some to decide they need to use the product and the chain rule the second time, etc. Then, they have a hard time “showing” that it works. They do not finish the problem properly, stating that the left side of the equation does not equal the right.

viii. Interval of Convergence – applying the ratio test to ratios that involve a variable seems to be the biggest weakness, although by this point it is not uncommon for students to have completely run out of time for these last three problems, not in terms of the test but in terms of being able to study, so they flunk miserably on this part of the exam. Common mistakes are students getting the radius of convergence and not checking the endpoints correctly. It seems they plug everything in correctly but then gloss over the necessary details or analysis of the resulting infinite series.

ix. Taylor Series -- there are two primary mistakes that students make on this particularly simple problem. First, they do not recall the McClaurin series, and second they incorrectly evaluate at x^2, which is a precalculus type of skill. Again, it is unfortunate but some students are pretty worn out by this stage of the course. Of course, some students find this problem extremely easy.

x. Taylor Series Coefficients – the first part of this problem is identical in terms of the level of difficulty as the one directly above. A common mistake is differentiating incorrectly. Another is not writing down a series at all. Simple algebra mistakes are common as well. It is interesting to note that this problem probably has the highest standard deviation for its scores. There are a lot of full credit scores for this problem, and unfortunately a lot with a zero. This indicates that if the students are caught up with their work they can certainly master the main concepts here. It is the ones who are behind in the class, and probably in others as well, that struggle to catch up at the end and their infinite series studies suffer, particularly the very last part that we cover, which is the type of problem covered in this problem.

Analysis of this assessment through the Institutional Goals lens

The concepts covered in Math 206 are at the high end of Quantitative Reasoning related concepts, particularly in terms of critical thinking and analytic skills. The problems chosen for this assessment, some of which are the more basic questions encountered in Math 206, still reflect this idea. The Fundamental Theorem of Calculus problem requires students to understand the implications of FTC, and then to apply them in a real world setting, performing multi-level computations and analysis. The volume of revolution problem requires students to visualize in three dimensions and to be able to extract information from that visualization. It also requires students to understand the concept of integration from a “one piece at a time” perspective and to extend that understanding to the implications of the definition of the definite integral as the limit of a sum, thereby allowing the transformation of the sum of individual pieces to a Definite Integral that can easily be computed either by hand or with the use of technology. The integration techniques problems require students to identify and analyze differentiation from the results end, and to be able to move between differentiation and anti-differentiation within the same problem, combined with faultless precalculus skills. The infinite series questions push students' analytic and computational skills to their limit, no pun intended. It is extremely pleasing to students and instructors alike to reflect on the students' abilities to tackle problems of such advanced mathematical sophistication, given the fact that for many it was less than six months prior that they had even learned the simple skill of differentiation. Students achieving competent scores for such Math 206 problems are certainly at the advanced levels intended by the Quantitative Reasoning institutional goals.

8. Closing the loop.

   As this assessment progressed Dr. Anderson made adjustments in his teaching, most notably allowing more instructional time for those topics the assessment results indicated students were struggling with, and pointing more frequently to the types of misunderstandings of former students, as noted in the weaknesses above, while still avoiding at all times a possible tendency to teach to the test. A discussion was held with the department on the results in Fall 2012 and a short discussion ensued as to what the faculty considered important learning outcomes for Math 206. It was also suggested that we could use a more comprehensive assessment across all sections of Math 206. This is one of the items included in our revised long range assessment plan.

Math 206 Assessment #2 of 3

1. Timeframe for the assessment.

   - Spring 2012.

2. Faculty involved.

   - Brian Wissman and Mitchell Anderson. (Shuguang Li was involved initially, but did not complete the assessment.)

3. Student Learning Outcomes Assessed

   - ILO's – Calculations, Analysis, and Critical Thinking (Quantitative Reasoning)

   - The following Math 206 CLO's

     - Identify appropriate methods of anti-differentiation (i.e. u-sub, parts, trig, trig sub) and be able to apply the methods
     - Compute radius and interval of convergence for power series

  - Compute and manipulate McLauren Series for sin, cos, exp
  - Compute [at least] the first few values for a Taylor Polynomial

4. Courses in which the assessment was administered.

   - Math 206

5. Audience (i.e. Math majors, NS majors, non-science majors), levels (i.e., freshmen/soph or junior/senior), and number of participants.

