Annual Report for Assessment of Outcomes 2012-13

Subject Area Committee Name: __Biotechnology SAC__
Contact person: _Jayme Gallegos__
For LDC/DE: Core outcome(s) assessed: _____
For CTE: Degree or certificate* assessed: _Biotechnology AAS/certificate_
*please attach a table showing the alignment of the degree or certificate outcomes with the College Core Outcomes

Please address the questions below and
send to *learningassessment@pcc.edu* by **June 21, 2013** with Annual Report in the subject line

Note: Information provided in this report may be inserted into or summarized in Section 2C Program Review Outline.

- Describe changes that have been implemented towards improving students' attainment of outcomes that resulted from recent outcome assessments. These may include but are not limited to changes to content, materials, instruction, pedagogy etc. Please be sure to **describe the connection** between the assessment results and the changes made.

Report from 2012:
Change 1: Apply knowledge of quality and regulatory issues, teamwork and good business practices to work in a bioscience laboratory or manufacturing environment.

- Most students did very well in this assessment with the exception of one or two who didn't perform appropriately as members of a team. Since teamwork is such a crucial aspect of working in a bioscience environment, especially in the context outlined in the class projects, we intervened by bringing in an outside expert from a local bioscience company to give a presentation/workshop to students covering teamwork and cooperation. This was done the following quarter in the BIT203 class but in the future it will be incorporated into the BIT125 or BIT126 classes where students routinely work in larger groups to do term-long projects. The teamwork workshop seemed to be a very positive experience and it was helpful to have someone from human resources in a bioscience company emphasize the importance of teamwork and cooperation in the workplace.
- Other changes to be implemented include the creation of a new course (BIT126) designed specifically to teach students more hands-on skills and documentation required to work in a regulated bioscience environment. Aspects of this project will be expanded on in the new course with students working as part of a team in a term-long project that is not just theoretical, but which they will work on in the bioscience laboratory. Future assessment of these outcomes will be done in BIT126 and will cover aspects of the term-long project to assess student achievement in all of these areas.

Change 2: Effectively, clearly and succinctly communicate the procedures, results and interpretations of laboratory activities to other staff in the bioscience workplace, using both informal and formal forms of scientific communication, including casual conference, the laboratory notebook, forms, memoranda, written reports and formal presentations.

- Student weekly summaries clearly showed that most of the students could take their work and translate the skills learned into both informal and formal forms of scientific communication. This assessment also helped identify the strong and weak points of communication in the assessed student group.
- With the understanding that each student has a different work experience/environment, the overall supervisor assessments illustrated that most students communicated effectively in the course of their work experience. One exception was a student with severe communication issues who, in spite of this, clearly made significant progress in communicating with others in her work experience environment.

- Students were and are counseled by BIT faculty at the end of the program (before beginning their work experience) on their specific strengths and weaknesses in both their laboratory and communication skills in order to help ensure their future success in the bioscience industry.

Change 3: Cultural Awareness

- This assessment was very valuable because it focused on the student's point of view and showed the value of bringing together people of different cultures. It was clear that students gained a much greater awareness of communicating with people who don't speak their language and they did extremely well with this.
- We will incorporate similar cultural exchanges in the program in the future whenever possible. Additionally, it will be important to try to discuss the global impact of biotechnology in the newly created BIT102 class (Current Topics in Bioscience Technology).

Change 4: Self-Reflection

- This assessment was very useful as a starting point to individually discuss strengths and weaknesses with each student. In general, students are aware of some of their weaknesses and this self-reflection allowed them to openly and honestly discuss their strengths and weaknesses. As an instructor, the self-evaluation made it much easier to be able to highlight the positive progress each student had made and discuss the areas that still needed work. Because the students had reflected honestly, the discussions were very positive and still allowed the instructor to point out areas of weakness to focus on for the remainder of the program.
- This "self reflection" and assessment will be incorporated into the BIT109 course in the future since it is best to do these assessments while there is ample time to correct and improve habits. Additionally, at the end of every year, an individual consultation is done with each student to help guide them as they enter the workforce and to highlight the areas that still need improvement in the future.

