

# 2010 Annual Assessment Update

## Mathematics Program

October 13, 2010

### I. Mission Statement and Student Learning Outcomes

#### A. Mission Statement

Our mission is to provide a program of study in mathematics and to assist students in their general intellectual, moral, and spiritual growth as Christian thinkers. We want students to:

- acquire mathematical knowledge and analytical ways of thinking,
- develop the ability to communicate mathematical ideas,
- mature as creative mathematicians and problem solvers, and
- ponder the connections between faith and mathematics.

Ultimately, we seek to serve others and glorify Jesus Christ by preparing scientists, teachers, scholars, and other professionals to use their mathematical gifts with competence and charity.

#### B. Student Learning Outcomes

1. **Core Knowledge.** Demonstrate knowledge of the main concepts, skills, and facts of the discipline.
2. **Communication.** Be able to communicate ideas from the discipline following the standard conventions of writing or speaking in the discipline.

3. **Creativity.** Demonstrate ability to formulate and attack a novel problem.
4. **Christian Connection.** Know how to incorporate their discipline-specific skills and knowledge into their thinking about their vocations as followers of Christ.

These learning outcomes have been in place since September, 2007.

### C. Alignment Table

The alignment table in Appendix A. was last revised in May, 2010.

## II. Follow up on Action Items identified in previous reports

The [response of the Program Review Committee](#) to last year's annual update is included in Appendix B.

### A. Action items

The following action items were suggested in the [PRC response](#).

1. Improve scoring reliability when applying writing sample rubrics.
2. Clarify goals for 2010–11 and refine six-year plan.
3. Add greater specificity to reporting the process of departmental decision making (e.g., curricular changes, updating rubrics).
4. Follow up on the effectiveness of curricular changes.

### B. Update on progress

1. This year we adopted a consensus scoring system for applying rubrics to the writing samples. If two reviewers scored the same paper differently, the two reviewers would discuss the discrepancy and agree on a single score for the paper. We found that one reviewer would often notice a detail that the other missed, and that consensus was easy to reach after a brief discussion.

2. At our 9/10/2010 department meeting, we discussed narrowing the focus for assessment in 2010–11. We decided to focus on either Core Knowledge or Communication. At our 10/8/2010 department meeting, we decided to focus on Communication, as we are still waiting for MFT subscore data.
3. We are working to create a culture of data-driven decision making. We have been keeping data on Google Docs and on the shared network drive so that all department members can access the data and make updates.
4. We need to discuss how the recent curricular changes (MA-015 in the major, MA-008, new calculus text) are working. We need to find sources of data to help our discussion.

### C. Additional Issues

This year we plan to discuss the role of our capstone courses in the major. For more details, see the section on [assessing the Christian Connection outcome](#).

## III. 2010 Focus

### A. Assessment of the Learning Outcomes

Learning outcomes and benchmarks are summarized in Table 3 in Subsection D. Data is stored in the mathematics shared drive on the `myfiles` Samba server.

#### Core Knowledge

The department administered the ETS's [Major Field Test in mathematics](#) (external link) to all graduating seniors. The results for 2010 are as follows:

Student ID	Date Taken	Score	%ile
<i>X</i>	4/20/2010	166	$\geq 70$
<i>Y</i>	4/16/2010	164	$\geq 65$
<i>Z</i>	4/13/2010	140	$\geq 15$

Table 1: ETS Major Field Test in Mathematics results, 2009.

These data are available on the ETS website (password required), along with data from previous years.

The department met in May 2010 to discuss these results. The Educational Testing Service will calculate subscore data for a cohort of size five or greater. However, we have decided to wait another year to request this data in order to provide a more representative sample. Subscore data will tell us more than raw score data, because it will indicate areas in which students are doing well and areas which need improvement.

In addition to the MFT, some of our students take the CSET exam. The following table shows the mathematics subject scores for the past five years (maximum score = 4).

