Pharmacy Education, June 2007; 7(2): 123–131

Attitudes of pharmacy students and community pharmacists to numeracy

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Abstract

There are many instances in which community pharmacists employ their numeracy skills as part of their professional practice. It is vital that pharmacists are able to routinely perform calculations accurately, so as not to compromise patient safety or damage the reputation of the profession. It has been reported that university admissions tutors and lecturers believe that the students they are taking in are increasingly less capable with respect to their mathematical abilities. The numeracy standards of pharmacy students have been called into question recently and the pharmaceutical societies have introduced a compulsory calculations section onto their registration examinations. In this study, the attitudes of pharmacy students and community pharmacists to numeracy were investigated. It was found that, although students may lack confidence when it comes to performing pharmaceutical calculations and their qualified peers may doubt their abilities, they consistently perform well in the calculations section of the registration examination.

Keywords: *Pharmacy, numeracy, mathematics, pharmacy student, community pharmacist, survey*

Introduction

Numeracy may be defined as competence in mathematics; the quality of being able to understand or use mathematics (Barnhart, 1985). Numeracy skills include understanding basic calculations, time and money, measurement, estimation, logic and performing multistep operations. Most importantly, numeracy also involves the ability to infer which mathematical concepts need to be applied when interpreting specific situations and to use this information to problem solve (Montari & Rothman, 2005). In the UK, 17.8 million people have numeracy skills below Level 2, equivalent to an A*–C grade at GCSE (Williams, Clemens, Oleinikova, & Tarvin, 2003). A survey of adults aged 16–65 in Northern Ireland carried out by the Central Survey Unit of the Northern Ireland Statistics and Research Agency (NISRA) in 1996 as part of the International Adult Literacy Survey (IALS) found numeracy standards to be "very low" in Northern Ireland (Morgan & Sweeney, 1996).

The impact of a numeracy difficulty on everyday lives can be enormous. It is clear that many people need to improve their skills to manage everyday tasks, such as helping children with homework, following a recipe or dealing with household accounts. In the UK, the Department for Education and Skills (DFES) launched an ambitious strategy in 2001, with a target to improve the skills of 2.25 million adults by 2010 (Bacon et al., 2006). It achieved its first milestone of 750,000 adults achieving qualifications by July 2004, with the 2007 target being at least 1.5 million adults achieving qualifications. The Department of Employment and Learning in Northern Ireland (DELNI) have attempted to address the findings of the IALS survey by launching "The Essential Skills for Living Strategy" in October 2002, commonly known as the "Lose your Gremlins" campaign. The strategy aims to promote the benefits of improving both numeracy and literacy skills, improve the quality of teaching in literacy and numeracy, and also to ensure that there is flexible and accessible provision suited to the needs

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ISSN 1560-2214 print/ISSN 1477-2701 online
DOI: 10.1080/15602210701264850

of adults in a wide range of settings, including the workplace, community and family.

The Nuffield Review of 14–19 Learning (Wilde, Wright, Hayward, Johnson, & Skerrett, 2006) questioned staff at 16 universities and it reports that university admissions tutors and lecturers believe that the students they are taking in are increasingly less capable. There was particular concern about standards in mathematics. It was reported, as a matter of general opinion, that students reach university with a lower level of numeracy than in the past. In addition, there is a perception among higher education lecturers of a general decline in mathematical fluency, as well as general concerns about basic numeracy skills (Wilde et al., 2006). It was reported that some lecturers are forced to postpone starting undergraduate courses so that students could be "brought up to speed". There was particular concern amongst the lecturers about mathematical competence in those subjects which rely upon mathematical knowledge and the ability to apply concepts. This applies to mathematics degrees, of course, but also to engineering, business studies, IT, chemistry, physics and medical sciences, such as pharmacy. While such concerns may seem a recent phenomenon, those teaching life science undergraduates expressed their growing anxieties that many of their entrants were no longer adequately equipped with many of the basic skills that broadly define a numerate individual (DFES, 1998) as early as 1999 (Phoenix, 1999). More recently, Tariq has provided additional evidence to support the view widely held among those in the biosciences that there is a skills deficit with regard to basic numeracy and mathematical skills among first-year bioscience undergraduates (Tariq, 2002a,b; 2003a,b); mathematical knowledge and skills that are essential if students are to develop the more advanced mathematical skills required by an increasingly quantitative discipline.

