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## Professional development for teaching in higher education

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Due to the changing nature of learning and teaching in universities, there is a growing need for professional development for lecturers and tutors teaching in disciplines in the mathematical sciences. Mathematics teaching staff receive some training in learning and teaching but many of the courses running at university level are not tailored to the mathematical sciences. This article reports on a collaborative research project aimed at investigating the type of professional development that Australian tertiary mathematics teachers need and their preference for delivery modes. Effective teaching promotes effective learning in our students and discipline-specific professional development will enhance outcomes for teachers, students, and mathematics.

**Keywords:** professional development; mathematics; university; teaching; statistics

### 1. Introduction

We argue that effective teaching contributes to effective learning in the mathematical sciences. While people can learn and develop mathematics themselves, for the vast majority, teaching will make a significant impact on their learning of mathematics. We make the assumption that academics employed to teach in mathematics programmes will have sufficient mathematical knowledge for their teaching – but what of their knowledge of learning and teaching? What do teachers in the quantitative disciplines want to know, and how would they like this delivered? How do they want to deliver their teaching, and what facilities and resources are available to them? This article reports on a comprehensive survey of Australian academics in the quantitative disciplines undertaken in order to understand their existing teaching situations and desired requirements in order to design a discipline-specific professional development programme in partnership with the Australian Mathematical Society.

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Kline [1] published a critique of undergraduate education in his book, *Why the Professor Can't Teach*, and based on his experience in higher education, he concluded that research was heavily privileged over teaching. In 1999, Krantz [2] in *How to Teach Mathematics* reported that academics were paying much more attention to teaching than described by Kline, but that there were still many who did not take their teaching seriously. Both books are useful for lecturers starting teaching in universities; both are from deep thinkers in mathematics education and are based on their personal experiences. So, how can mathematics academics take their teaching seriously and improve practice? Professional development is one way.

Internationally, there is growing interest in discipline-specific teaching practice in higher education [3]. Frameworks for discipline-specific professional development in mathematics in the higher education sector do exist, notably that developed by Cox [4]. In the Australian context, a generic framework adaptable for a disciplinary context has been developed by the authors [5], and then applied to the discipline of mathematics in order to design a programme of professional learning [6].

In the United Kingdom, the Mathematics, Statistics and Operational Research subject centre of the UK Higher Education Academy developed a short course designed for new higher education mathematics teachers. In the USA, the Mathematical Association of America offers a series of professional development workshops each year for new or recent PhDs in the mathematical sciences, in which teaching and learning are addressed.

Using a different professional development model, Paterson et al. [7] describe a professional development intervention they implemented at the University of Auckland in New Zealand. Eight academics used video recordings to review decision points in lectures in order to improve practice; there were four mathematicians and four mathematics educators, so there was opportunity for cross-fertilization of ideas.

The challenge in the Australian setting, where around 18,000 undergraduate students study a subject in the mathematical sciences each year [8], is to contextualize existing generic teaching and learning training to be relevant and meaningful for tertiary teachers in their own discipline. Mathematics teaching staff in Australian universities receive some induction in learning and teaching but many of the courses run at university level are not tailored to the mathematical sciences. The content of these courses is largely generic, dealing with pedagogical issues common to all subjects [9].

To address these issues and building on insights from the literature, we developed a project focused on the enhancement of effective teaching through discipline-specific professional development, with the underlying purpose being to improve the learning of students. It is a collaborative research project with participation by six Australian universities, funded by the Australian Learning and Teaching Council and supported by the Australian Mathematical Society.

An important feature of the project was the need to gain insight into the actual circumstances of teachers in Australian higher education and to tap into their ideas about challenges and solutions. We therefore undertook a preliminary survey of mathematics academics in Australian universities about their teaching situations, their learning and teaching needs and their future requirements.

The results of this study have been used subsequently to design a discipline-specific professional development programme targeted at teachers of quantitative disciplines [6]. This practical and evidence-based professional development supports

higher education teachers working across the quantitative disciplines. In this article, our aim is to describe the results of the survey, which gives a snapshot of the teaching challenges faced by these academics and their professional development needs.

## **2. Method**

A mixed methods approach to data collection was employed in the study, consistent with our aim to understand a real-world issue [10]. In order to obtain input from as many participants as possible, an online survey method was chosen and it was designed to elicit both quantitative and qualitative data through closed and open questions. An invitation to all academics and PhD candidates in mathematics departments and schools in Australian universities was distributed via heads of departments and schools at each university. Information sheets stressed the voluntary and anonymous nature of participating in the research, as well as the participation requirements and benefits.

