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Effective practices in developing and supporting science, technology and mathematics knowledge, skills and teaching

YORK'S MATHEMATICS, SCIENCE AND TECHNOLOGY PROGRAM

*A Unique Pre-service Teacher Education
Program at Seneca @ York*

BY DOUGLAS WATT

April 2001

York's specialist teacher education program in mathematics, science and technology (MST Program) is designed to empower its graduates to be highly effective mathematics and science educators by exposing them to current theory and research in MST education and education-related fields. One way it accomplishes this is by giving teacher candidates 50 per cent more supervised practicum days than any other faculty of education in Ontario.

Overview

Today's knowledge-based economy calls for individuals who are scientifically literate and technologically capable and who have the generic skills, attitudes and behaviours needed to function and perform at work, at home, at school and in their community. The demand for such individuals far exceeds the supply. In response, the Ontario Ministry of Education has increased its graduation requirements in mathematics, science and technology classes and has devel-

oped a new curriculum. But this alone will not be enough. Educators will require ongoing professional development and training to familiarize themselves with the new curriculum, and they will need to be introduced to new teaching tools, approaches and techniques to better implement the new curriculum. Teacher candidates will require pre-service educational programs to help them understand the new curriculum and become highly effective educators. The Mathematics, Science and Technology Program (MST Program) at the York/Seneca Institute for Science, Technology and Education (YSISTE) is one example of a teacher education program tailored to developing these very skills and overcoming existing barriers to effective science and mathematics teaching and learning.

*The York/Seneca Institute for Science,
Technology and Education*

Capitalizing upon the complementary strengths and resources of York University and Seneca College of Applied Arts

National Business and Education Centre (NBEC)

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NBEC Mission

We help business and education leaders work collaboratively to promote the development of a learning society that will prepare Canada's young people for a changing world.

YSISTE is supported by: York University, Seneca College, the Imperial Oil Charitable Foundation and 22 district school boards across Ontario.

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and Technology, the York/Seneca Institute for Science, Technology and Education is dedicated to supporting education in mathematics, science and technology in Ontario. Through its integrated and unique approach to teaching, curriculum, outreach and applied R&D, YSISTE is equipped to make significant impacts and set new standards in mathematics, science and technology education. For example:

- YSISTE staff helped develop both elementary science and technology and secondary science curricula for the Ministry of Education.
- YSISTE's Assessment of Science and Technology Achievement Program, in partnership with 22 boards from across the province, supports teachers' professional growth and the development of assessment materials.
- YSISTE is initiating a Teacher Fellowship Program, in partnership with publishers and others, that recognizes exemplary mathematics and science teachers.
- YSISTE, with support from the Canadian Foundation for Innovation, is developing the first on-line professional development course for teachers of technological studies.

The Mathematics, Science and Technology Program

With the growing confidence and support of school boards, schools and educators from across Ontario and throughout the country, YSISTE's MST Program is quickly becoming an exemplary model for developing new teacher candidates in mathematics, science and technology. Boards of education value MST Program graduates for their knowledge of current theory and research, their awareness of social justice issues, their

extensive classroom experience and their demonstrated level of maturity.

Teacher Candidates

Students with degrees or strong backgrounds in mathematics or the sciences, and who plan to become elementary or secondary school teachers, are attracted to YSISTE's MST Program for a number of reasons:

- It offers teacher candidates the most extensive practicum and experiential learning experience in Ontario.
- It is fully accredited by the Ontario College of Teachers (OCT) and supports the development of the OCT standards of practice.
- It is situated in one of the most wired and state-of-the-art educational facilities in Canada, Seneca @ York.

With over 300 applicants to the MST Program in 2000 and only 66 seats available, the calibre of teacher candidates admitted to the program is high. The MST Program selection committee believes that what each individual brings to the group and how a class of teacher candidates interacts with one another is important and fundamental to the learning component of the program. A candidate's "fit" into the experiential learning model of the integrated MST Program is therefore carefully considered. The level of maturity and background diversity of the MST Program teacher candidates add to the program's overall educational experience as well as to the host school's experience.

Top grades and strong backgrounds in mathematics or the sciences are not all that matters. Good communication, teamwork and problem-solving skills (employability skills) are equally important. As well, the MST Program, through

The York/Seneca Institute for Science, Technology and Education was established in 1999 through a long-term donation from the Imperial Oil Charitable Foundation. This partnership, along with partnerships with school boards across Ontario and other strategic collaborations, enables YSISTE to pursue activities that contribute to the scientific literacy and technological capability of Ontario students and schools.

