the survey research portion of the study was a group of thirteen Science, Engineering & Technology Gateway Ohio (SETGO) students who attended Bowling Green State University. SETGO is a collaborative venture in which Bowling Green State University and Owens Community College partner with local community-based organizations to increase the number of students graduating with associates and bachelor’s degrees in the STEM fields - science, technology, engineering and math (BGSU: SETGO, 2010). The SETGO student population was a valid population to use for this study, because they were some of the most esteemed students in the biology field who attended the university. Therefore, they were able to provide valid and reliable data concerning their experiences with lab and lecture content. More specifically, there were six males and seven females that participated. Ages of the participants ranged between 19-30 and their class ranking ranged from sophomores to seniors in college. Ethnic composition of the sample included Caucasian and African American students. The
researcher’s role in this portion of the study was to just administer the survey and answer any
to come back and have the follow-up interview. Surveys were coded to find any interesting
responses, and the participants who had made that cut were emailed to come back for the follow-
up interview. Interesting responses were responses that contradicted each other, or responses
that the participants clearly had strong opinions of. More specifically, six of the survey
participants were actually interviewed. Overall, the interviews ranged from 10-15 minutes long.
The researcher’s role in this portion of the study was to ask the interview questions, note any
observable behaviors, and to make judgment calls on the modification of questions during the
interview process.

Data Analysis

Quantitative Data Analysis

Upon completion of the surveys, descriptive statistics were used to analyze the
quantitative data. Descriptive statistics are simple mathematical procedures that serve to
simplify, summarize, and organize relatively large amounts of numerical data (Mertler, 2009).
More specifically, the category of descriptive statistics used in this study was frequencies and
percentages. Frequencies and percentages are commonly used when trying to describe how often
a particular response is chosen in a given data set (Mertler, 2009). The surveys that were
administered were kept in a file folder, and stored in a locked file cabinet for protection. Upon
analyzing the surveys, some of the survey responses were integrated into the interview. The
table of specifications below describes what survey questions directly relate to what research
question, and how they were statistically analyzed.
Table 1.
Table of Specifications of Quantitative Survey Data

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Survey Item(s)</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are students’ perceptions of biology lectures and biology labs?</td>
<td>• Section I: Items 1-13</td>
<td>Descriptive: Frequencies &amp;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentages</td>
</tr>
<tr>
<td>2. What are students’ beliefs about the integration of biology lectures and labs?</td>
<td>• Section II: Items 15-38</td>
<td>Descriptive: Frequencies &amp;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentages</td>
</tr>
<tr>
<td>3. Are the lab methods being used in biology classes causing students to use higher-order thinking skills?</td>
<td>• Section I: Items 10, 12, 13</td>
<td>Descriptive: Frequencies &amp;</td>
</tr>
<tr>
<td></td>
<td>• Section II: Items 15-22</td>
<td>Percentages</td>
</tr>
</tbody>
</table>

Qualitative Data Analysis

During the interview process notes were taken based on certain gestures the participant made, interesting reactions, or other pertinent happenings that occurred during the interview. The actual interview was recorded with a Digital Voice Recorder (DVR). Each interview was kept in a separate file, and downloaded to a password-protected computer as they were completed. Each interview was transcribed right after it was downloaded onto the computer. All of the interviews were transcribed entirely to ensure all pertinent data could be coded and used. The qualitative portion of my data was analyzed by using content analysis strategies. Stemler (2001) defines content analysis as a systematic, replicable technique for compressing many words of text into fewer content categories based upon explicit rules of coding. Therefore, it was easiest to use content analysis to sift through six interviews worth of data with relative ease in a systematic fashion. According to Krippendorff (1980), six questions must be addressed in every content analysis: (1) Which data are analyzed? (2) How are they defined? (3) What is the population from which they are drawn? (4) What is the context relative to which the data are analyzed? (5) What are the boundaries of the analysis? And (6) What is the target of inferences?
Upon completion of the content analysis, the pertinent assertions and warrants were extracted to serve as the qualitative portion of data.

The interviews were coded using an *a priori* coding strategy. This type of strategy occurs when certain categories are established prior to the analysis of the data based upon some theory (Stemler, 2001). For example, with research question three; asking whether biology labs are causing students to use higher-order thinking skills, the assertion that higher-order thinking does not take place in biology labs was created. Based on that assertion, each interview was coded to find evidence that higher-order thinking was not taking place in biology labs. Assertions were also made for the other two research questions to find evidence of perceptions of biology lectures and labs, and of beliefs about the integration of biology lectures and labs. Assertions can also be referred to as the themes of your data, and warrants are the pieces of evidence that support those themes (Ryan & Bernard, 2000). The assertions that were used to analyze the interviews were: students have positive and negative perceptions of biology lectures and labs, students feel the need for a linkage between lecture and lab, and higher-order thinking does not occur in biology labs.

*Limitations*

*Quantitative Limitations*

Surveys generally have four potential sources of error: sampling error, non-coverage error, non-response error, and measurement error. Sampling error occurs when the instrument does not represent the general population to a degree in which the researcher is intended to study (Cui, 2003). Participants for this study were not randomly selected, and the sample size was relatively small. Therefore, by not having a large random sample of participants, the amount of sampling error could not have been determined.
The second potential form of error that occurs when doing survey research is non-coverage error. Non-coverage error happens when the sampling frame does not cover some members of the population, so they have no chance at being selected into the sample (Cui, 2003). This is a major issue when it comes to this study, because there are many more students who are biology majors that are not in the SETGO program. However, I chose the SETGO program to gain general knowledge that can be extrapolated to the whole population of biology students.

Non-response error is another way that survey research can be a source of data error. Non-response error occurs when some members of the sample simply do not respond to the survey (Cui, 2003). To minimize this from occurring, the surveys were passed out in person. Once the participants were finished with the survey, they turned them in. If the participant was given a survey, they were not allowed to leave until they turned it back in. Therefore, there should be no error associated with non-response error.

