Program Review Six Year Report

Westmont College Mathematics Program

September 15, 2008

Contents

List of Figures

List of Tables

1 Departmental Mission and Role

1.A Mathematics Program 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.

1.B Contributions to College's mission

The current mission statement of Westmont College is the following:

> The mission of Westmont College is to provide a high quality undergraduate liberal arts program in a residential campus community that assists college men and women toward a balance of rigorous intellectual competence, healthy personal development and strong Christian commitments.

The Mathematics statement adds specificity to this statement in several ways. We identify several discipline-specific aspects of "rigorous intellectual competence:" mathematical knowledge, analytical thinking, mathematical communication, creativity, and problem solving skills. Our disciplinary contribution to "healthy personal development" takes the form of preparing students, through coursework and advising, to view their professional vocations as service to others and to the Kingdom of God. Finally, our role in strengthening the Christian commitments of our students lies, in part, in helping them understand the connections between faith and mathematics.

The majority of students in mathematics courses are majors from other disciplines. While we have always maintained a small but devoted cadre of mathematics majors, we are largely a service department to chemistry, biology, physics, psychology, kinesiology, and others.

1.C Contributions to General education

Several mathematics courses contribute to two main categories of Westmont's general education program: the Common Inquiry of Reasoning Abstractly (RA), and the Common Skill of Quantitative and Analytical Reasoning (QAR). The following mathematics courses currently satisfy one or both of these areas:

Course	**Title**	**GE**
MA 4	Mathematics in Western Culture	RA
MA 5	Statistics	RA, QAR
MA 7	Finite Mathematics	RA, QAR
MA 9	Calculus I	RA, QAR
MA 10	Calculus II	RA, QAR
MA 15	Discrete Mathematics	RA, QAR
MA 19	Multivariable Calculus	RA, QAR
MA 160	Fundamentals of Mathematics	RA
MA 165	Fundamentals of Mathematics II	RA, QAR

Table 1: Mathematics GE courses.

In addition, MA 108, 110, and 136 are listed as Writing Intensive, MA 140 and 155 are listed as Integrating the Major Discipline, and MA 190SS and 191SS satisfy the Serving Society, Enacting Justice requirement.

1.D Recent History

There have been four full-time positions in mathematics at Westmont for many years, and the last mathematics hire was in 2000. The department also houses two full-time computer scientists: Kim Kihlstrom was hired in 1999, and Wayne Iba was hired in 2003. For the purposes of program review and assessment, mathematics and computer science operate independently, so this report deals only with the mathematics program in our department. The Annual Update for computer science is attached to this report as an addendum.

The requirements for a mathematics major have not undergone significant revisions for many years. In 2004, some small changes to the catalog were made to dispense with separate tracks in the major, and the department now offers two mathematics degrees: a B.S. and a B.A.

Similarly, our course offerings have remained relatively constant in recent years. Number Theory (MA 123) and Discrete Mathematics (MA 15) were added to the catalog in 2004, and after a brief experiment with an interdisciplinary seminar requirement, Problem Solving (MA 180) was restored as a major requirement in 2007. Finite Mathematics (MA 7) has not been offered since the advent of the new general education requirements; the students who would have taken this course now take Statistics (MA 5), a course whose enrollments have been quite large in recent years.

Past efforts at assessment of the mathematics program have been somewhat checkered. While it is difficult to assign blame for past failures in this area, it seems clear that, for whatever reason, the goals and methods of systematic program review were not clearly communicated to department members for quite some time. Fortunately, this situation has improved, thanks to several institutional changes: a new Academic Dean with a more focused commitment to program review, a new Director of Assessment and clearer communication from the Program Review Committee, and a new Department Chair for Mathematics. The department now has a complete and sustainable program of assessment. However, because this program has only been recently implemented, we have only accumulated data over a relatively short period of time.

2 Statistical Information

2.A Current Full-Time Faculty

2.A.1 Faculty Data

The department has four full-time faculty positions in mathematics, but one of these is a shared/split position occupied by Patti Hunter and David Hunter. On the following tables, the Hunters are listed separately. (n/a = data not available)

Profile of Full-time Faculty (2002–2003)										
Faculty Member	Date Hired	Sex	Ethnicity	Rank	Tenure Status	Number of students Lower/Upper division		Number of advisees	Number of Preparations	Departmental Responsibilities
Howell	1978	M	Caucasian	Full	Ten.	99	5	n/a	4	Chair, Contest
Hunter, D.	2000	M	Caucasian	Assoc.	Unten.	96	0	n/a	2	
Hunter, P.	2000	F	Caucasian	Assist.	Unten.	53	4	n/a	2	
Leech	1985	M	Caucasian	Full	Ten.	12	29	n/a	5	
Rosentrater	1980	M	Caucasian	Full	Ten.	29	13	n/a	5	

Table 2: Profile of Full-time Faculty (2002–2003)

Profile of Full-time Faculty (2003–2004)										
Faculty Member	Date Hired	Sex	Ethnicity	Rank	Tenure Status	Number of students Lower/Upper division		Number of advisees	Number of Preparations	Departmental Responsibilities
Howell	1978	M	Caucasian	Full	Ten.	85	5	n/a	2	Chair, Contest
Hunter, D.	2000	M	Caucasian	Assoc.	Unten.	29	11	n/a	3	
Hunter, P.	2000	F	Caucasian	Assist.	Unten.	40	4	n/a	3	
Leech	1985	M	Caucasian	Full	Ten.	67	20	n/a	6	
Rosentrater	1980	M	Caucasian	Full	Ten.	45	27	n/a	3	

Table 3: Profile of Full-time Faculty (2003–2004)

Profile of Full-time Faculty (2004–2005)										
Faculty Member	Date Hired	Sex	Ethnicity	Rank	Tenure Status	Number of students Lower/Upper division		Number of advisees	Number of Preparations	Departmental Responsibilities
Howell	1978	M	Caucasian	Full	Ten.	86	10	4	4	Chair, Contest
Hunter, D.	2000	M	Caucasian	Assoc.	Unten.	40	4	4	3	
Hunter, P.	2000	F	Caucasian	Assoc.	Unten.	76	8	5	3	
Leech	1985	M	Caucasian	Full	Ten.	101	40	2	5	
Rosentrater	1980	M	Caucasian	Full	Ten.	0	33	2	3	

Table 4: Profile of Full-time Faculty (2004–2005)

Profile of Full-time Faculty (2005–2006)										
Faculty Member	Date Hired	Sex	Ethnicity	Rank	Tenure Status	Number of students Lower/Upper division		Number of advisees	Number of Preparations	Departmental Responsibilities
Calderon	2005	F	Latina	Instr.	Unten.	162	0	0	2	
Howell	1978	M	Caucasian	Full	Ten.	64	8	7	5	Chair, Contest
Hunter, D.	2000	M	Caucasian	Assoc.	Unten.	7	11	6	2	
Hunter, P.	2000	F	Caucasian	Assoc.	Unten.	15	5	6	2	
Leech	1985	M	Caucasian	Full	Ten.	31	2	2	3	
Rosentrater	1980	M	Caucasian	Full	Ten.	23	11	2	4	

Table 5: Profile of Full-time Faculty (2005–2006)

Profile of Full-time Faculty (2006–2007)										
Faculty Member	Date Hired	Sex	Ethnicity	Rank	Tenure Status	Number of students Lower/Upper division		Number of advisees	Number of Preparations	Departmental Responsibilities
Howell	1978	M	Caucasian	Full	Ten.	0	0	1	0	(Sabbatical)
Hunter, D.	2000	M	Caucasian	Assoc.	Ten.	24	0	5	2	
Hunter, P.	2000	F	Caucasian	Assoc.	Ten.	32	6	4	2	
Leech	1985	M	Caucasian	Full	Ten.	32	25	7	6	
Rosentrater	1980	M	Caucasian	Full	Ten.	0	21	2	3	
Taylor	2004	M	Caucasian	Instr.	Unten.	155	0	0	4	

Table 6: Profile of Full-time Faculty (2006–2007)

Profile of Full-time Faculty (2007–2008)										
Faculty Member	Date Hired	Sex	Ethnicity	Rank	Tenure Status	Number of students Lower/Upper division		Number of advisees	Number of Preparations	Departmental Responsibilities
Howell	1978	M	Caucasian	Full	Ten.	91	9	3	5	Contest
Hunter, D.	2000	M	Caucasian	Assoc.	Ten.	12	3	10	2	Chair
Hunter, P.	2000	F	Caucasian	Assoc.	Ten.	74	0	5	2	DDRS
Leech	1985	M	Caucasian	Full	Ten.	60	35	5	6	
Rosentrater	1980	M	Caucasian	Full	Ten.	0	8	5	3	

Table 7: Profile of Full-time Faculty (2007–2008)

2.A.2 Instructional Load

	FA-2002	SP-2003	FA-2003	SP-2004	FA-2004	SP-2005	FA-2005	SP-2006	FA-2006	SP-2007	FA-2007	SP-2008
MA-000	0	7		6		9						
MA-004		20		17		11		11				12
MA-005A	25	33	28	31	32	26	25	32	32	33	27	28
MA-005B	28	20	27	35	25	31	28	33	33	35	27	33
MA-005C												33
MA-007		12		18		7						
MA-009		12		25		36						
MA-009-A	30		16		26		22	19	25	15	21	22
MA-009-B	34		24		31		25		26		19	
MA-009-C	18		26		20		26		14		19	
MA-010-A	28	20	11	23	19	33	5	5	16	14	13	8
MA-010-B								20				
MA-010-H			14		18		15					
MA-015							7		8		12	
MA-019	26		13				23		26		17	
MA-020		17		6		8		11		11		11
MA-040								15		13		5
MA-080 *	1	2	2	1	7	4	0					
MA-090 *					0	3	4	4	1	3		
MA-108		5				10				9		
MA-109							4				3	
MA-110				8				5				6
MA-111	2				4							
MA-121			8									
MA-123					8				6			
MA-126 **	15											
MA-130		8				11				8		
MA-136			11				2				9	
MA-140				5				6				9
MA-145 **	7											
MA-155	4				8				6			
MA-160	11	14	12		22		20		15		5	
MA-165 **		18		18		27		17		11		13
MA-180 *	2	4	4	5			2				4	2
totals	231	192	196	198	220	216	208	178	208	152	176	182
	Notes: (* = 1hr course), (** = 2hr course)											

Table 8: Instructional load for Mathematics.

2.A.3 Faculty C.V.'s

The next several pages consist of the C.V.'s of the mathematics faculty.

Curriculum Vitae
Russell W. Howell

Education

1969	B.S. (Mathematics), Wheaton College, Wheaton, Illinois
1974	Ph.D. (Mathematics), The Ohio State University, Columbus, Ohio
	Dissertation: *Annular Functions in Potential Theory and Probability*
	Adviser: Professor Francis W. Carroll
1986	M.Sc. (Computer Science), University of Edinburgh, Edinburgh, Scotland

Military Service

1974 – 1975	Fort Bliss, Texas
	Officer Basic Training
	Nike-Hercules Operations and Management Training
1975 – 1977	White Sands Missile Range, New Mexico
	Operations Research/Systems Analysis
1977 – 1978	HHC I Corps (ROK/US) Group, South Korea
	G-3 Officer (Defense Analysis)
1978	Honorable Discharge (Rank: Captain; Clearance: Top Secret)

Teaching History

1978 – present	Westmont College, Santa Barbara, California
Spring 2000	University of Maryland, College Park, Maryland
Fall 1999	Calvin College, Grand Rapids, Michigan
Fall 1977	New Mexico State University, Las Cruces, New Mexico

Courses Taught

Mathematics and Philosophy in Western Culture, Mathematics in Western Culture, Mathematics for Education Majors, Computer Science for Education Majors, Elementary Statistics, Advanced Statistics, Elementary Calculus, Honors Calculus, Multivariable Calculus, Advanced Calculus, Differential Equations, Linear Algebra, Modern Algebra, Applied Mathematics, Combinatorics, Complex Analysis, Real Analysis, Elementary Problem Solving, Advanced Problem Solving, Introductory Computer Science (Using a variety of languages: BASIC, FORTRAN, Pascal, Turing, C, and C++), Data Structures and Algorithms, Assembly Language Programming, Operating Systems, Mathematics and Linguistics, Perspectives on Civilization, Christian Perspectives on Learning, Great Hymns of the Christian Faith, Mathematics in the Contemporary World

Major Committee Responsibilities

Christian Perspectives on Learning Committee (Chair)
Personnel Committee (Chair)
Faculty Council (Chair)
Computer Committee (Chair)
Student Development Committee (Chair)
Long Range Planning Committee
Hiring for Mission Task Force

Curriculum Vitae: Russell W. Howell, Page 2

Administrative Responsibilities

Department Head, Mathematics (1986 – 1991; 2000 – 2006)
Coordinator of faith-learning for pre-tenure faculty (2002 – 2006)
Coordinator of the NBS seminar and Pascal Society lecture series, 2004 – 2006
Creator and organizer for Westmont's annual high school mathematics contest (1987 – present)
Organizer for Westmont's third interdisciplinary symposium (February 3 – 4, 2006)
Convener and Mentor, CCCU Disciplinary Workshops in Mathematics and Computer Science (held at Westmont College, May 2003)
Creator and organizer for Westmont's theological workshops (1999 – 2001)
Vice Chair of the faculty (1996 – 1997)
Phi Kappa Phi scholastic honor society (Vice President, 1991 – 1993; President, 1993 – 1995)
Omicron Delta Kappa leadership honor society faculty adviser (1983 – 1991)
Director of Academic Computing, 1978 – 1985

Publications

[1] Russell W. Howell. Lewis's *Miracles* and mathematical elegance. In Jerry Walls Dave Bagit and Gary Habermas, editors, *C.S. Lewis as Philosopher*. InterVarsity Press, Downers Grove, IL, To appear.

[2] Russell W. Howell. Negative math: How mathematical rules can be positively bent. *Books and Culture*, Review, to appear.

[3] Russell W. Howell. Does mathematical beauty pose problems for naturalism? *Christian Scholar's Review*, XXXV(4):493–504, Summer 2006.

[4] Russell W. Howell. Does mathematical beauty pose problems for naturalism? *Journal of the ACMS*, 2006. (Published with permission from *Christian Scholar's Review*, this article is more mathematically technical than the one appearing with the same title in *CSR*) `http://www.acmsonline.org/journal2006.htm`.

[5] John H. Mathews and Russell W. Howell. *Complex Analysis for Mathematics and Engineering*. Jones and Bartlett, Sudbury, MA, fifth edition, 2006.

[6] Russell W. Howell. The divine challenge: on matter, mind, math and meaning. *Focus Online*, Review, 2005. Mathematical Association of America `http://www.maa.org/reviews/TheDivineChallenge.html`.

[7] Russell W. Howell. The divine challenge: on matter, mind, math and meaning. *Journal of the ACMS*, Review, 2005. (This review, while similar to that in *Focus Online*, concentrates more on biblical and philosophical issues) `http://www.acmsonline.org/journal2005.htm`.

[8] Russell W. Howell and W. James Bradley, editors. *Mathematics in a Postmodern Age: A Christian Perspective*. Eerdmans, Grand Rapids, 2001.

[9] Russell W. Howell. Creativity and the limits of computer reasoning. In Howell and Bradley (8), chapter 9. (Also co-wrote the introductory and concluding chapters).

[10] John H. Mathews and Russell W. Howell. The tangent parabola. *The AMATYC Review*, pages 25–32, Fall 2001.

Curriculum Vitae: Russell W. Howell, Page 3

[11] Robert H. Gundry and Russell W. Howell. The sense and syntax of john 3:14–17 with special reference to the use of οὕτος ...ὥστε in john 3:16. *Novum Testamentum*, pages 24–39, January 1999.

[12] Russell W. Howell and John H. Mathews. Computing square roots fast: illustrating the cubic order of convergence. *International Journal of Mathematics Education in Science and Technology*, 30(2):290–293, March–April 1999.

[13] John H. Mathews and Russell W. Howell. The investigation of tangent polynomials with a computer algebra system. *The AMATYC Review*, pages 20–27, Fall 1992.

[14] Rusell W. Howell. Using *Mathematica* to teach calculus. In *Proceedings of the ACMS*, pages 79–89. Association of Christians in the Mathematical Sciences, June 1991.

[15] Russell W. Howell. Simulated annealing on np-complete problems. In *Proceedings of the ACMS*, pages 104–123. Association of Christians in the Mathematical Sciences, June 1989.

[16] Russell W. Howell. Comparison of tank and tow losses in carmonette and dmb simulations. Technical report, USA TRADOC Systems Analysis Activity, 1977. Classified Secret.

[17] Russell W. Howell. Analysis of line-of-sight data in the iua-bonder model. Technical report, USA TRADOC Systems Analysis Activity, 1976. Classified Secret.

[18] Russell W. Howell. Annular functions in probability. *Proceedings of the American Mathematical Society*, pages 217–221, October 1975.

