Presentation on DQP for mathematics
October 21, 2011

I come to this with a perspective from the "front lines" of undergraduate teaching. I've spent 5 years as head undergraduate math advisor at U.O. This involves advising math majors and the many other students who need math courses. I've been mathematics department head for three years, teaching and supervising undergraduate (and graduate) teaching.

So the structure and pedagogical goals of bachelor degrees majors are of considerable interest to me.

I'm also interested in K-12 education, at least in part because in higher ed we care a great deal about the preparation our future students receive. I've watched (on the state level) CIM/CAM, PASS, Oregon Educational Act for the 21st Century and (nationally) NCLB. Most recently on the local front, we have the "Essential Skills for the Oregon Diploma" (Oregon Board of Ed., June 2008).

I've been in Oregon 16 years, and these efforts go back further than that (21st Century started in 1991). I've seen a lot ink spilled (or at least toner cartridges used) over these efforts, but no evidence that the quality of K-12 education has improved.

To me this doesn't mean we shouldn't try to improve college education, but it does make me wary of efforts to do so via grand schemes. None of the schemes mentioned about for K-12 (of varying grandeur) were backed up by scholarship demonstrating their efficacy, and personally I'm resistant to investing significant resources in such schemes without such evidence.

Lumina's DQP document: purpose and need for DQPs.

Assertion 1: The call for more high quality degrees in the US must be matched by a concrete description of what each degree means (that supports assessment in terms of competencies).

Assertion 2: This concrete description will allow educators to direct their programs appropriately and will give students clear statements of outcomes the students should hope to realize.

I think both of these assertions deserve consideration, although I'm not convinced of either off them.

I hear far more complaints that the US is not graduating enough engineers and doctors than I hear complaints about our engineering and medical graduates being insufficiently educated to do their jobs. (But I don't know how to evaluate either kind of complaint.)

I also am not certain that a concrete description at the level of "what is a bachelors degree" will help individual programs do a better job educating students in particular majors.

If we are to make concrete descriptions, there will probably be differences between vocational degrees (a degree intended to lead to ultrasound technician certification, for example), broader technical degrees (electrical engineering, for example) and liberal arts degrees (those in the traditional sciences and humanities, for example). Concrete descriptions are probably simpler in the first case, and harder in the last.

The notion of a common degree qualification profile for a bachelor's degree.

As with any attempt to make common sets of qualifications for a diverse group of people, the following tensions need to be considered:

1) The risk of trying to incorporate qualifications from every type of degree so that no one gets left out. (In mathematical language, taking the "union" of desirable qualifications for each degree.) This will result in an unwieldy and unusable set of qualifications.

2) The risk of a set of qualifications that is limited to what is in common to all degrees. (In mathematical language, the "intersection" of desirable qualifications for all degrees.) This will result in a lowest common denominator set of qualifications.

3) Language that is so specific that while it may make sense for degrees in one area, it doesn't have much meaning for degrees in another area.

4) Language that is so vague that it is effectively meaningless.

Many of us are familiar with projects of this nature at the level of qualifications for high school graduation. This, because it is less specialized, should be much easier.

For those of you who remember the heyday of the CIM/CAM in Oregon, I believe this embodied flaws 1) and 4). More recently, the State Board of Education's "Essential Skill's" requirements for high school graduation risk demonstrating both 1) and 4).

UO's Educational goals for math major (Dec. 2008)

Because a liberal arts major is in general not a vocational degree (and the math major is no exception), the educational goals are not intended as preparation for a specific job or career.
Educational goals of all tracks of the major are

(1) Familiarity with the ideas and proficiency with the calculational techniques of calculus.
(2) Awareness of the breadth of mathematics.
(3) Ability to engage in the process of mathematical reasoning and proof.
(4) Understanding of some area of undergraduate mathematics in depth.

The secondary education track of the math major is to some extent an exception as that track is specifically designed to help prepare future high school mathematics teachers both in terms of providing a depth of mathematics knowledge to support their teaching, and in terms of providing preparation to pass the appropriate licensure exam in mathematics.
So for students who are preparing to become high school mathematics teachers, we also expect the major to prepare them to take the licensure exam in mathematics.

Typical career paths for math majors

High school teacher

Actuarial work

Other work in finance

Graduate school:
-mathematics
-engineering
-law
-business
-economics
-medicine
-computer science

Miscellaneous careers in corporate world involving quantitative and analytical skills, but little advanced mathematics. Training: problem solving.

Degree Qualifications Profile for Bachelor's Degree (from Lumina Foundation Document dated January 2011).

Specialized knowledge:

- Defines and explains the boundaries and major sub-fields, styles, and/or practices of the field.

- Defines and properly uses the principal specialized terms used in the field, both historical and contemporaneous.

- Demonstrates fluency in the use of tools, technologies and methods common to the field.

- Evaluates, clarifies and frames a complex question or challenge, using perspectives and scholarship drawn from the student's major field and at least one other field.

- Constructs a project related to a familiar but complex problem in his/her field of study by independently assembling, arranging and reformulating ideas, concepts, designs and/or techniques.

- Constructs a summative project, paper, performance or practice-based performance that draws on current research, scholarship and/or techniques in the field.

Broad integrative knowledge:

- Frames a complex scientific, social, technological, economic or aesthetic challenge or problem from the perspectives and literature of at least two academic fields, and proposes a "best approach" to the question or challenge using evidence from those fields.

- Produces, independently or collaboratively, an investigative, creative or practical work that draws on specific theories, tools and methods from at least two academic fields.

- Explains a contemporary or recurring challenge or problem in science, the arts, society, human services, economic life or technology from the perspective of at least two academic fields, explains how the methods of inquiry and/or research in those disciplines can be brought to bear in addressing the challenge, judges the likelihood that the combination of disciplinary perspectives and methods would contribute to the resolution of the challenge, and justifies the importance of the challenge in a social or global context.