Lastly, one of the most common modes of survey research error comes from measurement error. Measurement error occurs when respondents fill out surveys, but do not respond to specific questions, or provide inadequate answers to open-ended questions, or fail to follow instructions telling them to skip certain sections depending on their answers to previous questions (Cui, 2003). Measurement errors also arise from lack of control sequence in which the questions were asked, and various respondents’ characteristics (Cui, 2003). To reduce the amount of measurement error with these surveys, I made sure to reiterate to the participants to read the directions carefully and to try not to skip questions. There was also a survey research expert and an expert on the content who helped to review and revise the survey so that it would contain clear and concise questions.
**Qualitative Limitations**

The biggest limitation when it comes to qualitative research is the subjectivity of the researcher when interpreting the qualitative interviews. There are a variety of ways a researcher can interpret certain things that were said. Often times, researchers interpret interviews based on how they want them to fit into their views. Therefore, in order to get the most out of the results and make sure they were accurate, I performed a member check of each interview. Member checking involved the sharing of interview transcripts, analytical thoughts, and drafts with the participants of the study (Mertler, 2009). Through this process I took each transcription back to the interviewee for them to double check what they said. The process of member checking adds to the trustworthiness of my research to ensure that what was transcribed was really what the participant meant or intended to say.

**Summary**

A mixed methods approach was taken when this research was conducted. A quantitative survey was given to a sample of SETGO students to gain a broad perspective of their perceptions of biology lectures and labs, their beliefs on the integration of biology lectures and labs, and about their levels of thinking involved in doing biology labs. Once the survey data was analyzed, six students were asked to participate in an interview that was designed to further investigate their opinions on biology lectures and labs. Upon completion of the student interviews, each interview was coded for the pertinent evidence to answer each research question. The results from the survey and interview data are presented in the Chapter Four.
CHAPTER IV

RESULTS

Purpose of Study & Research Questions

The purpose of this study was to find out how students perceive the integration of their lab and lecture content in biology classes. Researching the use of higher-order thinking among students in biology labs was another purpose for this study. The essential questions and research questions that were the focus for this study were:

1. What are students’ perceptions of biology lectures and biology labs?
2. What are students’ beliefs about the integration of biology lectures and labs?
3. Are the lab methods being used in biology classes causing students to use higher-order thinking skills?

Findings by Research Question

The results of this research study will be shared by research question for simplicity and organization. Both quantitative and qualitative data will be shared when appropriate for each research question. Integrating the quantitative and qualitative results provides greater depth and understanding of the research questions that were posed. A complete frequency distribution table recognizing the entire quantitative survey can be viewed in Appendix D.

Research Question One: What are students’ perceptions of biology lectures and biology labs?

Quantitative Results

The results for the first research question revolve around items 1-14 of the survey. Overall, most of the responses that were given in the survey had positive perceptions of biology lectures and labs. For example, items one and two from the survey states: *Doing hands-on activities were enjoyable in lecture/lab.* The results yielded that the majority of students believed that they agreed that doing hands-on activities were both enjoyable in lecture and lab.
There were not any students that disagreed with this statement. However, about 46% agreed that this was not applicable to them in lecture, and about 8% said that this statement was not applicable for their lab. Refer to Figure 1 to see the graphical results. Statements nine and 10 (I understood how concepts in biology related to other science disciplines in lecture/lab.) were another set of statement that did not have any participants disagreed or strongly disagreed.

Items 13 and 14 had some more variation across the scale, with some students indicating that they disagree or strongly disagree with the statements either in lecture or lab. As shown in Figure 2, items 13 and 14 indicate that there is a low percentage of students who disagree or strongly disagree to learning biological concepts through the discussions of real life issues in lecture and lab. However, the majority of the students agree that real life discussions do help their learning in lecture and lab. The percentage of students who indicated that learning through having real life discussions in lab and lecture was about 31%.

Figure 1.
Percentage of Students who Enjoy Doing Hands-On Activities in Biology Lecture and Lab
Other paired statements that had slight variation in the results were three and four, five and six, seven and eight, and 11 and 12. Items three and four (I usually understood what we were talking about in biology lecture/lab), seven and eight (I understood the relation of concepts in the field of biology when in lecture/lab), and 11 and 12 (I was taught to think through a problem or argument in biology lecture/lab) all had results that yielded a high percentage of students on the agree side, and a minimal percentage on the disagree side. Statements five and six (I often think, ‘I cannot do this,’ when a biology lecture/lab assignment seemed hard.) had the majority of the students disagreeing to the statement while there was a small percentage who agreed.

**Qualitative Results**

The qualitative results that were found for this section were coded from the student interviews. Unlike the survey responses, not all of the comments given in the interview were
positive towards students’ perceptions of biology lectures and labs. Instead, interviews allowed the students to elaborate on their ideas, and give specific examples to help guide the research question on perceptions of lectures and labs.

As the interview was conducted with Bryan, he reminded me of the essential questions I thought of during the beginning stages of this research. One of the main purposes for completing this study was to understand why students ask themselves, “Why are we doing this lab?” It could not have been more perfect when Bryan made the comment, “I try to take a step back and ask myself, ‘Why are they having me do this in lab? What’s the point?’ Many students just hurry through the lab to try and get out of there as fast as they can without thinking about the meaning of it.” Unfortunately, I believe this phenomenon to be one of the biggest reasons why students cannot make the link between lecture and lab. Lab is often perceived as a chore to many students, and Bryan made that point clear with his statement.

Many of the students perceived the biology lectures and labs as completely disorganized. Some students even went on to explain that they wished the biology labs would be more structured like that of the chemistry department. Ernie seemed very frustrated and passionate as he exclaimed, “[The biology lab] was very disorganized compared to the chemistry department, and the chemistry labs I have taken. The biology lecture and lab was very disconnected. They did not overlap hardly at all. That was the biggest problem I had with the class.” Once again, the struggle to bridge the gap between biology lectures and labs is a struggle for many students. Therefore, teachers and professors need to find a better way to make the link between lecture and lab. After all, as Sally said in her interview, “Being able to link the two (lab and lecture) is really what makes the lab worthwhile.” Without an appropriate linkage to the content being taught in lecture to the lab activities, students perceive their biology labs and lectures as two separate classes, which is backed up by Ernie saying, “I just saw my class as almost two different classes
Integrating biology labs and lectures is clearly important to students, which will be apparent in the second research question.