   - Students in these courses are typically freshmen or sophomore NS majors, with some juniors and seniors.

   - 65 students from three sections participated in this assessment, 26 from Mitchell's single section and the remainder from Brian's two sections.

6. Details of the Assessment

   - What type of assessment was administered (Direct or Indirect), and how was the data collected?

     This was a direct assessment in which 6 problems were embedded into two exams, 3 in the techniques of integration exam and 3 in the infinite series exam. (Note: the results for Mitchell's exams are also included in his multi-year assessment, with the difference being that Brian's results are included here as well, and Mitchell's first 3 multi-year problems as well as the ODE problem are omitted here.)

   - How was the assessment developed?

     Brian and Mitchell developed the problems long ago. These problems were either taken directly from those used in the multi-semester assessment #1 above, or were very similar, with essentially identical rubrics.

   - How was it analyzed? (e.g. What type of scoring rubric was developed, who developed it, and who did the scoring?)

     Brian and Mitchell developed the rubrics at the same time they identified the problems. They scored their results separately using the common rubric and combined the results.

7. Results and analysis.

	u-sub	Parts	Trig Sub	Interval of Convergence	Taylor Series	Taylor Series Coefficients
Possible Score	5	5	5	5	5	5
Sp 2012	.77	.84	.48	.59	.47	.51
ILO's	Analysis & Calculations	Analysis & Calculations	Analysis & Calculations	Analysis & Calculations	Analysis & Calculations	Analysis & Calculations
QR Translation	Competent	Advanced	Emerging	Competent	Emerging	Emerging

The results here indicate that students are struggling with Trig Sub and most aspects of infinite series.

8. Closing the loop.

The results of this assessment were presented at the same time as those for Math 206 assessment number one above. It was noted that one of the reasons the scores were a bit lower here was that some of the students did not even attempt some of the more difficult problems, such as trig sub, because the exam was a bit long. A discussion ensued as to how to ensure that if you embedded problems for assessment within an exam students would actually attempt it, resulting in a valid assessment of their capabilities for each problem. In the future this will be dealt with. Mitchell noted that he did not experience the same problem, making sure that time was not a critical issue for his exams.

Math 206 Assessment #3 of 3

1. Timeframe for the assessment.

   - Spring 2012.

2. Faculty involved.

   - Brian Wissman and Mitchell Anderson.

3. Student Learning Outcomes Assessed

   - ILO's – Computational, Analysis, Visual, and Critical Thinking (Quantitative Reasoning), and Organization and Structure (Communication)

- The following Math 206 CLO's

    - Understand and apply the Fundamental Theorem of Calculus
    - Use the definition of the Definite Integral to set up problem solving models
    - Understand and apply Integration as a process

- The following CLO's from the lab portion of Math 206

    - Determine when it is more appropriate to use technology for Math 206 level problems
    - Use technology to compute various approximations to a definite integral (e.g. Left(n), Right(n), and the best available approximation)
    - Use technology to compute a sequence of approximations to an applied definite integral problem, and make reasonable conclusions regarding convergence to the answer
    - Apply Euler's method and technology to create a sequence of approximations

4. Courses in which the assessment was administered.

    - Math 206

5. Audience (i.e. Math majors, NS majors, non-science majors), levels (i.e., freshmen/soph or junior/senior), and number of participants.

    - Students in these courses are typically freshmen or sophomore NS majors, with some juniors and seniors.

    - Approximately 27 students from three sections participated in this assessment, 15 from Mitchell's single section (about half his class) and the remainder from Brian's two sections.

6. Details of the Assessment

    - What type of assessment was administered (Direct or Indirect), and how was the data collected?

    This was a direct assessment consisting of a written group project. Mitchell has given two group projects for numerous years in his Math 206 course. Students typically work in groups of three, assigned by the instructor, and hand in a single written report for which they each receive the same grade. Mitchell has noted a marked decline in the quality of writing for his projects, which prompted this assessment.