Papers, seminar talks, panels

- "Is Mathematics Unreasonably Effective?"
  Oxford Philosophy Seminar, Merton Street, Oxford, England (March 8, 2007)
- "Mathematical Measurements: Applications and Implications"
  St. Edwards School, Oxford, England, (January 17, 2007)
- "The Impact of Gödel: Theories of Mind and Aposteriori Thinking
  (Who is right: Penrose and Lucas, or Wittgenstein?)"
  Gödel Interdisciplinary Symposium, Westmont College, (February 3, 2006)
- "Does Mathematical Beauty Pose Problems for Naturalism?"
  Oxbridge Conference, Oxford, England (July, 2005)
- ACMS Conference, Huntington, Indiana (May, 2005)
  - "Review of The Divine Challenge"
  - "Mathematical Success and Naturalism"
- Wheaton College science symposium invited speaker (March, 2004)
  - "Philosophical views of Mathematics and their Relation to Infinite Sets"
  - "The Subject and Object of Creativity" (chapel address)
- Abilene Christian University faith-learning symposium invited speaker (March, 2003)
  - "Mathematical Implications for Statistical Inference"

Curriculum Vitae: Russell W. Howell, Page 4

- "The Constrictions of Hilbert's Formalism"
- "Faith-Learning Perspectives in Mathematics and Computer Science: Do They Matter?"
- "The Practice of Christians in Academia"

- Panel organizer and participant: "Mathematics in a Postmodern Age" (January, 2002) Combined meetings of the Mathematical Association of America, American Mathematical Society, Society for Industrial and Applied Mathematics, etc., San Diego, California
- Panel member: colloquy for the installation of Stan Gaede as President of Westmont College (January, 2002), Panel Contribution: "Avoiding Affectation and Accommodation" Fess Parker's Doubletree Inn, Santa Barbara, CA
- Invited lectures: "Non-Linear Thinking: Implications for Computer Chip Design and Social Science Legitimacy"
  - Muhlenberg College, Allentown, PA (Spring, 2000)
  - Hope College, Holland, MI (Fall, 1999)
  - Calvin College, Grand Rapids, MI (Fall, 1999)
  - Westmont College, Santa Barbara, CA, Natural Science Seminar, (Spring, 1998)
- "Complementary Partial Orders and Rectangle Packing" Fall meeting of the American Mathematical Society and Mathematical Association of America, Claremont McKenna/Pfitzer College, Claremont, California, (October, 1997)
- "Probabilistic Surprises: The Mundane, the Mysterious, and the Esoteric" Westmont College, Santa Barbara, CA, Natural Science Research Seminar, (Spring, 1992)
- "Using Mathematica to Teach Calculus" Eighth Biennial Conference of the Association of Christians in the Mathematical Sciences, Wheaton College, Wheaton, IL, (June, 1991)
- "Simulated Annealing on NP-Complete Problems" Seventh Biennial Conference of the Association of Christians in the Mathematical Sciences, Messiah College, Grantham, PA, (June, 1989)
- "Randomized Optimization, or How to Pack a Suitcase" Westmont College, Santa Barbara, CA, Natural Science Research Seminar, (Spring, 1988)
- "Creativity and the Limits of Computer Reasoning" Phi Kappa Phi address at Westmont College, Santa Barbara, CA, (February, 1987)
- "Annular Functions and Probability" Summer meeting of the American Mathematical Society, Dekalb, IL, (Summer, 1974)

Professional Memberships

- The Mathematical Association of America (1974 – present)
- The Association of Christians in the Mathematical Sciences (1977 – present)
  - Board Member (1989 – 1997)

Curriculum Vitae: Russell W. Howell, Page 5

- Vice President (1991 – 1993)
- President (1993 – 1995)

- Council of Christian Scholarly Societies (1996 – 2002)
  - Executive Committee (1998 – 2002)
  - Chair (2000 – 2002)
- Phi Sigma Tau (1968 – present)
- Omicron Delta Kappa (1983 – present)
- Phi Kappa Phi (1980 – present)
  - Vice President 1991 – 1993)
  - President (1993 – 1995)

Honors and Awards

- Grant: The John Templeton Foundation, 2006 ($29,000)
  To develop a book connecting mathematical, philosophical, and theological ideas
- Grant: Lilly Foundation, 2005 ($12,000)
  To fund the faith-learning program at Westmont College for one year
- Grant: The John Templeton Foundation, 2003 – 2005 ($6000)
  Honorarium for participation in the John Templeton Seminars in Science and Christianity, held at Wycliffe Hall, Oxford, for four weeks in each of three consecutive summers. Also included were room and board plus transportation costs.
- Teacher of the Year, Westmont College, 1999, 1984
- Grant: Digital Equipment Corporation, 1980 ($4000)
  For the purchase of institutional computer equipment
- Army Commendation Medal (USA), 1978
- Korea Service Medal (ROK), 1978

Community Involvement

- Free Methodist Church, 1979 – present: various involvements, including
  - Regional Conference Delegate
  - Adult Education Teacher
  - Local Board of Administration
  - Worship Committee Chair
  - Pianist
- Creator and organizer of Westmont's annual high school mathematics contest (1987 – present)
- Organizer of Westmont's third interdisciplinary symposium, February 3 – 4, 2006
  (Celebrating the 100th anniversary of Gödel's birth, and the 75th anniversary of the publication of his famous incompleteness theorems)

Curriculum Vitae: Russell W. Howell, Page 6

- Participant for Cal SOAP (2001)

Consulting Activities

- California Thrift and Loan, Santa Barbara, California
- Sansum Medical Foundation, Santa Barbara, California
- ABACUS, Inc., Santa Barbara, California
- General Research Corporation, Santa Barbara, California

David J. Hunter

Education

Ph.D., Mathematics, University of Virginia, May 1997.
Dissertation: "Stable Homotopy Groups of Spheres and Brown-Gitler Spectra"
Thesis Advisor: Nicholas J. Kuhn

M.S., Mathematics, University of Virginia, May 1994.

B.S. *magna cum laude*, Mathematics, University of Illinois, May 1990.

Teaching Experience

Professor of Mathematics, Westmont College, August 2008–present.

Associate Professor of Mathematics, Westmont College, August 2002–August 2008.

Assistant Professor of Mathematics, Westmont College, August 2000–August 2002.

Assistant Professor of Mathematics, North Central College, September 1997–June 2000.

Taught Abstract Algebra I and II, Probability and Statistics I and II, Differential Equations I and II, Linear Algebra, College Geometry, and Calculus I–IV. Helped manage the College's web site, conducted faculty technology training workshops, sponsored the Math Club, and served on various committees.

Graduate Instructor, University of Virginia, August 1992–August 1997.

Taught Introduction to Statistics, Probability/Finite Mathematics, and Applied Calculus I and II as the primary instructor with full responsibility. Taught Graduate Algebra I–II, Calculus I, II, and III and Applied Calculus I as the teaching assistant. Participated in department and university-wide teacher training programs.

Teacher, Oak Park and River Forest High School, August 1990–July 1992.

Taught a range of high school mathematics courses, including computer science and statistics, to a racially and culturally diverse student body. Served on school-wide committees and coached the math and chess teams. Participated in meetings of professional organizations.

Journal Articles

Mahowaldean families of elements in stable homotopy groups revisited, D. J. Hunter and N. Kuhn, Mathematical Proceedings of the Cambridge Philosophical Society, (127), 1999, pp. 237–251.

Characterizations of spectra with $\mathcal{U}$-injective cohomology which satisfy the Brown-Gitler property, D. J. Hunter and N. Kuhn, Transactions of the American Mathematical Society, (352), March 2000, pp. 1171–1190.

How rare is symmetry in 12-tone musical rows? D. J. Hunter and P. T. von Hippel, American Mathematical Monthly, (110), February 2003, pp. 124–132.

Regular correspondent for *Media Highlights,* College Mathematics Journal, Summer 2001–present. Reviews appearing in:

> **32:4**, September 2001, **33:5** November 2001, **33:1** January 2002, **33:2** March 2002, **33:3** May 2002, **34:1** January 2003, **34:2** March 2003, **34:3** May 2003, **34:4** September 2003, **34:5** November 2003, **35:1** January 2004, **35:2** March 2004, **35:4** September 2004, **35:5** November 2004, **36:1** January 2005, **36:4** September 2005, **37:2** March 2006, **37:3** May 2006, **37:4** September 2006, **37:5** November 2006.

The Two Color Theorem, D. J. Hunter. Discrete Mathematics Resource Guide, Mathematical Association of America, to appear.

Books

Essentials of Discrete Mathematics, D. J. Hunter. Jones and Bartlett Inc. 2008.

Papers Presented († denotes invited speaker)

Why Biology Majors Should take Discrete Mathematics
Session on Biomathematics in the First Two Years, MAA National Meeting, San Jose, CA, August 2007.

Exercises in Reconstructing Evolutionary Trees
Session on Nifty Examples in Discrete Mathematics, MAA National Meeting, Albuquerque, NM, August 2005.

Widening the Audience for Discrete Mathematics
MAA National Meeting, Albuquerque, NM, August 2005.

The Perfect Shuffle: Mathematical Apologetics
Session on Applications of Mathematics in Computer Science, MAA National Meeting, Phoenix, AZ, January 2004.

Phylogenetic Distance and Coxeter Groups
SCNSMAA Meeting, Pomona, CA, October 2003.

† *How rare is symmetry in 12-tone musical rows?*
Mathematics Colloquium, University of Redlands, Redlands, CA, February, 2002.

Group exercises for abstract algebra
Session on Learning to Prove in Cooperative Learning and Technology Supported Environments, MAA National Meeting, San Diego, CA, January 2002.

Symmetry in 12-tone musical rows
SCSMAA Meeting, Los Angeles, CA, October 2001.

† *Group exercises for abstract algebra*
Panelist for discussion on modern pedagogy in upper division courses, ISMAA Meeting, Naperville, IL, March 2000.

† *Top ten reasons to have a course web page*
ISMAA Meeting, Naperville, IL, March 2000.

† *RSA cryptography: An application of "theoretical" mathematics*
Mu Alpha Theta induction ceremony, Joliet Catholic Academy, November 1999.

Duals of summands of $B\mathbf{Z}/p$
Topology Session, AMS National Meeting, San Antonio, TX, January 1999.

† *Characterizing spectra with* $\mathcal{U}$*-injective cohomology which satisfy the Brown-Gitler property*
Topology Seminar, Northwestern University, Evanston IL, April 1998.

† *Characterizing spectra with* $\mathcal{U}$*-injective cohomology which satisfy the Brown-Gitler property*
Topology Seminar, University of Chicago, Chicago IL, March 1998.

† *Some new infinite families in* ${}_p\pi_*^S$
Fields Institute Conference on Unstable Homotopy Theory, Toronto, Ontario, June 1996.

† *Brown-Gitler spectra,* $\Omega^2 S^3$ *, and* π_*^S
Regional Meeting of the American Mathematical Society: Special Session on Homotopy Theory, Lawrenceville, New Jersey, October 1996.

Student Research Projects

Investigation of Phylogenetic Tree Reconstruction, Chase Clanton, Summer, 2005. Presented at the 2005 Westmont College Celebration of Undergraduate Research.

Hybridization of Euclidean 2-space and the Poincaré Disk Model for Planar Geometry, Gib Gerard, Manuel Reyes and Kevin Kishiyama. Presented at the March 2004 SCNSMAA meeting in San Diego, CA, and at the 2004 Westmont College Undergraduate Research Symposium.

Transforming Origami Into Knots, Chase Clanton, Justin Marks, and Michael Strongman. Presented at the March 2004 SCNSMAA meeting in San Diego, CA, and at the 2004 Westmont College Undergraduate Research Symposium.

Is National Sovereignty Possible? A Geometric Look at International Agreements, Kristin Bailey. Presented at the 2004 Westmont College Undergraduate Research Symposium.

Applications of Group Theory to Rubik-Type Puzzles, Kerin Heck and Jody Radowicz. Presented at the March 2000 ISMAA meeting and at the May 2000 Rall Symposium for Undergraduate Research, North Central College.

Knots and DNA Gel Electrophoresis, Tammy Pudzimis, Haven Johnson, Anna Tollberg. Presented at the Rall Symposium for Undergraduate Research, North Central College, May 2000.

A Family of Torus Knots, Lisa Platkus, Evie Rote, Jenni Underhill. Presented at the Rall Symposium for Undergraduate Research, North Central College, May 2000.

Knots and their Effects on Manifolds, Sarah Schmidt, Jackie Regan, Carrie Schramm. Presented at the Rall Symposium for Undergraduate Research, North Central College, May 2000.

Traffic Flow on Chicago Avenue: A Dynamical Systems Approach, Norman Johnson, David Kang, Lisa Lim. Presented at the Rall Symposium for Undergraduate Research, North Central College, May 1999.

Differential Equation Models for Computer Virus Propagation, Anusha Gururajan, Tim Johnson, Rachel O'Toole. Presented at the Rall Symposium for Undergraduate Research, North Central College, May 1999.

Service to Mathematical Community

Referee for College Mathematics Journal, 2001–present.

Referee for Journal of Online Mathematics and its Applications, 2001–2004.

Board Member, Southern California Section of the Mathematical Association of America (Web Page Editor), October 2001–July 2008.

Grants Received

Implementing algebraic structures in C++
Summer Development Grant, Westmont College, 2001.

Computer Visualizations of Higher Dimensional Topological Phenomena
Summer Faculty Development Research Grant, North Central College, 1999.

Stable Decomposition of Classifying Spaces and Spanier-Whitehead Duality
Summer Faculty Development Research Grant, North Central College, 1998.

Recent Conferences and Workshops

MATHFEST, San Jose, CA, August 2007.

MATHFEST, Albuquerque, NM, August 2005.

Southern California-Nevada Section of the Mathematical Association of America Spring Meeting, Los Angeles, CA, March 2005.

NSF PREP Workshop on Nifty Applications in Discrete Mathematics, Valporaiso University, Valporaiso, IN, June 2004. Invited Participant.

Southern California-Nevada Section of the Mathematical Association of America Spring Meeting, San Diego, CA, March 2004.

National Meeting of the American Mathematical Society and Mathematical Association of America, Phoenix, AZ, January 2004.

Southern California-Nevada Section of the Mathematical Association of America Fall Meeting, Pomona, CA, October 2003.

NSF PREP Workshop on Knot Theory, Wake Forest University, Winston-Salem NC, June 2002. Invited Participant.

National Meeting of the American Mathematical Society and Mathematical Association of America, San Diego, CA, January 2002.

Southern California Section of the Mathematical Association of America Fall Meeting, Los Angeles, CA, October 2001.

Illinois Section of the Mathematical Association of America Annual Meeting, Augustana College, Rock Island, IL, March 2000. Regional Project NExT program.

MATHFEST, Providence, RI, July 1999. Project NExT Fellowship program. Included a short course on undergraduate research. Invited Participant.

Seminar on the Quests of the Historical Jesus, Westmont College, Santa Barbara, CA, June 1999. Invited Participant.

Illinois Section of the Mathematical Association of America Annual Meeting, Augustana College, Rock Island, IL, April 1999. Regional Project NExT program.

National Meeting of the American Mathematical Society, San Antonio, TX, January 1999. Project NExT Fellowship program. Invited Participant.

MATHFEST, Toronto, Ontario, July 1998. Project NExT Fellowship program. Included a short course on active learning techniques.

Awards and Honors

Project NExT Fellow, 1998–1999.

Society of Actuaries Exams 100 and 110 (60 credits)

Graduate Research Fellowship (competitive), University of Virginia, 1995–1996.

Graduate Assistantship, University of Virginia, 1992–1995, 1996–1997.

Department of Education Teacher Trainee Program, University of Virginia, 1992–1996

Bronze Tablet, University of Illinois, 1990.

Phi Beta Kappa, University of Illinois, 1990.

Professional Memberships

Mathematical Association of America

Association of Christians in the Mathematical Sciences

National Council of Teachers of Mathematics, 1990–1992

Illinois Council of Teachers of Mathematics, 1990–1992

Metropolitan Mathematics Club of Chicago, 1990–1992

PATTI WILGER HUNTER

CURRICULUM VITAE

Address:
Department of Mathematics
Westmont College
Santa Barbara, CA 93108

Telephone: (805) 565-6076

E-mail: phunter@westmont.edu

Research Area: History of Mathematics

Education:

Ph.D. in Mathematics, 1997	University of Virginia
M.S. in Mathematics, 1990	University of Virginia
B.S. in Mathematics, Summa cum Laude, 1988,	Westmont College

Employment History:

Fall 2000-present: Assistant Professor, Department of Mathematics, Westmont College.
Calculus I and II, Finite Mathematics, Introduction to Statistics, History of Mathematics

Winter, 1998, Winter, 1999: Instructor, Department of Mathematics, North Central College.
Multivariable Calculus

Spring and Summer, 1997: Instructor, Department of Mathematics, University of Virginia.
History of Mathematics (graduate level); Introduction to Statistics

Fall, 1992 to Spring, 1995 and Fall, 1988 to Spring, 1990: Teaching Assistant, Department of Mathematics, University of Virginia.
Calculus (I and II as primary instructor; III as teaching assistant); Introduction to Statistics (as primary instructor); History of Mathematics (as teaching assistant)

Fall, 1990 to Spring, 1992: Instructor, Department of Mathematics, Westmont College.
Basic Mathematics, Mathematics in Western Culture, Elementary Functions, Elementary Calculus (I, II), Multivariable Calculus, Fundamentals of Mathematics

Summer, 1990: Instructor, Summer Transition Program, University of Virginia.
Precalculus

Fellowships:
U.S. Department of Education-University of Virginia: Graduate Assistance in Mathematics (competitive). Included summer courses on the use of computers in teaching and research and on teaching statistics, as well as a year-long grant for dissertation research.

Professional Memberships:
Mathematical Association of America
Association of Christians in the Mathematical Sciences
History of Science Society
Canadian Society for the History and Philosophy of Mathematics

Publications:
"Drawing the Boundaries: Mathematical Statistics in Twentieth-Century America," *Historia Mathematica* 23 (1996): 7-30.

Articles on Max Mason, Artemis Martin, Jacob D. Tamarkin, and Dunham Jackson for *American National Biography* (New York: Oxford University Press, 1999).

"An Unofficial Community: American Mathematical Statisticians before 1935," *Annals of Science* 56 (1999): 47-68.

Review of Deborah J. Bennett, *Randomness* in *Isis* 93 (1999): 345-46.