CSET Subject Scores						
	04–05	05–06	06–07	07–08	08–09	09–10
Mathematics	4.0	3.875	4.0	4.0	4.0	3.8

Table 2: CSET Subject Scores: Mathematics, 2004–2010.

## Communication

Writing samples were collected in MA-110 (Spring 2010), an upper-division writing-intensive course within the major. Two sets of problems—one from early in the semester and one from late in the term—were graded using the department’s rubric. Multiple graders viewed each problem, and scores were agreed upon after a consensus was reached. The department met together in May 2010 to collectively grade the papers, discuss the rubric, and interpret the results. Results are summarized in Figure 1; prompts and rubrics are in Appendices C and D, respectively. Scanned data is on the program review shared directory.

	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B
I. Formatting	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3
II. Symbols	3	3	3	3	3	2	1	2	2	2	2	3	3	2	1	2	3	3
III. Typesetting																		
IV. Logic	3	3	3	2	2	3	1	3	1	1	2	3	1	1	1	2	3	3
V. Exposition	3	3	3	2	2	2	1	2	2	2	2	2	2	1	2	2	3	3

Figure 1: Tabulation of writing sample assessment data, 5/14/2010. Paired sample data: item  $nA$  is student  $n$ ’s paper from early in the semester, while item  $nB$  is student  $n$ ’s paper from late in the semester.

## Creativity

Results from Problem Solving (MA-180) are tabulated in Figure 2.

Student	Journal	Prob. Number	Solved	Submitted	Acknowledged
Fall 2009					
Brad Pearson	Math Mag.	1830	X	X	
Daniel Mathis	Math Horizons	235	X	X	X
William Hodge	Math Mag.	1824	X	X	
David Montgomery	Math Horizons	234	X	X	X
David Montgomery	Math Monthly	11449			
Sabrina Dangc	Math Monthly	11435	X	X	
Phil Davis	Math Mag.	1821			
Phil Davis	Math Mag.	1822			
Steve Bergen	Math Mag.	1822			
Aaron Panchal	Math Mag.	1821	X	X	
Spring 2010					
Kent Stormans	Math Horizons	244	X		
Kent Stormans	Math Monthly	11480			
Phil Davis	Math Monthly	11480			
Kaitlin Bagby	Math Monthly	11470			
Rebecca Akaka	Math Horizons	239	X		
Steve Bergen	Math Horizons	238	X		
Sabrina Dangc	Math Horizons	233	X	X	X

Figure 2: Data from MA-180, Problem Solving, 2009–2010.

In Fall 2009, four students had nonzero scores on the Putnam exam. The department met in May 2010 to discuss the performance of students in MA-180.

## Christian Connection

Papers reflecting on the connections between faith and mathematics were collected in MA-140 (Spring 2010), an upper-division capstone course within the major. These papers were graded using the department's rubric. The department met together in May 2010 to collectively grade the papers, discuss the rubric, and interpret the results.

We graded a sample of papers, with each faculty member grading two papers, and each sampled paper being graded by two faculty members. We assigned scores of 1 (lacking), 2 (adequate), or 3 (superior), and the five scores for each category (connections and perspective) were finalized after consensus between the two graders was

reached. Results are summarized in Figure 3; prompts and rubrics are in Appendices C and D, respectively. Scanned data is on the program review shared directory.

	A	B	C	D	E
Substantive Connections	2	2	2	3	2
Mature Perspective	2	2	2	3	2

Figure 3: Tabulation of reflective paper assessment data, 5/14/2010.

## B. Interpretation of the Results

### Core Knowledge

Both MFT and CSET scores continue to be satisfactory.

We continue to have concerns about the reliability and usefulness of the MFT. We decided to wait another year before requesting subscore data (and closing the current cohort). Once we have subscore data, we will be able to decide whether the MFT is worth the expense and effort.

We discussed making the MFT part of a senior capstone seminar, in which we review key topics in the curriculum in a framework that allows us to discuss integrative issues. We will discuss this idea in Fall 2010.