The standards of numeracy of pharmacy students was first called into question in 2000, when a pharmacist and a former pre-registration trainee were cleared of manslaughter charges arising from the death of a baby (The Pharmaceutical Journal, 2000). The charges arose from the death of three week old Matthew Young in May 1998, after he had been prescribed peppermint water to treat colic when he was four days old (The Peppermint Water case, The Pharmaceutical Journal, 1998). The pre-registration trainee had made up the peppermint water so that it contained an excessive amount of chloroform, i.e. it was 20 times too concentrated. The student's supervising pharmacist signed off the product without inquiring about how the product had been made up. Although both the pharmacist and the pre-registration trainee were cleared of the manslaughter charges, they were fined after pleading guilty to a charge of not supplying "a medicine of the nature or quality demanded"—a Medicines Act 1968 offence (The Pharmaceutical Journal, 2000). The Board of the National Pharmaceutical Association (NPA) believed that this case highlighted deficiencies in the baseline knowledge and competencies that could be expected of pre-registration trainees (NPA, 2000). This raised questions about the general preparedness for practice of pharmacy undergraduates and whether they were given sufficient tuition on the calculation of quantities of ingredients. In addition, it has been reported, as a matter of opinion, that pharmacy students reach university with a lower level of numeracy than in the past, and with an almost total reliance on calculators, which has led to an inability to judge the order of number, so that students will accept as correct an answer that is incorrect by a factor of 10, 100 or 1000 (Nathan, 2000). Concern about numeracy standards in pharmacy is now such that the Royal Pharmaceutical Society of Great Britain (RPSGB) introduced a compulsory calculations section (20 MCQs, 70% pass mark) onto the registration examination in 2002. The Pharmaceutical Society of Northern Ireland (PSNI) followed suit with a very similar format in 2005. In both cases, this section must be passed independently of the rest of the exam. The School of Pharmacy at Queen's University Belfast (QUB) has adjusted its curriculum to include additional teaching of numeracy and specific preparation for the calculations section on the registration exam.

Aims of this study

In the present study, we had four main aims. As community pharmacy is the biggest employer of pharmacy graduates in Northern Ireland (83.6% of pharmacists) and the UK in general (61% of practicing pharmacists), we firstly wanted to determine the needs of this sector with respect to the numeracy standards required of pharmacists and pre-registration students. Secondly, we wanted to investigate the opinions of pharmacy students on their own standards of numeracy and how they thought these may be improved. Thirdly, we aimed to determine the approaches taken by other schools of pharmacy to numeracy and teaching of mathematics in their MPharm courses. Finally, we wished to review the statistics relating to the new compulsory calculations section on the registration examination. Our overarching objective was to improve the quality of pharmacy education at QUB with respect to numeracy and, in so doing, enhance the preparedness of our graduates for practice.

Methods

Two focus groups were initially set up in the School of Pharmacy, QUB. The first consisted of two students from each of the four years of the MPharm and the

second of four teaching fellows and two lecturers, all of whom were still actively engaged in community pharmacy practice on a regular basis. These groups were used to test two pilot questionnaires aimed at pharmacy students and community pharmacists. The groups not only provided feedback on the questionnaires, but also allowed for useful discussion and provided helpful suggestions. In both groups, there was a tendency to choose the central response where five possible responses to a question were offered. Upon discussion, it was found that this did not always necessarily reflect the true opinion of the respondent. Consequently, the number of possible responses was reduced to a maximum of four. For a number of questions it was found that "yes", "no", or "no opinion" were the only possible response.

An amended self-completed questionnaire was then distributed to all students in each year of the MPharm programme at QUB. Questionnaires were distributed at the end of lectures and collected by a member of technical staff. It was decided to survey all available students (i.e. those attending lectures) so as to obtain as many viewpoints as possible. As there are currently less than 600 students in the MPharm at QUB, this task was not overly arduous. A selection of 150 community pharmacists was made at random from the PSNI register of pharmacists and each was sent an amended a self-completed questionnaire by post to their work address. Stamped addressed envelopes were enclosed along with a covering letter to increase the rate of return. The aim was to obtain a "snapshot" of opinion within community pharmacy practice, while receiving all responses in a similar timescale to which responses from the students were obtained. Consequently, a relatively small number of community pharmacists were sent the questionnaire. In order to obtain the relevant information from universities, a self-completed questionnaire and a covering letter was sent by email to the Advisor of Studies at each of the 23 UK schools of pharmacy. A reminder was sent to non-respondents after 14 days and again after 28 days. Responses were received by e-mail or post and treated anonymously. Local ethical committee approval was obtained in each case prior to distribution of questionnaires.

