Central Washington University  
Assessment of Student Learning  
Department and Program Report

Please enter the appropriate information concerning your student learning assessment activities for this year.

Academic Year of Report: 2014/2015  
College: COTS  
Department: Mathematics  
Program: BS, Mathematics

1. What student learning outcomes were assessed this year, and why?
In answering this question, please identify the specific student learning outcomes you assessed this year, reasons for assessing these outcomes, with the outcomes written in clear, measurable terms, and note how the outcomes are linked to department, college and university mission and goals.

Outcome 3 of Student Learning Outcomes (attached) was assessed, in agreement with the schedule. Outcome 3 is important because proof writing is an essential aspect of mathematics and this has been a problem for us in the past (see the 2008 report). In addition, we have overhauled the BS program in mathematics in response to departmental discussions. In those discussions, a common theme is the difficulty students have in adjusting to 400 level proof based classes, especially when their only prior exposure to proof was in Math 260. As a result, we have adjusted the program to ensure that all majors have at least two proof based 300 level classes in the year before their senior year.

2. How were they assessed?
In answering these questions, please concisely describe the specific methods used in assessing student learning. Please also specify the population assessed, when the assessment took place, and the standard of mastery (criterion) against which you will compare your assessment results. If appropriate, please list survey or questionnaire response rate from total population.

A) What methods were used?

We looked at student compiled portfolios to better understand student mastery at the conclusion of the student’s final year. The data consisted of portfolios of proofs assembled by students in the math major who graduated in spring of 2015. Each individual portfolio consists of five proofs, one for each major type of proof that arises in mathematics. Each proof was assessed using an appropriate rubric (attached).

B) Who was assessed?

Students in the Senior Seminar (Math 499S) offered in winter quarter of 2015 were assessed. This group of students consisted almost entirely of students who were graduating at the end of spring quarter 2015. A few of these students did not pass the course, and returned to repeat the course the following year.

C) When was it assessed?


3. What was learned?
In answering this question, please report results in specific qualitative or quantitative terms, with the results linked to the outcomes you assessed, and compared to the standard of mastery (criterion) you noted above. Please also include a concise interpretation or analysis of the results.

95% of the proofs met the satisfactory criterion according to the rubric. This suggests that students can produce isolated proofs in order to fulfill the requirements of MATH 499S. However, previous assessment suggested that proof writing remains problematic.

According to instructors of the senior sequences, many students struggle to produce a proof independently. Thus, instead of concentrating on content, the instructors of the senior sequences devote the first quarter to the mechanics of proof writing. In addition, the students find that the formal requirements for the Senior Sequences (MATH 260) fails to adequately prepare them for the expectations in these courses. As a result, we have overhauled the BS math majors, requiring more proof based classes prior to the senior sequences. The first students to graduate under the new program will graduate in the spring of 2017.

4. What will the department or program do as a result of that information?
In answering this question, please note specific changes to your program as they affect student learning, and as they are related to results from the assessment process. If no changes are planned, please describe why no changes are needed. In addition, how will the department report the results and changes to internal and external constituents (e.g., advisory groups, newsletters, forums, etc.).

Because the assessment information indicated that the majority of students could find correct proofs from their senior sequences in order to compile a portfolio even though instructors of the Senior Sequences had tremendous difficulty with student proof-writing, the department needs to discuss better methods for assessing proof-writing in the major.

5. What did the department or program do in response to last year’s assessment information?
In answering this question, please describe any changes that have been made to improve student learning based on previous assessment results. Please also discuss any changes you have made to your assessment plan or assessment methods.

As mentioned, we have changed the BS math majors to require more proof classes prior to the senior sequences. We intend to compare the results of this year’s assessment to future assessments to see if there is an improvement in students proof writing skills.