Review of Armand Borel, *Essays in the History of Lie Groups and Algebraic Groups* in *Isis* 93 (2002): 719.

"Foundations of Statistics in American Textbooks: Probability and Pedagogy in Historical Context," in *Using Recent History of Mathematics in Teaching Mathematics,* ed. Amy Shell-Gellasch and Richard Jardine (Washington, DC: Mathematical Association of America), accepted, to appear.

"Connections, Context, and Community: Abraham Wald and the Sequential Probability Ratio Test," *Mathematical Intelligencer* 26 (2004): 25-33.

Review of Alain Desrosières, *The Politics of Large Numbers: A History of Statistical Reasoning* in *Mathematical Intelligencer*, to appear.

Papers Presented:
"Drawing the Boundaries: Mathematical Statistics in Twentieth-Century America"

- Biennial Conference of the Association of Christians in the Mathematical Sciences, May, 1995;
- Statistics Division Colloquium, University of Virginia, September, 1995;
- Special Session on the History of Mathematics, Annual Meeting of the American Mathematical Society, Orlando, FL, January, 1996.

"'Hurling Equations at Hitler': World War II and the American Mathematical Statistics Community"

- Department of Mathematics Colloquium, Swarthmore College, November, 1996;
- Department of Mathematics, Wheaton College, March, 1998;
- Mathematics Club Seminar, Department of Mathematics, North Central College, January, 1998.

"The Mathematics of Statistics: Foundations of Probability in American Textbooks, 1925-1946"

- Special Session on the History of Mathematics, Annual Meeting of the American Mathematical Society, San Diego, CA, January, 1997.

Invited commentator, Conference on “What Is the History of Mathematics? Who Is It For?”

- University of Chicago, May 1997.

“An Unofficial Community: American Mathematical Statisticians before 1935”

- Oberwolfach Tagung, History of Mathematics, Oberwolfach, Germany, October, 1998.

“Connections, Context, and Community: Abraham Wald and the Sequential Probability Ratio Test”

- Special Session on the History of Mathematics, Annual Meeting of the American Mathematical Society, Washington, DC, January, 2000.

“Statistics in the U.S. Comes of Age: A Case Study in American Influence Abroad”

- Special Session on the History of Mathematics, Western Section Meeting of the American Mathematical Society, San Francisco, CA, October, 2000;
- Conference for the Canadian Society of the History and Philosophy of Mathematics, Quebec City, Canada, May, 2001;
- History of Science Society Annual Meeting, Denver, CO, November 2001.

“Spreading the Gospel: Gertrude M. Cox and the ISI Education Committee”

- Special Session on the History of Mathematics, Annual Meeting of the American Mathematical Society, San Diego, CA, January 2002.

“From Vienna to New York: Abraham Wald’s Converging Communities”

- Special Session on the History of Mathematics, Annual Meeting of the American Mathematical Society, Phoenix, AZ, January 2004.

“Questions with a Wider Focus: Looking Beyond the Big Names--Three Examples from the History of American Statistics”

- University of Richmond Quest: “The History of Mathematics: How Do We Know What Questions to Ask?” International Conference, May 2004.

“Foundations of Statistics in American Textbooks: Probability and Pedagogy in Historical Context”

- History of Science Society Annual Meeting, Austin, TX, November 2004.

Professional Activities:
Editorial Associate, *Historia Mathematica*, July, 1995 – June, 1997.
Contributor, Abstracts Section, *Historia Mathematica*, 1993-1995, 2002-present.
Organizer of “Internationalization and Trans-national Communication in Mathematics: Influence on Context and Community,” paper session at History of Science Society Annual Meeting, Denver, CO, November 2001.
Co-Organizer and Session Chair, Special Session on the History of Mathematics, AMS/MAA National Meetings, January 2005
Referee for *The American Mathematical Monthly* (1 paper reviewed, June 2004)
Reviewer for Houghton-Mifflin (1 textbook reviewed, August 2004)

Institutional Service (Westmont):
Coordinator, Program for President’s Scholars, 2001-present.
Personnel Committee, 2002-03.
Faculty Council, 2004-present

Current Community Service:
Volunteer, Transition House
Secretary, Parents Council, César Chávez Charter School, 2002-2003
President, Board of Directors, Las Barrancas Owners Association, 2002-2003
Teacher, Children's Ministry, Santa Barbara Community Church, 2002-2004
Homegroup leader, Santa Barbara Community Church, 2001-present

1

RESUME
Jonathan E Leech

Personal Professor of Mathematics
Dept. of Mathematics and Computer Science, Westmont College
955 La Paz Road, Santa Barbara, CA 93108-1099 USA
Phone: (805)-565-6184 E-mail leech@westmont.edu

Education BA (Mathematics), University of Hawaii, May, 1967
Ph.D. (Mathematics), UCLA, September, 1969
MA (Biblical Studies), Dallas Seminary, 1984

Experience Westmont College, 1985 – present, Professor (promoted 1994)
McKenzie University, Sao Paulo, Brazil, Visiting Professor, June-July 1992
Universidad de Granada, Granada, Spain, Visiting Professor, June-July 1988
Missouri Western State College, Associate Professor, 1977-1985
Case Western Reserve University, Visiting Associate Professor, 1982-1983
University of Tennessee, Assistant Professor, 1971-1977

Publications

Skew Boolean algebras derived from generalized Boolean algebras (with M. Spinks), Algebra Universalis, 58 (2008), 287-302.
Associativity of the ∇*-operation on bands in rings* (with K. Cvetko-Vah), Semigroup Forum, 76 (2008), 32-50.
Magic squares, finite planes and simple quasilattices, Ars Combinatoria, 77 (2005), 75-96.
Small Skew Lattices in Rings, Semigroup Forum, 70 (2005), 307-311.
Green's equivalences on noncommutative lattices (with G. Laslo), Acta Sci. Math. (Szeged), 68 (2002), 501-533.
Symmetric groupoids, free categories and E-unitary inverse monoids,* Proceedings of the Royal Society of Edinburgh (Series A), 129 (1999), 959-985.
Dual symmetric inverse monoids and representation theory (with D. FitzGerald), Journal of the Australian Mathematical Society (Series A), 64 (1998), 345-367.
On the foundations of inverse monoids and inverse algebras, Proceeedings of the Edinburgh Mathematical Society, 41 (1998), 1-21.
Recent developments in the theory of skew lattices, Semigroup Forum, 52 (1996), 7-24.
Skew Boolean algebras and discriminator varieties (with R. J. Bignall), Algebra Universalis, 33 (1995), 387-398.
Inverse monoids with a natural semilattice ordering, Proceedings of the London Mathematical Society, 70 (1995), 146-182.
The geometric structure of skew lattices, Transactions of the American Mathematical Society, 335 (1993), 823-845.
Normal skew lattices, Semigroup Forum, 44 (1992), 1-8.
Skew Boolean algebras, Algebra Universalis, 27(1990), 497-506.
Skew lattices in rings Algebra Universalis, 26 (1989), 48-72.
Constructing inverse monoids from small categories, Semigroup Forum, 36 (1987), 89-116.
The $\mathcal{D}$*-category of a monoid*, Semigroup Forum, 34 (1986), 89-116.
Towards a theory of noncommutative lattices, Semigroup Forum, 34 (1986), 117-120.
Cohomology theory for monoid congruences, Houston Journal of Mathematics, 11 (1985), 207-223.

Extending groups by monoids, Journal of Algebra, 74 (1982), 1-19.
Triangles with verticies at roots of unity, American Mathematical Monthly, 87 (1980), 674.
Filling an open set with squares of specified area,
American Mathematical, Monthly, 87 (1980), 755-456.
The $\mathcal{D}$-category of a semigroup, Semigroup Forum, 11(1976), 283-296.
The structure of a band of groups,
Memoirs of the American Mathematical Society, 157 (1975), 67-95.
$\mathcal{H}$-coextensions of monoids, Memoirs of the American Mathematical Society, 157 (1975), 1-66.

Preprints

Rings whose idempotents form a multiplicative set (with K. Cvetko-Vah), submitted.
Cancellation in skew lattices (with K. Cvetko-Vah, M. Kinyon and M. Spinks), submitted.

In Preparation

Distributivity in skew lattices (with M. Kinyon).

Some Presentations of Research

Mathematics Seminar, University of Tasmania, Hobart, Tasmania, March 2006.
Linear Algebra Workshiop, Lake Bled, Slovenia, May 2005.
Algebra Symposium, Babes-Bolyai University, Cluj-Napoca, Romania, May 2005
Special Session on Lattice Theory and Applications, American Mathematical Society,
National Meeting, San Diego, January 2002.
The Ninth International Colloquium on Numerical Analysis and Computer Science,
Plovdiv, Bulgaria, August 2000.
Symposium on Universal Algebra and Multiple-Valued Logic,
Winter Meeting of the Canadian Mathematical Society, Kingston, Ontario, Dec. 1998.
Workshop on Semigroup Theory in Honor of John W. Howie,
Universidade de Lisboa, Lisbon, Portugal, May 1996.
Conference on Semigroup Theory and its Applications in Memory of Alfred H. Clifford,
Tulane University, New Orleans, Louisiana, March 1994.
Special Session on Algebraic Semigroups,
Regional Meeting of the American Mathematical Society, Springfield, MO, March 1994.
International Conference on Lattices, Semigroups and Universal Algebras,
Lisbon, Portugal, June 1988.
Algebra Colloquium, Departamento de Algebra, Universidad de Granada,
Granada, Spain, June 1988.
Ring Theory Seminar, University of California, Santa Barbara, October 1986.
NIH Conference on Universal Algebra and Lattice Theory, Bethesda, Maryland, August 1986.

Other Scholarly and Professional Activities

Frequent reviewer for Mathematical Reviews.
Referee of numerous articles for various professional journals.
External reader for doctoral dissertations.
Templeton-Oxford Seminars on Science and Religion, Oxford University, 1999–2001.
Workshop on Mathematics in the Arts and Humanities, Dartmouth, July 1998.
Workshop on Universal Algebra and Category Theory, MSRI, Berkeley, July 1993.
20th International Congress of Mathematicians in Berkeley, August 1986.

Curriculum Vita
C. Ray Rosentrater

I. Personal

C. Ray Rosentrater,
Professor of Mathematics and Computer Science.
Associate Dean for Curriculum.
Westmont College
955 La Paz Road, Santa Barbara CA 93108
e-mail: rosentrater@westmont.edu
URL: http://homepage.westmont.edu/rosentr/
fax: 805.565.7036
phone: 805.565.6185

II. Education

1988, M.Sc., Computer Science, University of Toronto.
1980, Ph.D., Mathematics (Operator Theory), Indiana University.
1978, M.A., Probability and Statistics, Indiana University.
1975, M.A., Pure Mathematics, Indiana University.
1973, B.A., Mathematics, Messiah College.

Ph.D. Dissertation: "Weighted Shifts and d-Symmetry"
Advisor: J. P. Williams

III. Teaching Experience

1991-Present Professor, Westmont College.
1985-1991, Associate Professor, Westmont College.
1980-1985, Assistant Professor, Westmont College.
1975-1976, Interim Instructor, Houghton College.
1976-1979, 1974-1975, Associate Instructor, Indiana University.
(Including one year teaching in the Compensatory Education Program.)

IV. Administrative Experience

1981-1983	Faculty Senate (Personnel Committee).
1982-1983	Campus Security Task Force.
1983-1986	Athletic Committee (Chair).
1983-1987	Faculty Athletic Representative.
1984-1987	Computer Committee.
1986-1987	Faculty Council (Chair).
1986-1987	Vice Chair of the Faculty. *Developed college retrenchment policy which was later incorporated into the Faculty Handbook.*
Spring 1989	Computer Committee.
1989-1990	Personnel Committee.
1990-1995	Computer Committee (Chair).

	Developed networking proposal.
1991-1994	Academic Senate Executive Committee.
1991-1995	Chair, Department of Mathematics and Computer Science. *Coordinated a curriculum revision and the writing of a mathematics subject matter preparation program proposal for the California Commission of Teacher Credentialing.*
1991-1995	Academic Senate.
1996-1997	Faculty Salary and Benefits Committee. *Developed revised salary schedule.*
1997-1999	Faculty Council.
1998-1999	Vice Chair of the Faculty.
1998-1999	Accreditation Report Task Force.
1998-2001	Building Advisory Task Force.
1999-2002	G.E. Task Force
2003-present	Associate Dean for Curriculum *Chair Academic Senate and its subcommittees. Chair G.E. Committee. Serve on: WASC Committee, WASC Educational Effectiveness Subcommittee, Program Review Committee, and President's Council*

Awards/Grants

Faculty Development Grant, support for preparation of "Compact Operators and Derivations Induced by Weighted Shifts.", 1981.

Westmont College Faculty Research Award, 1987

Westmont College Teacher of the Year Award (Natural & Behavioral Sciences Division), 1991

Faculty Development Grant, support for preparation of group exercise workbooks for Fundamentals of Mathematics, 1993.

Filbright, Honduras, 1995.

V. Publications

"Not Every d-Symmetric Operator is GCR." *Proceedings of the American Mathematical Society,* **81** (1981), 443-446.

"Clustering Means: Problem 1122." *Mathematics Magazine,* **55** (1982), 238-239.

"Compact Operators and Derivations Induced by Weighted Shifts." *Pacific Journal of Mathematics,* **104** (1983), 465-470.

"Real Number Representations and the Distribution of Following Segments." *Proceedings of the ACMS*, **8** (1991), 90-100.

(with Jim Gleason) "The Mosaic and Principal Function of a Subnormal Operator." *Integral Equations and Operator Theory*, **55** (2006), 69-82.

"Another Stick-Breaking Game: Problem 11089." *The American Mathematical Monthly*, **113** (2006), 571-572.

"The Sample Correlation Coefficient from a Linear Algebra Perspective." *The College Mathematics Journal,* **36** (2006), 47-50.

(with Jim Glelason) "Xia's Analytic Model of a subnormal Operator and its Applications." *Rocky Mountain Journal of Mathematics*, **38** (2008).

In Progress:
"Representational Efficiency." (Submitted to *Mathematics Magazine*)

VI. Professional and related Activities

Memberships:
Association for Christians in the Mathematical Sciences (Board member 2002-2009, Vice-President 2005-2007, President 2007-2009)
Mathematical Association of America
Phi Kappa Phi (Chapter V.P. 1997-1999, Pres. 1999-2001)
Sigma Delta Pi
Sigma Xi

Presentations:

Respondent, Phi Kappa Phi Spring Lecture, 1987, 1993.

"A Gentle Introduction to d-Symmetric Operators."
Operator Theory Seminar, University of Toronto, 1989.

"The Theory of d-Symmetric Operators.",
Operator Theory Group, University of Waterloo, 1989.

"Leading Digits and the Efficiency of Real Number Representations." ACMS biannual conference, 1991.

"Efficiency of Real Number Representation."
Mathematics-Computer Science Colloquium, California Lutheran University, 1992

"Panel on Computer Science: The New ACM Curriculum."
ACMS biannual conference, 1993.

Curriculum:

Created several workbooks containing group exercises in Logic, Sets, Numeration systems and associated algorithms, Probability, Statistics, and Geometry for the Fundamentals of Mathematics courses. These courses are designed to provide prospective elementary education teachers with a mature understanding of the mathematical topics which appear in the elementary school curriculum.

"Finite Mathematics: Tools for Decision Making." (Textbook)

Other Activities:

Regular attendance at local and national professional meetings.

Submission of solutions to *Mathematical Monthly,* and *Mathematics Magazine* problems.

Periodic coach of the Westmont College Problem Solving Group and Putnam Competition Team.

Computing consultant to Financial Planning Services, Santa Barbara, 1981-1982.

Curriculum consultant to Compucamp, 1983.

Reviewer for Wiley, **Elementary Linear Algebra (5th Ed.)** by Howard Anton, 1990.

Reviewer for Houghton Mifflin, **Applied Finite Mathematics**, by Alan Hoenig, 1992

Statistical consultant to Scott Wentz. *Using impedance to estimate percentage of body fat*. 1992-1993

Reviewer for West Publishing, Prospectus for CS-1/CS-2 text based on C++, Spring, 1994.

Reviewer for West Publishing, **Programming and Problem Solving with C++**, Fall, 1994.

Statistical consultant, Bruce Hull, *Assessing real estate values from tax roll value*s, 1995 – 2000.

Reviewer for Addison Wesley, supplemental chapter to **Linear Algebra and Its Applications**, by David Lay, Spring, 2006.

Resident Director, Westmont in Mexico, Fall, 2006.

VIII. Community Service

Director: CYC, Santa Barbara Free Methodist Church, 1981-1982.

Choir Director, Santa Barbara Free Methodist Church, 1982-1985.

Member of chorus and soloist, "Music of Penman Lovingood," Labero Theater, March 1982.

Chair, Direction and Development Committee, Carpinteria Free Methodist Church, July-November 1989.

Treasurer, Carpinteria Free Methodist Church, 1989-1991.

Guest speaker, "Elementary Graph Theory," 4th grade class, Cold Springs School, April 1990.

Local coordinator, Bike-A-Thon to support St. Jude's Children Research Hospital, October 1990, October 1991.

Guest speaker, "Elementary Graph Theory," 5/6th grade class, Aliso School, October 1990.

Trustee, Santa Barbara Free Methodist Church, 1992-1995.

Teacher 3-4th grade Sunday School class, Free Methodist Church, 1991-2001.

Property and Finance Board, Santa Barbara Free Methodist Church, 1993-1999 (chair 1993-1996).

Director of Occasional Choir, Santa Barbra Free Methodist Church, 1998-present.

Official Board, Santa Barbara Free Methodist Church, 2000-2008.

Compensation Committee, Santa Barbara Free Methodist Church, 2006-present.