Positive comments on the perceptions of biology lectures and labs were rare in the interviews. However, there were comments such as “I just liked the lecture better,” from Lacey and “The lab was just really easy for me, so they did not need that much context” from Ernie. Another positive perception came from Ellen when she said; “I think the lab is important, because you have the hands-on experience.” Even though there were positive perceptions given about the labs and lectures, there was not any consistent evidence to justify whether there were more positives about the lecture or more about the lab.

**Research Question Two: What are students’ beliefs about the integration of biology lectures and labs?**

**Quantitative Results**

Quantitative results for the second research question all came from section two, items 15-38 from the survey. Statements from this section probed the students’ beliefs about the integration of biology lectures and labs. In general, students tended to agree on the majority of statements. However, there were some statements that were less defined when it came to an element of lecture helping them out in the lab or vice versa. Statement 29 (*The lecture content prepared me for lab activities.*) was one of the most intriguing pieces of evidence, and a major theme of this research. About 69% \( (n=9) \) of the students agreed that the lecture content prepared them for lab activities, but 31% \( (n=4) \) of the students disagreed with the statement. It is interesting that nearly 25% of the students feel that the lecture content did not prepare them for lab activities. However, in statement 34, 100% \( (n=13) \) of the students either agreed or strongly agreed that it is important to integrate lecture topics with lab activities. A graphical representation can be viewed in Figure 3 below.
Another interesting piece of evidence that was shown in the survey about students’ beliefs about the integration of biology lectures and labs was with item number 31. Item 31 states: *I could predict what kinds of lab activities we were going to do in lab based on the lecture content we were covering.* While about 61% \((n=8)\) of students agreed that they could predict what sorts of lab activities they were going to do based on the lecture content they were covering, there was about 31% of students \((n=4)\) who disagreed with the statement.

Figure 3. *Percentage of Students who Believe that the Lecture Content Prepared them for Lab Activities*

The remaining student \((n=1)\) stated that it was not applicable to him or her. Therefore, half of the students were unsure of the lab activities that they covered in lab just based on what they learned in lecture. Eighty-four percent \((n=11)\) of the students either agreed or strongly agreed that their biology class linked lecture topics with the lab activities from item number 32 of the survey. Therefore, if this many classes linked lecture with the lab, the students should be able to predict what types of labs they are going to cover according to the content, or at least have a
general idea of the material they would have covered in lab. A graphical representation of item 31 can be viewed in Figure 4.

Figure 4. Percentage of Students who Believe that they could Predict what kinds of Lab Activities they were going to do in Lab Based on the Lecture Content they were Covering

Qualitative Results

Along with the survey data, it was apparent throughout the interviews that the students were desperately seeking a common linkage between biology labs and lectures if they were not present. As Ellen was being interviewed, she gave a positive and negative experience of the integration of biology labs and lectures. She claimed that in the most current biology class she took, her “professor made an effort to coordinate lecture topics with what we were doing in lab, and pretty much we would go over the material we were covering in lab the day before we actually had the lab.” Conversely, Ellen stated “there were a few times in biology 205 (an introductory biology course) when we covered the material in lecture after the lab, and it was slightly harder for me to go through the lab, because we did not know it beforehand. I like
having the lecture first, because otherwise I do not learn as much by just doing the lab.” Sally also shared her concern for not learning the content in lecture before having a lab on it. She said, “If we had covered it in class it would have at least made more sense to us, because we just came in clueless and had to learn everything from scratch.” While it is important to learn lab techniques in the laboratory, students should learn at least some background information on the labs they are expected to perform in the lecture.

In other instances, some participants felt that biology lectures and labs were two different elements to a single class. For example, Ernie explained his experience with the integration of lecture and labs as, “So when it came to the lecture we definitely focused more on concepts. Concepts for learning and things of that nature. When we went to lab it was more: this is what you should be doing. There was nothing all encompassing about it. You had a certain itinerary or objective you had to complete, and that was it. There were not any discussions from the lecture. It was really disconnected I thought.” Many of Ernie’s thoughts were shared by many of the other participants as well. The interview data confirms item number 34 from the survey: It is important to integrate lecture topics with the lab activities; where every student chose agree or strongly agree.

Research Question Three: Are the lab methods being used in biology classes causing students to use higher-order thinking skills?

Quantitative Results

The quantitative results for the third research question reflect whether students believe that the lab methods being used in biology classes are causing them to use higher-order thinking skills. Item 12 from the survey yielded interesting results with respect to higher-order thinking in biology labs. Item 12 states: The lab taught me to think through a problem or argument in biology. There were about 61% (n=8) of the students who either strongly agreed or agreed to
thinking that the lab taught them to think through a problem or argument in biology. Twenty-three percent \( (n=3) \) of the students claimed that they disagree that the lab taught them to think through a problem or argument in biology. The remaining two students said that this statement was not applicable to them. These results are shown in Figure 5. These results are interesting, because thinking through problems are a component to higher-order thinking. If students are not taught to think through problems or arguments in biology labs, then it is likely that the labs are not causing the students to use their higher-order thinking skills.

Figure 5.
Percentage of Students who Believe that the Lab Taught them to Think Through a Problem or Argument in Biology

More significant evidence to support that higher-order thinking occurred in biology labs is from item number 10 from the survey. Item 10 states: *The lab helped me understand how concepts in biology related to other science disciplines (e.g. physics, chemistry, etc.)*. It was surprising to find that there were not any students who strongly disagreed or disagreed to the understanding how concepts related to other science disciplines when in the lab. There were
92% \((n=12)\) of the participants who agreed or strongly disagree to understanding how concepts in biology related to other science disciplines. One student claimed that this statement was not applicable to them. Refer to Figure 6 for the graphical representation of this statement.

Understanding the interrelation of science disciplines can be classified as a level of higher-order thinking, because they would be using previous knowledge from their other classes to make a connection with the content they are learning in their biology labs.