The survey was developed by the research team after a review of the literature, and the results of the PATHE project [9] were found to be particularly useful. The survey consisted primarily of closed questions, again to facilitate participation and also to cover factors that could be described easily by participants through selection from a list of choices; for example, one question was ‘What courses have you undertaken in tertiary teaching and learning?’ and a list of options was presented (more than one option could be selected). Open-ended questions asking for their opinions were also included in order to gain insights into particular challenges in the mathematical sciences, while avoiding imposing our preconceptions on the respondents.

The questionnaire was divided into two sections: the first was designed to elicit demographic and situational information from the respondents; for instance, concerning their role/s at the time (tutoring, lecturing, unit co-ordination, or head of department). Information was also collected to glean years of experience in each role/s and the nature of their employment (casual or continuing). In addition, participants were asked to indicate the level of students they taught, the size of classes and about the technological tools available in the teaching spaces, that is, the modes of delivery available to them. The second part of the survey related to the extent of prior professional development and their views on future training needs. Specific focus areas of these questions included what teaching and learning challenges they consider are faced by early career teachers; and their opinion of what should be covered in a training unit for lecturers or tutors in the mathematical sciences.

The data were analysed using basic descriptive statistics and open-ended comments were analysed through iterative categorization to identify emerging themes. To ensure the reliability and validity of the data coding process, two coders independently analysed the responses and classified them into themes. The coders then reviewed and cross-checked one another’s analysis until the themes were finalized; there were some responses which could not be categorized (such as ‘don’t know’). In such a qualitative method of analysis, the relative significance of themes can be elicited but the frequency cannot always be established [10]. We have presented the results under six main themes, which arose from both the closed and open-ended questions.

### 3. Results

#### 3.1. Background information for the respondents

There were 111 respondents in total; because the responses were anonymous, we do not know how many universities were represented. Many respondents performed multiple roles in their department or school and in these instances respondents were categorized in the position in which they exercised the widest scope of influence over teaching. For example, where a respondent noted they performed the roles of both lecturer and unit co-ordinator, they were categorized at the level of unit co-ordinator. Within the respondents, there were 29 tutors (26.1%), 29 lecturers (26.1%), 41 unit co-ordinators (UC) (36.9%), 7 heads of departments or schools (6.3%) and 5 others, such as research fellow (4.5%). Regarding the employment status of the respondents, 72.4% of the surveyed tutors were casual staff. In contrast, the majority of the lecturers, unit co-ordinators and heads of departments were non-casual/continuing staff (all above 90%).

For the respondents who were tutors at the time of the survey, the average number of years of experience in tutoring and lecturing were 7.2 and 3.1, respectively. For those classified as lecturers, the mean number of years spent lecturing was higher than that spent on tutoring (i.e. 14.4 and 12.3 years, respectively). These results indicate that most of the tutors and lecturers were early and mid-career academics.

In regard to the level of students taught by the respondents, Figure 1 describes the levels taught by each group. It can be seen that the majority of tutors taught first year students, and only around 10% of the tutors taught honours and postgraduate students; similarly, the majority of lecturers taught first year students (72.4%). For unit co-ordinators, approximately half taught all levels of students with a similar proportion teaching honours and postgraduate students. Finally, heads of departments tended to teach students within the latter years of an undergraduate programme. It is notable that a high percentage of all the respondents taught first year students; this even applied to the heads of department, who taught more of the higher years than any other academics: 70% of them nonetheless taught first year students.

Regarding the modes of instruction, 82.8% of the tutors were engaged in face-to-face teaching, and only around 7% of them taught students through distance and

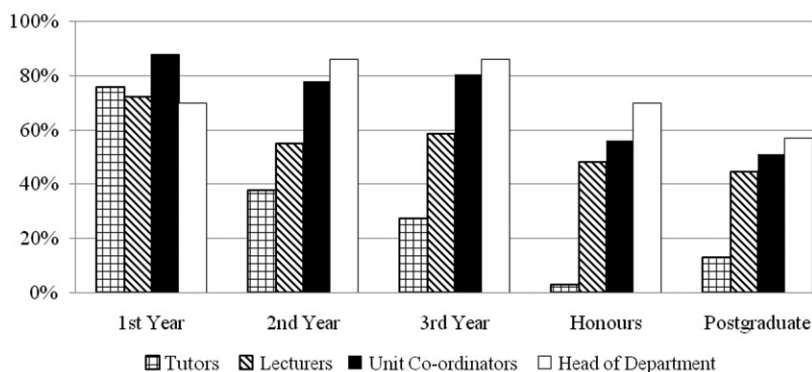


Figure 1. Level of students.

