2005-2009

Teaching Statement

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Teaching Experience

2005-2006	Teaching Assistant	Elementary Calculus	Carleton
2005-2006	Teaching Assistant	Ordinary Differential Equations	Carleton
2006-2007	Teaching Assistant	Linear Algebra for Business	Carleton
2006-2007	Teaching Assistant	Linear Algebra for Science	Carleton
2006-2007	Teaching Assistant	Real Analysis	Carleton
2006-2007	Teaching Assistant	Advanced Ordinary Differential Equations	Carleton
2007	Teacher/Consultant	High School Math/Physics	Kenya
2007-2008	Teaching Assistant	Viscous Flows	Oxford
2007-2008	Teaching Assistant	Waves and Compressible Flows	Oxford
2007-2008	Teaching Assistant	Applied Complex Variables	Oxford
2008-2009	Tutor	Viscous Flows	Oxford
2008-2009	Tutor	Perturbation Methods	Oxford
2008-2009	Tutor	Waves and Compressible Flows	Oxford
2008-2009	Tutor	Applied Complex Variables	Oxford
2009-2010	Tutor	Viscous Flows	Oxford
2009-2010	Tutor	Perturbation Methods	Oxford

Prepared class notes and worksheets can be found at www.ptrinh.com/teaching
Student evaluations and references can be found at www.ptrinh.com/studentref

1 Teaching Philosophy

As an undergraduate student, I rarely attended lectures.

"What's the point?" I asked myself. Previously, when I *did* attend lectures, I usually spent the entire time copying notes (often word-for-word repetition from the classroom textbook), deciphering handwriting, or making sense of obscure, vague lesson plans. I quickly came to the realization that textbooks provided a far superior mode of learning. As a student I had *my* choice from literally thousands upon thousands of books, such that even a modest shelf could provide me with everything a lecturer could. And more.

There were a few exceptions. The lectures and classes I *did* attend were the ones that offered something *beyond* the printed word. Some professors offered concise dissemination of pages and pages of mathematics—cutting through the fog of confusion like a bright spotlight. Others offered an interactive classroom environment, one that could revive me from my undoubtedly sleep deprived state. Still others offered help outside of mathematics, providing guidance and a greater perspective on life. Some were animated, some were wickedly funny, others were wise and calm; *all* offered a glimpse of a world beyond textbooks and formulae, a world every undergraduate student desperately wants and needs.

Undergraduate mathematics students are generally independent, studious, and proud learners. They've become accustomed to studying a subject that is often presented as authoritative and dualistic; a subject that *demands* independent learning. As the teacher then, I believe it's all the more important to offer students a unique learning experience, either through pedagogic restructuring of lessons, or perhaps by simply providing a supportive environment and a blank canvas, ready for their many discoveries to come.

"What can I give them that they can't get from a book?" is the question I ask myself before teaching all my classes.

2 Future Teaching and Research Supervision

In the future, I would enjoy teaching both low and high level courses in mathematics. Among the more elementary subjects, I would especially enjoy teaching introductory classes in calculus and differential equations, as they provide me with ample opportunities to motivate the younger students and guide them towards more advanced material. More specialized courses I would like to help develop and teach include ones covering methods in applied mathematics (including perturbation theory or complex analysis) or classes in fluid dynamics. Moreover, I would also relish the opportunity to supervise undergraduate and graduate students in research projects, either stemming from my own research work, or in collaboration with another member of the university.

3 Teaching Experience in Canada

I began teaching undergraduate-level math classes as an undergraduate myself. There, I was quickly exposed to the challenges of teaching low-level math courses to students in a variety of disciplines, including business, economics, and the general sciences. Although I was later asked by the department to teach higher level courses to honors math students (for example Real Analysis and Advanced Differential Equations), I've always tried to keep perspective on the difficulties faced by both student and instructor in classes aimed at the non-specialist. The ability to empathize with people of all ages and skill levels is important not only for teaching, but also for giving research talks to non-mathematicians, or for writing expository articles in mathematical or popular science journals.