Figure 6.
Percentage of Students who Believe that the Lab Helped them Understand how Concepts in Biology Related to Other Science Disciplines

Qualitative Results

Interview data yielded somewhat of a dichotomy with some participants suggesting that there was higher-order thinking occurring in biology labs, and others indicating that there was not any higher-order thinking happening at all within biology labs. However, the majority of the students stated that biology labs were not causing them to use higher-order thinking skills. For instance, Bryan said that he would not say that he had to use higher-order thinking skills in
labs. “Basically, because it is more of reading instructions. So it doesn’t really count. We just
did the experiment and got out of there as fast as we could.” Ellen had a similar experience with
a different biology class. She stated that, “I would probably say not so much of higher thinking
going on in lab. A lot of times it went really fast. Me and my partners did not really know what
was going on, so the teaching assistants were pushing us along.” This was an interesting
statement, because it seems that the personnel conducting these labs were not supporting the
higher-order thinking of their students.

Disconfirming evidence supporting that biology labs do support higher-order thinking
skills came from Lacey. Lacey said, “Yeah I would say you do, because lab is harder. You have
to do critical thinking and not just write definitions. You have to know the stuff.” Although she
agrees that labs do require higher-order thinking, she was unable to provide specific examples of
higher-order thinking done in the lab. Therefore, it is questionable whether or not her standards
of higher-order thinking were the same as the other participants who were interviewed.

It was also interesting to hear the responses to whether students would rather have labs
that give step-by-step instructions or labs that are inquiry-based. Inquiry-based labs are more
prone to students using their higher-order thinking skills than labs that provide step-by-step
instructions. Surprisingly, most students agreed that they would want labs that give step-by-step
instructions. For example, Lacey suggested that she would prefer labs with step-by-step
instructions, because the labs would be clearer, and so that they know what they were doing was
right. On the other hand, Bryan made an interesting point by saying, “I think step-by-step labs
are important, because you need to know how to do things, but you need inquiry-based [labs] to
give specific questions. I think it is important to give students the tools with the step-by-step
labs, but then have them go back over them and ask them conceptually why they did what they
did.” It seems as if students are comfortable with labs that give step-by-step instructions, but
some are willing to try inquiry-based labs to further develop their conceptual knowledge of the content they are learning.

Summary

The results within this chapter succinctly outline the research questions posed in this study. The first research question (What are students’ perceptions of biology lectures and biology labs?) had interesting and conflicting quantitative and qualitative results. The quantitative survey data yielded all positive perceptions of biology lectures and labs, but the interviews made it clear that not all of the participants’ perceptions were positive. There were a considerable amount of negative comments pertaining to biology lectures and labs.

The second research question inquired about the students’ beliefs on the integration of biology lectures and labs. Between the survey responses and the students’ feedback from the survey, it is of high importance to link lecture topics with the lab activities. Every participant agreed that it is important to link the lecture content in the survey, and then they reaffirmed this by clearly explaining why in the interview. For example, many of the participants felt that they did not feel as confident with the lab activities without going over the supplemental content in lecture beforehand.

Data for the final research question evaluated whether current lab activities that were being done by the students were causing them to use higher-order thinking skills. The bulk of the data collected for this research question came from the student interviews. However, there seemed to be a moderate percentage of students who claimed that the lab did not teach them to think through a problem in biology. A majority of the responses given in the interview reconfirm this notion. All participants but one claimed that higher-order thinking was not happening in their biology labs. The discussion of these results and their implications are outlined in chapter five.
CHAPTER V

CONCLUSIONS

Summary of the Study

Biology labs are an important element of biology classes in high school and college. However, there are times when students do not understand the link between the lecture content and the lab they are performing. Therefore, this study was designed to research students’ perceptions of biology lectures and labs, students’ beliefs on the integration of biology lectures and labs, and whether current biology labs at the college level are causing students to use their higher-order thinking skills. As shown in the literature, schools are pushing to reform traditional labs to be more inquiry-based to allow for higher-order thinking skills to develop among our young science students. Inquiry-based labs may include lab techniques such as virtual labs, case-based labs, and integrating labs right into the lecture. The research conducted in this study was done through mixed-methods to figure out these essential questions.

A quantitative survey was administered to 13 participants to gauge their perceptions of biology lectures and labs, and their beliefs on the integration of lab and lecture. There were also several questions used to analyze if higher-order thinking was done in their labs. To further the study, a subset of six participants from the original sample was asked to participate in an interview. The interview questions were tailored from their survey responses so that they could be asked why they chose a specific rating for certain questions. Upon analyzing the survey data and the interview data, there were some interesting findings for each research question.

Discussion of Findings

The findings of this research study will be shared by research question for simplicity and organization. Both quantitative and qualitative findings will be shared when appropriate for each research question. Integrating the quantitative and qualitative findings provides greater depth
and understanding of the research questions that were posed. It is also important to keep in mind
that the students were only describing one biology class in the survey and in the interviews, and
not every biology class the students were describing was the same. Therefore, variation among
biology classes that were spoken of is an element to consider when analyzing the findings.

Research Question One: What are students’ perceptions of biology lectures and biology labs?

It was interesting to note the positive perceptions of biology labs and lectures in the
survey, however, during the interviews there were positive and negative aspects of biology labs
and lectures that were mentioned by many of the participants. Still, the negative comments
outweighed the positive perceptions by many. A way to view these findings is that despite some
of the negative aspects of lab and lecture that were mentioned in the interviews, the students
were still positive about the several elements that were mentioned for lab and lecture in the
survey. It is also possible that the sample of participants felt pressured to make the positive
comments on the survey, because they felt like they had to. Keep in mind that I administered
this survey to only the SETGO students at one of their introductory meetings to the program
where many faculty members who teach these science classes were present. It is also possible
that the students were not comfortable selecting negative-type perceptions around their faculty
mentors.