Ministerial Education and Guidance Board, Free Methodist Church, Southern California Conference.

2.A.4 Sabbaticals and Grants

Russ Howell has brought the following grants to Westmont:

- The John Templeton Foundation, 2006 ($29,000)
  To develop a book connecting mathematical, philosophical, and theological ideas.

- Lilly Foundation, 2005 ($12,000)
  To fund the faith-learning program at Westmont College for one year.

- The John Templeton Foundation, 2003–2005 ($6000)
  Honorarium for participation in the John Templeton Seminars in Science and Christianity, held at Wycliffe Hall, Oxford, for four weeks in each of three consecutive summers. Also included were room and board plus transportation costs.

David Hunter received an internal Professional Development Grant in 2001 titled *Implementing algebraic structures in C++*. Professor Hunter also received an internal grant from the Provost's office in 2005 to fund an undergraduate research project with Chase Clanton: *Investigation of Phylogenetic Tree Reconstruction*. (Poster on display in the Mathematics Department.)

Ray Rosentrater received an internal Professional Development Grant in 2004 to fund an undergraduate research project with Manny Reyes and Justin Marks: *Machine Learning: An Analysis of the Nearest-Neighbor Algorithm*. (Poster on display in the Mathematics Department.)

Sabbaticals		
Faculty Member	*Date*	*Project*
Howell	F06–S07	Textbook on Mathematics for Liberal Arts Students. Also attended seminars and classes in Oxford, gave lectures, and wrote articles.
D. Hunter	S07	Textbook: *Essentials of Discrete Mathematics*
P. Hunter	S07	Research: Gertrude Cox and the formation of the discipline of statistics in the US.
Leech	S06	Research: Skew lattices and semigroup theory.
Rosentrater	S98	Textbook on Finite Mathematics

Table 9: Recent sabbaticals of mathematics faculty.

2.B Part-Time Faculty

For the following tables, "hours" means "credit hours," so an instructor teaching one course is listed as teaching 4 hours.

Profile of Part-time Faculty (2002–2003)				% of hours taught		
Faculty Member	Date hired	Gender	Ethnicity	Number of hours		Total hours
				Low. div.	Up. div.	
Throop	2002	M	Caucasian	4	0	4
Bates	2002	M	Caucasian	4	2	6

Profile of Part-time Faculty (2003–2004)				% of hours taught		
Faculty Member	Date hired	Gender	Ethnicity	Number of hours		Total hours
				Low. div.	Up. div.	
Throop	2002	M	Caucasian	4	0	4

Profile of Part-time Faculty (2004–2005)				% of hours taught		
Faculty Member	Date hired	Gender	Ethnicity	Number of hours		Total hours
				Low. div.	Up. div.	
Taylor	2004	M	Caucasian	8	0	8
Throop	2002	M	Caucasian	4	0	4

Profile of Part-time Faculty (2005–2006)				% of hours taught		
Faculty Member	Date hired	Gender	Ethnicity	Number of hours		Total hours
				Low. div.	Up. div.	
						0

Profile of Part-time Faculty (2006–2007)				% of hours taught		
Faculty Member	Date hired	Gender	Ethnicity	Number of hours		Total hours
				Low. div.	Up. div.	
Rehkopf	2006	M	Caucasian	4	0	4

Profile of Part-time Faculty (2007–2008)				% of hours taught		
Faculty Member	Date hired	Gender	Ethnicity	Number of hours		Total hours
				Low. div.	Up. div.	
Fong	2007	M	Asian	4	0	4
Taylor	2004	M	Caucasian	4	0	4

Table 10: Profile of Part-time Faculty (2002-2008).

The proportion of part-time help relative to the total number of hours of instruction has been consistently low, ranging from 0% to 13%. Usually we need only one or two classes covered by part-time faculty, depending on institutional needs. For the past two years, Ray Rosentrater has been serving half-time as Associate Dean, so we have had to cover 12 hours of his load with a combination of overloads, part-time help, and temporary full-time help.

2.C Graduates: 2004-2008

Profile of Graduating Seniors (2004–2008)												
Class	# of Seniors			Ethnicity							Tracks	
	F	M	Total	aa	Lat	asi	ca	Int	Na	oth	BA	BS
2004	0	1	1			1						1
2005	1	2	3		1		2				1	2
2006	4	3	7			1	6				2	5
2007	2	0	2			1	1				1	1
2008	2	2	4		1		3				1	3

Table 11: Mathematics graduates: 2004–2008.

2.D Graduate Employment: 1999-2008

Several mathematics graduates have attended graduate school in mathematics or statistics at a range of institutions: Manny Reyes (2005) UC Berkeley, Jesse Peterson (2001) UCLA, Adam Hammett (2001) Ohio State, Patricia Calderon (2001) Harvard, Justin Marks (2006) Colorado State, Jacqueline Diaz (2008) UNLV. Two recent graduates have completed Ph.D.'s in mathematics: Adam Hammett (2001) and Jesse Peterson (2001). After finishing an NSF postdoc, Jesse now holds a tenure-track position at Vanderbilt. Adam holds a tenure-track position at Bethel College (IN).

Several recent graduates are now teaching high school mathematics, including Kelly Ary (2001), Leilani Hernandez (2002), David Lee (2003), Devany Hunt (2005), and Megan Argabright (2006). Leilani Hernandez also holds a Masters in Administration from Cal Poly San Luis Obispo.

Many graduates work in industry in jobs that use mathematics, explicitly or implicitly. Kyle Bechler (2005) is an analyst for Peritus Asset Management. Alissa Sie (2006) works for TynanGroup Inc., a development services firm. Kevin Kishiyama (2005) and Michael Petty (2006) work in the computer and information sciences, and Kimberly Wong (2007) has a job as an Implementation Software Engineer for Banker's Toolbox, Inc. Patsy Calderon (2001) works as a statistician in the D.C area.

Kristin Kidd (2006) completed a nursing degree at Johns Hopkins and is now working as a nurse. Chase Clanton (2006) is in medical school at Loma Linda. Melissa McLeod (2006) works for college advancement at Westmont.

2.E Test Scores

As part of our ongoing assessment program, graduating seniors are required to take the ETS's Major Field Test in Mathematics. These scores are reported below in

Section 3.B. In addition, some of our students take the CSET exam. The following table shows the mathematics subject scores for the past three years (maximum score = 4).

CSET Subject Scores			
	04–05	05–06	06–07
Mathematics	4.0	3.875	4.0

Table 12: CSET Subject Scores: Mathematics, 2004–2007.

3 Programs

3.A Student Learning Outcomes

3.A.1 Comprehensive statement

During the 2006–2007 academic year, the department made significant revisions to its student learning outcomes. After several discussions within the department and also with faculty from other departments, we developed the following four goals.

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 goals more clearly and concisely articulate our view of the mission of the department. While we believe this mission is consonant with the six college-wide learning standards, we feel a greater sense of ownership of the above four goals. Furthermore, we expect that these goals will lend themselves better to assessment through evaluation of empirical data.

3.A.2 Learning Outcome Matrix

The following table gives a brief overview of these 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 15 and 19 are required for the major, and at least one of 136, 140, and 155 is required.

Table 13: Learning outcome matrix.

3.A.3 Description of curriculum

The following five pages give the current catalog description of the Mathematics major.

Mathematics

Professors R. Howell, D. Hunter (chair), J. Leech, C. R. Rosentrater
Associate Professor P. Hunter

Description of the Major. Mathematics is a language capable of clear and precise expression and an analytic tool that can solve complex problems. It is important because of its many applications, but many mathematicians view the subject as a creative art in which human reason finds its purest expression. The attention to precise reasoning in mathematics as well as its emphasis on abstraction and creativity identify it as a discipline central to the liberal arts and sciences. Students will find that this perspective permeates the teaching of mathematics at Westmont.

Distinctive Features. The program in mathematics provides solid preparation for graduate study; it also facilitates interaction, both academic and social, with faculty and peers. Among the educational advantages the program offers are opportunities for students to participate in various research projects, problem-solving groups, or work as teaching assistants. Westmont students also help prepare and run an annual high school mathematics contest that the College hosts. This popular event has helped place Westmont as a leader in mathematics education, and its graduates who choose to enter this field are highly regarded. For more information on teacher preparation in mathematics, see p. 151.

Career Choices. By choosing the appropriate courses, students can prepare for: graduate study in mathematics; a career in secondary education; opportunities in computer science and operations research; or study in disciplines akin to mathematics in methodology (e.g., linguistics) or which rely heavily on mathematics (e.g., engineering, actuarial science, statistics, economics).

Admissions Math Requirement

The admissions math requirement is a prerequisite for all mathematics courses, unless otherwise noted. The requirement is as follows: Three years of high school math, including Algebra II, or a math SAT I score of 550 or ACT math score of 22. For further information, see p. 243.

Requirements for a Mathematics Major (B.S. Degree): 54 units

Lower-Division Courses: 24 units

MA 9 Elementary Calculus I (4)
MA 10 Elementary Calculus II (4)

MA 15/CS 15 Discrete Mathematics (4) *or* MA 19 Multivariable Calculus (4)
MA 20 Linear Algebra (4)
One of the following applied course sequences: (8-9)
CHM 5, 6 General Chemistry I, II (4,4)
CS 10, 30 Introduction to Computer Science I, II (4,4)
PHY 21, 23 General Physics I, II (4,4)

Foundation Courses: 8 units
MA 108 Mathematical Analysis (4)
MA 110 Modern Algebra (4)

In-Depth Study *(Choose one of the following)*: 4 units
MA 109 Advanced Mathematical Analysis (4)
MA 111 Applied Modern Algebra (4)

Problem Solving: 2 units
MA 180 Problem Solving Seminar (1,1)

Capstone Course *(Choose one of the following)*: 4 units
MA 136 Geometry (4)
MA 140 Complex Analysis (4)
MA 155 History of Mathematics (4)

Breadth: 12 units
(Choose any 12 additional units chosen from upper-division mathematics courses or CS 135)

Requirements for a Mathematics Major (B.A. Degree): 46 units

Lower-Division Courses: 20 units
MA 9, 10 Elementary Calculus I, II (4,4)
MA 15/CS 15 Discrete Mathematics (4) *or* MA 19 Multivariable Calculus (4)
MA 20 Linear Algebra (4)
One of the following applied courses: (4)
CS 5 Fundamentals of Computing (4)
CS 10 Introduction to Computer Science I (4)
CHM 5 General Chemistry I (4)
PHY 21 General Physics I (4)

Foundational Courses: 8 units
MA 108 Mathematical Analysis (4)
MA 110 Modern Algebra (4)

Problem Solving: 2 units
MA 180 Problem Solving Seminar (1,1)

Capstone Course (*Choose one of the following*): 4 units
MA 136 Geometry (4)
MA 140 Complex Analysis (4)
MA 155 History of Mathematics (4)

Breadth: 12 units

(Choose any 12 additional units chosen from upper-division mathematics courses or CS 135)

Requirements for a Mathematics Minor: 24 units

MA 9, 10 Elementary Calculus I, II (4,4)
MA 15/CS 15 Discrete Mathematics (4) *or* MA 19 Multivariable Calculus (4)
MA 20 Linear Algebra (4)
One of the following: (4)
- MA 110 Modern Algebra (4)
- MA 123 Number Theory (4)
- MA 136 Geometry (4)
- MA 155 History of Mathematics (4)

One of the following: (4)
- MA 108 Mathematical Analysis (4)
- MA 121 Introduction to Numerical Analysis (4)
- MA 130 Probability and Statistics (4)
- MA 140 Complex Analysis (4)

Preparation for Teaching Mathematics at the Secondary Level

Students wishing to teach mathematics at the high school or junior high level should complete the requirements for a B.A. or B.S. degree. In order to complete a fifth-year Credential Program at Westmont, students should also complete four or more of the following prior to applying to the program:

KNS 156 Health Education for the Classroom Teacher (2)
ENG 106 Language Acquisition (4)
ED 101 Explorations in Teaching (4)
ED 105 Perspectives on Cultural Diversity and Education (4)
ED 130 Special Education for the Classroom Teacher (2)
ED 161 Computers for the Classroom Teacher: Secondary (2)

In many cases, it is possible to complete requirements for the mathematics major and the Westmont Credential Program in four years. Such a "fast-track" program requires early planning. All students wishing to explore secondary teaching are strongly encouraged to consult with faculty advisors in the Department of Education as early in their undergraduate program as possible, in addition to their major advisor.

Lower-Division Course Descriptions

MA 4 Mathematics in Western Culture (4) Prerequisite: Admissions math requirement. A survey of some of the great ideas and questions in mathematics in the context of their historical/cultural formulation. Emphasis on conceptual rather than computational skills.

MA 5 Introduction to Statistics (4) Prerequisite: Admissions math requirement. Exploratory data analysis, correlation and regression. Distributions: normal, binomial, Student's t, chi-square, F. Inferential statistics: parametric and non-parametric tests for population parameters; tests for goodness-of-fit and independence; t-tests; analysis of variance. Extensive use of spreadsheets.

MA 7 Finite Mathematics (4) Prerequisite: Admissions math requirement. Discrete mathematics: probability, linear programming, game theory, matrices, Markov chains.

MA 9, 10 Elementary Calculus I, II (4,4) Prerequisite for MA 9: Admissions math requirement. Prerequisite for MA 10: MA 9 or equivalent. Functions, graphs, limits, differentiation, integration, sequences, series. Introduction to numerical methods.

MA 10H Honors Calculus II (4) Prerequisite: MA 9 or equivalent and instructor approval. Functions, graphs, limits, differentiation, integration, sequences, series. Emphasis on theoretical aspects of the calculus, with extensive computer use to illustrate patterns and perform complex computations.

MA 15/CS 15 Discrete Mathematics (4) Prerequisite: Admissions Math Requirement. The study of ideas of discrete mathematics including sets, permutations, relations, graphs, trees, and finite-state machines. Using these concepts, students will learn mathematical skills such as: methods of proof; problem solving via advanced counting techniques; problem solving through the creation of algorithms.

MA 19 Multivariable Calculus (4) Prerequisite: MA 10 or 10H. Elements of vector analysis. Functions of several variables. Differentiation, partial differentiation, gradient, implicit functions. Integration, multiple integrals, line integrals, Green's Theorem.

MA 20 Linear Algebra (4) Prerequisite: MA 10 or 10H. Vector spaces, linear transformations, matrices, eigenvalues and eigenvectors; orthogonality; applications to differential equations, and optimization problems.

MA 40 Differential Equations (4) Prerequisite: MA 10 or 10H. First-order equations, linear equations, systems of linear equations. Series solutions, transform methods, numerical methods. Applications. Existence and uniqueness theorems.

MA 90 Seminar (1) Required attendance in the seminars offered by the Natural and Behavioral Science Division during a given semester. Students enrolled will be under the guidance of a faculty mentor and will meet periodically to discuss the wide range of topics presented in the seminars. Seminars usually occur on Friday afternoons.

Upper-Division Course Descriptions

MA 108 Mathematical Analysis (4) Prerequisite: MA 20. Topology of metric spaces, Riemann-Stieltjes integration, differentiation, sequences and series of functions, power series.

MA 109 Advanced Mathematical Analysis (4) Prerequisite: MA 108. Measure and integration theory, space of functions, Fourier series.

MA 110 Modern Algebra (4) Prerequisite: MA 20. Groups including permutation groups, subgroups, factor groups and isomorphism theorems. Rings and ideal theory. Fields and their extensions. Applications to solving polynomial equations and geometry.

MA 111 Advanced Modern Algebra (4) Topics will be selected from among the following: Group actions and Burnside's Theorem; Sylow Theorems; subnormal subgroup series, the Jordan-Holder Theorem; structure theorems for finitely generated abelian groups. Extension fields and their automorphism groups, Galois Theory; solvability of polynomials by radicals. Unique factorization in integral domains.

MA 121 Introduction to Numerical Analysis (4) Prerequisite: MA 10 or 10H, Recommended: CS 10. Numerical methods in the solution of equations; polynomial approximations; integration, and the solution of differential equations. Use of computer where applicable.

MA 123 Number Theory (4) Prerequisite: MA 19 or MA 20. Prime factorization and the distribution of primes. Congruences and residue class arithmetic; quadratic residues and Gauss reciprocity. Primality testing and pseudoprimes with applications to cryptography. Arithmetic functions. Theorems on sums of squares and other results inspired by Fermat.

MA 130 Probability and Statistics (4) Prerequisite: MA 10 or 10H. Probability spaces, random variables, discrete and absolutely continuous distributions, independence, conditional probability. Normal, binomial, Poisson distributions, joint distributions. Moments. Central Limit Theorem. Hypothesis testing, point estimation.

MA 135 Formal Languages and Automata (4) Prerequisite: CS 30. Regular languages; finite automata. Context-free languages; pushdown automata; Turing machines, halting problem. Computability. (Offered in alternate years, spring semester.)

MA 136 Geometry (4) Prerequisite: MA 20. Axiomatic systems; finite geometries, neutral and hyperbolic geometries, transformations of the Euclidean plane, projective geometry.

MA 140 Complex Analysis (4) Prerequisite: MA 19. Complex numbers, analytic and harmonic functions, integrals, series, residues and poles, conformal maps, Fundamental Theorem of Algebra and the classical theorems obtained in complex analysis. Discussion of some of the great topics in complex analysis such as the Tiemann Hypothesis and Bieberbach Conjecture (now a theorem).

MA 150 Topics (4) Prerequisite: MA 19 or MA 20. Course content will be determined by student interest and need.