4 Teaching Experience in Kenya

During the summer of 2007, I was brought in to teach and help develop the high school mathematics curriculum for a large orphanage (2000+ students) in Kenya, under the directive of a larger volunteer organization. In addition to teaching and lecturing in mathematics and physics, my main responsibility was to coordinate with the local teachers and school superintendent and provide advice on designing an effective educational system.

The experience was a rude awakening to the tremendous political, economic, and social difficulties which confronts educators in less privileged environments. Although the situation in Kenya is undoubtedly an *extreme* one, the experience was invaluable in teaching me about the many difficulties that are often present when attempting to enhance the reputation and prestige of a department or university within the confines of a larger community.

5 Teaching Experience in England

As a Canadian, the bewildering educational structure in Britain (and especially at Oxford) initially came as a shock:

> "Oxford is far more different [...] There are the miniature lecture courses [...]; the disjunction of duties between tutors and professors [...]; the walls between courses of study so high that numbers of students in each field are more or less fixed for eternity..." [11]

As a departmental tutor at Oxford, I was responsible for teaching weekly 1-1.5 hour classes on specialized topics to mathematics students. This included classes in Viscous Flows, Waves and Compressible Flows, Perturbation Theory, and Applied Complex Variables.

During the last two years, I began taking more active and central roles in helping to develop the courses I taught; this included small and modest changes in conjunction with the lecturer, as well as more significant changes to the classroom structure and exam preparation sessions. The response to these changes have been very positive. This is outlined in the section below.

6 Course Development and Materials

During my doctoral studies at Oxford, I've taken an active role in helping develop and improve various classes. For example, in terms of the B6.a Viscous Flows course taught to third year mathematics students, some of these roles involved collaborating with the course lecturer and have led to such changes as (i) offering seven weekly classes rather than four bi-weekly classes, and (ii) pedagogic reorganization of homework assignments and problems.

Most of my attention, however, has been confined to instituting changes to the class structure[1]. For example, the traditional method of teaching has always been to *lecture* for the duration of the 1-1.5 hour class, re-covering problems from the previous assignment. My problem with this has been:

- Students have *already* handed in the assignments. Those who did well are bored when the tutor reviews problems they already understand. Less capable students spend the time copying answers, which they won't review until the end of the academic term.
- The classes do not encourage student participation.
- Due to the aggressive examination and class schedule at Oxford, students have difficulty retaining concepts they learned during the term.

In order to address these (and other) perceived problems, I now offer classes which function as weekly workshops. Each class begins with the 8-15 students seated around a table. I lecture for the first 15-25 minutes, reiterating important ideas or common errors in their assignments, but then for the duration of the class, the students work individually on a prepared worksheet, designed to stress key ideas and methods in the course. Those who finish quickly are then assigned as *teachers*—to tour the room and to help guide their fellow classmates in a one-in-one fashion until the entire group has completed the set (for examples of the handouts I've prepared for my classes, see Figure 1 and 2).

This cooperative learning environment is designed so that weaker students are given the opportunity to actively learn and participate, rather than passively taking notes. The environment also challenges the stronger students to lead, to communicate, and to empathize with the group as a whole. Moreover, the solutions to their problem sets are made available in the form of a binder in my office, and students who wish to see them are encouraged to set up an appointment; this eliminates the need for the tutor to constantly rush through each class in a veiled attempt to cover every single problem.

In 2009, this system of cooperative learning was instated in all of my six classes ($\sim$60 students) during the fall term and the early response has been very positive. I've noticed large improvements in classroom participation and social interaction among the students, as well as improvements in general understanding and competency.