Statements one and two from the survey: Doing hands-on activities were enjoyable in
lecture/lab; were examples of positive perceptions of biology labs and lectures. However, noting
that a considerable number of students chose not applicable for this statement is the interesting
part about this survey item. If so many students agree that hands-on activities were enjoyable in
lab and lecture, why were there so many professors who are not doing them in their classes?
Cavana and Leonard (1985) support the idea of hands-on activities so that students can excel in
relating lab material to lecture content, which makes them also achieve a higher rate of success
Discussions of real life issues in the lecture/lab helped my learning in biology. The majority of students agreed or strongly agreed, but there were also a set of students who claimed that this was not applicable to them. If certain elements are causing students to perceive lecture and lab in a positive light, then instructors should be putting them into practice. Raghubir (1979) would agree that discussions of real life issues are an important part of lecture and lab, because he states that the higher-order thinking process the students would develop and exhibit during lab would allow students to make a real life connection to the content learned in lecture.

The qualitative evidence that was presented outlined some of the negative perceptions of biology lectures and labs. These pieces of evidence were able to disconfirm that all perceptions of biology lectures and labs were positive. One of the quotes that Bryan mentioned stood out the most: “I try to take a step back and ask myself, ‘Why are they having me do this lab? What’s the point?’ Many students just hurry through the lab to try and get out of there as fast as they can without thinking about the meaning of it.” The perception that lab is often viewed as a chore to students is a reason why traditional lab methods need to be reformed. Ernie also mentioned that it was almost as if the lab and lecture were two completely different classes. Johnston and McAllister (2008) were able to conclude from their research that the relevance of knowledge being learned is paramount in students’ perception of its importance. Therefore, if students believe that what is being taught in their biology labs and lectures are relevant, they will perceive it well. As seen in the next research question discussion, the perceptions of biology lectures and labs directly related to the students’ beliefs on the integration of biology labs and lectures. As shown in my study, students are more likely to perceive biology labs and lectures in a positive light if they are linked in some way.
Research Question Two: What are students’ beliefs about the integration of biology lectures and labs?

Research question one established that through the students’ perceptions, they desire a link between biology lectures and lab. Therefore, research question two analyzed the students’ beliefs about the integration of lecture and lab, and if and how it occurred in their previous biology class. The difference between perceptions and beliefs becomes clear in this research question. Perceptions, which are discussed in the first research question, are just the immediate insights to what students think. Beliefs, however, are the students’ convictions about biology lectures and labs, which can be more long-term than perceptions. Therefore, beliefs are much more powerful, especially when I talked about the integration of lab and lecture with these students.

All of the students believed that it was important to integrate the lecture topics with the lab activities, but through some of the other survey responses it was apparent that this did not happen in some instances. For example, item 29 from the survey states: The lecture content prepared me for lab activities. Nearly one-fourth of the students disagreed that the lecture content prepared them for lab activities. Once again, why are not more instructors trying to make a connection between the material they teach in lecture and what the students do in lab? Students should be able to at least have a general idea of the kinds of labs that they are going to cover after they learn a certain concept in lecture, but it turned out that a third of the students were unable to do that in their previous biology class.

Qualitative evidence that supported the integration of biology lectures and labs further extenuates the survey data. Ellen told of an introductory biology class where they usually had the lecture topic before they conducted a lab experiment on the same content, and she had no problems with the material. She claimed in the interview, however, that there were times when
they did a lab before the lecture content, and it was slightly harder for her since she had no background information on the material. Ellen and many of the other students interviewed felt strongly about having the lecture content before the lab, and that is how biology lectures and labs should be integrated to make more sense. The evidence that was found in this study matches the research done by Perkins et al. (2004). They found that students who come into a course with favorable beliefs are more likely to achieve higher learning gains. The students in this study were not necessarily doing poorly in their classes, but they indicated that they could probably have done better if the labs and lectures were linked.

**Research Question Three: Are the lab methods being used in biology classes causing students to use higher-order thinking skills?**

The third research question was aimed to analyze whether the students in biology labs did any higher-order thinking, and possibly to find out if any of the lab methods mentioned in the review of literature were being put into practice. Being able to think through a problem or argument in biology labs is an important component to higher-order thinking. However, there were almost a quarter of the students who responded that their biology labs did not teach them to think through a problem or argument. If students are not taught to think through a problem or argument in biology labs, then it is likely that the labs are not causing the students to use their higher-order thinking skills. However, there was a piece of evidence that did favor students using higher-order thinking in biology labs. Item 10 from the survey states: *The lab helped me understand how concepts in biology related to other science disciplines.* All of the students but one agreed to this statement. Being able to relate and understand material from one class to another is an important higher-order thinking skill for students in science. Between the survey responses on the these questions and what was said in the interviews, whether they were really using higher-order thinking skills is debatable, and most likely did not occur often if at all.
Throughout the majority of interviews when the students were blatantly asked if they used higher-order thinking skills in their biology labs, they quickly answered “no” or a variation of it. Bryan agreed that higher-order thinking was not done in labs, because all they would do is read instructions, and hurry up to leave the lab. It even seemed that the teaching assistants that were conducting the lab periods were not fostering the students’ level of thinking and abilities according to Ellen. She said they even though her and her partners did not know what was going on, the teaching assistants just pushed them along. Some students that inquiry-based labs would take too much time to complete, but the research indicates that even though the activities of science inquiry require more time to cover the same content, an inquiry approach to teaching may be well worth the cost in reduced content, because it will improve student outcomes and higher-order thinking skills (Ebert-May, Brewer, & Allred, 1997). According to the students who participated in this study, the push toward more inquiry-based labs that the research mentioned is not occurring.

The interview participants were also asked whether they would rather have labs that give step-by-step instructions or labs that were inquiry-based. Their responses were surprising, because it seemed that they do not seem confident in their own higher-order thinking skills since most of them agreed that they would rather have labs with step-by-step instructions or a variation of both. Students are simply not comfortable with having freedom with lab experiments. Many of the students commented that they liked the structure of the chemistry labs, and thought that they did a better job of connecting lab and lecture, probably because chemistry labs are set up in a highly structured and step-by-step fashion. I believe this to be the reason why the students are more comfortable with these types of labs and why they are so fond of chemistry labs. If biology labs are using an inquiry-based lab, as is standard at this university in introductory labs, students do not always have the direct instructions to completing the lab. Therefore, like McComas
(2005) states, it is important to start the inquiry-based experiments early on in the students’ educational career. Perhaps then, students would be able to use more higher-order thinking skills in biology classes.

