Teaching Dossier

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1 Honours

1998–1999 Faculty of Science Teaching Award of Excellence

2 Responsibilities

2.1 List of Courses

The primary mode of instruction in these courses is by lectures.

01–02	AM026[2], AM261b, AM475a/563a[4]
00–01	Sabbatical Leave
99–00	Faculty of Science Distinguished Research Professorship
97–98	AM361b, AM475b/563b, AM505b, PA478/531[4]
96–97	CS422a/CS539a, AM351a, AM361b, AM511y (Special Functions)[4]
95–96	AM475b, AM465b/AM511b (Applied Computer Algebra)
94–95	Sabbatical Leave[1].
93–94	AM026[2], AM511a (Applied Computer Algebra)
92–93	AM025a[2], AM026[2], AM372b[2]
91–92	AM026, AM372b[2], AM512b[3] (Applied Computer Algebra)
90–91	AM026, AM372b[2] (two sections)

Notes:

[1] Sabbatical leave extended to December 1995 to chair the Organic Mathematics Project (see section 5.1).
[2] Course Coordinator. One TA for AM372b, three TA's for AM026 (three sections) prior to 2001.
[3] The course numbers AM511 and AM512 are for 'special topics' courses. Renamed AM475/563, starting 1997.
[4] Volunteer basis, in excess of assigned load.

2.2 Undergraduate Honours Theses and Summer Students Supervised

Summer students:

2001	Kerry Evans
2000	Arthur Louie

Honours Theses:

2000	Arthur Louie
1999	N. Owen
1992	Martin Thompson
1991	Amanda Connell

3 Philosophy

Research, scholarship, and teaching are three facets of a "gem" professor. Each facet supports the others. Original, frontier *research* informs the whole process, through something intangible (but essential) that arises from direct connection to the hitherto unknown. *Scholarship* affects the research effort by giving a context in which the value of a particular direction may be judged. Scholarship affects the *teaching* (through the curriculum) with that same context.

When we do research, we teach ourselves (and the world) something *new*. When we work on our scholarship, we teach ourselves something new *to us*, and integrate it into our worldview. When we teach, we help others to learn what we have learned.

Put that way, it sounds as though teaching is the simplest of the three facets. This is not so, principally because different people learn in different ways. In fact, teaching others is an excellent tool for building your own scholarship, because it forces you to consolidate and contextualize your knowledge and to look at material from someone else's point of view. Finally, teaching others is also an excellent tool for helping your own research, not least because teaching others about the great and productive ideas brings them fresh into your mind, where they are handy for use.

Those paragraphs make it sound grand, to be a professor; and so it is. However, as I found out in my first week here, it is also extremely enjoyable. No-one had told me beforehand how much *fun* it is to teach! Many of the students are serious, hardworking, clever people, and there are some extraordinarily good students at Western (media perception to the contrary notwithstanding). Moreover, even ordinary students can provide extraordinary intellectual pleasure for a teacher.

Of course, no-one can deny the pleasure of scholarship—reading a beautiful book like D. F. Lawden's *Elliptic Functions* for no purpose except the general principle that an educated mathematician ought to know something about the subject, for example—and no-one can deny the gratification of discovering something really new.

These pleasures, I have found, are infectious. Since it's my job to encourage students to do the necessary work (*of course* learning at the university level is difficult; if it was easy, we'd all be doing something else), it helps to be able to say authoritatively that one of the payoffs of all the discipline and effort is a commensurate pleasure. And when the students see for themselves that you enjoy what you do, they know that you're not lying. There is no 'Royal Road' to mathematics (or indeed to any other discipline), and we have to do what is necessary to get students to go the distance the hard way. Recently I read "Talking about Leaving", by Seymour and Hewitt, which talks about why so many good students leave science programs; one conclusion I drew from the book was that getting the students to go the distance can't be done just with a good set of lecture notes.

One student said of my teaching style that "I have never seen a prof so aggressive (in a nice way) about getting us to work." If I can make their hair stand on end in class, electrify them, get them off their behinds and moving, then I have been successful.

4 Innovations

Beginning with my first year here I have a consistent record of innovation in teaching; new methods and tools of teaching classical material, revitalized classical material and brand new material in all of my courses. The principal source of my innovations is new technologies, but that is not the only source; for example, the modern theory of chaotic dynamical systems has had a profound effect on all my courses, from first year calculus through fourth year numerical methods for differential equations up to my graduate courses. These innovations are documented in my papers and books on mathematics, computer science, and engineering education.