online learning. All the lecturers were involved in face-to-face teaching, but 17% of them also taught distance learning courses. As with the lecturers, all the unit co-ordinators delivered face-to-face teaching, while half of them also taught students *via* distance learning mode. All the heads of departments did face-to-face teaching, and two also taught by distance. In summary, all the respondents were primarily engaged in face-to-face teaching, which accords with the usual study mode of Australian university students. An interesting result was the proportion of unit co-ordinators who were involved in distance learning (the highest of the four groups), which has implications not only for their professional development needs but also for the resources they may require to support their teaching.

Class size is another significant factor influencing the teaching needs of academic staff. The class size of lectures for these survey participants ranged from 30 to 1500, and for tutorials it ranged from 18 to 100. This indicates a need for flexibility in the design of teacher training programmes to allow for the different class situations in different universities, in particular to develop capabilities where necessary in teaching large classes.

### **3.2. Technological tools, supporting programmes, and resources**

#### *3.2.1. Technological tools*

Understanding academics' access to and use of technology is essential for acquiring a sense of future professional development needs – What are they using? What would they like to be using? What might they need training in? – and for planning future acquisitions. In the survey, lecturers and tutors were asked about their perception of the availability of a range of technological tools; unit co-ordinators and heads of departments, conversely, were asked to indicate the types of tools they considered to be accessible to tutors and lecturers. We were interested to see if the professional development available to full-time lecturing staff (such as in available technologies) was also available to tutors who tend to be casual or part time. The results indicate a difference in knowledge of available tools for teaching. Figure 2 describes the combined results for each of the more common technological tools, so when interpreting the graph this difference between the two groups must be borne in mind. Table 1 presents how accessible the tutors and lecturers viewed the tools to be; it has been included to highlight the differences in their perceptions of access.

Interestingly, when unit co-ordinators and heads of departments were asked to comment on how many of their tutors and lectures had access to these technologies, there were a number of discrepancies, as can be seen in Figure 2. In summary, there was a consistent trend that both tutors and lecturers considered they had access to desktop computers, internet connection, projectors and microphones for teaching. Unit co-ordinators and heads of departments were of the opinion that their tutors and lecturers were able to access these basic technological tools for teaching. However, there was quite a contrast between which extra tools (i.e. document camera, remote control and audio recorders), the tutors and lecturers believed were available, and the views of the unit co-ordinators and heads of departments. This points to a need for better orientation to teaching for casual staff.

There are a number of potential explanations for this; for instance, it is possible that these particular unit co-ordinators and heads of departments work in universities which do offer those tools in their teaching spaces, and therefore are

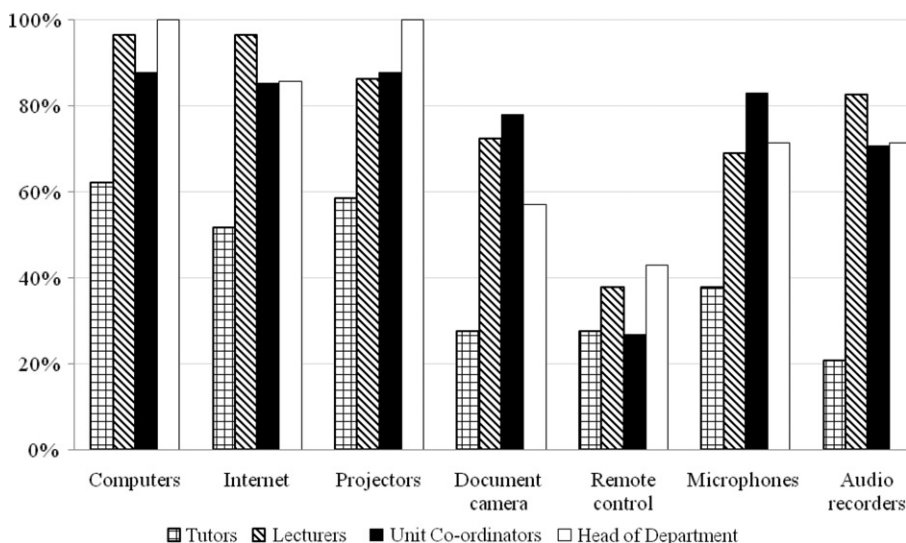


Figure 2. Accessibility to commonly used technological tools.