6. Questions or suggestions concerning Assessment of Student Learning at Central Washington University:
<table>
<thead>
<tr>
<th>Student Learning Outcome (performance, knowledge, attitudes)</th>
<th>Related CWU Strategic Outcome(s)</th>
<th>Method(s) of Assessment (What is the assessment?)*</th>
<th>Who Assessed (Students from what courses - population)**</th>
<th>When Assessed (term, dates)***</th>
<th>Standard of Mastery/ Criterion of A performance has</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Graduates will be able to use differential and integral calculus as well as sequences and series to solve problems.</td>
<td>1.1.1 Students will achieve programmatic learning outcomes.</td>
<td>Standardized question</td>
<td>Math 376 or 377</td>
<td>Winter/Spring</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>2. Graduates will be able to use concepts of vector subspaces of $\mathbb{R}^n$ and $\mathbb{R}^{n \times m}$ to solve problems.</td>
<td>1.1.1 Students will achieve programmatic learning outcomes.</td>
<td>Standardized question</td>
<td>Math 376 or 377</td>
<td>Winter/Spring</td>
<td>Yes/No</td>
<td></td>
</tr>
<tr>
<td>3. Graduates will be to write proofs using contrapositive, contradiction, cases, and mathematical induction.</td>
<td>1.1.1 Students will achieve programmatic learning outcomes.</td>
<td>499S Portfolio</td>
<td>Students in MATH 499S</td>
<td>Winter</td>
<td>Portfolio Criterion</td>
<td></td>
</tr>
<tr>
<td>4. Graduates will know standard applications of calculus, linear algebra, and statistics.</td>
<td>1.1.1 Students will achieve programmatic learning outcomes.</td>
<td>499S Portfolio</td>
<td>Students in MATH 499S</td>
<td>Winter</td>
<td>Portfolio Criterion</td>
<td></td>
</tr>
<tr>
<td>5. Graduates will be able to apply their understanding of mathematics to fields outside of mathematics.</td>
<td>1.1.1 Students will achieve programmatic learning outcomes.</td>
<td>499S Portfolio</td>
<td>Students in MATH 499S</td>
<td>Winter</td>
<td>Portfolio Criterion</td>
<td></td>
</tr>
<tr>
<td>6. Graduates will be able to describe the differences between the following types of mathematics: discrete/continuous, algebraic/geometric, pure/applied, deterministic/stochastic.</td>
<td>1.1.1 Students will achieve programmatic learning outcomes.</td>
<td>499S Portfolio</td>
<td>Students in MATH 499S</td>
<td>Winter</td>
<td>Portfolio Criterion</td>
<td></td>
</tr>
</tbody>
</table>
Many Student Learning Outcomes for this program are assessed through Portfolios.

For Standardized question based assessment, the Criterion of Achievement is “75% of students achieve a rating of Exemplary or Proficient” referred to as “Standardized question” in the table below.

For all Portfolio based assessment, the Criterion of Achievement is “75% of applicable Portfolio artifacts achieve a rating of Exemplary or Proficient” referred to as “Portfolio Criterion” in the table below.

*Method(s) of assessment should include those that are both direct (tests, essays, presentations, projects) and indirect (surveys, interviews) in nature

**Data needs to be collected and differentiated by location (Ellensburg campus vs University Centers) and modality (face-to-face, online)

***Timing of assessment should ideally be at different transition points of program (i.e., admission, mid-point, end-of-program, post-program)

rev. 11/14

### Assessment Cycle

<table>
<thead>
<tr>
<th>Analysis and Interpretation:</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement Actions:</td>
<td>Completed by June</td>
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<tr>
<td>Dissemination:</td>
<td>Completed by June</td>
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<table>
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<tr>
<th>Year SLOs</th>
<th>15-16</th>
<th>16-17</th>
<th>17-18</th>
<th>18-19</th>
<th>19-20</th>
<th>20-21</th>
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### Assessment Oversight

<table>
<thead>
<tr>
<th>Name</th>
<th>Department Affiliation</th>
<th>Email Address</th>
<th>Phone Number</th>
</tr>
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Rubric 2a: Direct Proof