As regards technology, I have used graphing calculators, microcomputers and labs, symbolic packages (Maple), numerical packages (Matlab), and most recently helped develop leading-edge software for the use of the Web in teaching (see the section on Organic Mathematics). I believe in a principled and thoughtful approach to the introduction of technology, and I believe that the curriculum—the material we teach—and not just the way we teach should change as we introduce technology.

4.1 Novel curriculum material

Samples of new material include chaotic dynamical systems and fractals (via iterations in Newton's method) in first year calculus; the singular value decomposition in first year linear algebra; the defect or residual in the numerical solution of differential equations; the unwinding number in complex variables; polynomial elimination and resultants in computer algebra (this is a revitalization of nineteenth century mathematics, made possible by technology; indeed the computer algebra course was wholly new to Western when I introduced it). The programs written for the HP48S for truncated power series algebra, and their description in FYEMUS, provide an example I am particularly proud of.

Regarding new methods and tools, I pioneered the use of programmable symbolic-capable calculators for engineering mathematics. I also introduced Matlab to numerical analysis courses (both for engineers and scientists), and Maple to computer scientists, physicists, applied mathematicians, and engineers.

In 1995 I used the Web and HTML tools to help deliver my Maple course, while I was at Simon Fraser University working on the Organic Mathematics Project under the auspices of the National Centre for Excellence in Telelearning. I was co-chair of the project and chair of the workshop. See the paper "What is Organic Mathematics", appended to this dossier, and section 5.1 below for more details on this, perhaps the most 'high-powered' of my experiments with technology in teaching.

I do not neglect the 'low-tech' route, either. Recently I have introduced the idea of handing out "classic" papers in numerical analysis and asking the students to read and summarize, as part of their assignments. This experiment has proved very successful, with some students counting this as the best part of the course.

4.2 Development of new courses, revision of existing courses

With the single exception of AM351 (Continuum Mechanics), I have profoundly revised (or outright invented) all the courses that I have taught. I give one or two sentences below outlining the major innovations for each course.

4.2.1 AM475/AM563: Applied Computer Algebra 1998

Invented a project-oriented course applying computer algebra (Maple) to problems (from all areas) of specific interest to the students. Six research papers have been published (at least) from these projects, and many students' theses have been profoundly affected.

4.2.2 PA478/531—Interdisciplinary course on Theory and Evidence in Gravitational Physics

I volunteered to help Bill Harper (Philosophy) and Ram Valluri (Physics) teach a course based on Newton's Principia and Chandrasekhar's book "Newton's Principia for the Common Reader". While my contributions are small, the course was both interesting and viable in the long term, for our inherently interdisciplinary campus.

4.2.3 AM511y (Special Functions)

In 1997 I pioneered this seminar course on Special Functions, with the help of Jim Talman in the second term. Special Functions have been revitalized by technology, though they have always been useful; this course was popular, and will be repeated.

4.2.4 AM475b: Numerical Solution of Initial-Value Problems

This course was substantially reworked based on modern developments including recent (within the last five years) work on chaotic problems, defect control, and differential algebraic equations.

4.2.5 CS422/CS539: Algorithms for Computer Algebra

This course, which differs from Applied Computer Algebra in that it is more an exploration of the mathematics and algorithms *of* computer algebra programs than use of such programs for physical problems, is another course new to Western. I based it strongly on the book of Geddes, Czapor, and Labahn but about half was created from scratch. It has been taught subsequently by a team consisting of myself, Mark Giesbrecht, Stephen Watt, Greg Reid, and Ilias Kotsireas.

4.2.6 AM372/272: Numerical Analysis for Engineers, AM361b Numerical Analysis for Scientists

These courses were completely reinvented, taking them from a cookbook 'methods' course and 'pure analysis' course respectively to be focussed analysis courses (flavoured for engineers and scientists separately) based on the following two principles: "A good numerical method gives you the exact solution to a nearby problem", and "Some problems are sensitive to changes." This gave the courses greatly improved integrity and usefulness for the typical engineer and scientist. The principles of this course are valid for *all* methods one uses for computer simulation; the lessons taught are always needed.

4.2.7 AM025a and AM026: Linear Algebra and Calculus for Engineers

The revisions and innovations—really, a revolution—in these courses in the years I taught them are described in detail in the papers listed in sections 8 and 4.4. The revolution was driven by the deliberate introduction of a high-end calculator, capable of computer algebra, into the courses. These innovations were carried out by a team of enthusiastic people, including Paul Sullivan, Chris Essex, David Jeffrey, and others; while I am very proud of the role I played in these revisions, every team member contributed, in a synergistic fashion. Finally, these innovations could not have been carried out without the enthusiastic support of Ian Duerden; we were all saddened by the news of his death, and we'll miss him.