Students in Dr. Anderson's class were provided, in addition to the group project, a document entitled Group Project Template[16] to assist them in understanding how the report should be written. Students were given a few weeks to work on the projects and each group turned in a single report, usually 2 – 3 pages in length. Students in Dr. Wissman's class worked on their projects individually.

- How was the assessment developed?

Brian and Shuguang developed the *Lead Balloon Analysis*[17] for their project and Mitchell used his usual *River Skipper*[18] group project. Brian and Mitchell met and discussed in detail the intent of the projects.

The purpose of this assessment was multifold.

i. To provide experience working collaboratively on larger endeavors.

ii. To further explore and understand integration as a process.

iii. To improve written communication skills.

- How was it analyzed? (e.g. What type of scoring rubric was developed, who developed it, and who did the scoring?)

A cross section of five of the total ten reports was selected from Mitchell's class, and a cross section of four reports was selected from Brian's class. Shuguang was not involved in this portion of the assessment. Brian and Mitchell decided to limit the number of reports to a cross section of each class to reduce the amount of work. However, they attempted to choose a representative cross section for both projects.

Brian and Mitchell met and after considerable discussion developed a scoring rubric prior to scoring the projects.[19] They agreed that these projects assessed both Quantitative Reasoning ILO's, including a more than usual level of Critical Thinking, and Communication ILO's. From the Quantitative Reasoning ILO's they identified both Analysis and Calculations. From the Communication ILO's they identified Organization and Structure, and Line of Reasoning. When they attempted to

[16] See Appendix – Math 206 River Skipper Template
[17] See Appendix – Math 206 Lead Balloon Analysis
[18] See Appendix – Math 206 River Skipper
[19] See Appendix – Math 206 Writing Project Rubric

distinguish which student learning outcomes to assess within each institutional goal it became clear that the Line of Reasoning outcome within Communications was directly tied to the Analysis outcome within Quantitative Reasoning. Students needed to identify the appropriate strategies to mathematically solve the problem, which falls within Analysis, and they needed to communicate them well enough for an outsider to understand, which falls within Line of Reasoning. Thus, they decided to first score Communication based on C1 – Professional Layout, C2 – Level of Prose, C3 – Communication of the Solution, and Quantitative Reasoning based on Q1 – Strategy, and Q2 – Results. They then averaged C1 and C2 (Organization and Structure), C3 and Q1 (Critical Thinking, Analysis, and Line of Reasoning).

After scoring each project individually they met again to compare results and discuss any minor discrepancies.

7. Results and analysis.

The philosophy guiding Dr. Anderson’s projects is that in today’s work environment fellow employees or colleagues often collaborate on large projects and must then present their results. Although Dr. Anderson has received many such reports over the years and has gone to great length to discuss in class the type of reports he expects, the reports he received this semester were unacceptable. He returned them to the students with instructions to re-do them. The poor quality of these “first drafts” prompted the assessment and prompted him to make more explicit his expectations by revising his Group Project Requirements and providing the students with the new version titled Group Project Template. The final drafts were much improved. In the table below A1, A2, etc. refer to group projects from Dr. Anderson’s class and W1, W2, etc. to those in Dr. Wissman’s class.

Math 206 Writing Project Results
Possible scores 1 - 4

Individual Reports	CI/C2	C3/Q1	Q2	Avg. Results
A1	4	3.75	4	Advanced
A2	3	2.5	2.5	Approaching Competent
A3	3.5	2.25	2.5	Approaching Competent
A4	2.75	2.25	3	Approaching Competent
A5	2.75	2	1.5	Emerging
W1	1.5	1.75	2	Emerging
W2	3	3.25	3	Competent
W3	3	2.25	2	Emerging
W4	1	1	1	Beginning
Institutional Goals Assessed	Organization & Structure	Reasoning & Analysis & Critical Thinking	Computations	

These writing projects are considerably more difficult than other work performed in the class, both in terms of the deeper level of critical thinking and understanding that is required and in terms of the need to communicate the solution in a manner conducive to the reader being able to understand the problem, the strategies for solving the problem, the steps utilized, and the results. For many students Math 206 is their last math class, and our last opportunity to contribute to their education and prepare them for the real world. As such our goal is for most students to demonstrate capabilities at the level of competent or above. While not every student reached this level, more than half reached an average level of Approaching Competency or better.