The MST Program prepares teacher candidates for junior/intermediate and intermediate/senior teaching positions. ►

The diverse backgrounds of the teacher candidates add to the MST Program. ►

York's Access Program, aims to have a good cross-section of visible minority candidates and male and female students with diverse backgrounds, varied career experience beyond school itself, and extensive community and school volunteer experience.

MST Program Teacher Candidate Makeup

- Age: ranges from 24 to 45 years
- Gender: 75 per cent female
- Diversity: over 50 per cent visible minorities
- Educational background: ranges from BA/BSc to PhD
- Work experience: ranges from software development through human resource recruitment to mechanics

Objectives

To help teacher candidates:

- acquire the skills, attitudes and behaviours needed to succeed as elementary and secondary school teachers of mathematics, science and technology;
- understand current theory and research in mathematics, science and technology education and education-related fields; and
- meet the Ontario College of Teachers' standards of practice.

Groups Served

- Teacher candidates
- School boards and schools
- Educators and students

Activities

The MST Program prepares teacher candidates as junior/intermediate (J/I: Grades 4–10) science and mathematics teachers and as intermediate/senior (I/S: Grades 7–12) science (biology, chemistry, physics, general and computer) and mathematics teachers through (1) a strong practicum component involving partner schools and teacher mentors and (2) an integrated coursework component utilizing the university and college's

faculty and staff and state-of-the-art educational facilities.

There is a near equal split between J/I and I/S teacher candidates enrolled in the MST Program. Of the approximately 30 J/I teacher candidates, half are focusing on mathematics and the other half on science; and of the approximately 30 I/S teacher candidates, half are specializing in biology and chemistry and the other half in mathematics, physics and computer science.

Basis of the MST Program

The MST Program is based on two fundamental principles. First, it reflects the MST Program faculty's conception of what a quality mathematics and science teacher should be. For example, all graduates should understand the importance and value of having strong employability skills; they should also understand the concept of sustainable development and recognize the connections between science, technology and society. Second, it ensures that the Ontario College of Teachers' standards of practice for the teaching profession are understood and demonstrable in all teacher candidates and program graduates. It is this combination of philosophies that makes the MST Program such a holistic and respected specialist teacher education program in Ontario and across Canada.

The MST Practicum and School Partnerships

The heart and soul of YSISTE's one-year MST Program lies in its practicum component. Teacher candidates are placed in schools under the supervision of a teacher/coach for approximately half of their program time. This amounts to between 75 and 80 days, or nearly one-half of the program. YSISTE considers the host schools and teachers/coaches to be equal partners in the instruction and development of the teacher candidates and integral to their learning experience. Graham Orpwood, Director, YSISTE, says "the host schools and teachers are critical to the success of

MST Program teacher candidates receive 50 per cent more supervised practicum days than other teacher candidates in Ontario.

our MST Program. The host teachers act as the coaches and supporters of the teacher candidates throughout their hands-on experiential learning experience.”

Currently, the MST Program enjoys local partnerships with 10 secondary and 8 elementary schools. The school partnerships enable teacher candidates to enjoy a full range of student teaching experiences and duties. These include developing course outlines and unit plans; tracking, assessing and recording student development; participating in yard/lunch/hall duty responsibilities; and engaging in extracurricular activities and special projects. The YSISTE Program coordinator and the host school site coordinators work together to arrange the teacher candidate visits over the school year.

No other teacher education program in Ontario offers its student candidates so much hands-on and in-the-classroom experiential learning. This in-school time is nearly twice the amount required by the Ontario College of Teachers’ regulations and about 50 per cent more time than experienced by teacher candidates at most other faculties of education. Consequently, teacher candidates have the opportunity to:

- investigate and observe teaching and learning;
- apply teaching techniques and assessment strategies in both junior and intermediate classroom situations;
- gain practical know-how and understanding of the curriculum and how it is put into action; and
- gain confidence in their teaching styles and abilities.

Teacher candidates are placed in host schools in groups of two to six. This gives them an opportunity to discuss and reflect upon their learnings and teaching experiences in a structured and conducive group environment. It also gives the teacher candidates an opportunity to discuss host teacher techniques and teaching styles with one another.