[1] The educational structure of Oxford mathematics courses is usually as follows: Students take weekly **lectures** given by the **lecturer**. They hand in regular assignments which are marked by the **teaching assistant**. They take weekly **classes** given by the departmental **tutor**. The final grade of a course is based on 100% weighting of the final exam.

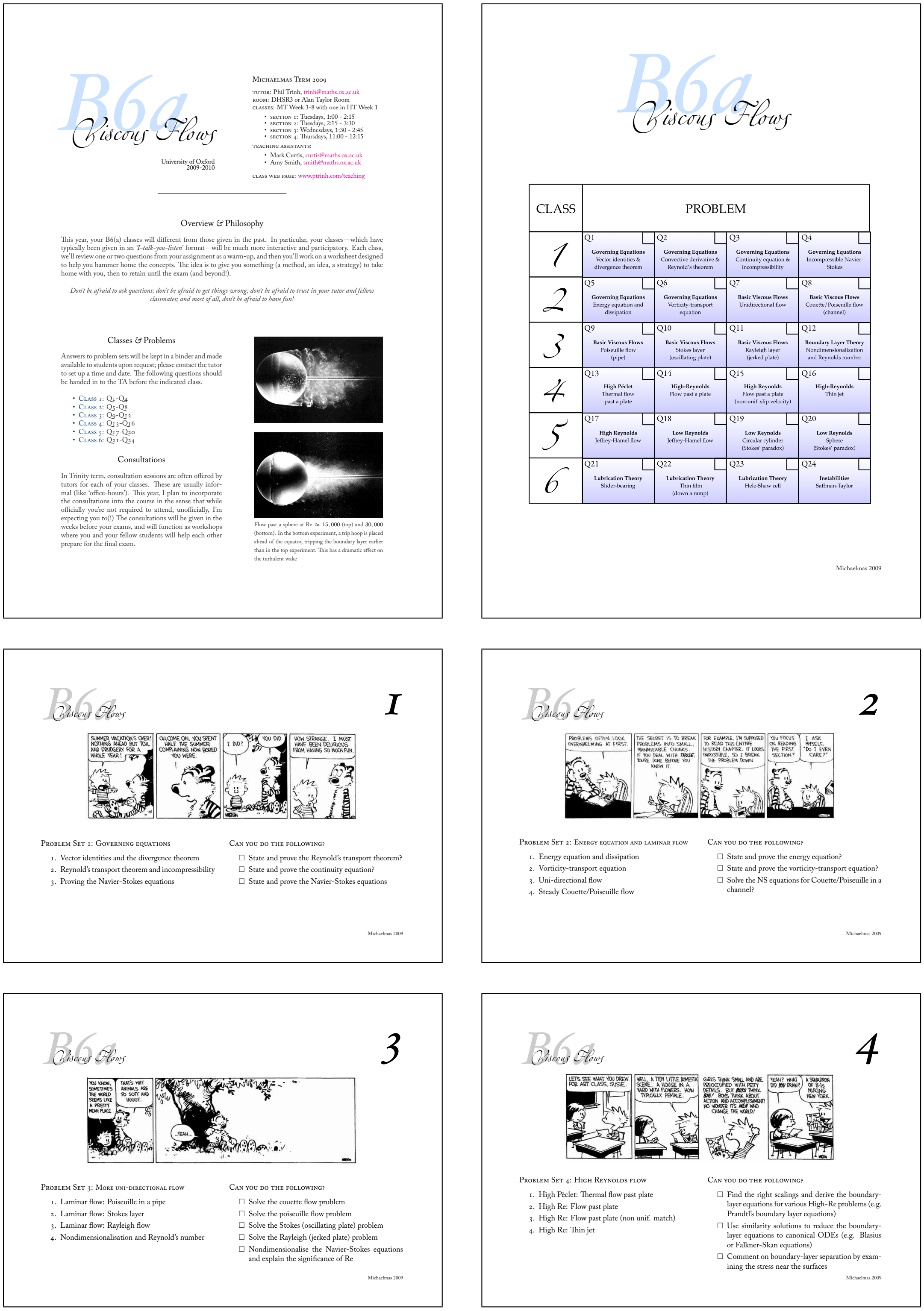
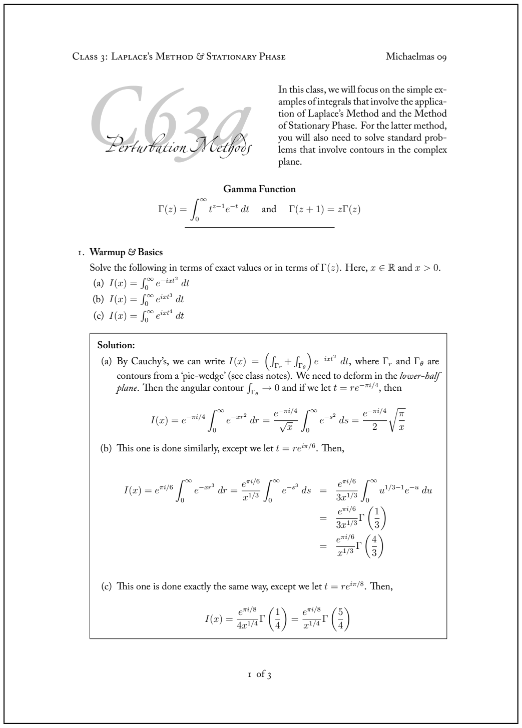