Weaknesses: The strategy for Mitchell's project, a non-standard integration problem, requires taking numerical approximations to time and distance traveled and then taking better and better approximations to simulate the convergence of a limit. In many instances students only utilize the first part of this strategy and omit the important second part. In other cases they state that "by the distance formula" something must be true, but it is not always clear if they are referring to the $d = rt$ formula or the distance between two points, both of which need to be used in different places for this problem. This particular weakness is a reflection of deficient communication skills, which show up throughout the students' writings. In other cases the entire strategy is wrong, in essence they missed the proverbial boat entirely, in which case their written explanations must necessarily be exceedingly poor as well. Two of the most common strategy mistakes are to try to find average velocity by averaging a bunch of velocities, and the second is to use horizontal distance in place of a linear approximation to distance traveled over a short x-interval. One of the more common communication weaknesses is to include whole paragraphs of irrelevant material, usually explaining how to find the distance the boat traveled. While this may be an interesting process, since they usually break up the river into small pieces and essentially apply the basis for the arc length theorem, which they could have alternatively used in any case, they never use this piece of information elsewhere in the problem.

Note: It should be noted that it is possible to answer this problem by setting up a definite integral, provided the velocity function used does not include a zero. Over the years only one group has ever achieved this, but it appeared at the time that it may have been by trial and error, or they simply tried to figure out a distance formula divided by velocity. The student who achieved this was pretty talented, so he may have understood what he did, but the justification was not very thorough.

In some cases the organization and structure of the writing was very poor. When the organization was adequate students still needed to overcome the challenge that it is very difficult to say just what is true and at just the right level of detail, and most of the students' papers reflected this difficulty at some level.

8. Closing the loop.

The results of this assessment were presented and discussed in a department meeting. The topic of student writing capabilities and weaknesses were discusses. As a result of this assessment Dr. Anderson implemented four short writing assignments into subsequent Math 206[20] classes and one in his Math 205[21]. He also developed a revised writing template for his group project that was more explicit and better guided the students in presenting a logically flowing and relevant report. The four short writing assignments used a very similar template and were intended to better prepare his students for the more detailed projects. He noted that the student writing improved notably from the first to the fourth, and these assignments helped students with their group projects as well, as the template and writing style became more familiar as the students progressed through the course.

[20] See Appendix – Math 206 Writing Assignments 1 – 4, Overview, and Rubric
[21] See Appendix – Math 205 Writing Assignment and Overview

Math 311 Assessment

1. Timeframe for the assessment.

   - Spring 2010 and Spring 2012.

2. Faculty involved.

   - Mitchell and Brian developed the problems and rubrics[22]. Mitchell conducted the assessments.

3. Student Learning Outcomes Assessed

   - ILO's – Calculations, Analysis, Visualization and Critical Thinking (Quantitative Reasoning)

   - The following Math 311 CLO's

     - Demonstrate an understanding of the structure of solutions to linear systems of equations. (eg. Given a single solution to AX = B, find and use the solutions to the homogeneous equation AX = 0 to find all solutions to AX = B.)
     - Apply the subspace theorem to show a subset under the inherited operations forms a vector space.
     - Show that a set of vectors in a vector space is linearly independent/dependent.
     - Find a basis for a [non-standard] vector space.
     - Compute the eigenpairs for a matrix.

   - The following Math Degree PLO's

     - Demonstrate mastery of the core material found in single and multi-variable Calculus and Linear Algebra.
     - Demonstrate mastery of the core concepts in Abstract Algebra and Real Analysis.
     - Identify, compare, and contrast the fundamental concepts within and across the major areas of mathematics, with particular emphasis on Linear Algebra, Abstract Algebra, and Real Analysis.
     - Use a variety of theorem-proving techniques to prove mathematical results.
     - Demonstrate the abilities to read and articulate mathematics verbally and in writing.