MA 155 History of Mathematics (4) Prerequisite: MA 19 or MA 20. Survey of the historical development of mathematics from antiquity through the early twentieth century. Topics included: mathematics in ancient Greece, mathematics in China and India during the medieval period, the mathematics of Islam, the evolution of ideas in such areas as geometry, number theory, calculus, algebra, and set theory. Includes exploration of historiographical questions and of questions about the nature of mathematical discovery and proof. Emphasizes use of primary sources.

MA 160, 165 Fundamentals of Mathematics I, II (4,2) Not for credit toward mathematics major. Logic, sets, numbers, natural numbers, numeration systems, algorithms for arithmetic operations, geometry, probability. (GE Reasoning Abstractly for MA 160; Quantitative and Analytical Reasoning for MA 165). MA 160 is a prerequisite for MA165

MA 180 Problem Solving Seminar (1) Solve published problems from sources such as *The American Mathematical Monthly*, *Mathematics Magazine*, or *Math Horizons*, and submit solutions for publication. Fall semester students will also prepare for the Putnam examination, while spring semester students will assist in organizing the annual mathematics contest. May be repeated for credit. Does not satisfy the Breadth requirement for the mathematics major.

MA 190SS, 191SS Mathematics Seminar for Service Learning Internship (1,0) Prerequisite: Consent of instructor. Students will spend one (MA-191SS) or three hours (MA-190SS) per week either (1) tutoring elementary, junior high, or high school students, primarily in mathematics or (2) running after-school enrichment programs in mathematics or computer science in local elementary, junior high, or high schools. Students will also attend three 1-hour course meetings, and write a reflective paper on the experience. Does not satisfy the Breadth requirement for the mathematics major. (By arrangement.)

Our catalog description aligns well with comparable institutions and national standards. The following table compares the number of courses required for Westmont's major with mathematics majors at other institutions.

Program	req'd MA courses #LD	#UD	Notes
Westmont (B.A.)	4	6.5	Two Problem Solving units account for the half course.
Westmont (B.S.)	4	7.5	Two Problem Solving units account for the half course.
St. Olaf	3	7	Requirements may vary based on individual programs. Some lower-division intermediate courses may be substituted for upper-division courses.
Gordon College	7	4	
Houghton College	4	3	One of these lower-division could be regarded as upper-division.
Asuza Pacific	6	5	Four lower-division courses are 4 units, one is 5 units, and all other courses are 3 units.
Pomona College	4	8	One upper-division course (Vector Calculus) may be substituted for a lower-division course (Multivariable Calculus).

Table 14: Curriculum comparison with comparable institutions.

The Mathematical Association of America's Committee on on the Undergraduate Program in Mathematics (CUPM) Curriculum Guide (2004)[1] makes the following recommendations.

> Every course should incorporate activities that will help all students progress in developing analytical, critical reasoning, problem-solving, and communication skills and acquiring mathematical habits of mind. More specifically, these activities should be designed to advance and measure students' progress in learning to
>
> - State problems carefully, modify problems when necessary to make them tractable, articulate assumptions, appreciate the value of precise definition, reason logically to conclusions, and interpret results intelligently;
> - Approach problem solving with a willingness to try multiple approaches, persist in the face of difficulties, assess the correctness of solutions, explore examples, pose questions, and devise and test conjectures;
> - Read mathematics with understanding and communicate mathematical ideas with clarity and coherence through writing and speaking.

These recommendations resonate in particular with the Communication and Creativity standards of our department.

[1]See http://www.maa.org/CUPM/curr_guide.html (external link).

3.A.4 Co-curricular activities

For more than 20 years, the department has hosted a mathematics contest for local high school students. The students in our program (majors, minors, and others) participate as proctors and graders of the contest. While we do not formally assess this co-curricular activity, it does suggest relationships to the four learning outcomes.

Core Knowledge. Students must understand the material in order to grade and proctor.

Communication. Students must be able to communicate clearly with contest participants, and students must judge how participants communicate their ideas.

Creativity. Most of the contest problems are non-standard.

Christian Connection. This event is an opportunity to serve our community.

For the past five years, the department has hosted a retreat for mathematics and computer science students. While the theme of the retreat varies, it is often a time to cast a general vision about what we want our majors to learn. Often these themes relate to the learning standards; in Fall 2007, the theme of the retreat was actually based on the four learning standards.

Holding the retreat simultaneously for both groups of students has been problematic, however, because the disciplines of mathematics and computer science are quite different. We are currently exploring alternatives to this event.

3.B Assessment of the Outcomes

3.B.1 Introduction

Since 2006, the department has worked very hard to develop a meaningful and sustainable program of assessment. The above learning outcome matrix summarizes our ongoing assessment program. Though this program has only recently been developed, we have already begun the process of collecting and interpreting assessment data. We assess the four learning standards using national standardized tests, student writing samples scored by rubrics, and results of peer-reviewed submissions to mathematics journals.

3.B.2 Evidence, Analysis, and Reflection

In this section we describe assessment results for each learning standard. Data is summarized below; original student papers are on file in the mathematics department, and can be accessed through the mathematics program review web page (external link).

Core Knowledge. Starting with the class of 2008, all graduating seniors in mathematics are required to take the ETS's Major Field Test in mathematics (external link). The results for 2008 are as follows:

Student ID	Date Taken	Score	%ile
W	4/9/2008	181	≥ 85
X	4/10/2008	143	≥ 20
Y	4/10/2008	146	≥ 25
Z	4/23/2008	184	≥ 90

Table 15: ETS Major Field Test in Mathematics results, 2008.

Discussion and interpretation of results: These results meet our benchmark: 50% of students scored above the 75th percentile of students taking the test nationally. The results also agreed with our shared expectations about these four students: classroom performance of students X and Y was routinely below that of students W and Z, and the highest scoring student (Z) had been previously selected as the Outstanding Graduate in Mathematics.

The Educational Testing Service will not release subscore data until at least five people have taken the test, so we will have to wait until 2009 to get further information on subscores. 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. The subscore data of the MFT will allow us to assess the first learning standard across a broad range of courses in our major.

Communication. In those courses identified as writing-intensive (MA 108, MA 110, MA 136), writing samples are gathered from each student at two points in the semester: within the first two weeks and during the last two weeks. These writing samples will be reviewed using the department writing rubric (see Figure 1) and various components of each paper will be rated as Weak, Acceptable, or Outstanding.

Our benchmark is that 75% of the students will show improvement in their cumulative score from the first writing sample to the second.

On 6/4/2008 the mathematics met to collectively evaluate data assessing the Communication learning standard.

Using the rubric for scoring mathematical writing that we developed in Spring 2008, we began by having each department member apply the rubric to the same writing sample (collected Fall 2007) to calibrate for interrater reliability. Using a modified Delphi technique, we obtained scores were generally in agreement, aside from minor variations attributable to subjective judgments. As a result of this exercise, we decided to modify the Exposition section of the rubric, adding a category for Spelling and Grammar.

Next, we collectively applied the rubric to two sets of writing samples, collected in January and March of 2008. Each writing sample was graded by two different department members. The results are tabulated in Figure 2.

Discussion and interpretation of results: We agreed that the students whose samples were collected were below the average ability of our typical students. However, we did notice that students who have taken more mathematics courses in the department tended to score higher as assessed by our writing rubric. We concluded that our upper-division courses are having a cumulative positive effect on the ability of our students to write well according to the norms of the discipline. Note that five of six students showed improvement, so the benchmark was achieved.

We discussed the need to assess this learning standard in the introductory and developmental stages (MA 4, 5, 9, 10, 15, 19, 20, 121, 160, 165), as well as in the mastery stage. (See the learning outcome matrix.) We decided that comparisons between lower-division and upper-division writing would be confounded by the differences in difficulty of material and expectations for originality. Therefore we plan to devote one meeting each year to discuss (informally) how we are addressing and assessing this learning standard in our lower-division courses. We also noted that when assessment instruments are developed for the QAR and RA areas of General Education, that these instruments may provide data on this learning standard. (Similar comments hold for the Creativity learning standard.)

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

I. Formatting	*Weak (1)*	*Acceptable (2)*	*Outstanding (3)*	*Score*
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.	
			Subscore:	
II. Variables/Symbols	*Weak (1)*	*Acceptable (2)*	*Outstanding (3)*	*Score*
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.	
			Subscore:	
III. Typesetting (if applicable)	*Weak (1)*	*Acceptable (2)*	*Outstanding (3)*	*Score*
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.	
			Subscore:	
IV. Logic	*Weak (1)*	*Acceptable (2)*	*Outstanding (3)*	*Score*
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.	
			Subscore:	
V. Exposition	*Weak (1)*	*Acceptable (2)*	*Outstanding (3)*	*Score*
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.	
			Subscore:	

Figure 1: Rubric for writing sample.

Mathematical Writing Assessment Data 6/4/2008

Category	*AA47*	*AA40*	*JW47*	*JW40*	*WH47*	*WH40*	*JD47*	*JD40*	*JG47*	*JG40*	*KZ47*	*KZ40*
I. Formatting												
Layout	2.5	1.5	2.5	2.5	1.5	2	3	2.5	2.5	1	3	2.5
Alignment	2.5	2.5	3	3	2	2	3	3	3	1	3	2.5
II. Symbols												
Names	3	3	3	2.5	3	3	3	3	2.5	2.5	3	3
Symbols	3	2	2.5	2.5	2.5	2.5	3	3	3	1.5	3	2.5
III. Typesetting	**N/A**											
Font												
Sub/super												
Formatting												
IV. Logic												
Sound	2.5	1.5	2	3	2	1	3	2	2	1	2	1.5
Definitions	2.5	1.5	2.5	2.5	1.5	1.5	3	2	3	1.5	3	2
Justified	2	1.5	3	2.5	1.5	1	3	2	3	1	3	2
V.Exposition												
Writing	2.5	1	2	2	1	1	2.5	2	2.5	1.5	3	2.5
Variation	2.5	2.5	2.5	3	1.5	1.5	3	2.5	3	1.5	3	2
Variables	2	3	1.5	3	1	1.5	2	3	2	2	3	2.5
Assumptions	2.5	2.5	2.5	2.5	1.5	1	2.5	3	1.5	1.5	3	3
Prose	2.5	1	2.5	2.5	1	1	3	2	1.5	1.5	2.5	2
Grammar	1	2.5	2	3	1	1	2.5	2.5	2	3	2.5	1.5
total raw:	*31*	*26*	*31.5*	*34.5*	*21*	*20*	*36.5*	*32.5*	*31.5*	*20.5*	*37*	*29.5*
Notes: Scores are averages of two graders for each item.												

Figure 2: Tabulation of writing sample assessment data, 6/4/2008.

Creativity. We have two ways to assess the Creativity standard:

1. All mathematics majors take the Problem Solving course (MA 180) in which they will attempt to solve novel problems found in mathematics journals such as *The American Mathematical Monthly*, *The College Mathematics Journal*, *Math Horizons*, and *Mathematics Magazine*.

2. Qualified mathematics and computer science majors will participate in undergraduate research projects.

The corresponding benchmarks are as follows.

1. 50% of all participants in MA 180 (Problem Solving) will produce a correct solution to a problem from a journal (as arbitrated by the journal).

2. Before graduation, 25% of mathematics majors will complete some form of summative work stemming from a research project (e.g., poster, paper, or presentation).

In Spring 2008, every participant in MA 180 produced at least one correct solution to a problem. Because of lag time in journal production, not all of these have been officially deemed correct by the respective journals, but we expect that all will. In any event, Benchmark #1 has certainly been attained.

The class of 2008 produced no research projects in mathematics, though one student had planned to complete a summer research project and later decided to do research in computer science instead.

Discussion and interpretation of results: As with the Communication standard, we discussed the need to meet annually for an informal discussion of how Creativity is being addressed in our introductory and developmental courses. Benchmark #2 is quite ambitious, given the difficulty of doing undergraduate research in mathematics. According to the CUPM subcommittee on Research by Undergraduates, there are costs to doing undergraduate research in mathematics.

> While undergraduate researchers in other disciplines often assist the project mentor in his/her own research projects, undergraduate research projects in mathematics are often created specifically for undergraduates. Thus, time spent on leading an undergraduate research project is often time taken away from the mentor's own research endeavors. While undergraduate research is extremely beneficial to the student and to the department, it does not always advance the faculty member's own research program. [CUPM] (external link)

Christian Connection. Students in capstone courses (MA 136, MA 140, MA 155) will write a short paper on some topic, part of which reflects on the nature of mathematics in the Christian context and/or the integration of faith and learning. These papers will be scored using the department reflective paper rubric (see Figure 3) and the over-all level of writing in each paper rated as Lacking, Adequate, or Superior in two categories. The rubric assesses whether students can make substantive connections between faith and mathematics, and whether their writing exhibits a mature perspective on the discipline of mathematics.

Our benchmark is that 50% of students in these classes will score Superior on at least one of the two categories.

On 6/5/2008, the five mathematics faculty met to collectively evaluate data collected in MA 140, Spring 2008. We applied a previous draft of the reflective paper rubric to all the papers collected in this class of seven students. Each faculty member scored two papers, in order to evaluate the interrater reliability of the rubric. Results are given in Table 16. Scores are given as $x : y$, where x scores substantive connections between faith and mathematics, and y scores the maturity of the perspective on the discipline of mathematics.

Discussion and interpretation of results: We were disappointed at the interrater reliability of our original rubric. As a result, we decided to add more specificity to the rubric in the form of more examples that would satisfy each criterion. In the first area of evaluation, we added the following example.

- Describes how Christian values influence one's approach to the discipline of mathematics.

In the second area of evaluation, we added the following.

- Displays an authentic appreciation for mathematics.
- Displays an understanding of what it means to do mathematics.

We agreed that, given the novelty of this learning standard, our rubric would have to be viewed as a work-in-progress, until we gain more experience evaluating these reflective papers. Note that the rubric itself leaves room for new examples to be added in future.

Even with the revisions to the rubric, our students fell short of the stated benchmark. We do note that, although this course is a capstone course, this particular section contained only one senior. We discussed the possibility of the same student writing multiple reflective papers, and agreed that it would be helpful to monitor the progress

	RH	JL	RR	DH	PH
KZ		3:3		2:1	
DR		1:2	1:1		
RC	2:2		2:2		
MG				2:1	2:2
JD	2:2		1:1		
JG		1:3		1:1	
JW	2:2				1:2

Table 16: Scoring data on reflective papers.

of individual students in this assessment category. We therefore propose an additional benchmark, to be used in conjunction with the above benchmark in future: 50% of students who have written reflective papers in the past will show improvement over their previous work.

We also discussed the need to assess how the Christian Connection learning standard is being addressed in introductory and developmental courses (see the learning outcome matrix). Student course evaluations have the potential to indicate whether professors are addressing these issues, even if mastery is not expected. The College is currently undergoing a review of the student course evaluation instrument, and our hope is that the new version will provide a more robust measurement of the extent to which faith-learning integration is present in the classroom. We plan to monitor the development of the new evaluation instrument, and also the results of these evaluations.

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

Criterion	Substantive connections between faith and mathematics.		
Score:________	**1: Lacking** Paper does not identify any substantive connections between faith and mathematics.	**2: Adequate** Paper identifies one or more substantive connections of the types listed below, but these connections are not developed completely.	**3: Superior** Paper contains well-developed, substantive connections of one or more of the types listed below.
Examples	• Describes how studying mathematics has shaped life goals, especially as a disciple of Christ. • Describes how studying mathematics has informed a Christian world view. • Uses ideas from mathematics as a basis for Christian apologetics. • Uses ideas from mathematics to illustrate or illuminate a theological concept. • Describes how Christian values influence one's approach to the discipline of mathematics. • Makes another isomorphic connection. (Add to rubric.)		

Criterion	Mature perspective on the discipline of mathematics.		
Score:________	**1: Lacking** Paper contains none of the following characteristics.	**2: Adequate** Paper contains one or more of the following characteristics, but fails to develop any of these ideas in depth.	**3: Superior** Paper contains one or more of the following characteristics, and develops at least one of these ideas in depth.
Examples	• Displays a sophisticated understanding of some mathematical idea. • Describes specific connections between different areas of mathematics. • Describes specific connections between mathematics and another discipline. • Refers to original research done by the student. • Displays an authentic appreciation for mathematics. • Displays an understanding of what it means to do mathematics. • Exhibits a mature perspective on mathematics in an isomorphic way. (Add to rubric.)		

Figure 3: Rubric for reflective papers.

3.B.3 Evidence of Conversations

Since 2001, the department has engaged in several attempts at program review. In Summer 2001, the department spent a week discussing how our curriculum relates to the six college-wide learning standards. In 2005, the department began a series of conversations with assessment coordinators from other departments. These early efforts at program review produced only modest progress toward establishing an assessment program.

Not until the 2006-2007 academic year was the goal of assessment and program review clearly communicated to the department. Significant progress was made while working with Laura Montgomery, an assessment coordinator from the Sociology Department. It was during this academic year that the four learning standards were developed.

Given the difficulty in getting our assessment program started, much of the important work has been done over the last academic year. Table 17 summarizes the assessment work that the department has completed in the year 2007–2008. An archive of meeting minutes is available on the mathematics program review web page (external link).

3.B.4 Responses

The exercise of drafting learning standards and implementing a meaningful assessment program has prompted the department to make some changes in our program.

As a result of our deliberation on assessing the Creativity learning standard, we have decided to replace Seminar (MA 90) with Problem Solving (MA 180) for the mathematics major. All mathematics majors are now required to take 2 hours of Problem Solving.

In order to provide data to assess the Christian Connection learning standard, we now require a paper in our capstone courses that includes a component reflecting on the relationship between Christianity and mathematics.

This academic year we will consider whether to replace MA9 with MA15 in the requirements for the mathematics major. There are several reasons for making this change, but one reason is that MA15 deals more directly with mathematical language, so it should improve student writing.