Figure 1: Sample handouts for the B6.a Viscous Flows class. Summaries (bottom-four) are given each week.



Class 3: Laplace's Method & Stationary Phase — Michaelmas 09

C63a Perturbation Methods

In this class, we will focus on the simple examples of integrals that involve the application of Laplace's Method and the Method of Stationary Phase. For the latter method, you will also need to solve standard problems that involve contours in the complex plane.

Gamma Function

$$\Gamma(z) = \int_0^\infty t^{z-1}e^{-t}\,dt \quad \text{and} \quad \Gamma(z+1) = z\Gamma(z)$$

1. **Warmup & Basics**

Solve the following in terms of exact values or in terms of $\Gamma(z)$. Here, $x \in \mathbb{R}$ and $x > 0$.

(a) $I(x) = \int_0^\infty e^{-ixt^2}\,dt$

(b) $I(x) = \int_0^\infty e^{ixt^3}\,dt$

(c) $I(x) = \int_0^\infty e^{ixt^4}\,dt$

Solution:

(a) By Cauchy's, we can write $I(x) = \left(\int_{\Gamma_r} + \int_{\Gamma_\theta}\right) e^{-ixt^2}\,dt$, where Γ_r and Γ_θ are contours from a 'pie-wedge' (see class notes). We need to deform in the *lower-half plane*. Then the angular contour $\int_{\Gamma_\theta} \to 0$ and if we let $t = re^{-\pi i/4}$, then

$$I(x) = e^{-\pi i/4}\int_0^\infty e^{-xr^2}\,dr = \frac{e^{-\pi i/4}}{\sqrt{x}}\int_0^\infty e^{-s^2}\,ds = \frac{e^{-\pi i/4}}{2}\sqrt{\frac{\pi}{x}}$$

(b) This one is done similarly, except we let $t = re^{i\pi/6}$. Then,

$$\begin{aligned} I(x) = e^{\pi i/6}\int_0^\infty e^{-xr^3}\,dr = \frac{e^{\pi i/6}}{x^{1/3}}\int_0^\infty e^{-s^3}\,ds &= \frac{e^{\pi i/6}}{3x^{1/3}}\int_0^\infty u^{1/3-1}e^{-u}\,du \\ &= \frac{e^{\pi i/6}}{3x^{1/3}}\Gamma\left(\frac{1}{3}\right) \\ &= \frac{e^{\pi i/6}}{x^{1/3}}\Gamma\left(\frac{4}{3}\right) \end{aligned}$$

