Undergraduate Academic Assessment Executive Summary
Natural Sciences: 2012-13

1. **Background**: The investigation of God's world to discover something new or to apply previously discovered knowledge to the benefit of God's people and his Creation are important goals of Christians in the Natural Sciences. In recent years, it has become expected that a young scientist's research training begin during their undergraduate education. The Natural Sciences department at Concordia welcomed the change in expectations and has been incorporating a research or targeted application component into its biology area for many years and its chemistry area for the past six or seven years; with the introduction of the new BS in Physics major, the physics area has done the same.
   In a previous evaluation cycle, student research papers in biology were evaluated for the quality and content of the writing, so the department has visited the research requirement in the past. However, although all three areas of the Natural Sciences department now have a required research or internship component, no systematic effort has yet been made to evaluate the quality of the research or to compare the required research component of all three areas. As the department agrees that the research components of our curriculum is a "capstone" experience and as students in all three areas present their results in the semi-uniform format of a research poster, investigating the research component of our natural sciences curriculum using the research posters as the primary artifact seems appropriate.

2. **Question**: The two questions that the Natural Sciences department initially attempted to answer were:
   1) What is the quality of our students' work represented by their research posters?
   2) How does the quality of our students work represented by their research posters vary among the areas of biology, chemistry, and physics?

3. **Methodology**:
   Question 1) The process of reporting research throughout the Natural Sciences, whether presented in a paper or a poster is expected to follow a very specific format that includes the following components: Introduction, Experimental/Methods, Results & Discussion, and the Conclusion. Because of the brevity expected in a research poster, the four or five separate components are not always clearly delineated; nonetheless, the inclusion of their substance is expected. Thus, the quality of the research as presented will be dependent on the quality of all of the components. An additional factor specific to research posters is simply "presentation". Namely, is the poster clearly organized and visually engaging?
   A simple rubric was used to generate a Quality Score (QS) from 5 - 25 for each research poster considered (see attached). It is to be understood that the QS may be a function of the number of students participating in the preparation of a research poster.
   Question 2) By examining the QSs of the various research posters associated with the three areas of the Natural Sciences Department and by discussing general impressions of the research posters in consultation with the faculty who taught the students, the department hopes to reach a consensus regarding the general success of our three areas to prepare students for research and poster presentations. The result of our discussion will serve as the kernel of our Departmental Action Plan.

4. **Summary of results**: Five members of the department initially met for three hours on June 6. During that time we used the attached rubric to evaluate research posters and power points from biology, chemistry and physics. This session included continuous discussion of the quality of the research experiences both from the perspective of students and professors. We met a second time on June 11 to complete our evaluation of student research projects and continue our discussion. After reviewing student research projects, each faculty member completed a questionnaire with the following two questions:
   1. List one or two of the most beneficial outcomes experienced (or anticipated) from your or someone else's research class from the instructor's perspective.

2. List one or two shortcomings experienced (or anticipated) from your or someone else's research class from the instructor's perspective.

After answering these questions, we discussed our answers and looked for themes/patterns across the department, which are presented in the Conclusions below.

5. **Conclusions**: The rubric was useful in helping us assess individual student research projects and in facilitating important discussion rather than generating data for this report. One interesting discussion revolved around how we as a science department actually define research.

   The discussion of the answers to question 1 in the previous section answered by faculty provided a meaningful discussion and gave us direction for our action plan. A summary of our discussion follows:

   i. Three of five faculty felt the following were beneficial outcomes of student research:
      a. Students were involved in the *actual experience* enabling them to determine if research (graduate school) is something they would like to pursue.
      b. Students taking *ownership* for a project that they see through to its completion

   ii. Additional beneficial outcomes of student research included:
      a. students learned high-level science content associated with their project
      b. students were involved in *analyzing* data/results associated with their project
      c. students were able to use more advanced scientific techniques
      d. through their research, students produced information useful for outside entities

   The discussion of the answers to question 2 in the previous section answered by faculty also provided a meaningful discussion and gave direction for our action plan. A summary of our discussion follows:

   i. Four of five faculty felt the following were shortcomings experienced in the student research class:
      a. There was limited time for students to complete all that is needed to conduct a quality research project in a one semester class

   ii. Additional shortcomings experienced in the student research class included:
      a. There is a significant jump in scientific ability and expectations from a non-research based science class to a research class leading to the question of how we can shorten that gap.
      b. At times, students lacked the ability and/or background information to come to the right conclusions based on their research leading to the question of what can we do to better equip them with these skills/tools.