### Communication

We found that collectively grading and discussing writing samples helps us assess student learning and also helps us refine our expectations for written student work. In order to measure progress through the semester, we used paired samples of student work: we scored papers from early and late in the semester for each student sampled. We noticed that students indeed make progress in their ability to write mathematics.

In future, it will be important to collect samples that require students to write more prose, as opposed to calculational problems with lots of symbol manipulation. One major lurking variable that is hard to control is the disparity in preparation among the students. We found that writing can be good, despite logical flaws.

We thought it might be useful to collect samples in MA-180 and critique them in the writing intensive courses (108/110), or *vice versa*.

## **Creativity**

We continue to be satisfied with the results of work in MA-180, more so with the Fall 2009 group than the Spring 2010 group. This year students gave oral presentations of their problems. These were spotty; perhaps more coaching is needed.

## **Christian Connection**

This learning standard continues to be the most difficult to assess, though it probably corresponds to the loftiest goal we have for our students.

Last year, we suggested giving a more detailed prompt for this paper. This year, we found that the very detailed prompt had the effect of directing the students' responses excessively. Perhaps the prompt should invite students to form their own metaphors, so the papers will be less homogeneous.

We agreed that the final exam is a good vehicle for this paper, though there might be benefits to assigning such a paper in the middle of the term to leave room for discussion. This paper could also be part of a possible capstone senior seminar.

## **C. Response**

In summary, the department plans to do the following in response to this year's assessment discussion.

- Request MFT subscore data after the 2011 class takes the exam. Interpret results, and decide whether to continue with the MFT.
- Explore the possibility of a 2-unit capstone course for seniors in the major. This may help address and assess the Christian Connection and Core Knowledge learning outcomes.
- Collect paired writing samples that include mathematical prose.

## **D. Learning Outcome Matrix**

Table 3 gives a brief overview of our learning outcomes, our assessment strategies, and the relationship to the college-wide outcomes and the departmental curriculum.

Learning Outcome Matrix: Major in Mathematics				
Student Learning Outcomes	Core Knowledge	Communication	Creativity	Christian Connection
Meaning	Demonstrate knowledge of the main concepts, skills, and facts of the discipline.	Be able to communicate ideas from the discipline following the standard conventions of writing or speaking in the discipline.	Demonstrate ability to formulate and attack a novel problem.	Know how to incorporate their discipline-specific skills and knowledge into their thinking about their vocations as followers of Christ.
Introduced	MA 4, 5, 9*, 10*	MA 4, 5, 9*, 10*	MA 4, 5, 9*, 10*, 15*, 19*, 20*, 160, 165	MA 4, 5, 9*, 10*, 15*, 19*, 20*, 160, 165
Developed	MA 15*, 19*, 20*, 121, 160, 165	MA 15*, 19*, 20*, 160, 165, 123, 130, 135, 136, 140, 155	MA 108*, 109, 110*, 111, 123, 130, 135, 136, 140, 155	MA 108*, 109, 110*, 111, 121, 123, 130, 135, 136, 140, 155
Mastered	MA 108*, 109, 110*, 111, 123, 130, 135, 136, 140, 155	MA 108*, 109, 110*, 111	MA 180*	MA 136, 140, 155, 190SS, 191SS
Assessment strategy	Major Field Test in Mathematics	Writing samples scored with rubric	Externally reviewed journal problems	Reflective paper scored with rubric
Benchmark	50% above 75th percentile	75% show improvement during term	50% get correct solutions according to journal	50% Superior
Links to learning standards	Critical-Interdisciplinary Thinking, Active Societal and Intellectual Engagement (Effective Participants)	Written and Oral Communication, Research and Technology	Critical-Interdisciplinary Thinking, Active Societal and Intellectual Engagement (Lifelong Learning, Responsibility)	Christian Orientation, Diversity, Active Societal and Intellectual Engagement (Christian Vocation)

Notes: \* = required for major. At least one of 136, 140, and 155 is required for the major.

Table 3: Learning outcome matrix.