For each outcome assessed this year:

- Describe the assessment design (tool and processes) used. Include relevant information about:
  - The nature of the assessment (e.g., written work, project, portfolio, exam, survey, performance etc.) and if it is direct (assesses evidence mastery of outcomes) or indirect (student's perception of mastery). Please give rationale for indirect assessments (direct assessments are preferable).
  - The student sample assessed (including sample size relative to the targeted student population for the assessment activity) process and rationale for selection of the student sample. Why was this group of students and/or courses chosen?
  - Any rubrics, checklists, surveys or other tools that were used to evaluate the student work. (Please include with your report – OK to include in appendix). Where appropriate, identify benchmarks.
  - How you analyzed results, including steps taken to ensure that results are reliable (consistent from one evaluator to another.

Beginning of 2013 Report:

Assessment 1: Laboratory Notebooks

Core Outcomes: Critical Thinking, Communication, Professional Confidence

Purpose: The purpose of this stage of the assessment was to measure the core outcomes of professional confidence, critical thinking and communication. These are following up on the studies completed as part of last year's assessment to expand the Change 2 criteria to assess other aspects beyond communication. Many of us had observed in the past and particularly with the recent cohort that it seemed that though they were very good at keeping their lab notebooks in a professional manner, this practice did not seem an accurate measurement of their confidence because they were still unsure about their performance and often would second guess themselves when performing laboratory tasks. Further even the most successful students had some issues with thinking critically about their data and conveying that in a formal written format. To better assess these issues and also to incorporate the comments we received last year about quantifying our data, we employed a rubric (see Appendix 1) designed to assess outcomes of critical thinking, communication and professional confidence.

Nature of the Assessment: This assessment is a direct measurement of the students' performance in a task common to many BIT classes – keeping a professional laboratory notebook. It is a task that is common for a technician in the bioindustry and universal for laboratory research technicians and in many ways summarizes a worker's ability to organize, communicate, and workplace.

Sample Size: There were 14 lab notebooks assessed in this study – 93.3% of our BIT 215 class. We are a very small department, and our current cohort is 15 students in this class. For this year's assessment, we wanted to examine an entire notebook to score an average performance in one class, so we chose an upper level long-term project-based class because at this point in the program, students have had ample practice in keeping notebooks and their styles tend to vary little over the course of the term. To maximize the sample number, we used the notebooks from the entire class. Please note: our data is gathered from 3 assessors because we are a very small department with only one current full time faculty member. Therefore, we recruited everyone who was actively teaching in the upper division classes to score this study as well as the department chair, who has prior experience teaching BIT courses.

Rubrics: (Please see Appendix 1.)

Method of Analysis: The data was collected by masking the student's name on the lab notebook with a number and scoring the notebooks. Since we only had three assessors, due to the small size of our department, and because we are all familiar with scoring notebooks and different types of assignments in each other's classes, we talked with each other as a way to normalize the data, since there are not enough of us assessing to use an entire group to normalize. In order to normalize, the lead instructor and creator of the scoring rubric (Jayme Gallegos) explained the requirements of the notebook assignment in her class and also where the other assessors might find information to fit each of the points of the rubric, as per her requirements for the class. The entire notebook was scored, as noted above, due to the fact that at this point in their studies (1 term before graduation) in BIT, the students are often very practiced at keeping notebooks and have developed a rather consistent notebook-keeping style. Further, the class that was scored was one in which there was an ongoing term project (term being 5 weeks in this case), rather than discrete lab activities. The assessors scored for what they felt were average trends in each notebook .

Assessment 2 (Pilot Study) Practical Exams

Purpose: The purpose of this assessment was to do a pilot study of the efficacy of using practical exams as a measurement of student competency in classes. We are a technical program, so there is a high level of focus on practical technical skills. Practical exams were implemented over the past two years in several classes in the program as a way to measure and grade on individual achievement of practical skills; these practical exams were implemented as a change in response to a previous assessment by the program that suggested that practical exams would be beneficial. However, after using these exams in several classes, we became

concerned because several students were quite visibly stressed leading up to and during performance on the practical exam. Further, we were concerned that this stress was causing negative impacts on overall learning and was, for some students, causing grade competition with classmates that overshadowed other outcomes, such as teamwork and time management. We were concerned that the stress was causing negative impacts on overall learning and was, for some students, causing grade competition that overshadowed other outcomes such as teamwork and time management. In order to decide whether we should keep using this method of examination or modify it to benefit the students, we did a small pilot. This pilot study, if successful may be implemented as part of a larger assessment on the topic next year.