6. **Action Plans**: it became clear through our discussion that while some issues in research (the definition of research, time limits) are common to the entire department, others are unique to specific disciplines within the department. This is reflected in our action plan below.

   1. During the next academic year, we will meet as a department and develop a definition of research that is applicable across all disciplines within the department that will lead to assessable goals.
   2. The physics program has a concern that students in the research class are being asked to work at a level of independence and to use equipment, techniques, and methods that are a significant step up from what students have done in all their other classes prior to the research experience.

      Therefore the physics program will attempt to integrate more advanced equipment, data collection methods, and statistical methods into a wider range of courses, and give students more opportunities for more guided but independent work at an earlier time. This should provide more of a smooth transition from the bulk of the physics courses to the research experience. Some opportunities for this are to include more statistical analysis and independent exploration into the advanced lab, and to utilize more advanced technology and programming in the Electronics course. There may be an opportunity to include more advanced, real-world data analysis into the Astronomy course.

If these changes are implemented successfully, students in the research class should be able to develop research questions faster and more effectively, and to begin work on their research much earlier in the semester, as they will not be learning so many new things at the start of their project. The measurable assessment will include the timing and scheduling of the students' research projects; the quality of the research design, analysis and conclusions; and the completeness of the final papers and posters.

3. The chemistry program has a concern that the number of projects in a given semester influences the quality of the work due to the difficulty in effectively mentoring too many student projects. This was especially evident in analysis and generating supportable conclusions. As a result, the chemistry area will limit the number of simultaneous independent projects to a maximum of ten in any given research class. Given expected enrollments, this is not likely to be a problem in the foreseeable future.

   Following our departmental research discussions, it is clear that many aspects of the research experience encountered by students in the chemistry area meets or exceeds expectations. Students are able to pursue valid, highly technical projects of considerable personal interest. This is largely a result of the research experience being embedded in the latter half of a two-semester sequence that gives students the opportunity to become familiar with literature in the area of Physical Chemistry and typical questions asked in the discipline. Also, the technique of "molecular modeling" used in the research experience is fairly standard across a range of projects allowing students to identify questions and generate data more rapidly than other techniques.

   The biggest challenge for our research students was clearly the interpretation of the data generated by the software. To address this difficulty and provide students with a final opportunity to defend and modify their work, each research project team will schedule an ~20 min "final" during reading week (groups that include graduating seniors) or finals week (everyone else). A successful implementation of this action plan is expected to result in a marked decrease in the number of spurious conclusions mistakenly generated by research students and lead to a more satisfying experience overall. A decrease in the number of spurious conclusions from one in every two or three to one in every five posters will constitute success.

4. The biology program has concerns similar to the physics program in that students in the research classes are being asked to work at a level of independence requiring background information and understanding of methodology that is a significant step up from what they have done in classes prior to the research experience. With multiple emphases in the biology program, recently students have taken a research class focusing on an area outside their emphasis with very little background in the research conducted. This has created challenges for both the students and professors in completing quality research. To ensure that students were prepared for the research class, permission from the instructor was previously required to register for the biology research class, but this is not currently implemented. The biology program plans to reinstitute this practice and, like the physics program, to focus on developing experiences in supporting courses taken before the research class that will better prepare students for the research class. These courses will vary depending on the research direction desired by the student. For example, Bio 317 Ecology and Field Biology is an important course preparing students for a research class associated with the Organismal Emphasis while Chem 345 Biochemistry is an important course preparing students for a research class associated with the Cell and Molecular Emphasis. In addition, biology professors/advisors will attempt to better communicate with students to ensure that students ultimately enroll in the research class most appropriate for their program and goals. The biology program will assess these changes in a manner similar to that proposed by the physics program.