Table 1. Perception of accessibility of tools – tutors and lecturers (%).

	Tutors	Lecturers
Desktop computers	62.1	96.6
Internet connection	51.7	96.6
Overhead projectors	58.6	86.2
Document camera	27.6	72.4
Remote control for presentations	27.6	37.9
Microphones	37.9	69.0
Audio recorders	20.7	82.7

correct in believing that teachers have access to them. It is equally possible that unit co-ordinators and heads of departments are mistaken about the degree of access; and/or tutors and lecturers are simply not aware that these tools are available. In any case, the results highlight the different infrastructures available in different learning and teaching spaces (tutorial rooms *versus* lecture theatres) and the potential to provide more technology-rich learning environments for tutorial classes, as well as professional development for teachers on how to use these tools.

Figure 3 similarly describes the perceptions of tutors and lecturers *versus* those of unit co-ordinators and heads of department, in this case regarding more recent forms of technology (tablet PCs, SMART boards and pen-enabled screens). The results show the availability of these tools is less common than those mentioned above; in contrast, in a related question, tutors and lecturers indicated a desire to have more training on these particular resources. This might imply that despite their poor accessibility, these staff considered these tools would be valuable for the teaching of mathematics. In addition, there was again quite a difference between the perceptions



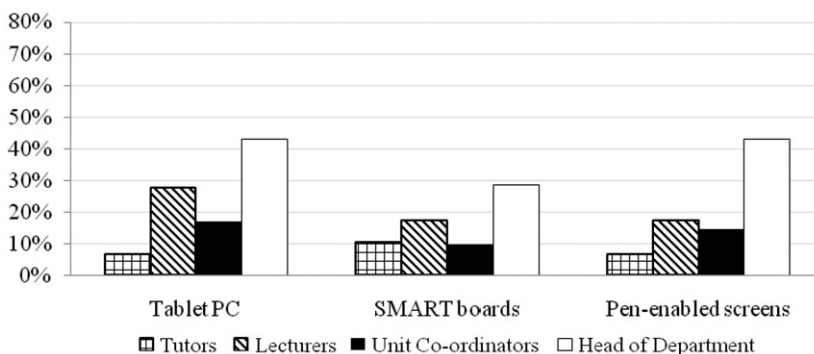


Figure 3. Accessibility to less commonly used technological tools.

of the unit co-ordinators and heads of departments *versus* the tutors and lecturers in relation to the accessibility of these tools.

### 3.2.2. Professional development programmes and resources

There are many potential variations on the programmes and resources that universities and departments can offer for the professional development of teaching staff. These range from teaching practice guides or funding to attend conferences, to formal teaching programmes. For the question on this topic, tutors and lecturers were again asked about their own experience, while unit co-ordinators and heads of department were asked about what they considered to be available.

The results for tutors indicate that 13.7% had department-based supervision and evaluation by heads of departments. For 20.7% of them, department-based peer support or observation was available and 34.5% had participated in a buddy system. A handbook of procedural matters relating to managing a lecture or course was available to 41.3% of the tutors. A smaller percentage (13.8%) had received funding to attend teaching conferences and seminars, and even fewer (6.9%) had received money to support innovative teaching. Finally, 20.7% reported having received recognition and/or encouragement for their research on learning and teaching; and the same percentage of tutors had enrolled in formal teacher training programmes. The results for lecturers were very similar, with notable differences being for funding to attend teaching conferences and seminars (20.7%) and to support innovative teaching (27.6%); and for enrolment in formal teaching programmes (62%).

There were once again differences between what tutors and lecturers had experienced, and what the unit co-ordinators believed was available. In particular, 48.8% of them considered that lecturers and tutors obtained department-based supervision and evaluation by heads of departments; 48.8% thought that buddy systems were provided to the lecturers and tutors; and 39% of the unit co-ordinators noted that money was made available to support innovative teaching. For the heads of department, the results were quite distinctive and, in general, it was evident that they regarded the forms of support as far more readily accessible to the lecturers and



tutors than the lecturers and tutors did themselves. Noteworthy differences included their views that:

- department-based supervision and evaluation were given to tutors and lecturers (42.9%);
- lecturers and tutors had department-based peer support (71.4%);
- buddy systems were provided (57.1%); and
- handbooks of procedural matters relating to managing a lecture or course were available (28.6%).