<table>
<thead>
<tr>
<th>Arguments</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>correct and complete</td>
<td>5</td>
</tr>
<tr>
<td>one minor error, omission or inappropriate inclusion</td>
<td>4</td>
</tr>
<tr>
<td>two minor errors, omissions, or inappropriate inclusions</td>
<td>2</td>
</tr>
<tr>
<td>multiple minor errors or a single major error</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Terminology and Notation</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>all technical terms, concepts, and notations are used correctly</td>
<td>3</td>
</tr>
<tr>
<td>arguments have one lapse in terminology or concepts</td>
<td>2</td>
</tr>
<tr>
<td>there are minor problems in terminology or concepts</td>
<td>1</td>
</tr>
<tr>
<td>there are major problems in terminology or concepts</td>
<td>0</td>
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<table>
<thead>
<tr>
<th>Written Presentation</th>
<th>Score</th>
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</thead>
<tbody>
<tr>
<td>all written guidelines followed</td>
<td>2</td>
</tr>
<tr>
<td>follows almost all of the guidelines with one or two lapses</td>
<td>1</td>
</tr>
<tr>
<td>has more than two lapses</td>
<td>0</td>
</tr>
</tbody>
</table>

**Overall Score**

Satisfactory Score: 8

**Specific Criteria**

n/a
Rubric 2b: Proof by Contrapositive

Arguments
- correct and complete: 5
- one minor error, omission or inappropriate inclusion: 4
- two minor errors, omissions, or inappropriate inclusions: 2
- multiple minor errors or a single major error: 0

Terminology and Notation
- all technical terms, concepts, and notations are used correctly: 3
- arguments have one lapse in terminology or concepts: 2
- there are minor problems in terminology or concepts: 1
- there are major problems in terminology or concepts: 0

Written Presentation
- all written guidelines followed: 2
- follows almost all of the guidelines with one or two lapses: 1
- has more than two lapses: 0

**Overall Score**

Satisfactory Score: 8

Specific Criteria
- proof by contrapositive appropriate technique
- correct conversion to contrapositive
Rubric 2c: Proof by Contradiction

Arguments
- correct and complete: 5
- one minor error, omission or inappropriate inclusion: 4
- two minor errors, omissions, or inappropriate inclusions: 2
- multiple minor errors or a single major error: 0

Terminology and Notation
- all technical terms, concepts, and notations are used correctly: 3
- arguments have one lapse in terminology or concepts: 2
- there are minor problems in terminology or concepts: 1
- there are major problems in terminology or concepts: 0

Written Presentation
- all written guidelines followed: 2
- follows almost all of the guidelines with one or two lapses: 1
- has more than two lapses: 0

**Overall Score**
- Satisfactory Score: 8

Specific Criteria
- technique is appropriate
- correct assumptions
Rubric 2d: Proof by Mathematical Induction

Arguments
- correct and complete 5
- one minor error, omission or inappropriate inclusion 4
- two minor errors, omissions, or inappropriate inclusions 2
- multiple minor errors or a single major error 0

Terminology and Notation
- all technical terms, concepts, and notations are used correctly 3
- arguments have one lapse in terminology or concepts 2
- there are minor problems in terminology or concepts 1
- there are major problems in terminology or concepts 0

Written Presentation
- all written guidelines followed 2
- follows almost all of the guidelines with one or two lapses 1
- has more than two lapses 0

**Overall Score**
- Satisfactory Score 8

Specific Criteria
- appropriate technique
- correct base case
- correct inductive hypothesis
Rubric 2e: Proof by Cases

Arguments
  correct and complete 5
  one minor error, omission or inappropriate inclusion 4
  two minor errors, omissions, or inappropriate inclusions 2
  multiple minor errors or a single major error 0

Terminology and Notation
  all technical terms, concepts, and notations are used correctly 3
  arguments have one lapse in terminology or concepts 2
  there are minor problems in terminology or concepts 1
  there are major problems in terminology or concepts 0

Written Presentation
  all written guidelines followed 2
  follows almost all of the guidelines with one or two lapses 1
  has more than two lapses 0

**Overall Score**
  Satisfactory Score 8

Specific Criteria
  cases are exhaustive