Nature of the Assessment: This assessment is an indirect assessment in the form of a student exit survey that is then averaged and scored. As part of the practical under question, the students enrolled in BIT 201 Immunochemical Methods, perform a common laboratory procedure twice as part of their requirements: Western blot. As part of the practical, the students had the rubric two weeks prior to them that they were to be graded on and completed two weeks of lab and lecture devoted to the topic of Western blot. It is a technique that they will use commonly if they enter any molecular biology lab. Further, we implemented the practice of giving the students a rubric several weeks ahead of time. This practice was not always consistently followed by instructors giving previous practical exams.

Sample Size: There were 12 student subjects for this study, 100% of the students enrolled in BIT 201. This class was chosen because it has been using practical exams as an indicator of technical performance for two years and every person in the class had taken at least one other practical exam for a class in BIT, aside from the one attached to the survey. It is also a class given during the last term of the program for most students, so we wanted to assess a whole cohort for professional confidence as they were close to graduating and finding work for this initial study.

Rubrics: (Please see Appendix 2 for exit survey.)

Method of Analysis: One evaluator (the class instructor, Jayme Gallegos) administered the practical exam, which was the setting up of a transfer of an SDS-polyacrylamide gel and the probing of it; this process was a mock-technique to keep it as a dry lab. Each student was given several pieces of the transfer and probing equipment, and they were allowed to bring in and reference their laboratory notebooks as they would be able to do in their future work. They then had to perform the procedures in front of the instructor as if they were training the instructor as a student. The instructor then graded them on performance and provided them with feedback. Then, the students were provided with the exit survey (See Appendix 2) and told that the results would not be examined until after the exam grades were posted – which they were not.

- Provide information about the results (i.e., what did you learn about how well students are meeting the outcomes)?
  - If scored (e.g., if a rubric or other scaled tool is used), please report the data, and relate to any appropriate benchmarks.
  - Results should be broken down in a way that is meaningful and useful for making improvements to teaching/learning. Please show those specific results.

Results of Assessment 1: Our results are compiled in Appendix 3. The raw data spreadsheet is available upon request. It should be noted that in most cases, the scores of the three reviewers was very close, so our normalization through communication worked well. In the case of these scores, anything above a 3 was agreed as meeting the program outcomes, anything below was a criterion that we need to address. At the outset, the data is not surprising when compared with what we as educators have been observing in our classes, which is heartening.

For the critical thinking section, the first two points of accurately providing a short description of the problem and distinguishing between fact an opinion were met adequately (3.01, 3.07) meaning that they had accurately provided a brief summary of the problem and were able to distinguish well between fact and

opinion. The remaining three points about considering the influence of variables, demonstrating higher level thinking and identifying and drawing conclusions were lower than optimal (2.75, 2.96 and 2.89). In all cases, these scores reflect a lack of "connecting the dots" between the data and the actual meaning of that data. These scores are not surprising because we have noticed in several cases that the students were often performing the laboratory procedure but not deeply analyzing the data or not conveying the analysis well in their lab notebooks.

The communication data was slightly better. They are using professional language (3.21) and their general writing skills are good (3.07). However, we are still slightly below the acceptable level on the use of professional vocabulary (2.96) and professional notebook format (2.98). One thing we noted was that several students continue to use "student" centered language that is commonly acceptable in a traditional science class. For example, in many cases students conclude with phrases such as "Overall, I learned a lot", or "I enjoyed having a chance to do this procedure".

As far as the professional confidence piece, this data was also very heartening. Their purpose and conclusions were confidently expressed (3.18 and 3.11). We may need to continue helping them improve in the areas of data reporting, prioritization, goal setting and time management (2.94, 2.64, 2.77 and 2.82). Again, these data are in line with our observations of this cohort. They are very good at doing what is required as per an assignment in the class setting, but their confidence and independent management need a bit more of a boost.

In all cases, this assessment verified what we suspected as instructors in the department and also was positive in the sense that though there are minor changes we may need to make, there should not be many major changes needed to make our goal. Due to the small sample size, we would like to note that these results could turn out to be characteristic of this cohort and we do not necessarily anticipate the same results for subsequent groups of students. However, the trends are worth noting.