Each questionnaire was based on a series of set questions relevant to each subject group, but did, however, include a section for respondents to add free text (additional comments) regarding the subject matter of the investigation. Free text sections of questionnaires allow respondents an opportunity to express thoughts, beliefs and opinions relevant to the survey (Taylor, Harding, Bissenden, Shepherd, & Shooter, 2004). Such data are effectively documentary data and belongs to a qualitative research tradition (Scott 1990). However, free text can offer insights which place the quantitative data in context. Here the free text was used to place the quantitative data into some form of broader context, allowing expression of students', pharmacists' and academics' views on numeracy as a component of the education of future pharmacists. Numerical data from each individual questionnaire was entered into Microsoft Excel, which was then used to construct frequency distributions, plot graphs and compile tables.

In a change to previous years, students in Level 2 were given two lectures on basic pharmaceutical calculations involving doses, concentrations and quantities of ingredients as part of their training in extemporaneous formulation and dispensing. Students were also asked to complete nine online calculation exercises over the 12 weeks of the first semester. In addition, this year group completed two multiple choice calculations exams of the same format and standard as the PSNI Pre-Registration calculations exam.

Results

The results of the survey of pharmacy students are summarised in Tables I and II (91% response rate, 467 respondents). When it came to rating their mathematical ability, the Level 2 students appeared to be the most confident. The Level 1 and 4 students seemed to be the least confident in their mathematical ability. Looking more closely at the way in which the pharmacy students rated their mathematical ability, it was noted that approximately 90% of those students who studied A-Level maths rated their mathematical ability as "excellent" or "good", compared to just under 25% of those students without A-Level maths. Approximately 50% of students without A-Level maths rated their mathematical ability as "fair" and almost a quarter of them rated their ability as "poor".

Table II shows that as students progress through their MPharm degree they feel that they are less able to perform mathematical calculations. A large proportion of the Level 2 students (53%) feel "more able" to perform mathematical calculations since starting their MPharm degree. This is in contrast to 64.8% of Level 4 students, who feel either "no change" or "less able" to perform mathematical calculations since starting their MPharm degree.

In relation to the students' confidence in carrying out various mathematical operations, the students felt most confident in "converting units", "rearranging equations" and "concentrations" (data not shown). The Level 2 students appeared most confident over all operations, closely followed by the Level 3 students. Students felt least confident in performing "differentiation" and "integration". Over three quarters of the students surveyed felt that they would benefit from extra classes in basic mathematics (aspects of mathematics mentioned included factorisation, concentrations, differentiation and integration), with the majority of students in each level feeling they would

Table I. Student responses to numeracy questionnaire.

1. Did you study A-Level maths?				
Level 1 ($n = 130$, 91.5% response rate)		Yes (52.3%)		No (47.7%)
Level 2 ($n = 109$, 81.3% response rate)		Yes (59.0%)		No (41.0%)
Level 3 ($n = 89$, 73.0% response rate)		Yes (53.8%)		No (46.2%)
Level 4 ($n = 111$, 84.7% response rate)		Yes (57.1%)		No (42.9%)
2. Do you feel that the ability to perform mathematical calculations will be important to you as a future pharmacist?				
Level 1	Yes (86.5%)	No (13.5%)		
Level 2	Yes (93.6%)	No (6.4%)		
Level 3	Yes (79.6%)	No (20.4%)		
Level 4	Yes (86.7%)	No (13.3%)		
3. How often do you use a calculator when carrying out calculations?				
Level 1	Always (47.7%)	Sometimes (50.0%)	Rarely (2.3%)	Never (0%)
Level 2	Always (46.2%)	Sometimes (51.3%)	Rarely (2.5%)	Never (0%)
Level 3	Always (53.8%)	Sometimes (45.2%)	Rarely (1.0%)	Never (0%)
Level 4	Always (52.3%)	Sometimes (45.7%)	Rarely (1.0%)	Never (1.0%)
4. Do you feel that there is adequate teaching provided by the School of Pharmacy with relation to numeracy skills needed to complete the MPharm degree?				
Level 1	Yes (86.4%)	No (13.6%)		
Level 2	Yes (93.6%)	No (6.4%)		
Level 3	Yes (79.6%)	No (20.4%)		
Level 4	Yes (86.7%)	No (13.3%)		
5. Do you think there is sufficient support within the School of Pharmacy in relation to problems encountered by students with calculations?				
Level 1	Yes (56.8%)	No (40.9%)	No opinion (2.3%)	
Level 2	Yes (80.8%)	No (15.4%)	No opinion (3.8%)	
Level 3	Yes (58.1%)	No (41.9%)		
Level 4	Yes (47.6%)	No (52.4%)		
6. Do you think there should be more of an emphasis placed on pharmaceutical calculations within the MPharm degree course?				
Level 1	Yes (70.5%)	No (29.5%)		
Level 2	Yes (26.9%)	No (70.5%)	No opinion (2.6%)	
Level 3	Yes (30.1%)	No (69.9%)		
Level 4	Yes (57.1%)	No (41.9%)	No opinion (1.0%)	
7. Do you feel that you would benefit from extra classes in basic mathematics?				
Level 1	Yes (84.1%)	No (15.9%)		
Level 2	Yes (68.0%)	No (32.0%)		
Level 3	Yes (71.0%)	No (29.0%)		
Level 4	Yes (83.8%)	No (15.2%)	No opinion (1.0%)	