[22] See Appendix – Math 311 Problems and Rubrics.

4. Courses in which the assessment was administered.

   - Math 311

5. Audience (i.e. Math majors, NS majors, non-science majors), levels (i.e., freshmen/soph or junior/senior), and number of participants.

   - Students in these courses are typically Sophomore or Junior Math or Computer Science majors.

   - The Spring 2010 assessment involved 16 students and the Spring 2012 assessment involved between 7 and 13 students (this class had a very high drop rate, with surprisingly many students unprepared for the level of work).

6. Details of the Assessment

   - What type of assessment was administered (Direct or Indirect), and how was the data collected?

     This was a direct assessment in which 1 and 3 problems were embedded into three exams, for a total of 5 questions each semester. The problems used within the more comprehensive set of problems developed by Mitchell and Brian were System of Equations # 2, Vector Spaces #2, Linear Independence #2, Basis and Span #1, and Eigenvalues/Eigenvectors #1.

     These five problems are representative of the combination of skills and concepts students should be exposed to and learn in Math 311. Showing a set of vectors is linearly independent and finding eigenpairs are primarily computational problems that can be successfully completed without a deep understanding of the underlying concepts. On the other hand, finding all solutions to a non-homogeneous system, given only one solution and a row-equivalent representation of the coefficient matrix, requires students to understand the fundamental structure of solutions to linear systems as well as being able to perform rudimentary algebra. Similarly, proving a subset of vectors forms a vector space is for some students their first foray into theorem proving, and the specific problem used requires familiarity with the concepts of functions that can only be gained through practice from earlier classes. Finally, finding a basis, even for the simplest set of non standard vectors, requires a deep understanding of vectors, linear independence, and span, but no computations.

- How was the assessment developed?

  Brian and Mitchell developed the problems and rubrics.

- How was it analyzed? (e.g. What type of scoring rubric was developed, who developed it, and who did the scoring?)

  See scoring rubric. Mitchell scored the problems himself, based on the agreed upon rubric.

7. Results and analysis.

This assessment covered student learning outcomes within both Math Dept. Program Goals and Institutional Goals. As indicated by the department's Course Alignment Matrix, Linear Algebra crosses all program SLO's. Accordingly, each of the problems utilized within this assessment required students to demonstrate their understanding of at least one standard Linear Algebra Concept. Not surprisingly, this assessment also assessed learning outcomes found within the Quantitative Reasoning institutional goal, including critical thinking, analysis, and computation. The specific program and institutional learning outcomes addressed by each problem are included in the results table below. Critical thinking, while not listed in the institutional goals, is included in each and is not listed for convenience.

Results for the Math 311 Assessment

	Sys Eqns	Vec Spaces	Lin Ind	Bases/Span	Eigen
Possible Score	3	4	3	3	4
Spring 2010	1.89	3.88	2.81	2.39	3.25
Spring 2012	2.15	2.89	2.33	1.11	3.14
Avg %	.67	.85	.86	.58	.80
Program SLO's	1 & 3	1-5	1 & 3	1 & 3	1 & 3
Institutional Goals Assessed	Analysis & Calculations	Analysis	Analysis & Calculations	Analysis	Analysis & Calculations
Translation	Competent	Advanced	Advanced	Approaching Competence	Advanced

Again, with a multi-year assessment it would be nice to see improvement from year to year. However, in hindsight the Spring 2012 semester was perhaps not the best in which to conduct an assessment. It began with 16 students, ended with 13 registered but only 7 taking the final exam. It was the worse class in terms of sporadic attendance that

Mitchell has experienced in his long career. That said, a comparison of scores in such a small sample is perhaps not all that useful. On the other hand, the scores from Spring 2010 indicate the students had a very good grasp of the material and except for the first problem consistently reached levels that we could describe as competent or advanced. It appears that the students in that class improved dramatically after their first exam, which Mitchell has found typical for Math 311.

Weaknesses: As long as the students have a good understanding of the basic concepts, each of the problems used is very straightforward.