Conclusions

It is important for future educators of biology and other science classes to link what they are teaching in lecture to what the students are doing in lab. According to this study, students want their biology lectures and labs integrated with common links with respect to the material and content being taught. If there is linkage between lecture and lab, students are more likely to have positive perceptions of biology labs and lectures (Johnston & McAllister, 2008). Most of the negative perceptions occurred when there was a lack of common themes between the lab and lecture. Even though students seem to be attached to having labs that do not promote higher-order thinking, they are not opposed to having some labs that may be inquiry-based. My recommendation to fix the problem is if students were weaned off of labs that give step-by-step instructions, and are slowly replaced with guided-inquiry labs. This way, the instructor still has guidelines for the lab, but the students have a little freedom on how to conduct the experiment and ask their own questions.

Implications

Biology teachers who teach all ages can potentially benefit from this research. In addition, the same principles of this research can even be extrapolated to the other science disciplines. It is important for educators to know the perceptions and beliefs of their students on the classes that they teach. Moreover, it is especially important for college biology instructors because they can lecture and teach all they want, but without knowing the type of impact they are having on their students. If instructors take a step back to make sure that their labs coincide with the content they are teaching in lecture, it is likely to have a positive effect on their students. Lab
instructors can also benefit from this research by incorporating some inquiry-based labs into their instruction. Inquiry-based labs allow the students to harness their higher-order thinking skills. Moreover, the students will be more confident in their work and be less reliant on the instructor.

Recommendations for Future Research

Based upon the research that was completed in this study, further research is possible in many areas. In order for Americans to be front-runners in the areas of science again, a survey of the types of labs occurring at the high school level and college level need to be taken. If there is an overwhelming amount of institutions that are still using the cookbook-type labs, they need to be slowly extracted and replaced with inquiry-based lab methods. It is also recommended that the same type of study that was done here should be done with high school students. The key to a successful turnover rate of lower-order thinking labs to higher-order thinking labs is to start them out early. It would also be valuable to survey and interview the instructors of biology labs to analyze their perceptions and beliefs on the integration of biology labs and lectures.
REFERENCES


Lawson, A. (1999). What should students learn about the nature of science and how should we teach it?. *Journal of College Science Teaching, 28*(6), 401-411.


APPENDIX A
The following survey is being used for thesis research purposes and is completely voluntary. You may choose to not participate or stop participating at any time without consequence. For confidentiality purposes, please do not put your name on this paper. You are giving consent to participate in this research by completing and turning in the survey.

The purpose of this survey is to get an understanding of your feelings towards a recent college biology lecture and lab. Furthermore, we would like to better understand the ways in which your lab and lecture were integrated.

Preliminary Question A.
Identify the most recent college biology class you have taken that included a lab: ______________________.

SECTION I.
Please circle the response that best indicates your beliefs based on the biology lab and lecture that you stated above in Preliminary Question A.

<table>
<thead>
<tr>
<th>Strongly Disagree = SD</th>
<th>Disagree = D</th>
<th>Agree = A</th>
<th>Strongly Agree = SA</th>
<th>Not Applicable = N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Doing hands-on activities in lecture were enjoyable.</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Doing hands-on activities in lab were enjoyable.</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I usually understood what we were talking about in biology lecture.</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I usually understood what we were talking about in biology lab.</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I often think, ‘I cannot do this,’ when a biology lecture assignment seemed hard.</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. I often think, ‘I cannot do this,’ when a biology lab assignment seemed hard.</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. I understood the relation of concepts in the field of biology when in lecture.</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. I understood the relation of concepts in the field of biology when in lab.</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. The lecture helped me understand how concepts in biology related to other science disciplines (e.g. physics, chemistry, etc.).</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. The lab helped me understand how concepts in biology related to other science disciplines (e.g. physics, chemistry, etc.).</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. The lecture taught me to think through a problem or argument in biology.</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. The lab taught me to think through a problem or argument in biology.</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Discussions of real life issues helped my learning in lab.</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Discussions of real life issues helped my learning in lecture.</td>
<td>SD D A SA N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SECTION II.
Please circle the response that best indicates your beliefs about the integration of lecture and lab for the biology class you listed as Preliminary Question A.

<table>
<thead>
<tr>
<th>Strongly Disagree = SD</th>
<th>Disagree = D</th>
<th>Agree = A</th>
<th>Strongly Agree = SA</th>
<th>Not Applicable = N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>15. Gathering scientific data in labs or in the field helped my learning in lecture.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>16. Analyzing scientific data in lab helped my learning in lecture.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>17. Using scientific methods in lab helped my learning in lecture.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>18. Learning how real science is done in labs helped my learning in lecture.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>19. Summarizing scientific results in lab helped my learning in lecture.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>20. Lab activities helped my learning in lecture.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>21. Completing written assignments in lab helped my learning in lecture.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>22. I understood the lab activity better when we covered the material in lecture.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>23. The tests in lecture helped my learning in lab.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>24. The professor’s enthusiasm for the material in lecture helped me with my learning in the lab.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>25. The supplemental readings in lecture helped my learning in lab.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>26. Knowing that the material in lecture was what the lab was going to be about helped my learning in lab.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>27. Group work in lecture helped my learning in lab.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>28. There were demonstrations in lecture that helped me with lab.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>29. The lecture content prepared me for lab activities.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>30. Completing written assignments in lecture helped my learning in lab.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>31. I could predict what kinds of lab activities we were going to do in lab based on the lecture content we were covering.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>32. This biology class linked lecture topics with the lab activities.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>33. There are times when I felt confused as to why we were doing a lab, because I felt it did not have to do with what we were being taught in lecture.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>34. It is important to integrate lecture topics with lab activities.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>35. I understood the lecture topic better when we did a lab on it.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>36. I tend to do better in the lecture portion of a biology class.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>37. I tend to do better in the lab portion of a biology class.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
<tr>
<td>38. I tend to perform equally as well in the lecture and lab.</td>
<td>SD</td>
<td>D</td>
<td>A</td>
<td>SA N/A</td>
</tr>
</tbody>
</table>

SECTION III: Demographics

In the following items, please check the response that best describes you.