benefit from extra classes. When asked, if the school of pharmacy provided optional classes in pharmaceutical calculations would they attend, over three quarters of the students surveyed said that they would attend additional classes (data not shown). A larger proportion of Level 1 (89%) and Level 4 (79%) students said that they would attend additional classes.

Free text comments at the end of the questionnaire provided some interesting insights. These included; "Since starting pharmacy my mathematics skills have improved. However, there are still some areas that I am not sure about or am not confident enough in to answer questions on" (Level 2 student) and "Revision of important calculations should take place each year to help students to keep up to scratch. There is no

Table II. How pharmacy students rate their mathematical ability and ability to perform mathematical calculations and pass rates for the RPSGB Registration examination.

1. How would you rate your mathematical ability?				
Level 1	Excellent (7.94%)	Good (51.14%)	Fair (29.55%)	Poor (11.37%)
Level 2	Excellent (19.23%)	Good (47.44%)	Fair (26.92%)	Poor (6.41%)
Level 3	Excellent (8.60%)	Good (46.24%)	Fair (32.26%)	Poor (12.9%)
Level 4	Excellent (6.67%)	Good (52.38%)	Fair (29.52%)	Poor (11.43%)
2. Since starting your pharmacy degree do you feel more or less able to perform mathematical calculations?				
Level 1	More able (32.95%)	No change (55.68%)	Less able (11.36%)	
Level 2	More able (52.57%)	No change (38.46%)	Less able (8.97%)	
Level 3	More able (39.78%)	No change (40.86%)	Less able (19.35%)	
Level 4	More able (35.24%)	No change (25.71%)	Less able (39.05%)	
3. Pass rates for the RPSGB Registration examination since the introduction of a compulsory calculations section in 2002.				
2002	Passed calculations section (97.70%)		Passed overall (94.80%)	
2003	Passed calculations section (91.90%)		Passed overall (82.40%)	
2004	Passed calculations section (93.70%)		Passed overall (91.30%)	
2005	Passed calculations section (95.00%)		Passed overall (91.90%)	

Table III. Community pharmacist responses to numeracy questionnaire.

1. Did you study A-Level maths?				
	Yes (56.9%)	No (43.1%)		
2. Do you feel confident carrying out simple pharmaceutical calculations without a calculator? Example given: 'A doctor requests 35 g of 0.05% w/w salicylic acid cream, what is the amount of salicylic acid required to prepare this cream?'				
	Yes (69.4%)	No (30.6%)		
3. How often do you carry out pharmaceutical calculations in the course of your professional practice?				
	Daily (36.1%)	Weekly (47.2%)	Monthly (13.9%)	Yearly (2.8%)
4. How often do you use a calculator when carrying out calculations?				
	Always (30.6%)	Sometimes (50.0%)	Rarely (19.4%)	Never (0%)
5. Pharmacy students should be taught basic mathematics at university.				
	Agree (36.1%)	Neither agree nor disagree (12.5%)	Disagree (51.4%)	
6. Are you a Pre-Registration tutor?				
	Yes (70.8%)	No (29.2%)		
7. Do you teach pharmaceutical calculations to your Pre-Registration students? (For Pre-Registration tutors only)				
	Yes (66.7%)	No (33.3%)		
8. Do you provide a practice calculations exam for your Pre-Registration students? (For Pre-Registration tutors only)				
	Yes (47.6%)	No (52.4%)		
9. Pre-Registration students should be allowed to use a calculator in the registration examination.				
	Agree (72.2%)	Neither agree nor disagree (19.5%)	Disagree (8.3%)	

point in having optional classes—must be compulsory" (Level 4 student) and "I used to know how to do calculations but the aspects referred to in this survey need to be refreshed. Lectures are not a good way to teach mathematics" (Level 4 student).