The assessment data that we have gathered and analyzed indicates that we are doing well in general with respect to the four learning standards, but more data is needed to establish a clearer pattern. Early indications are that Core Knowledge, Communication, and Creativity are being taught effectively, but Christian Connection is an area in which we need to improve. We expect that the implementation of the reflective paper will make us more systematic about drawing connections between faith and mathematics in our classes.

Given Task	**Resolution**
In Fall 2007, the department will decide on a mechanism to ensure that all majors complete the major field test in their junior or senior year.	The department decided to offer the online ETS MFT to all graduating seniors. Students will be encouraged to participate with gift certificates, and high scorers will get more substantial gifts.
The department chair will order the MFT and selected faculty will administer it to the appropriate students in Spring 2008.	Tests were administered in April 2008, and the results were interpreted collectively by the department in June 2008.
In those courses identified as writing-intensive (MA 108, MA 110, MA 136), writing samples will be gathered from each student.	Data was been collected for previous sections of MA 109 and MA 111. Jonathan Leech collected this data in MA 110, Spring 2008.
During the 07–08 academic year, the department will meet to develop and refine the writing rubric.	In April 2008, the department worked together to develop the writing rubric. In June, 2008 the department met to apply the rubric to the collected papers and collectively interpret the results. .
Collect data on MA 180 during Fall 2007, and discuss if we are satisfied with our benchmarks.	Data was collected in Fall 07 and Spring 08. In June, we discussed this data collectively. .
In Fall 2007, we will decide on a mechanism and format for the reflective paper.	This year. Russ Howell assigned a reflective paper in Complex Analysis (MA–140). Similar papers will be assigned in all future capstone courses (136, 140, 155).
In Spring 2008, we will design a rubric for evaluating these papers, and set appropriate benchmarks.	Work began in April 2008 on developing a reflective paper rubric, and the rubric was finalized in June 2008.
In May 2008, we will apply this rubric to the first sample of reflective papers.	In June 2008, the department met to apply the reflective paper rubric and interpret results.
Develop Mission Statement for the Mathematics program.	The mission statement was discussed in March and April of 2008 and finalized in June 2008.

Table 17: Assessment and program review activities, 2007–2008.

3.B.5 Next Steps

The department now has a sustainable and meaningful assessment program. At this stage, we need to continue to collect and interpret data, refine our rubrics, and monitor our benchmarks.

Ongoing annual assessment tasks. The department will do the following tasks every year.

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 18.

Year	Program review overall	Details for assessment work
2008–09	Submit six-year program review report, 9/15/2008. Discuss admissions practices and recruitment of students. Decide whether to replace MA9 with MA15 in the major requirements.	Ongoing annual tasks. Review Creativity learning standard (#3). Conduct graduate school content survey.
2009–10	Discuss vision for future department staffing. Discuss alumni survey.	Ongoing annual tasks. Review Core Knowledge learning standard (#1).
2010–11	Review library holdings, check against MAA list.	Ongoing annual tasks. Review Christian Connection learning standard (#4).
2011–12	Review contributions to GE. Decide on status of Statistics (MA 5) as an Abstract Reasoning course.	Ongoing annual tasks. Review Communication learning standard (#2).
2012–13	Discuss vision for undergraduate research. Discuss quality of preparation for graduate school.	Ongoing annual tasks. Discuss/Revise learning standards.
2013–14	Prepare for six-year program review report, due 9/15/2014.	Ongoing annual tasks. Summarize assessment work from past six years.

Table 18: Six-year plan for assessment and program review.

3.C Conclusion

Much of the work by department members over the last six years has been devoted to learning the principles and goals of assessment and designing a meaningful and sustainable assessment program. From the department's perspective, the institution's more focused and concrete emphasis on assessment and program review in recent years has been very helpful. We appreciate having clear expectations, and the current Academic Dean, Assessment Coordinator, and Program Review Committee have been clear about what the department is supposed to be doing.

While we anticipate that the assessed data of future years will provide a clearer picture of the strengths and weaknesses of our program, the data that we have analyzed so far has provided preliminary indications about the state of our program. Many of these indications agree with our intuitive sense of the quality of our program, while others suggest that we need to pay more attention to aspects of our instruction that we have always taken for granted.

Our best students are doing very well. Several have succeeded in first-tier Ph.D. programs, and test scores of good students are high. Many go on to careers that use mathematics. Our top students are excellent mathematical writers.

Our majors have a wide range of native ability, and those with less ability probably retain less mathematical content than we would like, according to the results of the MFT. However, even these students show creativity in their approach to nonstandard problems, and their ability to write mathematically generally improves.

Drawing connections between faith and mathematics is challenging for most students. Students tend to approach issues of faith more experientially than intellectually, especially when compared to the approaches of most faculty. We need to continue to think about ways to help students make these connections with authenticity.

4 General Education

Our department contributes to two main areas of General Education: the Common Inquiry of Reasoning Abstractly (RA) and the Common Skill of Quantitative and Analytical Reasoning (QAR). The General Education Committee is responsible for developing assessment programs for these categories. So far, progress has been made for RA, but QAR still needs to be addressed. The following table summarizes the course that satisfy these two areas.

Course	**Title**	**GE**
MA 4	Mathematics in Western Culture	RA
MA 5	Statistics	RA, QAR
MA 7	Finite Mathematics	RA, QAR
MA 9	Calculus I	RA, QAR
MA 10	Calculus II	RA, QAR
MA 15	Discrete Mathematics	RA, QAR
MA 19	Multivariable Calculus	RA, QAR
MA 160	Fundamentals of Mathematics	RA
MA 165	Fundamentals of Mathematics II	RA, QAR

Table 19: GE course summary.

4.A Learning Outcomes

The following learning outcomes have been articulated for RA.

1. *Recognition:* Students can identify instances of abstract deductive reasoning about abstract objects or concepts (in the form of arguments, explanations, proofs, analyses, modeling, or processes of problem solving) and can distinguish premises from conclusions (or their analogues).

2. *Construction:* Students can construct an instance of valid deductive reasoning about abstract objects or concepts (in the form of arguments, explanations, proofs, analyses, modeling, or processes of problem solving).

3. *Evaluation:* Students can distinguish valid forms of deductive reasoning about abstract objects or concepts (in the form of arguments, explanations, proofs, analyses, modeling, or processes of problem solving) from invalid and/or fallacious forms of reasoning.

4.B Evidence

Our department has embarked on some pilot collection and evaluation of evidence to assess these learning outcomes. We designed the instrument in Figure 4 and applied it to several students in RA classes, as well as to faculty from other departments.

Patti Hunter designed a rubric for assessing abstract reasoning and applied the rubric to a sample of student work from a statistics class. The results are shown in Figure 5.

4.C Conversations

The mathematics and computer science faculty have had three very interesting meetings with philosophy professor and GE Committee member Jim Taylor, in which we discussed assessing RA. The minutes for these meetings, which took place on 10/26/07, 2/27/08, and 4/21/08, are available at the archive of meeting minutes on the mathematics program review web page (external link). Professor Taylor may also have additional minutes of these meetings.

4.D Conclusions

Assessing this area of the GE is going to be very difficult.

The pilot assessment instrument in Figure 4 was designed to test simple deduction from a set of axioms, and to do so in a neutral context. The hope was that students from all the RA courses—in math, computer science, and philosophy—would be able to use the same instrument. The results were very mixed: several good students (and some faculty) got the answers wrong, while several weaker students (and one 10-year-old child) got the answers right.

The pilot rubric in Figure 5 will probably provide more robust results. However, this rubric has the disadvantage of being course-specific: it can assess RA in the context of MA 5 (Introductory Statistics), but not in the context of another course.

We are skeptical that it will be possible to design a single instrument that all RA classes can use. A more promising strategy would be to design rubrics like the one in Figure 5 and apply them to student work early and late in the term.

4.E Suggested Changes

Work on assessing the GE is still in its infancy. We need to continue our work with the GE committee to develop an assessment strategy for RA.

1. Consider the following rules for forming "words" using only the letters `m`, `n`, and `o`.

   `m` is a word.

   `n` is a word.

   `o` is a word.

   If $\square$ is a word and $\triangle$ is a word, then $\square \triangle \square$ is also a word.

   If $\square$ is a word and $\triangle$ is a word, then $\triangle\square \triangle \square$ is also a word.

   Which of the following are words?

   (a) `mnonono`

   (b) `momonmomo`

   (c) `mno`

   (d) `nonom`

   (e) Both (a) and (b) are words.

   (f) Both (c) and (d) are words.

2. Consider the following rules for manipulating the symbols $\ominus$, $\odot$, and $\otimes$.

   $\ominus \odot \ominus$ can be replaced by $\otimes$.

   $\odot\odot$ can be replaced by $\ominus$.

   $\otimes\ominus$ can be replaced by $\odot$.

   By performing a sequence of replacements on $\ominus\otimes\ominus\ominus\otimes\ominus\otimes\ominus$, which of the following can be obtained?

   (a) $\ominus$

   (b) $\odot$

   (c) $\odot\otimes$

   (d) $\ominus\odot$

   (e) Both (c) and (d) can be obtained.

   (f) None of the above can be obtained.

Figure 4: Pilot assessment questions for Reasoning Abstractly.

Data from Spring 2008, P. Hunter

Reasoning Abstractly Assessment Rubric for MA-005 (Introduction to Statistics)

Construction: **Given premises, a student can construct the appropriate sequence of inferences for a significance test and draw the correct conclusion from that deductive reasoning.**

Exam Question

In a study of the effects of "subliminal" messages, a group of students who had failed the mathematics part of the New York Skills Assessment Test were randomly assigned to two treatment groups. All received a daily subliminal message, flashed on a screen too rapidly to be consciously read. The treatment group of 10 students was exposed to "Each day I am getting better in math." The control group of 8 students was exposed to a neutral message, "People are walking on the street." All students participated in a summer program designed to raise their math skills and all took the assessment test again at the end of the program. The table below gives data on the subjects' scores before and after the program.

You are going to carry out a matched pairs t test to determine if scores in the treatment group improved significantly. State your hypotheses symbolically, calculate a statistic and a p-value, and state your conclusion. Be sure to specify the meaning of any variables you introduce. ***For full credit, show all your work neatly and clearly.***

	Before		After		Gain	
	x-bar	**s**	**x-bar**	**s**	**x-bar**	**s**
Treatment group	19.7	2.21	31.1	4.48	11.4	3.17
Control group	20	3.16	28.5	4.89	8.25	3.69

State Hypotheses and define parameter(s):

Test statistic (show your work):

P-value:

Conclusion (state in terms of the context of the problem):

****

# of students	Proficiency Levels
15	**High Proficiency** States the hypotheses correctly using the correct parameter; Uses the correct formula for the test statistic and the appropriate data; Conclusion is consistent with reported p-value.
19	**Some Proficiency** States the hypotheses correctly using the correct parameter; Uses incorrect formula or inappropriate data for the test statistic; Conclusion is consistent with reported p-value. OR States the hypotheses *incorrectly* but Uses formula and data for the test statistic consistent with hypotheses; Conclusion is consistent with reported p-value. OR States the hypotheses *correctly* Uses correct formula and data Conclusion is incorrect.
27	**Inadequate Proficiency** Incorrect answers for 2 out of 3 questions (hypotheses, test statistic, or conclusion)

Figure 5: Rubric for assessing Reasoning Abstractly.

5 Resources

The discussion of resources for the department is complicated by the fact that two programs, Mathematics and Computer Science, are currently housed in a single department. These two programs are undergoing separate program review processes, and this report deals only with the Mathematics Program. However, the two programs share the same budget, even though their needs for resources may differ. In this section we will discuss the adequacy of the resources for the Mathematics Program, with the understanding that the departmental budget may not be adequate to support both programs.

5.A Adequacy of Current Budget

It is difficult to assess the adequacy of the current departmental budget, because the software the college uses to manage financial data (Vendorlink/Simpler Financials, by Simpler Systems Inc.) is terrible. What follows is our best guess, given the data we have.

The attached budgets[2] indicate that overall resources have been mostly adequate. To cover costs associated with our assessment program, we have been able to use money from other categories (e.g., system software). Hospitality (which includes the mathematics contest) was slightly over budget, possibly as a result of inviting several seminar speakers.

Our student wages had been a concern before this year, but we were under budget in 2007–2008. While data is difficult to access, we suspect that the surplus this year was due to extremely low enrollments in computer science courses. Computer science faculty currently teach only a 5/6 load, and courses are currently very small; if and when their teaching load goes back to normal and classes become more full, it is very likely that money for grading will be a concern.

5.B Additional Resources Needed

None of the program changes described above have had a significant impact on our budget. We have been able to realign our spending categories to meet current needs.

[2] See the six pages at the end of Section 5.

5.C Library Collection and Databases

The department met with our library liaison, Claudia Scott, on 10/16/2007. The consensus at that meeting was that there are no major shortcomings in our collection that can be reasonably addressed at a small college. While it would be nice to have a collection of mathematics journals, institutional subscriptions are prohibitively expensive. We would like to have access to MathSciNet (external link), Mathematical Reviews, but the number of times we use this service would not really justify the expense.

This year we had exactly enough money in our collection budget to buy all the books we wanted. Furthermore, the interlibrary loan service has been excellent. Given the reality of being an undergraduate institution (as opposed to being a research university), we are satisfied with our library resources.

5.D Auxiliary Academic Services

In September 2006, Dana Alexander and Celia Howen from the Office of Life Planning spoke at our departmental retreat. We were very grateful to have them, and we are satisfied with the resources their office provides our majors.

On 9/7/2007, a subset of the department met with Jennifer Taylor of the Internship Office. Jennifer helped us implement a new course, MA190/191SS, Mathematics Seminar for Service Learning Internship, which satisfied the Serving Society component of General Education. This office and also OLP contribute to our fourth learning standard (Christian Connection) by helping students understand how to use mathematics to serve others.

While the mathematics major does not require an off-campus experience, many of our students do participate. Courses that are required for the major and that are integral for assessment are offered in the spring to accommodate students who go off campus in the fall. Our students are now able to study mathematics in Hungary, as part of the Budapest Semester in Mathematics program. In fact, we have already sent one student on this program, and he fared reasonably well in the assessment instruments for the first three learning standards (though, of course, a single student is not a representative sample of our majors). The department believes that off-campus experiences can be a wonderful part of a Christian liberal arts education; as such, this office also contributes to the fourth departmental learning outcome.

Unrestricted Balances

As of 6/30/2008

Object	Month-To-Date Actual	Year-To-Date Actual	Year-To-Date Encumbrances	YTD Actual + Encumbrances	Fiscal Year Adj. Budget	Variance Fav. / (Unfav.)
Fund 11 -- Operations						
Department 24500 -- Mathematics and computer sci						
Expenditures - Operations						
51210 -- Faculty full time	0.00	466,627.86	0.00	466,627.86	466,630.00	2.14
51220 -- Faculty part time	0.00	4,550.00	0.00	4,550.00	4,550.00	0.00
51310 -- Support staff	0.00	24,216.50	1,232.00	25,448.50	26,510.00	1,061.50
51410 -- Student wages	0.00	5,005.54	0.00	5,005.54	7,710.00	2,704.46
51510 -- Temporary agency employees	0.00	0.00	0.00	0.00	0.00	0.00
51610 -- Vacation	-15.51	-15.51	0.00	-15.51	-15.51	0.00
51710 -- Allocated benefits	168,194.71	168,194.71	0.00	168,194.71	0.00	-168,194.71
52110 -- Printing and reprographics	303.40	1,080.33	0.00	1,080.33	1,510.00	429.67
52310 -- Postage	65.60	154.21	0.00	154.21	240.00	85.79
52410 -- Hospitality	0.00	4,185.83	0.00	4,185.83	4,040.00	-145.83
52630 -- Equipment rental	0.00	0.00	0.00	0.00	0.00	0.00
52631 -- Media equipment rental	0.00	0.00	0.00	0.00	0.00	0.00
53010 -- Supplies and materials	57.27	522.75	0.00	522.75	850.00	327.25
53012 -- System software	0.00	330.00	0.00	330.00	1,520.00	1,190.00
53020 -- Supplies materials classroom	92.97	312.09	0.00	312.09	1,250.00	937.91
53110 -- Minor furniture and equipment	179.76	179.76	0.00	179.76	0.00	-179.76
54020 -- Business travel	106.57	106.57	0.00	106.57	110.00	3.43
55050 -- Telephone long distance	1.84	30.02	0.00	30.02	320.00	289.98
58510 -- Outstanding advances	0.00	0.00	0.00	0.00	0.00	0.00
58910 -- Dues and subscriptions	0.00	350.00	0.00	350.00	150.00	-200.00
Total Expenditures - Operations	168,986.61	675,830.66	1,232.00	677,062.66	515,374.49	-161,688.17
Total Mathematics and computer sci	-168,986.61	-675,830.66	-1,232.00	-677,062.66	515,374.49	-161,688.17
Total Operations	-168,986.61	-675,830.66	-1,232.00	-677,062.66	515,374.49	-161,688.17