4.3 Books

1. Robert M. Corless, C. Essex, & P. J. Sullivan, *First Year Engineering Mathematics Using Supercalculators* (FYEMUS), SciTEX, University of Western Ontario, 1991, 1992. (400pp)

2. Robert M. Corless, David J. Jeffrey, & S. J. D. D'Allessio, *Pick Your Mark, Get Set, Go*, book in progress.

3. Robert M. Corless, *The Numerical Solution of Initial Value Problems*, book, 250pp, in progress.

4.4 Journal papers from new undergraduate curricular material

Some mathematics journals contain sections aimed at instructors of lower-level courses. I have reported on new curricular developments in several papers for such sections. A list follows.

1. Robert M. Corless, "Variations on a theme of Newton", Mathematics Magazine, Volume 71 *pp.* 34–41 (1998).

2. Robert M. Corless, "Differential Equations with Maple V by Abell and Braselton", SIGSAM BULLETIN vol 30 no. 1, March (1996) 57–60. [Book Review]

3. Robert M. Corless, "Fourier Series without Calculus", developed by request for high-school students (St. Patricks), unpublished.

4. T. Scott, B. Madore, & Robert M. Corless, "Maple in Science Education", Special Issue of MapleTech, (1994) 58–68.

5. Robert M. Corless, "Six, Lies, and Calculators", *The American Mathematical Monthly*, vol. 100, no. 4, (1993) 344–350.

4.5 Evidence of impact and effectiveness

A half-dozen refereed papers joint with graduate students, and a paper joint with an undergraduate student (Amanda Connell, whom I sent to Louisiana to give a talk on the paper), have arisen out of projects for my Maple course or out of undergraduate supervision; one more paper is in preparation from the Special Functions course (with Mike Haslam); in addition, three students published refereed papers on their own (Amir Fariborz, Dhavide Aruliah and Nelly Simoes) strictly based on their projects for my course. In addition, several Engineering Ph.D. theses (including those of Yuan Jing and P. Young) have been strongly influenced by my course. Naturally, theses in our own department have also been affected (the most outstanding example is Dr. Pratibha, who was David Jeffrey's student).

4.6 Classroom Teaching

4.6.1 Summary of student ratings

The grad courses and AM475b are not listed here as student ratings are not taken for these courses. Mean ratings are given, even when the median ratings are higher (e.g. the median rating for AM361b in 1997 was 7.0 out of 7.0).

	26	3(2)61	372	CS422	
Size	110	12	80	14	
Type	In.	Mnd.	El.		
00–01	—	—	—	—	Sabbatical Leave
99–00	—	—	—	—	Distinguished Research Professorship
98–99	—	6.2	—	—	
96–97	—	6.2	—	5.6	
95–96[1]	—	—	—	—	
94–95	—	—	—	—	Sabbatical Leave
93–94[2]	4.6	—	—	—	

Notes:

[1]: Extended Sabbatical (National Centre of Excellence for Telelearning; Organic Mathematics Project). I taught AM475b and AM511b on my return in January 1996—both are unrated.

[2]: Ratings prior to 1995 are out of 5, ratings afterwards are out of 7.

4.6.2 Letters

The following appeared in Absolute Zero, MICD, No. 15, April 1997 (the "Prof Evaluations" issue), under the AM361b heading, on p. 3.

> An interesting course with an excellent professor. Robert Corless not only knows his stuff inside-out, but has the rare ability to convey his ideas in a clear and interesting way. He values student input and takes time to answer every question presented to him. Potential students should know that assignments in this course are primarily based on computers, though most of the work is based on theoretical results.

4.6.3 Objective indicators

Successful (computer teaching lab related) ADF grant applications:

year	co-workers	amount
90–91	DJJ, SCRD, MAHN	$ 30,000
93–94	DJJ	$22,000
96–97	HR	$10,000

DJJ	=	David Jeffrey
SCRD	=	Stan Dennis
MAHN	=	Paddy Nerenberg
HR	=	Henning Rasmussen

4.7 Course Content and Course Management

Course management can be delicate, particularly when you are revolutionizing the course content. For the first year engineering mathematics courses (AM026 and AM025), when I was the program director in charge of both courses, I used the methods of the previous director (Paul Sullivan) to attempt to ensure that morale was high among the five instructors and six TA's involved. The TA's were selected as an 'elite' group, "Team 26", and given encouragement and incentives (the most effective being that they were treated as colleagues) to put in the extra work required for this TAship, as opposed to some of the easier TAs which usually only involved marking. Morale among the faculty is an issue, too; it is clearly more work to use technology creatively in class than to use traditional methods.