Systems of Equations – The system of equations problem requires students to identify the solution space to a homogeneous system, given by a reduced 3 x 3 matrix, and to combine those results with one solution to an associated non-homogeneous system. Most of the mistakes on this problem result from not understanding the fundamental structure of such systems, not from computational mistakes.

Vector Spaces – This problem requires students to show that the subset of P_3 with roots at 1 and 2 forms a subspace. The biggest weakness for this problem is not knowing that in order to check closure of addition you need to check whether the sum of two such functions still has roots at 1 and 2. This is a weakness in being able to read mathematics. Students also frequently simply write down necessary results with no work shown, in essence hard wiring the work to indicate it has closure because it has closure. They fail to see, for example, the significance of the difference between addition in P_3 and addition in the real numbers, each playing a role in this problem.

Linear Independence – This problem is highly computational and really only requires one to take the determinant of a 3 x 3 real matrix and check to see if the result is zero or not. The only obvious weakness for this problem, apart from not being careful with the computations, is not realizing that the determinant is all that is required.

Bases and Span – This problem requires no computation; it only requires students to list a basis for a subspace of M_3. For a mathematician this is a trivial problem, and as long as the student understands a couple of key concepts, that is still the case. However, students tend to make very serious mistakes on this problem. The biggest mistake, and the most common, is to give as their answer a single or set of vectors that do not even lie in M_3. This indicates a severe misunderstanding of the underlying concepts. Mitchell has noted to the students that this is the biggest mistake past students have made, and provides numerous examples. Nevertheless, many students continue to make this critical error.

Eigenvalues and Eigenvectors – This problem simply requires students to identify eigenpairs for a 2 x 2 matrix. It is highly computational, but has numerous steps. There does not appear to be any serious misunderstandings associated with this problem. That is not to say that students do not find ways to make critical errors. One aspect that is worrisome is that students do not seem to check their answers, which seems to indicate they do not really understand the concept of Eigenvectors and Eigenvalues.

8. Closing the loop.

   These results were presented at a Fall 2012 department meeting and a short discussion ensued. Due to time constraints and the limited nature of the discussion, alternatively faculty members were encouraged to pay particular attention to the weaknesses that were identified and noted in the assessment report and to adjust their teaching accordingly. However, until there is increased participation in assessment, with increased discussion of the results, it is unlikely that this assessment will benefit their teaching. It is the hope of those that have been more fully involved that once the department begins following the assessment plan, with two assessments presented each year, ample time will be allotted for discussion and faculty members will become more engaged in the continuous improvement process.

Math 431 Assessment

1. Timeframe for the assessment.

   Fall 2010 - Spring 2011.

2. Faculty involved.

   - Mitchell Anderson developed the problems and was the instructor. Mitchell, Brian Wissman, Efren Ruiz, and Roberto Pelayo developed the rubrics[23]. Mitchell conducted the assessments, and the team did the scoring.

3. Student Learning Outcomes Assessed

   - ILO's – Calculations, Analysis, Visualization and Critical Thinking (Quantitative Reasoning)

   - The following Math 431 CLO's[24]

[23] See Appendix – Math 431-432 Assessment Problems and Rubrics. Also see Appendix – Math 431-432 Full Problem Set for a complete list of the problems presented in the course.
[24] See Appendix – Math 431-432 Course Outline

- Demonstrate an understanding of the basic theorems and their implications regarding the topology of the line (and Euclidean n-space if they take 432), sequences and subsequences, compactness, denseness, convergence, continuity, differentiability, the definite integral, cardinality, and metric spaces.
- Utilize a variety of standard theorem proving techniques to construct valid proofs, presented in a logically correct order (e.g. defining variables before using them).
- Construct counter-examples to false statements, and when feasible conjecture hypothesis that would make the statements true.

➢ The following Math Degree PLO's

- Demonstrate mastery of the core material found in single and multi-variable Calculus and Linear Algebra.
- Demonstrate mastery of the core concepts in Abstract Algebra and Real Analysis.
- Identify, compare, and contrast the fundamental concepts within and across the major areas of mathematics, with particular emphasis on Linear Algebra, Abstract Algebra, and Real Analysis.
- Use a variety of theorem-proving techniques to prove mathematical results.
- Demonstrate the abilities to read and articulate mathematics verbally and in writing.