(c) This one is done exactly the same way, except we let $t = re^{i\pi/8}$. Then,

$$I(x) = \frac{e^{\pi i/8}}{4x^{1/4}}\Gamma\left(\frac{1}{4}\right) = \frac{e^{\pi i/8}}{x^{1/4}}\Gamma\left(\frac{5}{4}\right)$$

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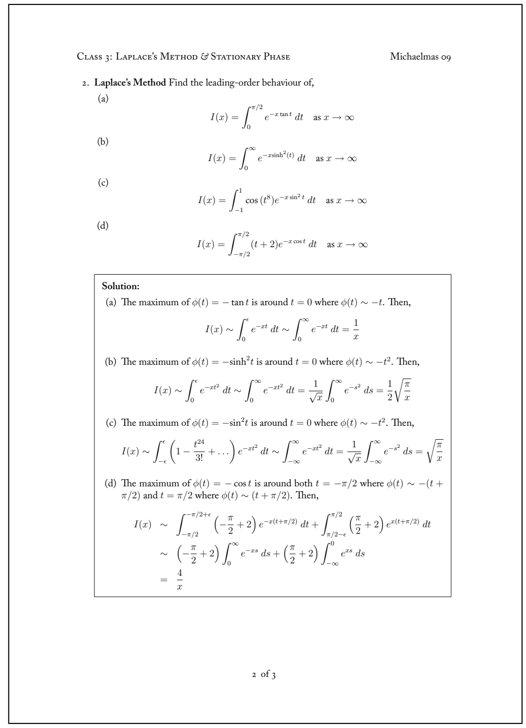

Class 3: Laplace's Method & Stationary Phase — Michaelmas 09

2. **Laplace's Method** Find the leading-order behaviour of,

(a)
$$I(x) = \int_0^{\pi/2} e^{-x\tan t}\,dt \quad \text{as } x \to \infty$$

(b)
$$I(x) = \int_0^\infty e^{-x\sinh^2(t)}\,dt \quad \text{as } x \to \infty$$

(c)
$$I(x) = \int_{-1}^1 \cos(t^8)e^{-x\sin^2 t}\,dt \quad \text{as } x \to \infty$$

(d)
$$I(x) = \int_{-\pi/2}^{\pi/2} (t+2)e^{-x\cos t}\,dt \quad \text{as } x \to \infty$$

Solution:

(a) The maximum of $\phi(t) = -\tan t$ is around $t = 0$ where $\phi(t) \sim -t$. Then,

$$I(x) \sim \int_0^\epsilon e^{-xt}\,dt \sim \int_0^\infty e^{-xt}\,dt = \frac{1}{x}$$

(b) The maximum of $\phi(t) = -\sinh^2 t$ is around $t = 0$ where $\phi(t) \sim -t^2$. Then,

$$I(x) \sim \int_0^\epsilon e^{-xt^2}\,dt \sim \int_0^\infty e^{-xt^2}\,dt = \frac{1}{\sqrt{x}}\int_0^\infty e^{-s^2}\,ds = \frac{1}{2}\sqrt{\frac{\pi}{x}}$$

(c) The maximum of $\phi(t) = -\sin^2 t$ is around $t = 0$ where $\phi(t) \sim -t^2$. Then,

$$I(x) \sim \int_{-\epsilon}^\epsilon \left(1 - \frac{t^{24}}{3!} + \dots\right) e^{-xt^2}\,dt \sim \int_{-\infty}^\infty e^{-xt^2}\,dt = \frac{1}{\sqrt{x}}\int_{-\infty}^\infty e^{-s^2}\,ds = \sqrt{\frac{\pi}{x}}$$