Resource management. In several courses (not just first year engineering mathematics), software and hardware have to be managed. This means researching and selecting the appropriate technology, making sure that all components are available (in some cases raising money for the purpose), working with lab managers such as Barry Kay in Engineering, learning how to use the technology properly, training TA's and colleagues if necessary, running extra tutorials for the students, debugging and troubleshooting, and finally developing curricular materials that make all this extra effort worthwhile.

Student Feedback. This university has a formal mechanism for student feedback about the courses via teaching ratings, which I find useful. However, I have found it even more useful to ask for written feedback during the course (informal, spoken feedback is also fine, but many students prefer anonymity and/or time for reflection). I have habitually asked the students, twice a year, to take a half-hour out of lecture time and write their comments down. For the AM026 students, I often write a bunch of topics on the board (e.g. "what do you like least about the calculator? What do you like most?", etc) as hints, but I have found it better to let the students write freely. This is the way we discovered that the students wanted (nearly uniformly) more instruction in programming, for example.

4.8 Student Supervision

For letters from students, see Sections VII and VIII of the complete P & T dossier.

4.9 Colleague evaluations

For letters from colleagues, see the complete P & T dossier. No formal colleague evaluations of teaching, such as in-class monitoring, are available at this time.

5 Prior Recognition

5.1 The Organic Mathematics Project

See `http://www.cecm.sfu.ca/~organic` for a full description of this workshop, or some of the papers in section 8. This ambitious project was the first phase of "M^3-plexus" funded by the National Centre of Excellence in Telelearning at Simon Fraser University. Its goals were to use (possibly existing, possibly research-level) articles written to a high expository standard as a test-bed for teaching mathematics on the Web. The papers were 'activated' using new tools and enthusiastic people, and presented by the authors at a conference following the 1995 Winter Annual Meeting of the Canadian Mathematics Society. The electronic proceedings were the main goal of the project; a hardcopy version is also available.

I was the Chair of the workshop, financially supported by Simon Fraser University, Western, and the National Centre for Excellence in Telelearning; I worked closely with Jon and Peter Borwein and Loki Jörgenson on all aspects of the workshop. It was an extremely interesting experience. The main lesson we learned is that it is possible to be simultaneously on the cutting edge and yet obsolete; technology changes very quickly! The other main lesson is that there are many nontrivial issues that have yet to be worked out before mathematics can really be taught over the Web; and in some cases these issues (archival value, for example) run counter to current directions of the Web.

5.2 International Summer School

I was invited (with full travel support) to give four lectures and a workshop at the (undergraduate student organized) International Summer School "Let's Face Chaos through Nonlinear Dynamics", at the University of Ljubljana, Ljubljana, Slovenia, in September 1993.

5.3 Invited Talks

In addition to conference talks (see section 8) on educational subjects, and local talks such as those I gave to COMPASS (three so far), the following talks were invited (i.e. expenses were paid in full by the organizers).

1. "Computer-Mediated Thinking", Inaugural Conference of the Esso Centre for Mathematics Education (keynote talk), April 21, 2001.

2. Research Weekend on Symbolic Linear Algebra, SUNY Geneseo February 2001 (one college-wide talk, one math talk, and a one-day workshop for 18 invited student participants).

3. "How technology affects the curriculum in mathematics", given at the Fields-Nortel Workshop on Mathematics Education, Toronto, July 1997, and also by invitation to the Department of Mathematics, Statistics, and Computer Science of the University of Cantabria, in Santander, Spain, June 1997.

4. "Scientific Computing in Mathematics Education: One Third of the Revolution", Workshop in New Technology for Symbolic Computational Mathematics in Research and Education, CAIP Center, Rutgers University, New Jersey, June 1994.

5. "Is Mathematics Education Good Enough for Calculus", (joint work with David Jeffrey, talk presented by David Jeffrey) at the Conference on Computation in the Calculus, Renssalear Polytechnic Institute, Troy, New York, November 1992.

6 Professional Development

6.1 Workshops attended

- Perspectives on Teaching, September 1997.
- Innovation in Teaching Workshop, Guelph, May 1997. The talk by Robert J. Young (1997 CASE Professor of the Year) was one of the most thought-provoking and motivational talks on teaching I have ever attended. I highly recommend getting him to come to Western. His talk emphasized many crucial virtues of traditional methods of instruction, including (formal) personal contact.
- EDO Fall 1987: How to use overheads (I attended this in 1987, and unfortunately I have forgotten the speaker's name: however, I use his lessons in every talk I give with overheads.)
- EDO (date unrecorded): Ray Rasmussen. His technique of requiring the students to read some of the material themselves *really works*.
- EDO (date unrecorded): Pat Rogers 'You Can't do That in My Classroom'. Her ideas on discussion groups in class and going out into the class to work with the students also really work.