Selection Criteria: Filtered By: None

Vendorlink for Westmont Data Last Updated: 9/6/2008 5:20 AM Page 1 of 1

Unrestricted Account Balances

11-13-245 -- MATHEMATICS & COMPUTER SCIENCE **As Of: 06/30/2007**

	MTD Actual	YTD Actual	Encumbrance	YTD Actual + Encumbrance	Budget	Variance (Over) / Under
Expenditures						
5121 -- Compensation-full Time Faculty	46,155.66	415,400.94	0.00	415,400.94	415,400.00	-0.94
5122 -- Compensation-part Time Faculty	0.00	7,400.00	0.00	7,400.00	7,400.00	0.00
5131 -- Compensation-support Staff	0.00	23,536.40	0.00	23,536.40	25,680.00	2,143.60
5135 -- Vacation	0.00	0.00	0.00	0.00	0.00	0.00
5141 -- Compensation-student	0.00	4,245.12	0.00	4,245.12	7,490.00	3,244.88
5145 -- Compensation - Student Summer Labor	0.00	0.00	0.00	0.00	0.00	0.00
5151 -- Temporary Service Agencies	0.00	0.00	0.00	0.00	0.00	0.00
5161 -- Allocated Benefits	0.00	0.00	0.00	0.00	0.00	0.00
5211 -- Contract Serv-printing & Advertising	0.00	1,437.11	0.00	1,437.11	1,470.00	32.89
5214 -- Hospitality & Honoraria	244.67	1,815.93	0.00	1,815.93	3,920.00	2,104.07
5217 -- Contract Serv-rent	0.00	0.00	0.00	0.00	0.00	0.00
5219 -- Media Rental/charges	0.00	0.00	0.00	0.00	0.00	0.00
5222 -- Systems Programs & Software	150.84	150.84	0.00	150.84	1,480.00	1,329.16
5231 -- Supplies & Materials-academic	0.00	236.08	0.00	236.08	1,210.00	973.92
5239 -- Supplies & Materials-office	0.00	627.50	0.00	627.50	830.00	202.50
5251 -- Postage	14.17	64.76	0.00	64.76	230.00	165.24
5253 -- Telephone	6.06	104.04	0.00	104.04	310.00	205.96
5271 -- Transportation, Meals & Lodging	0.00	0.00	0.00	0.00	110.00	110.00
5273 -- Advances	0.00	0.00	0.00	0.00	0.00	0.00
5281 -- Dues & Subscriptions	0.00	0.00	0.00	0.00	150.00	150.00
5311 -- Minor Furniture & Equipment	0.00	0.00	0.00	0.00	0.00	0.00
Total Expenditures	46,571.40	455,018.72	0.00	455,018.72	465,680.00	10,661.28

Unrestricted Account Balances

11-13-245 -- MATHEMATICS & COMPUTER SCIENCE **As Of: 06/30/2006**

	MTD Actual	YTD Actual	Encumbrance	YTD Actual + Encumbrance	Budget	Variance (Over) / Under
Expenditures						
5121 -- Compensation-full Time Faculty	86,463.90	461,621.64	0.00	461,621.64	461,990.00	368.36
5122 -- Compensation-part Time Faculty	0.00	9,200.00	0.00	9,200.00	8,850.00	-350.00
5131 -- Compensation-support Staff	333.84	21,337.96	0.00	21,337.96	23,420.00	2,082.04
5135 -- Vacation	0.00	0.00	0.00	0.00	0.00	0.00
5141 -- Compensation-student	0.00	4,072.71	0.00	4,072.71	5,520.00	1,447.29
5145 -- Compensation - Student Summer Labor	0.00	-3,717.44	0.00	-3,717.44	0.00	3,717.44
5151 -- Temporary Service Agencies	0.00	0.00	0.00	0.00	0.00	0.00
5161 -- Allocated Benefits	0.00	0.00	0.00	0.00	0.00	0.00
5211 -- Contract Serv-printing & Advertising	10.18	2,417.99	0.00	2,417.99	1,440.00	-977.99
5214 -- Hospitality & Honoraria	0.00	5,511.20	0.00	5,511.20	2,850.00	-2,661.20
5217 -- Contract Serv-rent	0.00	0.00	0.00	0.00	0.00	0.00
5219 -- Media Rental/charges	0.00	0.00	0.00	0.00	0.00	0.00
5222 -- Systems Programs & Software	0.00	179.95	0.00	179.95	1,450.00	1,270.05
5231 -- Supplies & Materials-academic	19.16	356.55	0.00	356.55	1,180.00	823.45
5239 -- Supplies & Materials-office	0.00	1,090.90	0.00	1,090.90	810.00	-280.90
5251 -- Postage	1.83	450.40	0.00	450.40	220.00	-230.40
5253 -- Telephone	0.00	309.88	0.00	309.88	300.00	-9.88
5271 -- Transportation, Meals & Lodging	0.00	0.00	0.00	0.00	110.00	110.00
5273 -- Advances	0.00	0.00	0.00	0.00	0.00	0.00
5281 -- Dues & Subscriptions	0.00	170.00	0.00	170.00	150.00	-20.00
5311 -- Minor Furniture & Equipment	56.26	56.26	0.00	56.26	0.00	-56.26
Total Expenditures	86,885.17	503,058.00	0.00	503,058.00	508,290.00	5,232.00

Unrestricted Account Balances

11-13-245 -- MATHEMATICS & COMPUTER SCIENCE **As Of: 06/30/2005**

	MTD Actual	YTD Actual	Encumbrance	YTD Actual + Encumbrance	Budget	Variance (Over) / Under
Expenditures						
5121 -- Compensation-full Time Faculty	93,115.01	398,310.09	0.00	398,310.09	396,880.00	-1,430.09
5122 -- Compensation-part Time Faculty	0.00	23,029.00	0.00	23,029.00	23,030.00	1.00
5131 -- Compensation-support Staff	790.00	18,332.39	0.00	18,332.39	22,070.00	3,737.61
5135 -- Vacation	63.45	63.45	0.00	63.45	63.45	0.00
5141 -- Compensation-student	0.00	5,754.67	0.00	5,754.67	5,410.00	-344.67
5145 -- Compensation - Student Summer Labor	3,031.20	5,887.44	0.00	5,887.44	1,750.00	-4,137.44
5151 -- Temporary Service Agencies	0.00	13,032.06	0.00	13,032.06	10,000.00	-3,032.06
5161 -- Allocated Benefits	144,760.00	144,760.00	0.00	144,760.00	144,760.00	0.00
5211 -- Contract Serv-printing & Advertising	15.07	1,272.06	0.00	1,272.06	1,430.00	157.94
5214 -- Hospitality & Honoraria	25.00	5,080.57	0.00	5,080.57	2,820.00	-2,260.57
5217 -- Contract Serv-rent	71.94	71.94	0.00	71.94	0.00	-71.94
5219 -- Media Rental/charges	0.00	0.00	0.00	0.00	0.00	0.00
5222 -- Systems Programs & Software	0.00	40.00	0.00	40.00	1,440.00	1,400.00
5231 -- Supplies & Materials-academic	19.28	551.02	0.00	551.02	1,170.00	618.98
5239 -- Supplies & Materials-office	0.00	1,310.45	0.00	1,310.45	800.00	-510.45
5251 -- Postage	24.81	106.53	0.00	106.53	220.00	113.47
5253 -- Telephone	9.15	63.39	0.00	63.39	300.00	236.61
5271 -- Transportation, Meals & Lodging	1,242.80	1,278.08	0.00	1,278.08	110.00	-1,168.08
5273 -- Advances	0.00	0.00	0.00	0.00	0.00	0.00
5281 -- Dues & Subscriptions	236.00	236.00	0.00	236.00	150.00	-86.00
5311 -- Minor Furniture & Equipment	0.00	0.00	0.00	0.00	0.00	0.00
Total Expenditures	243,403.71	619,179.14	0.00	619,179.14	612,403.45	-6,775.69

Westmont College, VendorLink Printed: 9/1/2005 8:49 am **Page 34 of 99**

Unrestricted Account Balances

11-13-245 -- MATHEMATICS & COMPUTER SCIENCE **As Of: 06/30/2004**

	MTD Actual	YTD Actual	Encumbrance	YTD Actual + Encumbrance	Budget	Variance (Over) / Under
Expenditures						
5121 -- Compensation-full Time Faculty	85,659.90	371,192.91	0.00	371,192.91	371,550.00	357.09
5122 -- Compensation-part Time Faculty	0.00	11,547.00	0.00	11,547.00	11,710.00	163.00
5131 -- Compensation-support Staff	183.00	8,664.25	0.00	8,664.25	11,660.00	2,995.75
5135 -- Vacation	0.00	0.00	0.00	0.00	0.00	0.00
5141 -- Compensation-student	31.18	6,284.19	0.00	6,284.19	4,660.00	-1,624.19
5145 -- Compensation - Student Summer Labor	1,330.00	1,330.00	0.00	1,330.00	1,750.00	420.00
5151 -- Temporary Service Agencies	0.00	3,083.45	0.00	3,083.45	0.00	-3,083.45
5161 -- Allocated Benefits	126,592.00	126,592.00	0.00	126,592.00	126,592.00	0.00
5211 -- Contract Serv-printing & Advertising	24.86	1,193.77	0.00	1,193.77	1,430.00	236.23
5214 -- Hospitality & Honoraria	50.00	3,612.61	0.00	3,612.61	2,570.00	-1,042.61
5217 -- Contract Serv-rent	0.00	0.00	0.00	0.00	0.00	0.00
5219 -- Media Rental/charges	0.00	0.00	0.00	0.00	0.00	0.00
5222 -- Systems Programs & Software	0.00	0.00	0.00	0.00	1,440.00	1,440.00
5231 -- Supplies & Materials-academic	1.06	1,106.57	0.00	1,106.57	1,170.00	63.43
5239 -- Supplies & Materials-office	0.00	797.55	0.00	797.55	800.00	2.45
5251 -- Postage	30.17	198.23	0.00	198.23	220.00	21.77
5253 -- Telephone	6.84	85.83	0.00	85.83	300.00	214.17
5271 -- Transportation, Meals & Lodging	0.00	116.00	0.00	116.00	110.00	-6.00
5273 -- Advances	0.00	0.00	0.00	0.00	0.00	0.00
5281 -- Dues & Subscriptions	0.00	160.00	0.00	160.00	150.00	-10.00
5311 -- Minor Furniture & Equipment	0.00	38.71	0.00	38.71	0.00	-38.71
Total Expenditures	213,909.01	536,003.07	0.00	536,003.07	536,112.00	108.93

Unrestricted Account Balances

11-13-245 -- MATHEMATICS & COMPUTER SCIENCE **As Of: 06/30/2003**

	MTD Actual	YTD Actual	Encumbrance	YTD Actual + Encumbrance	Budget	Variance (Over) / Under
Expenditures						
5121 -- Compensation-full Time Faculty	70,367.34	304,925.00	0.00	304,925.00	304,940.00	15.00
5122 -- Compensation-part Time Faculty	0.00	23,360.00	0.00	23,360.00	23,360.00	0.00
5131 -- Compensation-support Staff	854.83	11,774.43	0.00	11,774.43	12,870.00	1,095.57
5135 -- Vacation	0.00	0.00	0.00	0.00	0.00	0.00
5141 -- Compensation-student	0.00	4,720.66	0.00	4,720.66	4,570.00	-150.66
5161 -- Allocated Benefits	0.00	0.00	0.00	0.00	0.00	0.00
5211 -- Contract Serv-printing & Advertising	27.87	1,136.58	0.00	1,136.58	1,430.00	293.42
5214 -- Hospitality & Honoraria	0.00	3,967.36	0.00	3,967.36	4,070.00	102.64
5217 -- Contract Serv-rent	0.00	0.00	0.00	0.00	0.00	0.00
5219 -- Media Rental/charges	0.00	0.00	0.00	0.00	0.00	0.00
5222 -- Systems Programs & Software	0.00	0.00	0.00	0.00	140.00	140.00
5231 -- Supplies & Materials-academic	102.72	954.28	0.00	954.28	1,020.00	65.72
5239 -- Supplies & Materials-office	0.00	567.61	0.00	567.61	700.00	132.39
5251 -- Postage	32.22	238.51	0.00	238.51	220.00	-18.51
5253 -- Telephone	5.31	156.85	0.00	156.85	200.00	43.15
5271 -- Transportation, Meals & Lodging	0.00	274.00	0.00	274.00	260.00	-14.00
5273 -- Advances	0.00	0.00	0.00	0.00	0.00	0.00
5281 -- Dues & Subscriptions	0.00	150.00	0.00	150.00	150.00	0.00
5311 -- Minor Furniture & Equipment	0.00	0.00	0.00	0.00	0.00	0.00
Total Expenditures	71,390.29	352,225.28	0.00	352,225.28	353,930.00	1,704.72

6 Conclusion and Long-Term Vision

The review information and assessment data in this report reinforce our own perceptions of mathematics at Westmont as a stable and effective program. Our least senior full-time faculty are beginning their ninth year at Westmont, and the level of staffing in mathematics has been consistent for many more years. While our upper-division major classes are small, our overall instructional load is healthy because of the number of courses we teach that serve other disciplines. And perhaps most importantly, many of our majors go on to meaningful and impactful careers that use mathematics, explicitly and implicitly.

6.A Departmental Accomplishments: 2003–2008

Over the past six years, the department has offered a consistently high quality program in mathematics. Mathematics faculty have engaged in peer-reviewed research and have authored books that reach wide audiences. Mathematics graduates serve society and God using skills and gifts they developed through our work with them. Our primary accomplishment lies in stewarding a program that has a track record of many years of effectiveness.

In the area of assessment, we have constructed and implemented a set of learning outcomes and measurement tools that we find meaningful and sustainable. At long last, the mathematics faculty now feel ownership of the assessment program.

The above faculty C.V.'s attest to the many individual contributions our faculty have made in past years. Much of the departmental accomplishments fall into the category of sustaining: for example, this year we hosted the 21st annual mathematics contest for local high school students. This consistency extends to the full range of our duties as faculty. We have continued to monitor and refine our program: supporting undergraduate research projects, offering mathematical internship opportunities, supporting off-campus study, revising our curriculum, implementing new textbooks, developing and revamping courses, tweaking major requirements, using new technologies, and supporting each other's pedagogy.

6.B Goals and Strategies

Our main concern over the next six years will be increasing the number of students who major in mathematics. To this end, we propose the following action items.

1. Monitor and evaluate current admission practices. Compare Westmont's mathematical admission requirements with comparable institutions.
2. Evaluate our major requirements, and compare to comparable institutions.
3. Continue to participate in admission recruitment events.
4. Promote the secondary education credential program as an accelerated "$3 + 1$" track for motivated students.
5. Continue to host events aimed at developing an ethos conducive to recruitment and retention of majors.

In addition to this concern, the department plans to maintain and develop its assessment program, as described in Section 3 of this report.

6.C Individual Contributions

All of the action items in Section 6.B represent duties that the department will share. However, the following faculty will serve as "point persons" for each action item. These faculty hold the responsibility of keeping these action items on the department agenda.

1. Russ Howell
2. Ray Rosentrater
3. Dave Hunter
4. Patti Hunter
5. Jonathan Leech

Education professor Andrew Mullen has offered to help with action item #4.

The department chair has the responsibility of shepherding all the action items necessary to maintain our assessment program, as described in Section 3.B.5.

7 Addendum: Computer Science Annual Update

The remaining pages consist of the annual program review and assessment update report for computer science. This report can be found as a separate document on the mathematics program review web page (external link).

Annual Assessment and Program Review Report

Westmont College Computer Science Program

September 15, 2008

Contents

I. Mission Statement and Learning Outcomes

I.1. Computer Science Program Mission Statement

Core Values: Who We Are
Like many excellent and rigorous computer science programs around the world, we emphasize the fundamental and theoretical foundations of computation. At the same time, we ground the formal concepts in current advances in technology. Many aspects of the field are constantly changing, and staying current with new developments is a significant challenge. We believe that the best way to enable graduates to efficiently stay on top of the field is to lay a solid foundation of the fundamentals on which constant changes are ultimately based. We believe that the best way for us as faculty to remain current in the field is to conduct research and contribute to the field of computer science in our respective areas of emphasis. The formal foundation we lay serves our students well in their continued education in graduate school. For those who choose to enter the workforce immediately, this foundation equips them to be among the more versatile thinkers, learners and developers of their peers.

A number of schools provide similar rigor in their CS programs, yet two core values help set Westmont apart from other similar programs. First, the faculty commitment to research is coupled with an active intention and practice of including undergraduates in their research. These research opportunities for students greatly enhance the depth of their education and significantly improve their options for graduate school. The second distinguishing characteristic of CS at Westmont comes from the small intimate nature of the program. The faculty enjoy the opportunity and privilege of working one on one with students in course work to ensure that concepts are acquired. Thus, students are not left behind when difficult concepts are introduced as may happen in programs at larger universities. Similarly, our size allows us to support students when they want to combine CS with another major or to create an individual major.

Context: Where We Are
The excellence and rigor with which we pursue the fundamentals and the distinctive characteristics of our program are set against and within a rich multi-faceted context consisting of the liberal arts, Christian faith, social and community life and service, and simply a fantastic physical surrounding.

CS and the Liberal Arts
Studying CS at a liberal arts institution such as Westmont is particularly enriching because of the strong influences from the complete range of disciplines. A computer scientist's ability to solve problems is substantially enhanced by exposure and training

in analytical techniques practiced in history or literary criticism. Our understanding of diverse computer languages is broadened and deepened by exposure to multiple natural languages and the study of linguistics. The creativity necessary to construct complex algorithms that solve difficult problems is in part developed through exposure to the fine arts. More importantly, the ability to communicate with peers, advisors, managers, and customers is critical to a successful career in computer science; the liberal arts emphasis on communication enables our graduates to serve as leaders in a field that has traditionally suffered from low communication skills. In essence, a liberal arts education addresses the development of the whole person and we believe that building a rigorous mastery of computer science only makes sense within such a context.

CS and Christianity

Computer science at Westmont lives and breathes in the context of a Christian faith perspective. What this means for CS is that studies of computation inform our growing faith, and that faith guides our study of computer science. There are a number of ways that this interaction can take shape, but two of the most significant would be in the areas of service and leadership. As computers have become ubiquitous beyond any other technological device, our students have the opportunity to exercise Christian service through their chosen vocations, regardless of specialty. We seek to develop a heart of service in ourselves and our students. Just as importantly, computer scientists have the awesome responsibility of guiding a discipline that holds tremendous promise as well as danger for humanity. Fully embracing our faith, we provide and develop leadership by pursuing scholarship that engages issues that will impact our society now and in the future.