Throughout the year, MST Program

teacher candidates never lose touch with their host schools and host teachers. In addition to an opening week block slated during the beginning of the school year, teacher candidates are expected to teach for two blocks in each term: two blocks of two weeks’ and three weeks’ duration before the winter break, one three-week block before the March break and a final three-week block in May. The teaching blocks are intended to give the teacher candidates as rich a variety of experiences as can be arranged based on the teaching subject for which they seek certification and the scope of the programming within the host schools. During the periods of university classes, teacher candidates visit their host schools once a week. This way there is some mix of theory and practicum offered at all times.

The goal is to move the teacher candidates over the course of a year toward a full day of teaching, starting with observing, to working with small groups, to team teaching, to teaching lessons independently.

Host Schools’ Involvement

Although there is a substantial time commitment required in being an MST Program host site, many local schools are now approaching YSISTE. The schools and staff see the association with the Institute as beneficial not only to their students, teachers and science, mathematics and technology classes but also to the reputation of the schools themselves. In addition:

- ✓ Host schools receive \$750 per teacher candidate per year from YSISTE to be used any way the school wants in support of science and mathematics education (e.g., purchasing supply teachers to free up school teachers for training and professional development).
- ✓ YSISTE contributes to the professional development of teachers in the host schools. And in the future YSISTE envisions partner schools receiving specially designed professional

Host schools value their association with the MST Program and the teacher candidates.

► *The combination of university coursework, extensive practicum experience and understanding of mathematics and science theory makes MST Program graduates highly sought after.*

► *The complementary staffing model of tenured professors and seconded school teachers offers a good balance between theory and practice in the MST Program.*

development as well (e.g., annual seminars on what it means to be a host teacher).

- ✓ Host schools gain a window into the future class of teacher graduates—graduates they may want to recruit.

Course Work

In addition to the practicum component, teacher candidates are required to take a series of five university courses streamed into two groups: (1) seminar courses that provide preparation for and reflection on the school experience and (2) foundation courses that provide background knowledge for teaching by integrating theories of learning and instructional strategies with the candidate's experience in the classroom. This coursework, combined with the teacher candidates' background knowledge and experience in mathematics and sciences and the extensive practicum, means that MST Program graduates are highly sought after.

MST Program Faculty

The balance between theory and practice in the MST Program is made possible, in part, by YSISTE's unique complementary staffing model. Half of the faculty working in pre-service education are full-time Seneca and York faculty members with ongoing research and writing projects. The other half are seconded school board personnel working full-time at YSISTE for up to three years. Together, the tenured professors and seconded school teachers are able to provide MST Program teacher candidates with a unique blend of current theory, research and classroom practice. In particular, the seconded teachers can bring first-hand experience about what works and what does not in a classroom setting into the learning environment of the MST Program.

Seneca @ York Facilities

YSISTE prides itself on being the most wired educational facility in Canada, with

the most up-to-date computers, a technology "commons area," Internet connections in every classroom and good technical resources. Just as important is the MST Program faculty's commitment to advancing an understanding of the pedagogical uses of technology among its teacher candidates: all teacher candidates are required to integrate technology into their learnings and make use of their connectedness and access to information and communications technologies on a regular, if not daily, basis. The commitment to the pedagogical uses of technology is manifested in various ways. For example:

- ✓ The MST Program faculty has an on-line learning network, Current Practice, linking teacher education with projects in the field, including "Writers in Electronic Residence," "Kids From Kanata" and the "Hands On IT Project."
- ✓ Teacher candidates are issued a personal account to Current Practice early in the program, which gives them use of e-mail and enables participation in educational conferences and projects using First Class on-line software.
- ✓ Teacher candidates have a critically important on-line component to their program in the way assignments are distributed and collected; moreover, on-line support for discussions is available between classmates and faculty 24 hours a day, seven days a week.

Demonstrating Achievement of the Standards of Practice

Teacher candidates in the MST Program are required to compile professional portfolios of their work, including course assignments, lesson plans, daily class reports, practicum tracking and observation records. Throughout the year, teacher candidates are asked to select evidence from their portfolios that illustrates their development; they are asked to reflect on their choices and establish personal goals to proceed further. The portfolios help the teacher candidates to:

Teacher candidates are required to compile a professional portfolio of their work. ▶

The MST Program exposes teacher candidates to subject matter and issues other than mathematics and the sciences. ▶

- ✓ direct their own learning;
- ✓ track how successful they are in meeting the standards of practice, by illustrating effort, progress and achievement; and
- ✓ develop an understanding of how portfolios can be a powerful learning and assessment tool.