7 Educational Leadership

7.1 Conferences, Workshops, and Seminar Series Organized

I have organized the following conferences and seminar series, all aimed at either educational issues (specifically to do with technology), or aimed specifically at graduate student education, or (in the case of MSIC) promotion of a broad and general environment for education of our graduate students and colleagues in all mathematical sciences departments.

1. Canadian Applied Mathematical Society Annual Meeting 1997, minisymposium on Technology in Mathematics Education
2. The Mathematical Sciences Interdepartmental Colloquium Series (MSIC) (started Spring 1996)
3. Flow-Induced Vibration Day, May 1996
4. Numerical Analysis Day, 1991, 1996, 2000
5. Computer Algebra Day (since 1988)
6. Fractal Friday (Spring 1995)

7.2 Committees

1. Joint Area University Committee on High School Curriculum and University Entrance Examinations, John Bland (Math, U. Toronto, Chair). (1997)
2. Mathematics Education Forum, W. F. Langford (Fields Institute, Chair) (1997)
3. 1996 Provost's Task Force on First-Year Mathematics, Peter Cass, Chair.
4. 1996 Honours Restructuring Committee (R. Migneron, Chair)
5. 1991 Honours B.Sc. Committee (R. Haines, Chair)
6. Committee on Mathematics in Post and Secondary Schools (COMPASS) (member since 1991).

8 Research on Teaching

This is a list of papers on the use of technology in mathematics and engineering education.

1. Robert M. Corless & David J. Jeffrey, "Scientific Computing in Mathematics Education: One Part of the Revolution", J. Symb. Comp. **23**, *pp.* 485–495 (1997) (invited).
2. Jonathan M. Borwein, Peter B. Borwein, Steven Braham, Robert M. Corless, and Loki Jörgenson, "Digitally Activated Mathematics for a Brave New World Wide Web", Australian Journal on Education, Research, and Perspectives, volume 23, No. 2, *pp.* 28–47, (1996).
3. Jonathan M. Borwein, Peter B. Borwein, Robert M. Corless, Loki Jörgenson, & Nathalie Sinclair, "What is Organic Mathematics", Proc. Organic Mathematics Workshop, Simon Fraser University, Vancouver, Dec. 12–14, (1995) Borwein, Borwein, Corless, & Jörgenson, eds. Hardcopy appears in Proceedings of the Canadian Mathematics Society, volume 20, pp. 1–18, (1997).
4. Robert M. Corless, "Simple Engineering Mathematics with Maple", Special Issue of MapleTech on Engineering, Ross Taylor, ed. (1995) 2–7 (invited).
5. Robert M. Corless, "Trim *vs.* Stewart: a comparative review", review of calculus texts, commissioned by Prentice-Hall. unpublished.
6. P. A. Rosati, Robert M. Corless, C. Essex, & P. J. Sullivan, "An Evaluation of the HP28S calculator in calculus", Australian J. Engineering Education, vol. 3, no. 1, (1992) 79–88.
7. P. A. Rosati, Robert M. Corless, C. Essex, & P. J. Sullivan, "Student Reaction to the HP28S Calculator in Calculus", Proc. East-West Congress on Engineering Education, Jagiellonian University, Cracow, Poland, (1991) 80–84.
8. Robert M. Corless, C. Essex, P. J. Sullivan, & P. A. Rosati, "Using the HP28S calculator in the calculus course for engineering students", Proc. 7th Canadian Conference on Engineering Education, U. Toronto, (1990) 511–527.
9. Robert M. Corless, C. Essex, T. Lookman, P. A. Rosati, & P. J. Sullivan, "The HP28S/HP48S in first year engineering mathematics", Proceedings of The Fourth Annual Conference on Technology in Collegiate Mathematics, Lewis Lum, ed., Portland Oregon November 15–17, (1991) 353–361.

Total Paper count: 5 on curriculum and 9 on pedagogy, one book published, and two in progress.

A Course Outlines

A.1 AM026 — Calculus for Engineers

A.2 AM 351a — Continuum Mechanics

A.3 AM 361b — Numerical Analysis

A.4 AM475 (old numbering) — Numerical Solution of Ordinary Differential Equations

A.5 CS422a/539 — Algorithms for Computer Algebra

A.6 AM 475/563 (formerly 511 or 512) — Applied Computer Algebra

A.7 AM 511y — Special Functions

A.8 Physics & Astronomy 478/531, Philosophy 470/565 — Theory and Evidence in Gravitational Physics