## IV. Next Steps

### A. Action Items

The following is a summary of currently active initiatives.

- Explore the possibility of a senior capstone course. The department chair will put this on the agendas for department meetings in Fall 2010.
- Decide whether to continue giving the MFT. The department will address this issue during our assessment meetings in Summer 2011. We will request subscore data after the 2011 graduates complete the MFT.
- Follow up on recent curricular changes: new calculus text, inclusion of MA-015 in the major, reinstatement of MA-008. The department chair will put these items on the agenda for department meetings in Spring 2011.



## B. Multi-Year Assessment Plan

Table 4 in Appendix E gives a plan for assessment and program review over the next six years. Our next six-year report is due in the fall of 2014. We will continue to collect assessment data each year via the following annual tasks. The department chair has the responsibility of making sure these tasks are accomplished.

1. Administer the Major Field Test to every graduating senior in the spring. Meet to interpret results.
2. Collect mathematical writing samples from MA 108 (Spring, Odd years) or MA 110 (Spring, even years). Apply writing rubric to these samples. Interpret results.
3. Collect data each semester of the number of solutions submitted and published by students in MA 180. Meet to interpret results.
4. Collect a reflective paper or writing sample in MA 136 (Fall, odd years), MA 140 (Spring, even years), and MA 155 (Fall, even years). Apply reflective writing rubric to these samples. Interpret results.
5. Devote two meetings to informal discussions of the Communication and Creativity learning standards in the context of introductory and developmental courses.
6. Monitor course evaluations in introductory and developmental courses for evidence that the Christian Connection learning standard is being addressed.

In addition to these annual tasks, the department plans to address several additional topics over the next six years. A plan for these discussions is given Table 4.



## B. PRC Response to 2009 Report

To: David Hunter  
Chair, Mathematics and Computer Science Department

From: Bill Wright, Associate Provost  
for the Program Review Committee

Re: Response to the Annual Assessment and Program Review Report for Mathematics dated September 15, 2009

The Program Review Committee wants to thank the department for the preparation of the 2009 annual report and all of the departmental work it represents. It was particularly helpful that the department developed the report conforming closely to the annual report template. I appreciated the department faculty's willingness to meet with me to discuss the report and progress being made through the program review process. We had a productive discussion on November 9, 2009 while you and Patti were in Mexico leading the WIM program.

### **General Observations**

The department is to be commended for developing scoring rubrics for assessing several student learning outcomes and using multiple scorers on several assignments. It would have been interesting if you had reported what you learned about inter-rater reliability and if you did find differences between scorers, what steps were taken to improve scoring reliability.

Several times in the report you described program changes you were making as a result of what you were learning about student performance (ex. change in Calculus text book; adding MA 15 to the curriculum). The department appears to be making these changes as a result of perceived deficiencies. It was not clear by what process you had determined these changes were needed.

The September 2009 report summarizes the results of the department's focus on several goals for 2008-09 as outlined in your 6-year report time-line for future activity (lower division major requirements; review of the creativity learning standard). Admissions and recruitment of students and a graduate school content survey had also been stated goals for 2008-09 but there was no mention of these in the report. It would have been appropriate to mention why these were deferred and if they were still priorities that would be considered at a future time.

Your reference to multiple department meetings to discuss the meaning of data is great. You also mention conclusions drawn and action taken. Providing additional information in the report would have been helpful to understand why exactly you reached the conclusions you did and how you decided what specific changes to make.

**A Few Specific Remarks**

Figure 1 and 2 summarize data generated from departmental rubrics. Without having the rubric in hand, the reader is limited in understanding the meaning of the data. Adding copies of the rubrics as an appendix would solve this problem.

Again with Figures 1 and 2, it was not immediately clear that the columns represented individual students or that Figure 1 represented the repeated measure of individual students. A little more information labeling the Figures would greatly assist the reader.

Professor Leech should be persuaded to contribute requested information to the department's program review efforts in the future (p.11).