(d) The maximum of $\phi(t) = -\cos t$ is around both $t = -\pi/2$ where $\phi(t) \sim -(t + \pi/2)$ and $t = \pi/2$ where $\phi(t) \sim (t + \pi/2)$. Then,

$$\begin{aligned} I(x) &\sim \int_{-\pi/2}^{-\pi/2+\epsilon} \left(-\frac{\pi}{2} + 2\right) e^{-x(t+\pi/2)}\,dt + \int_{\pi/2-\epsilon}^{\pi/2} \left(\frac{\pi}{2} + 2\right) e^{x(t+\pi/2)}\,dt \\ &\sim \left(-\frac{\pi}{2} + 2\right)\int_0^\infty e^{-xs}\,ds + \left(\frac{\pi}{2} + 2\right)\int_{-\infty}^0 e^{xs}\,ds \\ &= \frac{4}{x} \end{aligned}$$

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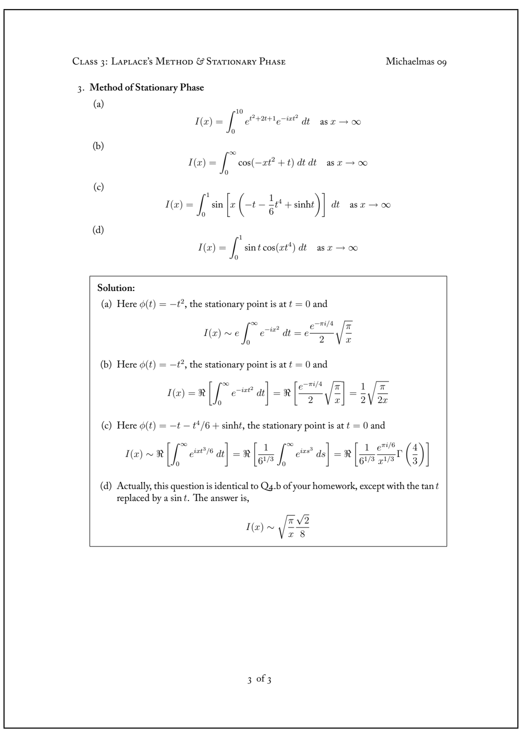

Class 3: Laplace's Method & Stationary Phase — Michaelmas 09

3. **Method of Stationary Phase**

(a)
$$I(x) = \int_0^{10} e^{t^2+2t+1}e^{-ixt^2}\,dt \quad \text{as } x \to \infty$$

(b)
$$I(x) = \int_0^\infty \cos(-xt^2 + t)\,dt\,dt \quad \text{as } x \to \infty$$

(c)
$$I(x) = \int_0^1 \sin\left[x\left(-t - \frac{1}{6}t^4 + \sinh t\right)\right]\,dt \quad \text{as } x \to \infty$$

(d)
$$I(x) = \int_0^1 \sin t\cos(xt^4)\,dt \quad \text{as } x \to \infty$$

Solution:

(a) Here $\phi(t) = -t^2$, the stationary point is at $t = 0$ and

$$I(x) \sim e\int_0^\infty e^{-ix^2}\,dt = e\frac{e^{-\pi i/4}}{2}\sqrt{\frac{\pi}{x}}$$

(b) Here $\phi(t) = -t^2$, the stationary point is at $t = 0$ and

$$I(x) = \Re\left[\int_0^\infty e^{-ixt^2}\,dt\right] = \Re\left[\frac{e^{-\pi i/4}}{2}\sqrt{\frac{\pi}{x}}\right] = \frac{1}{2}\sqrt{\frac{\pi}{2x}}$$

(c) Here $\phi(t) = -t - t^4/6 + \sinh t$, the stationary point is at $t = 0$ and

$$I(x) \sim \Re\left[\int_0^\infty e^{ixt^3/6}\,dt\right] = \Re\left[\frac{1}{6^{1/3}}\int_0^\infty e^{ixs^3}\,ds\right] = \Re\left[\frac{1}{6^{1/3}}\frac{e^{\pi i/6}}{x^{1/3}}\Gamma\left(\frac{4}{3}\right)\right]$$