CS and Social Contexts

At Westmont, we have achieved and maintained a social community context that defies the norms and stereotypes of computer science. We recognize that in order to be effective in their future careers – either in graduate school and beyond or in the commercial sector – our students must be effective communicators and problem solvers in group contexts. As a faculty, we have taken this requirement and turned it into significant element of our nature. Most of our courses involve group projects of one kind or another; we actively address interpersonal issues and group dynamics inherent in the processes of software development and problem solving. Beyond the classroom, we foster community strength and interpersonal skills through regular social gatherings both on and off campus. In every situation, we seek to develop an enjoyment of each other as social beings created in God's image.

I.2. Student Learning Outcomes

1. **Core Knowledge.** Know the core ideas and methods in the field of computer science.
2. **Communication.** Be able to communicate ideas in writing or orally, following standard conventions of the discipline.
3. **Creativity.** Be able to independently learn new ideas and techniques and to formulate and solve a novel problem in computer science.
4. **Connections.** Be able to incorporate computer science knowledge and skill into a wider interdisciplinary framework and especially into a personal faith and its accompanying worldview.

These four learning outcomes are much the same as the four outcomes established for the joint department of mathematics and computer science. [See the 2007 annual update (external link).] As a result of separating the assessment and program review schedules for mathematics and computer science, the faculty in each program are now free to modify the learning outcomes to fit their disciplines. The changes made this year to the computer science outcomes are mostly minor adjustments to the language to conform to issues specific to computer science. The most significant change is the addition of the word "interdisciplinary" to the fourth standard, and the corresponding change in the name of the standard from "Christian Connection" to "Connections."

II. Data and Interpretation

II.1. Assessment of Learning Outcomes

The Learning Outcome Matrix in Table 1 summarizes the current assessment program in computer science. Many of the designations in this matrix are preliminary and will be reviewed and revised as necessary during the Spring of 2009.

The Computer Science Program Roadmap in Figure 1 expands on the information in the matrix, including extracurricular activities and other possible sources of assessment data.

The four subsections (II.1.i–iv) that follow these two graphics detail what has been done over the last academic year for each learning standard.

Learning Outcome Matrix: Major in Computer Science				
Student Learning Outcomes	Core Knowledge	Communication	Creativity	Connections
Meaning	Know the core ideas and methods in the field of computer science.	Be able to communicate ideas in writing or orally, following standard conventions of the discipline.	Be able to independently learn new ideas and techniques and to formulate and solve a novel problem in computer science.	Be able to incorporate computer science knowledge and skill into a wider interdisciplinary framework and especially into a personal faith and its accompanying worldview.
Introduced	CS 5, 10*, 15*	CS 10*, 15*	CS 10*, 15*	CS 15*
Developed	CS 30*, 45	CS 30*	CS 30*	CS 50, PHI 104, 113
Mastered	CS 105, 116, 120*, 125, 130*, 135, 140, 145	CS 120*, 130*, 192*, 195*, 198*	CS 192*, 195*, 198*, MA 180	CS 190SS, CS 195*, Emphasis courses from other depts.
Assessment strategy	Major Field Test in Computer Science	Writing samples scored with rubric	Externally reviewed presentations and papers	Reflective paper scored with rubric
Tentative benchmark	50% above 75th percentile	75% show improvement during term	50% produce some externally reviewed work	TBD
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. One of CS 50, PHI 104, PHI 113 is required for the major.

Table 1: Tentative learning outcome matrix.

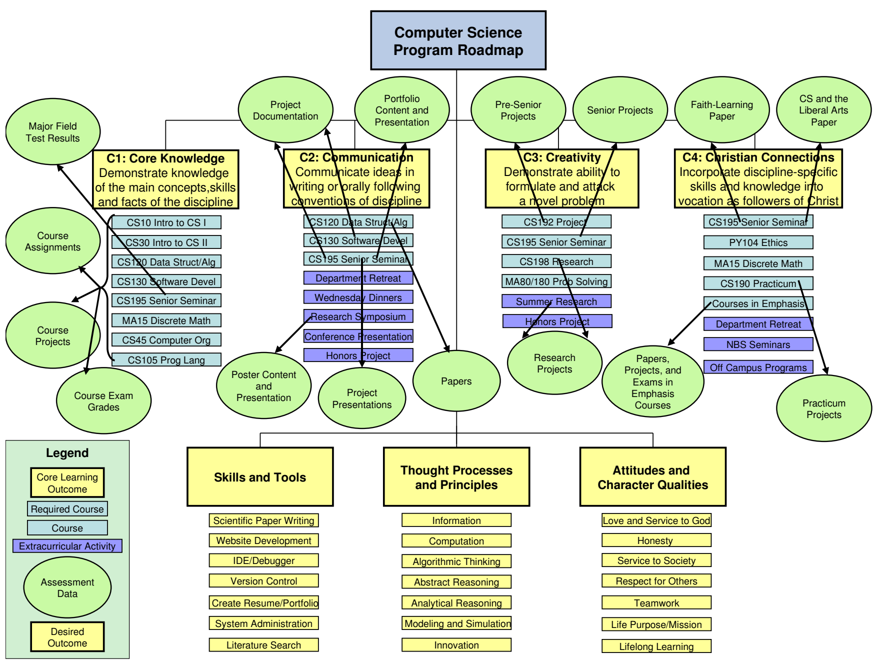

Figure 1: Computer Science Program Curriculum Roadmap.

II.1.i Core Knowledge

Starting with the class of 2008, all graduating seniors in computer science are required to take the ETS's Major Field Test in Computer Science (external link). The results for 2008 are as follows:

Student ID	Date Taken	Score	%ile
X	4/2/2008	165	≥ 80
Y	4/23/2008	170	≥ 85

Table 2: ETS Major Field Test in Computer Science results, 2008.

These results meet our tentative benchmark: 50% of students scored above the 75th percentile of students taking the test nationally.

The Educational Testing Service will not release subscore data until at least five people have taken the test, so we will have to wait until at least 2009 to get further information on subscores. 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.

II.1.ii Communication

In August 2008, the computer science faculty met and formulated a rubric for evaluating student writing in CS courses. Data was collected from CS 130 (Software Development), a total of six papers. Both computer science faculty members read each paper, and evaluated them with respect to the rubric. This triggered a reorganization of the rubric and a lesson learned regarding the formulation of writing assignments and the clarity needed in the original prompt.

II.1.iii Creativity

The following students were involved in research during the past year:

Fall 2008: Ben Fisk (Senior)
Summer 2008: Kelsey Marshman (Fresh), Robin Elliot (Soph), Aaryn Smith (Soph), Ben Fisk (Junior)
Spring 2008: Toby Lounsbury (Soph)
Fall 2007: Adrian Rogers (Junior), Joel Stewart (Junior)
Summer 2007: Daniel Rufener (Soph), Michael Magnason (Grad), Adrian Rogers (Soph), Joel Stewart (Soph)

The following papers were accepted for publication in peer-reviewed journals (* indicates student author).

W. Iba, K. Marshman*, and B. Fisk*, Evaluating a Parallel Evolutionary Algorithm on the Chess Endgame Problem, in *Proceedings of the 2008 International Conference on Genetic and Evolutionary Methods*, Las Vegas, Nevada, July 2008, to appear.

K. P. Kihlstrom, R. S. Elliott*, K. A. Marshman*, and A. C. Smith*, Intrusion-Tolerant Dissemination in Large-Scale Systems, in *Proceedings of the 2008 International Conference on Parallel and Distributed Processing Techniques and Applications*, Las Vegas, Nevada, July 2008, to appear.

K. P. Kihlstrom, J. L. Stewart*, N. T. Lounsbury*, A. J. Rogers*, and M. C. Magnuson*, Implementation and Performance Testing of a Gossip-Based Communication System, in *Proceedings of the 19th IASTED International Conference on Parallel and Distributed Computing and Systems*, Cambridge, MA, November 2007, pp. 194-199.

The following posters and presentations were made.

Joel Stewart*, Daniel Rufener*, Kelsey Marshman*, Ben Fisk*, and Wayne Iba , *Evaluating a Parallel Evolutionary Algorithm on the Chess Endgame Problem*, poster at Westmont Student Research Symposium, April 2008, and at Southwest Regional Conference of the Consortium for Computing Sciences in Colleges, April 2008 (received Best Student Poster Award).

K. P. Kihlstrom, J. Stewart*, N. T. Lounsbury*, M. C. Magnuson*, and A. Rogers*, *Intrusion-Tolerant Dissemination in Large-Scale Systems*, presentation at the Forty-first Annual Hawaii International Conference on System Sciences, Waikoloa, HI, January 2008.

J. Stewart*, A. Rogers*, N. T. Lounsbury*, M. C. Magnuson*, and K. P. Kihlstrom, *Implementation and Performance Testing of a Gossip-Based Communication System*, poster at Westmont Summer Research Celebration, September 2007, and at Westmont Student Research Symposium, April 2008.

N. T. Lounsbury*, A. Rogers*, J. Stewart*, M. C. Magnuson*, and K. P. Kihlstrom, *StarblabFS: Replicated userspace file system*, poster at Westmont Summer Research Celebration, September 2007, and at Westmont Student Research Symposium, April 2008.

Undergraduate research clearly remains an area of strength for the department. These peer-reviewed results represent the work of a range of students of varying abilities, from our outstanding graduate of 2007 to a student who failed introductory classes. These results easily exceed our tentative benchmark that 50% of graduates produce some peer-reviewed work.

II.1.iv Connections

Assessment work on the fourth learning standard will be the focus of assessment discussions in 2008-2009.

II.2. Interpretation of Results

The preliminary indications of our assessment work so far suggest that the program is effectively promoting the outcomes of Core Knowledge and Creativity. The other two outcomes, Communication and Connections, are going to be harder to assess, and work on these outcomes will be a priority for the next few years.

III. Using the Results and Next Steps

The computer science curriculum has undergone continual revision since its reinception in 1999. This revision has been necessitated by the nature of the discipline: on the national level, technology, techniques, and pedagogy have undergone many changes in past years.

While we do not yet have enough results of assessed data to justify changes in the computer science curriculum, the process of crafting learning outcomes and assessment strategies has helped focus the design of our curriculum.

The current 2008–2009 catalog reflects the most recent changes to the computer science major. These changes streamline the core of the major while allowing flexibility for pursing various emphases, within and beyond the discipline. The curriculum roadmap illustrates how our assessment strategy is related to the current redesigned major. To ensure inputs and provide assessment data for the Communication, Creativity, and Connections outcomes, all students are required to take a senior seminar, participate in research, produce significant written work in Software Development, and study ethics, preferably from a disciplinary perspective in CS 50.

The focus for the next academic year will be the fourth learning outcome: Connections. In particular, the computer science faculty plan to do the following:

- Decide on a mechanism and prompt for a reflective paper.
- Design a rubric for scoring the reflective paper.
- Collect writing samples.
- Apply the rubric and revise as necessary.
- Decide on appropriate benchmarks.

In addition, the program plans to continue the assessment activities of the other learning outcomes:

- Administer the MFT, discuss the results, and revisit benchmarks.
- Collect and analyze more writing data and revisit benchmarks.
- Continue to involve students in peer-reviewed research.

Throughout this process, the computer science faculty will consider revisions to several components of this report: the learning outcome matrix, the curriculum roadmap, and the six-year plan.

IV. Data for Program Review

The next several pages contain data that will be helpful when the six-year report is compiled in 2014.

Faculty Information for Wayne Iba, 2007–2008

Date of Hire: 2003

Sex and Ethnicity: Male Caucasian

Rank: Associate Professor

Tenure Status: Untenured

Teaching Load:

	Classes	# students	# advisees	Other departmental responsibilities	New Preps
Fall 2007			20		1
	CS 10	18			√
	CS 105	3			
Spring 2008			12		1
	CS 130	4			
	CS 150	4			√
Average load	2	7.25	16		1
Mayterm					
Ind. Studies					
Internships					

Table 3: Teaching load for Wayne Iba, 2007–2008.

Note: Computer Science faculty currently teach 5 courses per year. Wayne Iba received a course release for chairing the Academic Resources Committee.

Faculty Information for Kim Kihlstrom, 2007–2008

Date of Hire: 1999

Sex and Ethnicity: Female Caucasian

Rank: Associate Professor

Tenure Status: Tenured

Teaching Load:

	Classes	# students	# advisees	Other departmental responsibilities	New Preps
Fall 2007	CS 5 CS 30	10 5	23		0
Spring 2008	CS 30 CS 45	15 2	19		0
Average load	2	8	21		0
Mayterm					
Ind. Studies					
Internships					

Table 4: Teaching load for Kim Kihlstrom, 2007–2008.

Note: Computer Science faculty currently teach 5 courses per year. Kim Kihlstrom had a grant pay for a course release this year.

Computer Science Alumni Survey

LAST	FIRST	MIDDLE	Deg.	YEAR	Current Ocupation (title, company, etc.)
Eastvold	Benjamin	Seth	BS	2001	
Chambers	Luke	Wilson	BA	2002	
Te Velde	Michael	Henry	BA	2002	
Conant	Tyler	John	BS	2002	
Andrews	Christopher	Richard	BA	2003	
Hanson	James	Daniel	BS	2003	
Lassonde	Nicholas	Adam	BS	2003	Startup company (Vesora?)
Gibbs	Anna	Katheryn	BS	2004	
Labarbera	Benjamin	Carl	BS	2004	
Carroll	Dustin		BS	2004	Grad student finishing Masters at MBARI
Hanson	James	Rodney	BS	2004	
Thurman	Jesse	Lee	BS	2004	
Sullivan	Jonathan	Robert	BS	2004	System admin consultancy
Cox	Joseph	Walter	BS	2004	Cytrix
Kishiyama	Kevin	Takeo	BS	2004	Software developer
Cook	Patti	Lee	BS	2004	
Broadus	Robert	Lee	BS	2004	IT
Roby	Seth	A.	BS	2004	
Jensen	Brian	Alan	BS	2005	Opera singer
Ritchey	Christopher	Charles	BS	2005	
Phillips	Christopher	Dale	BS	2005	Grad student finishing Masters at UCSB and developer at Callwave
Johnson	Kerby	Obadiah	BS	2005	Finished Masters at UCSB and working Genentec
Yankoski	Michael	George	BS	2005	
McElfresh	Rebecca	Joy	BS	2005	
Newell	Ryan	M	BS	2005	
Cantrell	Thomas	Bruce	BS	2005	Software developer at Green Hills Software (SB)
Jensen	Bradley	Alan	BS	2006	
Shank	Daniel	Philip	BS	2006	Software developer/tester at Appfolio (SB)
Hilp	John	Tilford	BS	2006	
Kaddatz	Matthew	Martin	BS	2006	
Burwell	Nicholas	James	BS	2006	Software developer at Callwave
Watters	Kyle	Padia	BS	2006	PhD grad student in Physics at Stanford
Evans	Anne	Iten	BS	2007	High School computer science teacher, CO
Cannon	Cuyler	Elisha	BS	2007	
Holm	Joshua	Thor	BS	2007	Software developer at Callwave
Magnuson	Michael	Carl	BS	2007	
Raub	Stephen	Benjamin	BS	2007	Software developer at Green Hills Software (SB)
Willson	Julia	Kathleen	BS	2007	
Barquer	Kristin	Noel	BS	2007	Grad student in Kinesiology (Univ Iowa?)

Work with other departments and offices:

In September 2006, Dana Alexander and Celia Howen from the Office of Life Planning spoke at departmental retreat for mathematics and computer science.

On 9/7/2007, Kim Kihlstrom and Dave Hunter met with Jennifer Taylor of the Internship Office. Jennifer helped us implement a new course, CS190/191SS, Computer Science Seminar for Service Learning Internship, which satisfies the Serving Society component of General Education. This office and also OLP contribute to our fourth learning standard (Christian Connection) by helping students understand how to use computer science to serve others.

The Mathematics and Computer Science Department met with our library liaison, Claudia Scott, on 10/16/2007. The consensus at that meeting was that there are no major shortcomings in our collection that can be reasonably addressed at a small college.

V. Time-line for Completion of the Six-year Report

After discussions with Assessment Coordinator Marianne Robins, the department agreed to separate the program review schedules for mathematics and computer science. The Mathematics Program is submitting a Six-Year report this year (2008), while the Computer Science program will not submit a Six-Year report until 2014. Table 5 gives the current six-year plan for assessment and program review in computer science. This plan will be reviewed and revised in the 2008-2009 academic year.

Year	**Program review overall**	**Details for assessment work**
2008–09	Submit annual progress report, 9/15/2008. Justify need for a third department member using program review data. Discuss admissions practices and recruitment of students.	Ongoing annual tasks. Review Connections learning standard (#4).
2009–10	Actively pursue the creation of a third faculty line in computer science, using program review data.	Ongoing annual tasks. Review Core Knowledge learning standard (#1).
2010–11	Discuss the implications of a third faculty line for curriculum and program review. Discuss the transition to a separate computer science department, once a third faculty member is hired.	Ongoing annual tasks. Review Creativity learning standard (#3).
2011–12	Review contributions to GE.	Ongoing annual tasks. Review Communication learning standard (#2).
2012–13	Discuss quality of preparation for graduate school.	Ongoing annual tasks. Discuss/Revise learning standards.
2013–14	Prepare for six-year program review report, due 9/15/2014.	Ongoing annual tasks. Summarize assessment work from past six years.

Table 5: Tentative six-year plan for assessment and program review in computer science. This plan will be revised during the 2008–2009 academic year.