Twice it was mentioned that the rubrics were modified (pp 5 & 6). Improving the rubrics as needed is good but it would be informative to know what shortcoming in the rubrics had been detected and how the rubrics were actually altered.

**Conclusions**

The mathematics faculty have developed a clear mission statement and developed student learning objectives which correspond well with the department's mission. The September 2009 report summarizes valuable assessment work measuring student performance in several of these outcome areas. It appears the faculty are using the results to make modifications in the mathematics program. The department will want to do follow-up work in the future to assess the effectiveness of the changes made in producing the desired result. As referenced several times in this memo, future reports can be improved by adding a more information for the readers benefit.

The mathematics faculty are to be commended for the work they are doing. Thanks.

## C. Prompts and instruments

### Prompts for mathematical writing samples

1. Let  $H$  and  $K$  be subgroups of a group  $G$ . Prove that their intersection  $H \cap K$  is a subgroup of  $G$ .
2. Prove that  $\mathbf{Q}(\sqrt{2}, \sqrt{3}) = \mathbf{Q}(\sqrt{2} + \sqrt{3})$ .

### Prompt for reflective paper

Complex Analysis is one of the three courses designated as a *capstone* course for majors. Part of Westmont's assessment process requires documentation that gives the department's evaluation of these courses. With that end in mind, please turn in an essay (500–750 words) that addresses the following two “capstone” issues. Don't give “fakey” answers; spend a good amount of time thinking about the questions before putting your ideas to paper. Your essay will be read by every mathematics faculty member.

- (a) Comment on how well and in what ways this course helped pull together ideas from various subjects you've studied in mathematics.
- (b) Comment on how this course has helped shape your view of the relationship between mathematics and the Christian faith. Draw your remarks from the following perspectives: (1) Attitudinal, i.e., how this course has, directly or indirectly, helped you see how to model Christian virtues or attitudes as they relate to academic matters; (2) Worldview, i.e., how this course has, directly or indirectly, helped shape your thinking about mathematics and/or its relation to the Christian faith, and/or the value of Christians being engaged in the mathematical enterprise.

D. Rubrics

Rubric for scoring mathematical writing (revised 6/4/2008)

<b>I. Formatting</b>	<i>Weak (1)</i>	<i>Acceptable (2)</i>	<i>Outstanding (3)</i>	<i>Score</i>
General layout.	Poor or inconsistent choices.	Generally appropriate choices.	Consistently good choices.	
Proper alignment in displayed sequences of equations	No discernible alignment protocol	Occasionally inconsistent or non-standard alignment.	Standard alignment used throughout.	
<i>Subscore:</i>				
<b>II. Variables/Symbols</b>	<i>Weak (1)</i>	<i>Acceptable (2)</i>	<i>Outstanding (3)</i>	<i>Score</i>
Appropriate variable names.	Poor or inconsistent choices.	Notation sometimes ambiguous or misleading.	Consistently good choices.	
Appropriate use of symbols.	Excessive misuse of symbols.	Occasional misuse of symbols.	Consistently correct use of symbols.	
<i>Subscore:</i>				
<b>III. Typesetting (if applicable)</b>	<i>Weak (1)</i>	<i>Acceptable (2)</i>	<i>Outstanding (3)</i>	<i>Score</i>
Use of proper font.	Poor or inconsistent choices.	Generally appropriate choices.	Consistently good choices.	
Use of sub/superscript.	Poor or inconsistent choices.	Generally appropriate choices.	Consistently good choices.	
Formatting as mathematics.	No special formatting.	Generally appropriate formatting.	Consistently good formatting.	
<i>Subscore:</i>				
<b>IV. Logic</b>	<i>Weak (1)</i>	<i>Acceptable (2)</i>	<i>Outstanding (3)</i>	<i>Score</i>
Deductions are sound.	Many logical errors.	Only occasional logical errors.	Free of logical errors.	
Appropriate use of definitions.	Seldom applies definitions correctly.	Generally applies definitions correctly.	Consistently applies definitions correctly.	
Deductive steps are justified.	Many steps not justified correctly.	Some nontrivial steps not justified correctly.	All nontrivial steps are justified correctly.	
<i>Subscore:</i>				
<b>V. Exposition</b>	<i>Weak (1)</i>	<i>Acceptable (2)</i>	<i>Outstanding (3)</i>	<i>Score</i>
Writing is complete and economical.	Incomplete thoughts or excessive wordiness.	Generally complete and concise.	Always complete and concise.	
Appropriate variation in sentence structure.	Repetitious and rote sentence structure.	Only occasional repetition of sentence structure.	Good variety of sentence structure.	
All variables introduced/defined.	Many omissions.	Only occasional omissions.	Consistent introduction of all variables.	
All assumptions clearly identified.	Many omissions.	Only occasional omissions.	Consistent identification of all assumptions.	
Proper use of prose.	Poor word choice.	Generally adequate word choice.	Consistently good word choice.	
Spelling and grammar.	Many grammatical errors.	Some grammatical errors.	No grammatical errors.	
<i>Subscore:</i>				