Results of Assessment 2: The second pilot assessment reflected that the practical exams have not only been a positive addition to our teaching and evaluation but also that the students are responding to them in a positive fashion and feel that they are a useful measurement of both their learning in class and their readiness for the workplace (See Appendix 4). However, it should be noted that this practical exam was administered for less weight and under a much smaller and less complex rubric than used by some instructors in the past. Also the students in this cohort were very accustomed to taking practical exams.

- Identify any changes that should, as a result of this assessment, be implemented to help improve students' attainment of outcomes. (These may include, but are not limited to, changes in curriculum, content, materials, instruction, pedagogy etc).

Changes Corresponding to Assessment 1: Assessment 1 showed that for critical thinking, we will need to place more emphasis on classroom exercises that stress this type of analysis in the future. The students already have practice with questions that stress critical thinking in the classroom and critical thinking questions are always a challenge. For the notebooks, it would be good to have data from earlier classes and perhaps implement some exercises that lead them early through a more step-by-step write up of formal data, or have a sort of guided notebook taking exercise at the beginning of their 200 level classes when they are doing more formal lab write-ups. Also, this class was one in which there was an ongoing term project, so there is a chance that we would see slightly better scores on this rubric with a class more focused around discrete laboratory activities or experiments. For this class however, it may be beneficial to have a beginning of project intro write-up where they outline the project start to finish with the purpose of each step thoroughly and an end of

term all encompassing conclusion. They are provided something of the sort in their lab manuals, but it would still be good to have them work through the process to think through and solidify why they are doing each step and how it fits in with the larger whole. Also it may be beneficial for us to come up with a way to represent that better or more definitely on our scoring rubrics. It is possible too that these data could be interpreted as a reflection of classroom time constraints, but in this case the students were allowed to take the notebooks home to work on them outside of class, so time should not have been an issue in any lack of critical thinking that was displayed.

These communication scores seem very good. Not many changes seem in order, just re-emphasis of the notebook format and watching consistency between classes and instructors. Again, these were students at the end of the program. Some of the lower scores likely stemmed from a few students of the class who did not typically keep notebooks well. Again, it would benefit to have a scoring of notebooks from more than one class and at the beginning and the end of a cohort to notice trends over time. Many of our instructors are already stressing the professionalism and importance of the notebook more in the strictness of our scoring. We are a small department so it is quite easy for us to make and implement changes as we go along and this minor change is something that we are already working on. Also, it should be noted that the notebooks are often times a large percentage of their course grade so the weighting in the curricula already matches our high expectations.

For the professional confidence, again overall the trends are good and we just need to emphasize a few key points in slightly better ways or repeat what we are already doing. Data reporting, prioritization, goal setting and time management are constant challenges for our students and also for our instructors to carry through since all the classes are slightly different in their approach to each due to the differing work each involves. In all cases, many instructors take some time in their classes to go over each of these topics in relation to the course and many have materials that are built in to the courses to help them practice these skills. However, there is little emphasis or discussion as to what works best for each individual, since these skills are very individual in their execution. At this time, many of our instructors lecture on the topic, but perhaps it would be a greater teaching tool to incorporate a group exercise or discussion. Therefore, perhaps we should also include a short time for such an exercise or discussion of these topics at the beginning of each course or lab period; say 15-30 minutes where we discuss approaches to data reporting, have the students identify course goals as a group and share their thoughts on what pieces of the experiments are higher priority or require more time than others.

Changes Corresponding to Assessment 2: These results suggest that having similar practical exam that are a smaller percentage of the total course grade and also focus on a more discrete, less complex process might be more useful and less stress inducing than the practical exams we have administered in the past. Further we are striving as a department to have more standardization in the scope and grading of practical exams so that instructors can still tailor the exams to their classes while the students have confidence that they should have similar expectations to the standard of performance and grading between instructors. In the future, it would be very useful to couple this data with the instructor grading as well as administer the assessment in more than one class at more than one level in the program.

- Reflect on the effectiveness of this assessment tool and assessment process. Please describe any changes to assessment methodology that would lead to more meaningful results if this assessment were to be repeated (or adapted to another outcome). Is there a different kind of assessment tool or process that the SAC would like to use for this outcome in the future? If the assessment tool and processes does not need to be revised, please indicate this.