MST Program Linkages to Other Subject Matter and Issues

MST Program teacher candidates do not just learn how to become good mathematics, science and technology teachers. They are also exposed, albeit minimally, to subject matter other than mathematics and the sciences and, in this way, become well-rounded educators who are better able to recognize and act on the connections between different subjects. Over the course of the year, MST Program teacher candidates are required to attend four education conferences

where they are encouraged to intermingle with teacher candidates from other subject areas and levels. These conferences include the:

- Environment Conference—exploring the links between science and the environment;
- Science and Technology Conference—exploring the connections between science and technology;
- Equity Conference—dealing with equity and diversity in schools; and
- Fine Arts Conference—exploring ways to connect fine arts with mathematics and science.

Resources Required

Staffing

- ✓ One full-time faculty and four part-time faculty, to deliver and oversee the course material and progression of the teacher candidates.

Ontario College of Teachers' Standards of Practice

The Ontario College of Teachers (OCT) is the self-regulatory body for the teaching profession in Ontario. The OCT standards of practice for the teaching profession provide the foundation for all pre-service and in-service programs. The following five statements comprise the standards of practice:

- ✓ Commitment to students and student learning—members of the OCT are dedicated in their efforts to teach and support students and student learning and to assist students to become life-long learners.
- ✓ Professional knowledge—members of the OCT know the curriculum, the subject matter, the student and teaching practice. They know education-related legislation, methods of communication and ways to teach in a changing world.
- ✓ Teaching practice—members of the OCT apply professional knowledge and understanding of the student, curriculum, teaching and the changing context of the learning environment to promote student learning. They conduct ongoing assessment and evaluation of student progress. They modify and refine teaching practice through continuous reflection.
- ✓ Leadership and community—members of the OCT are educational leaders who create and sustain learning communities and learning partnerships in their classrooms, in their schools and in their profession. They collaborate with their colleagues and other professionals, with parents and with other members of the community to enhance school programs and student learning.
- ✓ Ongoing professional learning—members of the OCT are learners who acknowledge the interdependence of teacher learning and student learning. They engage in a continuum of professional growth to improve their practice.

Source: *Standards of Practice for the Teaching Profession* (Toronto: Ontario College of Teachers, 1999).

Seneca @ York is the most wired educational facility in Canada. ►

- ✓ One administrative support specialist, half-time, to oversee the day-to-day functions and operations of the program.
- ✓ One practicum co-ordinator responsible for the placement of teacher candidates in the host schools.
- ✓ Host teachers to mentor 60 teacher candidates.
- ✓ Site co-ordinators to oversee the assignment of classrooms and teacher mentors, as well as teacher candidate responsibilities and duties.

Facilities and Equipment

- ✓ Upwards of 15 host schools.
- ✓ YSISTE classrooms, administrative offices and a resource centre.
- ✓ Access to technology, computer and A/V equipment, information and communications technology (ICT), and software resources including e-mail.

Strategic alliances with businesses and community partners are of critical importance to the MST Program. ►

Funding

It takes a tremendous amount of resources to design, implement and sustain a teacher education program like the MST Program. Moreover, with the relative decline in provincial funding to the universities, the program is on a very tight funding leash. To overcome this resource challenge, the MST Program strikes strategic alliances with businesses and community partners, such as the Imperial Oil Charitable Foundation, to make purchases that would not otherwise be possible.

The partnership between host schools and YSISTE is the foundation upon which the MST Program is built. ►

Challenges

The Ontario government currently bases faculty of education funding on number of seats and not the quality of graduates. Because innovative teaching practices or innovative teacher candidate programs are not supported, faculties of education do not necessarily strive to be best at what they do or to seek out continuous improvement. It is a continuous challenge, financially and otherwise, for the MST Program to implement and maintain the type of teacher candidate program that it has.

Funding Challenges

- Finding new foundations and corporate supporters willing to support existing and new initiatives that contribute to the scientific literacy and technological capability of Ontario students, teachers and schools.