1. What is your sex? ____Male   ____Female
2. What is you class rank? ____Freshman   ____Sophomore   ____Junior   ____Senior
3. What is your race/ethnicity?
___African American ___Native American ___Latino/Hispanic
___Asian ___White ___Other:__________________

4. What is your age? ______
APPENDIX B
Dear Students,

My name is Matt Reising, and I am currently a graduate student in the Curriculum & Teaching program within the School of Teaching & Learning at Bowling Green State University. My advisor and chair for my thesis is held by Dr. Tracy Huziak-Clark. Dr. Huziak-Clark is also the Curriculum & Teaching program coordinator. I am focusing my research on what lab methods work best in biology classes, and how certain lab methods best bridge the gap between lecture material and lab activities. You are being asked to participate in this study, because you are a member of the SETGO program, and therefore, have experience with many biology classes that are complemented with a lab. Your contact information was obtained from the SETGO program roster.

The purpose of this research is to answer the question: What lab methods best bridge the gap between biology labs and lectures. This research will benefit teachers and curriculum directors to better tailor their curriculum to accommodate students’ learning needs. It will also benefit the students taking biology courses, because they will gain a better understanding of why they are doing certain lab activities. There is no direct benefit such as monetary awards, class credit, a raffle, etc. to the participants in this research.

The data that will be collected for this research will be done through surveys and interviews. You will be asked to complete a survey that consists of various statements based on lab methods, how students connect lab and lecture, and thinking processes involved in lab work. Each of the statements will be rated via Likert Scale from Strongly Disagree – Strongly Agree. You will be given up to 10 minutes to complete the survey, but is not required to use the whole time. Once all of the surveys are complete, they will be analyzed for the interview portion of the data collection process. The interview will be semi-structured and tailored to the survey responses. For example, if they survey data indicates that you strongly agreed on a certain statement, you might be asked to explain why that choice was picked for further explanation. The interview can take up to 20 minutes, but it is possible that it will conclude before then. It is also possible that you might not be called back for the interview.

Your participation is completely voluntary. You are free to withdraw at any time. You may decide to skip survey or interview questions at any time. Deciding to participate will not affect your grades, class standing, or you relationship with Bowling Green State University.

The survey data does not require your name to be attached in order to keep your answers confidential. The interviews will be recorded with a digital video recorder and uploaded on my personal computer once completed. A pseudonym will be given to you in order to protect your privacy when transcribing the interviews. All surveys will be kept in a folder and will only be accessible to myself and my thesis committee. Interview data will be saved on my computer which is password protected, and the transcripts will only be accessible to me and my thesis committee. The data will be destroyed after one year of publication of my thesis. There are no physical or mental risks associated with the collection of these data.

If there are any questions are concerns regarding this research, feel free to contact Matt Reising through email (mreisin@bgsu.edu) or phone (440-371-0985). You may also contact my advisor,
Dr. Tracy Huziak-Clark through email (thuziak@bgsu.edu) or phone (419-372-7363). You may also contact the Chair, Human Subjects Review Board at 419-372-7716 or hsrb@bgsu.edu, if you have any questions about your rights as a participant in this research. Thank you for your time and participation within this research.

\textit{Article 1.}

I have been informed of the purposes, procedures, risks and benefits of this study. I have had the opportunity to have all my questions answered and I have been informed that my participation is completely voluntary. I agree to participate in this research.

\begin{center}
\underline{Participant Signature}
\end{center}

I agree to be audio taped for the interview and have my responses transcribed.

\begin{center}
\underline{Participant Signature}
\end{center}

\begin{tabular}{lll}
Dr. Tracy Huziak-Clark & Dr. Toni Sondergeld & Dr. Lan Li \\
Thesis Chair Member & Thesis Committee Member & Thesis Committee Member \\
(419)-372-7363 & (419)-372-3840 & (419)-372-7335 \\
thuziak@bgsu.edu & tsonder@bgsu.edu & lli@bgsu.edu \\
\end{tabular}
APPENDIX C
Student Interview Questions

1. What types of biology classes are you currently taking, or have taken in the past?

2. Describe a typical lab period from the biology class you mentioned in the survey.

3. According to the statement: This biology class linked lecture topics with the lab activities, from the survey, please elaborate on how your professors link or do not link lab and lecture topics.

4. Explain how you think inquiry-based labs, would help or not help you bridge the gap between lecture and lab.

5. Do you believe inquiry-based labs would help you more with the content, or would you rather just have labs that give you step-by-step instructions? Why?

6. What are some elements from lecture that helped you with the lab activities?

7. Would you say that throughout your biology career in the laboratory, you have had to use many higher-order thinking skills to complete your labs? Why or why not?

8. When you performed lab experiments in that class, did you usually need any information that you have been taught in lecture to complete the lab? Why or why not?