### 3.3. Challenges for early career teachers

One of the open-ended questions in the survey asked respondents for their opinions about the types of teaching and learning challenges faced by early career teachers in the mathematical sciences. We present a selection of quotes (in italics) from respondents below to illustrate the main themes. Grouping of the open-ended responses revealed six major themes:

- management of large classes;
- gaps and diversity in student knowledge and abilities;
- negative attitudes of students;
- balancing research and teaching time;
- lack of knowledge of effective and contemporary teaching methods; and
- lack of sufficient funding for teaching support.

The issues of greatest concern to tutors related to teaching practice, such as management of large class sizes (especially for first year students). They were also concerned about a perceived lack of guidance and training in teaching mathematics courses and deficiencies in their understanding of effective and contemporary teaching methodologies, as one tutor noted: *lack of training in knowing how to teach and interact with students*. In relation to difficulties with students, they identified gaps and diversity in student knowledge and abilities, and highlighted poor student attitudes as being problematic; for instance, another remarked: *problems with student attitude viewing maths as irrelevant to future career*.

Lecturers also considered teaching large classes as a primary challenge. Some pinpointed difficulties with associated tasks that were required by the universities, as one lecturer noted: *over-emphasis on supervision and evaluation rather than focusing on the content of courses*. In common with the tutors, they too suggested that their lack of knowledge of effective and contemporary teaching methods was a significant barrier. Gaps and diversity in student knowledge and abilities (*ensuring students learn and clarify pre-existing confusions*) was another challenge they identified. Some found it difficult to strike a balance between research and teaching tasks, and some believed that there was insufficient funding available for teaching support.

Unit co-ordinators concurred in considering teaching large classes to be the issue of most concern for early career teachers, and one of them also mentioned *uses of technology in teaching* as a challenge. Heads of departments took a longer view, and their comments included: *technological progress over the last decade*, and the need to change the *outdated conservative way of delivering mathematics to new age students* in order to incorporate an *appreciation of students' ability to draw upon a wider range of sources*.

Having identified teaching challenges, respondents specified areas in which they personally would benefit from further training in a separate open-ended question. Tutors commonly named presentation skills as an area of need, for example: *basics of presentation skills with wit, humour, no pomposity, etc., in keeping content engaging*. A number of lecturers cited their desire to receive more training on facilitating group work and discussion, and the need for more guidance in the comparative merits of mathematical technology and software was also raised. Unit co-ordinators tended to focus on the importance of tutors' ability to identify and act on student issues, for example one remarked that, *tutors need to be able to identify the origin of problems students have and address them*. They also cited approaches to assessment, communication and presentation skills, building graduate capabilities within the discipline and teaching service mathematics as areas needing greater attention in terms of training.

### **3.4. Professional development**

Respondents were asked to select the types of training that they had received from a choice of seven options; more than one option could be chosen. Figure 4 describes the overall patterns of professional development. For tutors, nearly half had participated in teaching induction sessions when they first started in their current positions; two had taken a foundation learning and teaching unit; and only one had undertaken a formal education qualification. Ten did not have any training in teaching and learning at all. Of the lecturers, 41.4% had participated in induction sessions at their institution and two had taken a more formal education qualification; around 44% had not undertaken any professional development in learning and teaching. Unit co-ordinators were the most likely to have had some formal professional development, although 28% of them had not taken any courses.

