Developing Graduate Skills

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Views of HE curriculum from 'Young Researchers in Mathematics'

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At the Young Researchers in Mathematics 2011 Conference [1] on 14th March 2011 at the University of Warwick I contributed a session, rather grandly titled 'Innovation in mathematics HE teaching & learning', which was peppered with periods of group discussion around teaching methods and graduate attributes. This paper is an account of that discussion, which I recorded with permission and made available online[1].

Young Researchers in Mathematics is an annual conference organised by and for postgraduate students and early career researchers, around 60 of whom attended my session. I didn't collect institutional affiliations but you may have your own view on what sorts of institutions and types of educational environments such an audience may have experienced.

This paper presents an account of the responses given to questions I put to the audience followed by some discussion of these. This is not intended to be a representative sample or anything other than an interesting set of views from a particular audience, presented to provoke thought.

Account of the session

First, I asked the audience to "describe mathematics teaching at university". Answers given were: chalk and talk; lots of lectures; someone stands at the front and talks; not interactive; small group tutorials with four or five students. I asked about assessment methods. The answers were exams and lots of example sheets for homework. I asked whether the homework involved short or long problems. The answer was these tend to be short, 3 or 4 problems per week. One audience member said sometimes in their first year there would be a 1.5 hour session in which students work in groups and at the end hand in a piece of work together. I asked whether they were ever given group work to take away or more in depth work and no examples were offered of either of these.

Next I asked the audience to "describe a first class student". I received two types of answer here. The first was procedural: someone who can remember proofs and knows how to do exams well. The second was more conceptual: someone who can think for themselves and solve problems they weren't taught how to solve. I asked if this meant "unseen problems, slightly outside of what they've seen" and the answer was yes.

Now I asked them to "describe a typical student". The answers given were: very quiet in class; they wait for you to do something on the board then copy it down; they are

used to doing standard techniques but aren't used to going beyond that and thinking for themselves; they're not very good at knowing when the standard techniques can be applied to other sorts of problems that don't look exactly like the one in lectures; they write things up sloppily so it's very easy for them to make mistakes and hard for them to tell where they went wrong.

The next question I asked was "what makes a good PhD student?" There were some answers here that appeared to be at least partially in jest and got laughs from the audience: going to conferences (we were at a conference); reading five papers a day; drinking lots of beer. More apparently serious answers were the qualities: willing to ask questions; ability to communicate with other mathematicians; motivation; enthusiasm; discipline; perseverance; being meticulous. I prompted with the question "what about working undirected, taking a piece of work away and working on it?" and was greeted with several yeses and the quality: "initiative".

I asked "how do you get onto a PhD?" The quick answer, "luck", got another laugh. I asked "are you better placed if you have a first class degree?" and was greeted with the answer: yes. At this point I said: "So first class students are good at regurgitating proofs and blah, blah, blah, and then when they become PhD students they're suddenly independent workers and self-motivating and...". I trailed off as several audience members started laughing.

Next I asked "what do your students do when they graduate?" The first answer, "make more money than we do", got a laugh. "Doing what?" I asked. The answers: finance; teaching; some become unemployed; some don't do anything necessarily relevant. I prompted with: "what about engineering and scientific research? Some of them might become statisticians. A lot of mathematicians seem to go into defence."

Finally I asked "what skills should a graduate of a mathematics degree be able to demonstrate?" The first answer was "numerical". I asked "what do you mean, basic numeracy?" and the answer was "you'd expect that of any graduate". Another suggested "analytic thinking skills". When asked what that means I suggested "thinking clearly and structuring your thoughts". One audience member asked "is that true of any graduate?"

This generated a list of attributes more specific to mathematics, which were: being able to make ideas more precise; dealing with abstraction; going between the specific example and the abstract case; being able to think in more than 3 dimensions; some mathematical methods, not necessarily *everything* they've learned; being able to construct mathematical models from real world problems; to understand 15% of what is at a maths conference; a good sense of what mathematics is, so they understand philosophy of mathematics, perhaps education and history of mathematics, as well as having studied a set of mathematical topics; to be aware of important unsolved problems; taking a problem, defining it properly and thinking it through; knowing how to approach a problem, knowing multiple approaches exists and knowing which is the best to try; being able to understand when you're wrong and when you're right and being able to explain why; being able to follow a logical argument and identify flaws; not needing someone to "babysit" them through hard problems; to understand when there is an optimal solution everyone can agree on and when it's a matter of opinion and different viewpoints arise.

Discussion

The discrepancy between the list of attributes of a 'typical' student and those expected of graduates is quite stark. The typical student is said to be quiet, unable to work on their own and unable to apply techniques in ways beyond what they have been shown. The graduate is expected to be able to move comfortably between specific and abstract cases, engage fully with the problem solving process and not need someone to "babysit" them through problems. Those who become PhD students must be motivated, independent workers who communicate well with other mathematicians.

The development from one stage to the other is said to take place in a teaching environment which consists mainly of a lecturer standing at the front and delivering a lecture by chalk and talk, with assessment by short problem exercise sheets and exams. My audience said they were not given in depth work as undergraduates and most did not work in groups. Quite how the independent problem solvers and able communicators are to be developed, except by chance, is not clear.

It is interesting to observe the two types of first class student identified. The first is the student who memorises proofs and knows how to do well in timed exams. The second is someone who can think for themselves and solve unseen problems. I would observe that the latter may be an aspiration of a mathematics education and the former is used as its proxy measure. I was told a first class degree would help someone get onto a PhD programme and that a capable PhD student is a motivated and disciplined independent researcher working with enthusiasm and perseverance on their own initiative. Whether the proxy is a good indicator of the desired measure is thus drawn out as a key question in understanding graduate attributes.

References

1. Young Researchers in Mathematics 2011
http://go.warwick.ac.uk/yrm2011
[Last accessed 07/10/11].