Alternative Approaches to Assessment 1: The addition of the rubric this year made it much easier to quantify the data from this assessment. We will likely keep that rubric in place next year with minimal modification or to include suggestions following this report.

We would like to ideally expand this assessment next year to include more than one class and perhaps a larger cohort in order to expand our data set to include more students and look for trends over their matriculation in the program. It would be particularly interesting and informative to look at the same group of students in a lower division class versus an upper division class to see if there is improvement or other trends in the outcomes from the beginning of the program to the end of the program, particularly because most of our data has been gathered this year from students nearing the end of the program. Also the greater length of time might allow us to recruit one or two more faculty assessors to have a slightly larger data set.

Additionally, for critical thinking skills it may be a good measurement to have a second, non-lab notebook based assessment since some of the students who are not showing critical thinking in their lab notebook may be doing better in a different format, such as reading and interpreting a journal article or data set (homework assignment).

Alternative Approaches to Assessment 2: In the future, it would be very useful to couple this data with the instructor grading as well as administer the assessment in more than one class at more than one level in the program.

BIT Assessment Appendices 2013

Appendix 1 – Notebook Rubric

Outcome	Rubric Criteria	4	3	2	1
Critical Thinking	**Identifies and summarizes the problem/question at issue.**	Accurately identifies the problem/question and provides a well-developed summary.	Accurately identifies the problem/question and provides a brief summary.	Identifies the problem/ question and provides a poor summary or identifies an inappropriate problem/question.	Does not identify or summarize the problem/question accurately if at all.
Critical Thinking	**Identifies and assesses the quality of supporting data/evidence**	Provides a well-developed examination of the evidence and questions its accuracy, relevance, and completeness. Clearly distinguishes between fact and opinion.	Examines evidence and questions the quality. Distinguishes between fact and opinion.	Merely repeats information provided. Does not justify position or distinguish between fact and opinion.	Does not identify or assess the quality of supporting evidence.
Critical Thinking	**Identifies and considers the influence of indirect variables on the experimental or procedural results.**	Accurately identifies and provides a well-developed explanation of all variables with a clear sense of scope.	Accurately identifies and provides an explanation of some or most variables	Does not explain potential relevant variables; provides inaccurate information; or merely provides a list.	Does not identify or consider any relevant indirect variables.
Critical Thinking	**Demonstrates higher level thinking by interpreting the relevance of experimental results to past and future procedures and experiments**	Accurately identifies the relevance of results in appropriate context and provides a well-developed explanation.	Accurately identifies relevance of the results and provides a brief explanation.	Does not explain, or merely lists inferred meanings.	Provides inaccurate information and/or fails to interpret relevance of results.
Critical Thinking	**Identifies and evaluates conclusions and scientific or higher order technical evidence**	Accurately identifies conclusions, implications and consequences with a well-developed	Accurately identifies conclusions, implications, and consequences with a brief evaluative	Does not explain, provides inaccurate information, or merely provides a list of ideas; or only discusses	Does not identify or evaluate any conclusions, implications or consequences.

		explanation of own assertions.	summary.	one area.	
Communication	**Reports data and explanations in clear to understand professional language**	Reports data and explains in very clear, precise form, that reader can immediately follow.	Reports data and explanations in clear, understandabl e fashion.	Report and data explanations somewhat understandable, but not clearly explained.	Structure of report very difficult to understand or follow.
Communication	**Uses professional lab notebook format followed by academic and industrial scientists**	Notebook follows format to extremely high level – appears professional	Notebook follows format appropriate for educational environment	Notebook mostly follows class format, but falls short in one or more areas	Notebook does not follow format guidelines well or at all.
Communication	**Uses vocabulary and terminology appropriate for the subject and experiment**	Demonstrates a high level of understanding of professional terminology and vocabulary acquired from more than one class in the program. No usage of informal language	Demonstrates correct usage and understanding of professional terminology and vocabulary from class where they kept notebook. No reliance on informal language.	Understanding of professional terminology and vocabulary mostly correct, with a few errors. Relies more often on informal language.	Poor understanding, if any, of professional terminology or vocabulary. Relies almost entirely on informal language.
Communication	**General writing, sentence structure, and language usage.**	General writing, sentence structure, and language usage shows high level of language competency.	General writing, sentence structure, and language usage shows a standard level of language competency.	General writing, sentence structure, and language are inconsistent and have several mistakes in grammar, punctuation and language usage.	There is a very poor understanding of basic writing skills, sentence structure and language usage.
Professional Confidence	**Experimental purpose detailed in direct, definite manner that shows understanding.**	Purpose is explained directly and confidently in their own words in professional manner.	Purpose is explained using close to instructor or literature-provided wording.	Purpose is partially or not well explained in several places.	Purpose is entirely incorrect or missing in several places.
Professional Confidence	**Conclusions reported in accurate, direct terminology.**	Conclusions reported accurately and thoroughly in a professional	Conclusions reported accurately and directly. May not always cite	Several inaccuracies in reporting conclusions and little connection	Very inaccurate conclusions or none at all, not associated with data. Wording