9. How do you bridge the gap between lab work and lecture?

10. Do you find that you do better in the lab portion of your class or the lecture portion? Why or why not?

11. If you had the opportunity to teach a college biology course with a lab section, what kinds of labs would you use and why?
<table>
<thead>
<tr>
<th>Item</th>
<th>Strongly Disagree f(%)</th>
<th>Disagree f(%)</th>
<th>Agree f(%)</th>
<th>Strongly Agree f(%)</th>
<th>Not Applicable f(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Doing hands-on activities in lecture were enjoyable.</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>1(7.69%)</td>
<td>6(46.15%)</td>
<td>6(46.15%)</td>
</tr>
<tr>
<td>2. Doing hands-on activities in lab were enjoyable.</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>3(23.08%)</td>
<td>9(69.23%)</td>
<td>1(7.69%)</td>
</tr>
<tr>
<td>3. I usually understood what we were talking about in biology lecture.</td>
<td>0(0%)</td>
<td>1(7.69%)</td>
<td>5(38.46%)</td>
<td>7(53.85%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>4. I usually understood what we were talking about in biology lab.</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>8(61.54%)</td>
<td>5(38.46%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>5. I often think, ‘I cannot do this,’ when a biology lecture assignment seemed hard.</td>
<td>7(53.85%)</td>
<td>5(38.46%)</td>
<td>1(7.69%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>6. I often think, ‘I cannot do this,’ when a biology lab assignment seemed hard.</td>
<td>6(46.15%)</td>
<td>6(46.15%)</td>
<td>1(7.69%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>7. I understood the relation of concepts in the field of biology when in lecture.</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>5(38.46%)</td>
<td>8(61.54%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>8. I understood the relation of concepts in the field of biology when in lab.</td>
<td>0(0%)</td>
<td>2(15.38%)</td>
<td>3(23.08%)</td>
<td>8(61.54%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>9. The lecture helped me understand how concepts in biology related to other science</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>10(76.92%)</td>
<td>2(15.38%)</td>
<td>1(7.69%)</td>
</tr>
<tr>
<td>Statement</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>10(76.92%)</td>
<td>2(15.38%)</td>
<td>1(7.69%)</td>
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<tr>
<td>10. The lab helped me understand how concepts in biology related to other science disciplines (e.g. physics, chemistry, etc.).</td>
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<tr>
<td>11. The lecture taught me to think through a problem or argument in biology.</td>
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<tr>
<td>12. The lab taught me to think through a problem or argument in biology.</td>
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<tr>
<td>15. Gathering scientific data in labs or in the field helped my learning in lecture.</td>
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<tr>
<td>16. Analyzing scientific data in lab helped my learning in lecture.</td>
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<tr>
<td>17. Using scientific methods in lab helped my learning in lecture.</td>
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<tr>
<td>18. Learning how real science is done in labs helped my learning in lecture.</td>
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</tr>
<tr>
<td>19. Summarizing scientific results in lab helped my learning in lecture.</td>
<td>0(0%)</td>
<td>2(15.38%)</td>
<td>7(53.85%)</td>
<td>4(30.77%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>20. Lab activities helped my learning in lecture.</td>
<td>1(7.69%)</td>
<td>0(0%)</td>
<td>7(53.85%)</td>
<td>5(38.46%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>21. Completing written assignments in lab helped my learning in lecture.</td>
<td>1(7.69%)</td>
<td>0(0%)</td>
<td>10(76.92%)</td>
<td>2(15.38%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>22. I understood the lab activity better when we covered the material in lecture.</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>7(53.85%)</td>
<td>6(46.15%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>23. The tests in lecture helped my learning in lab.</td>
<td>2(15.38%)</td>
<td>3(23.08%)</td>
<td>8(61.54%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>24. The professor’s enthusiasm for the material in lecture helped me with my learning in the lab.</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>7(53.85%)</td>
<td>5(38.46%)</td>
<td>1(7.69%)</td>
</tr>
<tr>
<td>25. The supplemental readings in lecture helped my learning in the lab.</td>
<td>1(7.69%)</td>
<td>5(38.46%)</td>
<td>6(46.15%)</td>
<td>1(7.69%)</td>
<td>1(7.69%)</td>
</tr>
<tr>
<td>26. Knowing that the material in lecture was what the lab was going to be about helped my learning in lab.</td>
<td>1(7.69%)</td>
<td>1(7.69%)</td>
<td>8(61.54%)</td>
<td>3(23.08%)</td>
<td>1(7.69%)</td>
</tr>
<tr>
<td>27. Group work in lecture helped my learning in lab.</td>
<td>1(7.69%)</td>
<td>1(7.69%)</td>
<td>4(30.77%)</td>
<td>2(15.38%)</td>
<td>5(38.46%)</td>
</tr>
<tr>
<td>28. There were demonstrations in lecture that helped me with lab.</td>
<td>1(7.69%)</td>
<td>3(23.08%)</td>
<td>5(38.46%)</td>
<td>2(15.38%)</td>
<td>2(15.38%)</td>
</tr>
<tr>
<td>29. The lecture content prepared</td>
<td>1(7.69%)</td>
<td>3(23.08%)</td>
<td>7(53.85%)</td>
<td>2(15.38%)</td>
<td>0(0%)</td>
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</tr>
<tr>
<td>30. Completing written assignments in lecture helped my learning in lab.</td>
<td>1(7.69%)</td>
<td>1(7.69%)</td>
<td>7(53.85%)</td>
<td>1(7.69%)</td>
<td>3(23.08%)</td>
</tr>
<tr>
<td>31. I could predict what kinds of lab activities we were going to do in lab based on the lecture content we were covering.</td>
<td>1(7.69%)</td>
<td>3(23.08%)</td>
<td>5(38.46%)</td>
<td>3(23.08%)</td>
<td>1(7.69%)</td>
</tr>
<tr>
<td>32. This biology class linked lecture topics with the lab activities.</td>
<td>1(7.69%)</td>
<td>1(7.69%)</td>
<td>9(69.23%)</td>
<td>2(15.38%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>33. There are times when I felt confused as to why we were doing a lab, because I felt it did not have to do with what we were being taught in lecture.</td>
<td>2(15.38%)</td>
<td>6(46.15%)</td>
<td>3(23.08%)</td>
<td>2(15.38%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>34. It is important to integrate lecture topics with lab activities.</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>4(30.77%)</td>
<td>9(69.23%)</td>
<td>0(0%)</td>
</tr>
<tr>
<td>35. I understood the lecture topic better when we did a lab on it.</td>
<td>0(0%)</td>
<td>1(7.69%)</td>
<td>5(38.46%)</td>
<td>6(46.15%)</td>
<td>1(7.69%)</td>
</tr>
<tr>
<td>36. I tend to do better in the lecture portion of a biology class.</td>
<td>0(0%)</td>
<td>4(30.77%)</td>
<td>4(30.77%)</td>
<td>3(23.08%)</td>
<td>2(15.38%)</td>
</tr>
<tr>
<td>37. I tend to do better in the lab portion of a biology class.</td>
<td>0(0%)</td>
<td>4(30.77%)</td>
<td>5(38.46%)</td>
<td>2(15.38%)</td>
<td>2(15.38%)</td>
</tr>
<tr>
<td>38. I perform equally as well in the lecture and lab.</td>
<td>1(7.69%)</td>
<td>2(15.38%)</td>
<td>8(61.54%)</td>
<td>2(15.38%)</td>
<td>0(0%)</td>
</tr>
</tbody>
</table>