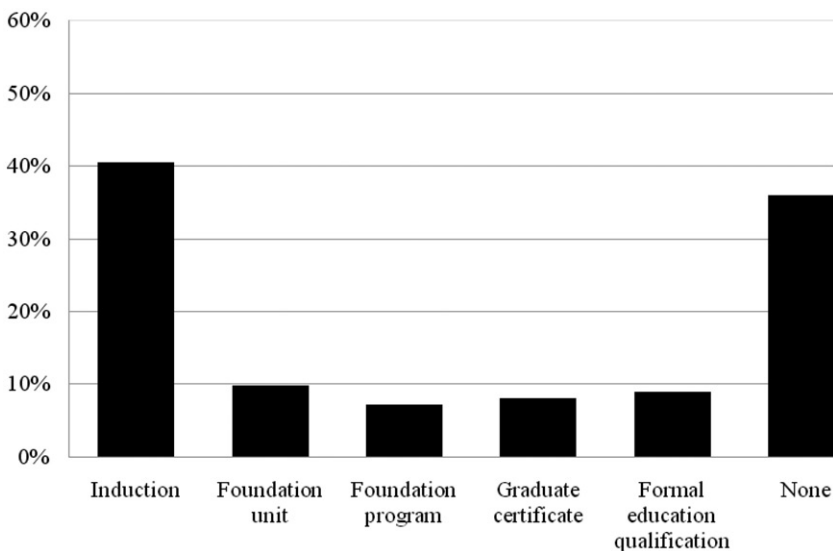


Figure 4. Professional development undertaken in tertiary teaching and learning.

For heads of departments, two had taken education induction sessions and foundation programmes, but three had not done any formal courses.

In summary, over one-third of the respondents had not had any formal induction or training in tertiary learning and teaching. Most only undertook teaching induction sessions when they first started their jobs. More training in learning and teaching, particularly in the area of the quantitative disciplines, clearly needs to be provided.

The survey also included information about the goal of our project – that is, the development of a tertiary teaching unit focused on teaching and learning in the mathematical sciences – and in an open-ended question they were asked to suggest their preferred modes of delivery for such a unit. Various modes were presented (see Figure 5 for the full results). More tutors than lecturers preferred online learning over face-to-face interactions, for instance through workshops, conferences and training days at each university. Respondents also suggested various benefits of an online learning mode, which included working through content at their own pace.

Those participants who responded that they had undertaken some form of training (induction session, foundation unit, foundation programme, graduate certificate and formal education qualification) were asked in an open-ended question if there were any specific aspects that they would like to see addressed but which were not included in the course. The main theme emerging from this item was that courses should be more directly relevant to the mathematical sciences; for instance, one of the lecturers commented that a Graduate Certificate in Higher Education addressed almost nothing on mathematics teaching.

Tutors also raised the need for training in specific teaching issues, such as guidance on the similarities and differences between mathematics education and

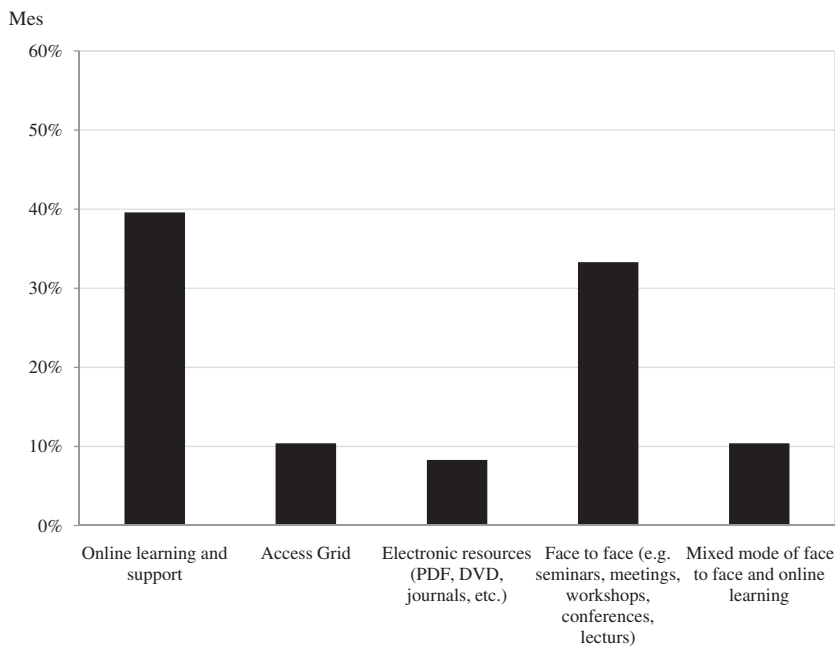


Figure 5. Preferred format/mode of delivery of a professional development unit.

other subject disciplines; strategies on how to teach first year *versus* final year subjects; and for samples of best practice materials in teaching mathematics. In addition to the need for specific training, some lecturers proposed the establishment of formal mentoring programmes where senior mathematicians serve as mentors for new staff. There were lecturers who would also like to have the opportunity to visit lectures and tutorials of those who consistently scored high ratings on student evaluation surveys. Comments from the unit co-ordinators concurred with the main theme, suggesting that universities should run courses that address mathematics education, providing teaching tools and techniques that are relevant to mathematics, statistics, and related sciences. Finally, all the heads of departments who responded emphasized that such courses should provide teachers with the resources and skill sets to engage students in learning mathematics.