		manner citing specific data.	specific data, but has the conclusion associated with the experiment and lets the reader assume they are connected.	to specific data and the conclusion. Also indirect wording showing some lack of confidence.	shows little or no confidence.
Professional Confidence	**Each potential problem listed and dealt with systematically with no effort to hide or gloss over "poor" data outcome**	Several problems listed and dealt with systematically including both external and personal sources of error	A few key problems listed and dealt with systematically including both external and personal sources of error	Very few problems listed, some attempts made to hide or not acknowledge "poor" data outcome	Significant effort to hide, change or manipulate data or misinterpret it to give an inaccurate outcome.
Professional Confidence	**Problem solving shows prioritization of future goals.**	Goals for future experiments/next day very clearly outlined and prioritized.	Goals for future experiments/next day clearly outlined.	Few goals for future experiments, spotty day-by-day goal recording.	Seldom or never records goals or priorities.
Professional Confidence	**Introduction, methods, or other appropriate section shows prioritization of current experimental goals**	Goals for current experiment very clearly outlined and prioritized.	Goals for current experiment clearly outlined.	Few goals for current experiment or inaccurate goals	Seldom or never records goals or priorities.
Professional Confidence	**Usage of planning tools appropriate to class (ie. Flow chart, time line, summary tables) to help with time management**	Uses both the instructor's tools or develops tools on their own to help with time management and organization	Uses the tools provided in class by the instructor to help with time management and organization	Has the tools, or only partially includes tools for time management and clearly uses them infrequently or little.	Little or no demonstration of tools used to help organize time and resources.

Appendix 2 – BIT Practical Exam Exit Survey

This exit survey is being used as an assessment tool by the department to determine the effectiveness of using practical exams as a teaching tool in the BIT courses. Your answers will help us improve on how we administer and grade the practical exams. This *survey is meant to be anonymous*, so do not include your name and please answer honestly. I will not read these answers until after the exam grades have been determined. Thank you!

Have you ever taken practical exams in other classes (circle one)?
Yes No
Have you ever taken a practical exam in a BIT course (other than this one – circle one)? Yes No
If you answered yes to any of the questions above, please specify the classes:

For the following questions, please rate each point 1-5, with 1 = entirely disagree, 3 = not sure or no comment and 5 = entirely agree

This exam was a fair representation of class/lab material
1 2 3 4 5
This exam was a fair representation of what I would expect to encounter as a technician 1 2 3 4 5
The practical format is the best way for testing this concept
1 2 3 4 5
I expect to encounter the methodology used in this exam in my career
1 2 3 4 5
I felt adequately prepared for this exam (either by studying or attending class)
1 2 3 4 5
I felt more stress than usual taking this type of an exam
1 2 3 4 5
I felt that this exam was a good way to show my professional skills
1 2 3 4 5
It was helpful to have the exam rubric given to us in advance
1 2 3 4 5
I felt this exam was a true reflection of my knowledge of the material
1 2 3 4 5
I felt that this exam was a good way to get feedback on my lab technique
1 2 3 4 5

Please include any additional comments you would like below:

Appendix 3 – Compiled Data from BIT Notebook Survey

Outcome	Rubric Criteria	Average Score
Critical Thinking	**Identifies and summarizes the problem/question at issue.**	3.01
Critical Thinking	**Identifies and assesses the quality of supporting data/evidence**	3.07
Critical Thinking	**Identifies and considers the influence of indirect variables on the experimental or procedural results.**	2.75
Critical Thinking	**Demonstrates higher level thinking by interpreting the relevance of experimental results to past and future procedures and experiments**	2.96
Critical Thinking	**Identifies and evaluates conclusions and scientific or higher order technical evidence**	2.89
Communication	**Reports data and explanations in clear to understand professional language**	3.21
Communication	**Uses professional lab notebook format followed by academic and industrial scientists**	2.98
Communication	**Uses vocabulary and terminology**	2.96

	appropriate for the subject and experiment	
Communication	**General writing, sentence structure, and language usage.**	3.07
Professional Confidence	**Experimental purpose detailed in direct, definite manner that shows understanding.**	3.18
Professional Confidence	**Conclusions reported in accurate, direct terminology.**	3.11
Professional Confidence	**Each potential problem listed and dealt with systematically with no effort to hide or gloss over "poor" data outcome**	2.94
Professional Confidence	**Problem solving shows prioritization of future goals.**	2.64
Professional Confidence	**Introduction, methods, or other appropriate section shows prioritization of current experimental goals**	2.77
Professional Confidence	**Usage of planning tools appropriate to class (ie. Flow chart, time line, summary tables) to help with time management**	2.82

Appendix 4 – Data from Student Exit Survey about Practical Exams

Question	Average Score
This exam was a fair representation of class/lab material	4.42
This exam was a fair representation of what I would expect to encounter as a technician	4.50
The practical format is the best way for testing this concept	4.25
I expect to encounter the methodology used in this exam in my career	4.50
I felt adequately prepared for this exam (either by studying or attending class)	4.50
I felt more stress than usual taking this type of an exam	2.83
I felt that this exam was a good way to show my professional skills	4.33
It was helpful to have the exam rubric given to us in advance	4.67
I felt this exam was a true reflection of my knowledge of the material	4.33
I felt that this exam was a good way to get feedback on my lab technique	4.67

1 = entirely disagree, 3 = not sure or no comment and 5 = entirely agree

Appendix 5 – Proposed Practical Exam Rubric to be used in 2014 in Conjunction with the Exit Survey

Outcome	Rubric Criteria	4	3	2	1
Professional Confidence	**Notebook is used appropriately as a tool for future experiments.**	Had notebook and if consulted it, was able to find information quickly.	Had notebook and if consulted it, found information in a timely fashion.	Had notebook and could not find information efficiently or did not have it and needed it for help.	Did not have notebook and definitely needed it for help or the notebook was unusable for help in a timely fashion.
Professional Confidence	**Procedure is performed in an efficient and well-prepared manner.**	Procedure is performed very efficiently with little consultation of the notebook.	Procedure was performed in a timely fashion with some consultation of the notebook.	Procedure was performed slowly – uses the notebook as a crutch.	Procedure performed as slowly as a first-time experimenter checking notebook at every step.
Professional Confidence	**Explanation of procedure confident.**	The procedure is explained in direct, accurate	The procedure is explained in somewhat	The procedure is poorly explained or	The person cannot explain the procedure or

		language as the person is performing the practical.	awkward or nervous language as the person is performing the practical.	very inaccurate as the person is explaining the protocol.	is so inaccurate that the listener cannot follow him or her.
Professional Confidence	**Exit survey answers about their feelings about their performance on the exam**	Questions about feelings about the exam very positive	Questions about feelings about the exam shaky but positive overall.	Questions about feelings about their performance answered mostly negatively.	Questions about their feelings about their performance answered entirely negatively.
Professional Confidence	**Exit survey answers about their feelings of preparedness for the exam material reflect confidence that coincides with their performance.**	Exit survey answers show realistic confidence (confidence matched exam performance).	Exit survey answers reflect some lack of personal confidence, but they underestimate themselves (ie. they are not confident but performed well).	Exit survey answers reflect extreme lack of confidence, but performance is still average.	Exit survey answers are either entirely not confident or demonstrate unrealistic confidence (they think they are performing at A range when they got a C or D).
Professional Confidence	**Exit survey answers about their feelings of preparedness for their job reflect confidence.**	Exit survey answers reflect that they feel the exam demonstrated very accurately that they are ready for their job.	Exit survey answers reflect the fact that their exam performance may not be up to their usual standard.	Exit survey answers reflect that the exam showed them they were not prepared for their job and they were worried about their lack of preparedness before.	Exit survey answers reflect that they feel completely unprepared for their job after the exam and they did not feel that way before.