4. Courses in which the assessment was administered.

➢ Math 431-432

5. Audience (i.e. Math majors, NS majors, non-science majors), levels (i.e., freshmen/soph or junior/senior), and number of participants.

➢ Students in these courses are typically Junior or Senior Math majors.

➢ The Fall 2010 class has 16 students and the Spring 2011 class had 14 students.

6. Details of the Assessment

➢ What type of assessment was administered (Direct or Indirect), and how was the data collected?

This was a direct assessment in which Mitchell gathered a portfolio of 21 proofs presented in class. In this course students were provided definitions and statements that may or may not have been true. Students were required, without the benefit of lecture, discussion, or textbook to identify if a statement was true or false, and in the case it was false to provide a counterexample and perhaps a change of hypothesis to make it true, and in the case it was true to provide a proof. Students then orally presented their results in class. For this academic year Dr. Anderson asked some students to provide him with an electronic copy of their presentations once the class felt they were valid. Dr. Anderson compiled those results into a class portfolio[25], including 21 proofs, removed the names, and the four department members scored them based on their common rubrics. They then assembled to discuss their scores and any discrepancies.

Since most of the work had been validated by the rest of the class, most of the portfolio is free from error and hence does not offer the range of results found in other assessments. Nevertheless, it does demonstrate that ILO's, PLO's and CLO's are being met at an advanced level. The 21 proofs ranged from theorems involving the existence of limit points and limits of sequences, to proving that continuous functions over a compact set are uniformly continuous, Cauchy sequences converge, every point in the Cantor set is a limit point of the Cantor set, which is also of measure zero, and integrability existence theorems.

Note: Math 431 – 432 is one of the most difficult course sequences offered by the department, and when offered in this format provides students an unparalleled opportunity for intellectual growth. Since all of the proofs were "accepted" through a peer reviewed presentation process it was expected that most of the scores would be high. This type of assessment appears to be appropriate for this type of class if one wants to assess the level of achievement *possible* by the class as a whole, particularly in terms of providing students the necessary preparation for graduate school. That being said, in Mitchell's opinion this particular class did not stand out as exceptional in terms of the quantity and quality of the proofs presented.

- How was it analyzed? (e.g. What type of scoring rubric was developed, who developed it, and who did the scoring?)

Mitchell, Bob, Brian, and Efren developed the rubrics. Mitchell removed the names from each proof, made copies, and passed them along to the team. Each team member then scored a sample of five of the proofs individually, based on the rubric, and then the team met to discuss the results.

[25] See Appendix – Math 431 Portfolio

7. Results and analysis.

   Overall it was agreed that the level of work demonstrated that the class offered the appropriate level of work in order to meet the PLO numbers 2, 4, and 5. Outcome 2 requires mastery of the core concepts of Abstract Algebra and Analysis. Outcome 3 requires students to use a variety of theorem proving techniques. Outcome 4 requires students to demonstrate the abilities to read and articulate mathematics verbally and in writing. The five theorems the team evaluated included the intermediate value theorem, the convergence of Cauchy sequences, countable number set have measure zero, and the property of bounded variation for non-decreasing functions. Some of the comments the team made dealt with questioning whether or not standard notation was followed for the students (it was), in particular when defining sequences, requirements to include every detail within a proof, and whether or not students were covering every case when more than one case held (e.g. the set in question was finite or infinite).

   The team did not find any deficiencies it felt needed addressing, noting that the work indicates a proper level for preparing students for graduate level mathematics. It did however suggest that it would be nice to conduct a more thorough assessment in the future, one that tracked individual student performance and improvement from the beginning of the class to the end, to show value added. The department's assessment plan has a spot designated for something involving outcomes 2 – 5, which might address this well.

8. Closing the loop.

   The results were discussed at a full department meeting. The department echoed the views of the assessment team and agreed that a future more comprehensive assessment might provide valuable information on a more refined level.