MST Program Challenges

- Consistently finding and maintaining good host schools close to the Seneca @ York facility.
- Having the time to complete all of the required theory, research and classroom learning components in a one-year program.
- Integrating the use and application of technology and ICT into the school classrooms during the teacher candidates' practicum component.
- Ensuring that the focus on mathematics, science and technology does not discourage teacher candidates from discovering and connecting with other subject areas such as art, history and geography—MST Program teacher candidates are given little formal time to explore how other subject areas connect with mathematics and science other than through attending the Arts, Equity and Environment Conferences put on by York's Faculty of Education.
- Having to continually consider short-, medium- and long-term design options around how best to deliver the MST Program. New approaches to recruitment and instruction need to be thought out today if the MST Program is to remain viable and provide the sorts of training needed for tomorrow's diverse and changing environment. Many school boards, for example, are hiring upwards of 75 per cent of their staff on a part-time basis, making it more and more necessary for teacher candidates to be able to receive training on an "anytime," "anywhere" basis.

Achievements and Outcomes

- In the past year, has received over 300 applications and accepted just over 60

Teacher candidates are a useful resource of knowledge and new teaching methods for host teachers. ►

The MST Program adds to the quantity and quality of mathematics, science and technology education in Ontario. ►

students into the program. Of the 60 successful applicants, only half are from York University's undergraduate programs.

- Successfully contributes to the supply of science and mathematics elementary and secondary school teachers each year.
- Uses technology and ICT as an integral part of the learning practice.
- Places teacher candidates in schools for more days and more time than any other faculty of education program.
- Receives accolades from schools and school superintendents on the high level of experience, practical knowledge and maturity of its teacher candidates.
- Produces teacher candidates who have a better-than-expected understanding of the conceptual underpinnings of the provincial curriculum, due in part to YSISTE's role in the design of the elementary and secondary curriculum.
- Upon graduation, its student alumni keep in touch with one another to share teaching experiences, lesson plans, ideas and knowledge using the First Class e-mail software.

Benefits for Teacher Candidates

- Learn through experience.
- Are taught by a mix of tenured faculty and seconded teachers.
- Recognize how mathematics and science learning and teaching are connected and interrelated.
- Understand the value of teaching and learning employability skills.
- Use and apply ICT in their learning and teaching approaches.
- Recognize the importance and value of a holistic approach to teaching and learning.
- Demonstrate OCT standards of practice.
- Use co-operative learning, problem-solving and assessment techniques.

Benefits for Host Schools

- Are confident in the teaching abilities and knowledge of the MST Program teacher candidates.

- Teacher candidates transfer knowledge from their coursework into the classroom by sharing new ideas, new evaluation techniques and new theories on how young people think and act.
- The longer practicum allows school students to become familiar with the teacher candidates. As well, class teachers know more about the teacher candidates, their knowledge and their particular teaching characteristics.
- Teacher candidates provide classroom teachers with an extra resource and help with students.
- Receive funding from YSISTE to use in support of science and mathematics education.
- Get a first look at the new mathematics and science teacher candidates, with a view to hiring them upon graduation.

Benefits for MST Education

- The quantity and quality of education in mathematics, science and technology increases at all levels of education.
- Numbers of specialized mathematics and science elementary and secondary school teachers in the province increase.
- A cycle of effective learning and development is achieved, as MST Program graduates become the mentors of future MST Program teacher candidates.

Innovation

- ✓ Provides students with a good balance of current theory, research and classroom practice.
- ✓ Breaks down the barriers between elementary and secondary teaching and learning practices by encouraging J/I and I/S teacher candidates to communicate and interconnect with one another.

Keys to Success

- Having a strategic partnership with the Imperial Oil Charitable Foundation and other organizations.

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MST Program teacher candidates

- Having a blended staffing model involving a mix of tenured professors interested in R&D and seconded teachers from the schools interested in keeping a practical focus on the program's goals and objectives.
- Selecting the right mix and right calibre of teacher candidates for the program. It is important to take a holistic approach when looking at grades, school and community volunteer experiences, and what each candidate has to offer to the program and to their fellow classmates. A wealth of backgrounds, ages and previous work and life experiences adds to the value of the teacher candidates' MST learning experiences by exposing them to a range of ideas, personalities and points of view.
- Being located in an urban area and in close proximity to the practicum schools.
- Having good relationships with the practicum schools.
- Having an outstanding site co-ordinator who is able to find and keep practicum schools.
- Having access to up-to-date technology and equipment.
- Being located in the most wired educational facility in Canada.
- Establishing the credibility of the MST Program and its faculty through the work done on the elementary science and technology and secondary science curricula.
- Having a funding model in place with the host schools to help support their needs and to bring the best schools into the program.

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