Rethinking the undergraduate mathematics curriculum: What role does technology play?

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University Undergraduate Degree Level Expectations: UUDLES

- These are mandated by the Council of Ontario Universities, for all Undergraduate Programs in Ontario.
- **The Six OCAV** categories for all University Undergraduate Degree Level Expectations (UUDLES) are:
- Depth and Breadth of Knowledge
- Knowledge of Methodologies
- Application of Knowledge
- Communication Skills
- Awareness of Limits of Knowledge
- Autonomy and Professional Capacity

UUDLES for Math Programs

- Which Math Programs in Ontario will include knowing how to use technology in their UUDLES?
- When there is a Degree Level Expectation around technology, then the program must be able to point to courses in each of the years of the program that build this capacity.
- In addition, the courses must contain assessment which connects to that expectation.
- Some examples from York.

Statistics Program

- It is assumed that all graduating students will know several computer packages for statistics:
- Minitab is in the first year course (all math majors);
- R and SAS are in upper level courses;
- Students need to know some programs to get many of the jobs, in the summer or on graduation.
- May be explicit in the UUDLES – or implicit in and expectation around Knowledge of Methodologies
- Should be implicit, perhaps explicit, under Awareness of Limits of Knowledge
- Autonomy and Professional Capacity

Applied Mathematics Program

- The capstone course includes some use of technology – but needs to adapt to what has been used;
- It is assumed that all graduating students will know several computer packages for computation:
- Maple is taught (by CSE) as a first-year course;
- The capstone course and required numerical analysis courses require the ability to use some combination of programs (Maple, MatLab, C+, …);
- Current draft Applied Mathematics UUDLEs include:

- *ability to use computer programs and algorithms: numerical and graphical, to obtain useful approximate solutions to difficult mathematical problems and to present and visualize the numerical results appropriately.*

- Issue of choosing just a few core pieces of software

Mathematics for Commerce

- Includes substantial statistics.
- Uses minitab, Excel, R
- Includes OR stream with LINDO modeling
- R includes significant capacity to do simulations – an important process.
- Have not yet accessed UUDLEs
- relevance of Awareness of Limits of Knowledge
- Question of evolution of Actuarial Exams – when they reference technology, courses will adapt!

Mathematics for Education Program

Ontario High School Curriculum includes the following mathematical processes:

- *selecting tools and computational strategies to solve problems and aid conceptual understanding;*
- *representing and modelling mathematical ideas in multiple forms: concrete, graphical, numerical, algebraic, and with technology;*

  Geometer's SketchPad (licensed for all students), Fathom, Data Exploration software, licensed for all schools and all teachers. Graphing Calculators are in the curriculum.

  Excel is ubiquitous.

  Smart boards are becoming common.

In our program:

- Maple is taught (by CSE) as a first-year course – but Maple is not used in high school;
- A stats course required – but software used may not connect to what is in the schools.

Mathematics for Education Program

- The Geometry course uses Geometer's Sketchpad, free programs (Spherical Easel, Google Sketch-Up).
- Heavy use of manipulatives.
- Capstone course: some use of technology and discuss research on use of technology.
- Aside: Consecutive Education students who do not yet know how to use the technology are anxious.
- Current draft Mathematics for Education UUDLEs include:

- *use computer programs and algorithms: both numerical and graphical, to obtain useful approximate solutions to mathematical problems and to present and visualize numerical results and reasoning appropriately;*
- *employ technology effectively, including computer software, to investigate open-ended problems and to illustrate mathematical and statistical concepts and solutions to these problems.*

Many graphical displays (forms of communication within mathematics) are well done with technology of some type.

Pure Mathematics?

- Includes one course in statistics,
- one course taught by CSE in Maple
- No other requirements around technology.
- Some courses will talk about existence of algorithms, but may never look at an implementation.
- Some will give option of using software (Maple, SAGE)
- relevance to Awareness of Limits of Knowledge?

A coming shift?

- Technology is ubiquitous in the practice of mathematics, particularly in interdisciplinary teams and other disciplines.
- In the curriculum replace:

  Use technology when appropriate

with

  Use pencil and paper when appropriate

Zal Usiskin

Algorithms and Computers: Big Ideas of Mathematics?

- Large goal of mathematics is to create algorithms.
- Research is often about: *is there an algorithm? Is it scalable (exponential, … linear)*?
- On some scale, the algorithms can be implemented with technology (computers, hand-held devices, …)
- Knowing when there is an implementable algorithm or no algorithm is an important issue for 'limits if knowledge'.
- Where do students learning that?

A Big Ideas of Mathematics?

- Many applications of mathematics using computers.
- Some mathematics can *only be done* by computers,
- is *only interesting* because of computers,
- The shift: 1944 'computers' meant a room full of women doing hand calculations for code breaking.
- Now it is a big question: *why have humans learn to do badly and slowly what computers do quickly and accurately?*
- Our frozen curriculum fails to adapt, fails to prepare students for this environment, these judgments.