(d) Actually, this question is identical to Q4.b of your homework, except with the $\tan t$ replaced by a $\sin t$. The answer is,

$$I(x) \sim \sqrt{\frac{\pi}{x}}\frac{\sqrt{2}}{8}$$

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Figure 2: Sample worksheet for the C6.3a Perturbation Methods class. These worksheets are designed to reinforce basic concepts and techniques from the week's problem set. In each class, following a 15-25 minute introduction by the tutor, students are then seated around a table and given the opportunity to work individually on the sheet. The ones who finish quickly are then paired-up with a fellow classmate—with the mission of guiding them to completion. Classes are very lively and interactive, but still governed by a set of rules and a degree of formality (see [10] for a discussion) .

7 Research in Mathematics Education

Currently, I'm working towards an Associate qualification of the Higher Education Academy (AHEA) in conjunction with the Oxford Learning Institute. This qualification requires the submission of a research article, along with a teaching portfolio that demonstrates both the applicant's knowledge of relevant literature in educational research, as well as evidence of having applied this knowledge to classroom teaching.

In particular, I've been interested in William Perry's scheme as it relates to mathematics teaching at the University of Oxford. In 1970, Perry proposed a model of student development which describes a student's necessary journey through nine stages of intellectual development, ranging from complete dualism, to a commitment of relativism [8]. This scheme was supported through lengthy interviews with undergraduate students at Harvard throughout the 1950s and 1960s, and has been well studied since.

Perhaps the most important implication of the study as it relates to scientific teaching is that, whereas most undergraduate students are dualistic thinkers (stage 2-3), university faculty are usually located much higher on the scheme (stages 6-9). Optimum teaching occurs at roughly "plus one" (stage 3-4)—challenging enough to promote students through the scheme, but not so much as to present an insurmountable challenge (See Figure 3).

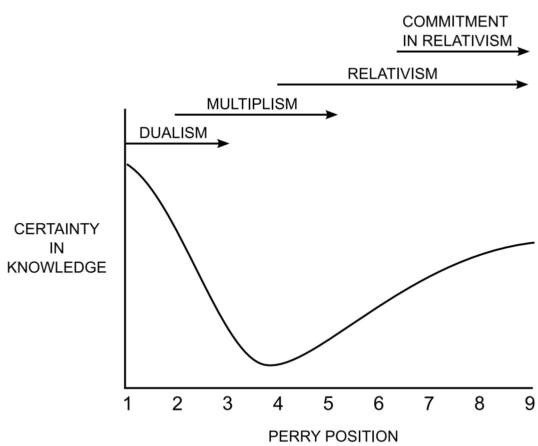

FIGURE 3: Perry claimed that undergraduate students progress through nine stages of intellectual development. In stages (1-2), students see the world in a dualistic fashion; in (3-4), students begin to see diversity and uncertainty; in (5-6), students recognize that knowledge is relativistic; and in (7-9), students make a commitment to relativism. Although the theorems and statements of (pure) mathematics are arguably dualistic, the methodologies and the historical advancement of knowledge certainly is not. For example, many paradoxes are found in the study of viscous flows [5], the most famous of which is perhaps the Stokes/Oseen problem. Dualistic-thinking students should be challenged so as to advance through the scheme.

In my article, I discuss Oxford's teaching system, and whether the style of teaching is appropriate for advancing students through Perry's scheme. I also discuss how a different classroom structure recently implemented in my own teaching can perhaps yield improvements. Use is made of research on issues in cooperative learning in mathematics, [2, 7, 9, 12], on issues related to the importance of social intelligence [1, 6], as well as ideas from previous research on Perry's scheme applied to undergraduate science courses [3, 4].

The article should be submitted in 2010 to the Journal for Research in Mathematics Education, in conjunction with completion of the AHEA qualification.

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