**Rubric for scoring reflective paper connecting faith and mathematics – revised 6/10/08**

Criterion		Substantive connections between faith and mathematics.		
Score: _____		<b>1: Lacking</b> Paper does not identify any substantive connections between faith and mathematics.	<b>2: Adequate</b> Paper identifies one or more substantive connections of the types listed below, but these connections are not developed completely.	<b>3: Superior</b> Paper contains well-developed, substantive connections of one or more of the types listed below.
Examples		<ul style="list-style-type: none"> <li>● Describes how studying mathematics has shaped life goals, especially as a disciple of Christ.</li> <li>● Describes how studying mathematics has informed a Christian world view.</li> <li>● Uses ideas from mathematics as a basis for Christian apologetics.</li> <li>● Uses ideas from mathematics to illustrate or illuminate a theological concept.</li> <li>● Describes how Christian values influence one's approach to the discipline of mathematics.</li> <li>● Makes another isomorphic connection. (Add to rubric.)</li> </ul>		
Criterion		Mature perspective on the discipline of mathematics.		
Score: _____		<b>1: Lacking</b> Paper contains none of the following characteristics.	<b>2: Adequate</b> Paper contains one or more of the following characteristics, but fails to develop any of these ideas in depth.	<b>3: Superior</b> Paper contains one or more of the following characteristics, and develops at least one of these ideas in depth.
Examples		<ul style="list-style-type: none"> <li>● Displays a sophisticated understanding of some mathematical idea.</li> <li>● Describes specific connections between different areas of mathematics.</li> <li>● Describes specific connections between mathematics and another discipline.</li> <li>● Refers to original research done by the student.</li> <li>● Displays an authentic appreciation for mathematics.</li> <li>● Displays an understanding of what it means to do mathematics.</li> <li>● Exhibits a mature perspective on mathematics in an isomorphic way. (Add to rubric.)</li> </ul>		

## E. Updated Multi-Year Plan

Table 4 gives a tentative plan for program review leading up to the next six-year report in 2014.

Year	Program review overall	Details for assessment work
2010–2011	Review library holdings, check against MAA list.	Ongoing annual tasks.  Review Communication learning standard (#2).
2011–2012	Review contributions to GE.	Ongoing annual tasks.  Review Core Knowledge learning standard (#1).
2012–2013	Discuss vision for undergraduate research.  Discuss quality of preparation for graduate school.	Ongoing annual tasks.  Discuss/Revise learning standards.
2013–2014	Prepare for six-year program review report, due 9/15/2014.	Ongoing annual tasks.  Summarize assessment work from past six years.
2014–2015	Submit six-year program review report, 9/15/2014.	Ongoing annual tasks.  Review Christian Connection learning standard (#4).
2015–2016		Ongoing annual tasks.  Review Creativity learning standard (#3).

Table 4: Six-year plan for assessment and program review.