Analytical inquiry:

- Differentiates and evaluates theories and approaches to complex standard and non-standard problems within his or her major field and at least one other academic field.

Use of information resources:

- Incorporates multiple information resources presented in different media and/or different languages, in projects, papers or performances, with citations in forms appropriate to those resources, and evaluates the reliability and comparative worth of competing information resources.

• Explicates the ideal characteristics of current information resources for the execution of projects, papers or performances; accesses those resources with appropriate delimiting terms and syntax; and describes the strategies by which he/she identified and searched for those resources.

Engaging diverse perspectives:

• Constructs a cultural, political, or technological alternative vision of either the natural or human world, embodied in a written project, laboratory report, exhibit, performance, or community service design; defines the distinct patterns in this alternative vision; and explains how they differ from current realities.

Quantitative fluency:

• Translates verbal problems into mathematical algorithms and constructs valid mathematical arguments using the accepted symbolic system of mathematical reasoning.

• Constructs, as appropriate to his or her major field (or another field), accurate and relevant calculations, estimates, risk analyses or quantitative evaluations of public information and presents them in papers, projects or multi-media events.

Communication fluency:

• Constructs sustained, coherent arguments and/or narratives and/or explications of technical issues and processes, in two media, to general and specific audiences.

• In a language other than English, and either orally or in writing, conducts an inquiry with a non-English-language source concerning information, conditions, technologies and/or practices in his or her major field.

• With one or more oral interlocutors or collaborators, advances an argument or designs an approach to resolving a social, personal or ethical dilemma.

Applied Learning:

• Presents a discrete project, paper, exhibit or performance, or other appropriate demonstration that links knowledge and/or skills acquired in work, community and/or research activities with knowledge acquired in one or more disciplines; explains in writing or another medium how those elements were combined in the product to shape its intended meaning or findings; and employs appropriate citations to demonstrate the relationship of the product to literature in its field.

• Formulates a question on a topic that addresses more than one academic discipline or practical setting, locates appropriate evidence that addresses the question, evaluates the evidence in relation to the problem's contexts, and articulates conclusions that follow logically from such analysis.

• Completes a substantial field-based project related to his or her major course of study; seeks and employs insights from others in implementing the project; evaluates a significant challenge or question faced in the project in relation to core concepts, methods or assumptions in his or her major field; and describes the effects of learning outside the classroom on his or her research or practical skills.

• Explains diverse positions, including those of different cultural, economic and geo- graphic interests, on a contested issue, and evaluates the issue in light of both those interests and evidence drawn from journalism and scholarship.

• Develops and justifies a position on a public issue and relates the position taken to alter- native views within the community/policy environment.

• Collaborates with others in developing and implementing an approach to a civic issue, evaluates the strengths and weaknesses of the process and, where applicable, the result.

Questions about Lumina's beta DQPs:

(Thanks Karen Mongelle

• Are the DQP-defined outcomes different than our current 'business as usual?' If so, do the DQP-defined outcomes represent a set of outcomes that are more robust or more useful for our students? How much does this depend on what students plan to do with their degrees?

• Will the DQP prompt departments to review their curriculums with the lens of preparing students for life and jobs in the 21st century? Do departments/programs need such prompting? What are the benefits/costs of undertaking such review with the DQP (versus not reviewing at all or reviewing via some other mechanism, framework, or lens)?

• Suspend reality and imagine that we adopt the DQP outcomes. What are the potential benefits and drawback for students? For faculty?

• Are students getting the best education that they can get right now in our programs? What evidence do we have to answer this question? Can the DQP help answer this question?)

How would this affect a typical undergraduate math major?

I will focus on a paragraph from "applied learning:"

"Completes a substantial field-based project related to his or her major course of study; seeks and employs insights from others in implementing the project; evaluates a significant challenge or question faced in the project in relation to core concepts, methods or assumptions in his or her major field; and describes the effects of learning outside the classroom on his or her research or practical skills."

Currently not done by vast majority of math majors.

Analogous in level of effort to undergraduate honors thesis in mathematics. This requires the equivalent of at least one quarter full time. Occupies about 1/10 of the teaching time of a faculty member for one year.

In our department (as is common in mathematics) those mathematicians engaged in applied mathematics are using mathematics substantially beyond undergraduate-level mathematics. So supporting this outcome will require additionally significant department time developing contacts/recruiting in the "field" to find people with projects who are willing to collaborate with undergraduate students on their first project. Program exist that support outcomes like this, but are very few and are, as far as I know, confined to engineering institutions in major cities.

Such projects, if they could be done, would certainly be valuable for some groups of students. They would not be valuable, though they would be time-consuming for typical graduate school bound students, or for students expecting to become high-school teachers.

Some students will be doing this sort of work after graduation. But most of those students will be joining teams in companies working on such projects and become team members working under the supervision of experienced people, rather than working on projects independently.

We graduate roughly 70 math majors per year. A rough order of magnitude for our department of implementing this item would involve a faculty increase of about 15%.

Consideration of other items from Lumina DQP draft:

The specific item tackled above is something that _could_ be done at the undergraduate level in mathematics, although it would require considerable resources and (in my opinion) would not be universally advantageous to students.

Many of these items are simply inaccessible to undergraduate math majors, though they may be sensible for masters or Ph.D. level graduates.

Others might be accessible and sensible for some subgroups of majors but not for others.

All of this changes if we are not concerned with meeting these requirements in a serious way. If we provide a rubric that outlines mechanical ways that students can demonstrate these competencies, it may be possible to shoehorn this into our current way of business. But it isn't likely to increase the quality of our degrees.