At the end of the survey, respondents were asked whether they had any further comments and a range of ideas was presented. Some tutors noted they would have liked to have had training before they started teaching, especially in the areas of teaching large classes, international students, and students with diverse levels of background knowledge. Support for a discipline-specific professional development initiative was expressed by lecturers and relevant resources were suggested by them. Comments from unit co-ordinators' flagged the necessity to cater better for tutors' needs; to find a comfortable balance between research and teaching; and to focus on distance teaching needs. Other unit co-ordinators noted the challenges of designing a professional development programme that would span different disciplines across the university (i.e. service teaching).

#### **4. Discussion**

Mathematics education is a specialized teaching pursuit with its own forms, functions, representations and concepts [11,12]; as such, it requires its own discipline-specific approach to professional development. The results of this national survey highlight the diverse needs of different academic roles and provide greater insight into the specific challenges confronting teachers at the coalface.

The survey revealed that, for instance, tutors mainly teach first year students as opposed to honours or postgraduate students, and thus require support for teaching entry-level and service-course mathematics. There was also a differential perception of access to learning and teaching technologies, that is, between heads of department and unit co-ordinators *versus* lecturers and tutors. This implies that strategies need to be put into place to familiarise teachers with the technological tools and training programmes that may in fact be available to them. The need for enhancing support for all academics was a persistent theme across the study and tutors in particular felt that they had limited access to human guidance (such as supervision, evaluation, and peer support) and to assistance in dealing with specific teaching challenges.

A surprising result was that only a minority of the participants in the survey had completed any studies in tertiary teaching beyond their initial induction – in fact, for most tutors a short induction was the most they had received in terms of training – which indicates there is indeed a gap to fill within academics' professional learning pathways. Where more formal programmes had been completed, a majority indicated that it would have been beneficial if courses had been more focused on the mathematical sciences.

The results of the survey also highlighted the importance of developing soft skills, such as communication and management capabilities, in order to be an effective teacher in the mathematical sciences; the major challenges identified included addressing the negative attitudes of students, balancing research and teaching time, and methods of managing large classes.

The results represent a sample of lecturers' and tutors' teaching experiences and professional development needs in the quantitative disciplines. Consequently, the survey did not yield responses about direct learning experiences or outcomes for their students, nor do the responses explicitly demonstrate the impact of effective teaching on learning.

## **5. Conclusions**

Clearly, there is a need for more formal, discipline-specific professional training for mathematics educators to address the issues raised in this survey, and a foundation course in teaching, coupled with mentoring by senior staff, would appear to be highly appropriate. The casual basis for employment of tutors, however, may be a barrier to investment of resources in their training and, in addition, an individual tutor may have limited capacity to engage with such a course due to other obligations (such as a PhD or other work). Mathematics departments nonetheless need to allocate resources for professional development of tutors, even where they are not permanent staff members, since they can have a significant impact on student learning.

This study has provided an unprecedented insight into the teaching contexts of lecturers and tutors in the quantitative disciplines in Australia. A major focus of this research was the professional learning needs of teachers in these disciplines. From secondary school research, professional development of teachers is accepted to be an essential driving factor for improving student achievement in mathematics [13–15]; it is not unreasonable to contend that this will also be the case in the higher education setting. Understanding the needs of teachers in higher education and guiding their professional learning is therefore essential.

The findings from the survey have been used as a basis for the design of a professional development programme for tertiary teachers of the mathematical sciences [6]. The programme focuses on the different needs of the different roles (tutors and lecturers, unit co-ordinators and heads of department); provides discipline-specific frameworks and approaches for teaching mathematics; and addresses soft skills such as social skills/communication and support provision. The programme emphasises the role of technology and how it can be used to enhance both instruction and the learning environment. The course has recently been piloted with considerable success and it will be offered in future semesters by the Australian Mathematical Society. This addresses the need for a discipline-specific approach to developing the mathematics teaching profession in Australia and should lead to more effective learning and the advancement of mathematics.

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