Of the community pharmacists who completed the questionnaire ($n = 98$, 65% response rate) the mean age was 28.1 years, the earliest date of registration was 1975 and the most recent registration was 2005). The mean age of registered pharmacists in Northern Ireland is 38.8 years. The results of the survey of community pharmacists are summarised in Tables III and IV. When it came to the circumstances in which community pharmacist respondents employed pharmaceutical calculations, 94.4% used them whilst working out quantities and 91.6% when working out doses. Other circumstances included extemporaneous preparations, working out concentrations, dilutions, formulation studies, analysis and business management.

As expected, all respondents agreed that "A pharmacist should be highly competent in carrying out pharmaceutical calculations". In fact, as can be seen from Table IV, strong opinions exist with respect to numeracy and the ability of pharmacists to carry out calculations accurately. However, when it came to whether pharmacy students should be specifically taught basic mathematics at university, the majority (51%) disagreed. Only 36% of community pharmacists thought that undergraduate students should be taught basic mathematics at university (Table III).

The minimum attainment level in mathematics required for entry to the MPharm degree course in the UK is a grade C in GCSE mathematics. Of the universities that responded, 75% require only a grade C at GCSE, with 16.7% requiring a minimum of grade B at GCSE and 6.3% requiring a minimum of a grade B at A-Level. The proportion of "home" students entering into the MPharm degree course

Table IV. Examples of free text responses from community pharmacists completing the numeracy questionnaire.

"Pharmacists should use calculators to double check their calculations—however, they should also be able to perform basic calculations without a calculator. From contact with pharmacy students, their mental arithmetic skills are not, in general, up to this."
"In my experience, young Pharmacists (including Pre-Registration students) seem less able to do simple mental arithmetic, e.g. 4×14, 6×28, etc. but are better at more complicated calculations where calculators are necessary."
"I think that a calculator is a labour saving device that is very important in a busy shop where time is an issue."
"Doing pharmaceutical calculations without a calculator is dangerous and unprofessional—no Pharmacist should do a calculation without checking it with a calculator therefore why would Pre-Registration students not be allowed to use one?!"
"If a Pharmacist doesn't have the basic numeracy skills required to do simple calculations I would worry about their ability to do their job! Calculations are part and parcel of the job."
"I believe it is essential that all Pharmacists are competent in Mathematics. It must be made clear to students when at University that one error in a calculation could be fatal. They must be made understand this from entry in Level 1."
"Any Pharmacist should be able to carry out pharmaceutical calculation without the use of a calculator and, therefore, in an exam situation calculators should not be allowed. I use a calculator as a double check to ensure that I am right because in a work situation you are constantly interrupted from your work and it is a useful double check—think clinical governance. All students are required to have GCSE Mathematics, surely this should cover basic calculations. I don't believe that basic mathematics is something that should be specifically taught at University."
"Having only completed the Registration exam last year, I feel the use of calculators should be banned as it is in England. I feel such calculations should be able to be done without their use and we are making it too easy to qualify as a Pharmacist. I welcome the introduction of the calculations but feel we need to go further."
"Pre-Registration students should not be penalised for not being mathematically gifted. Being good at Mathematics does not make a person a good Pharmacist. Help with calculations is always available."

Table V. UK Universities responses to numeracy questionnaire.

1. Do perform a mathematics diagnostic test on new students to gain an indication of their abilities?	Yes (73%)	No (27%)
2. Is there a support network available for those who have difficulties with mathematics?	Yes (90.9%)	No (9.1%)
3. Has the school changed its approach to the teaching of pharmaceutical calculations since the Peppermint Water case?	Yes (60%)	No (40%)
4. Has the school changed its approach to the teaching of pharmaceutical calculations since the introduction of a compulsory calculations section onto the registration examination?	Yes (44.4%)	No (56.6%)

at the various universities with A-Level maths ranges from 20 to 100%. The mean from the universities that responded to the survey is 45.6% of students having studied A-Level maths prior to entering the MPharm programme. The proportion of overseas students entering into the MPharm at the various universities with qualifications equivalent to A-Level maths ranges from 15 to 100%. The mean from the universities that responded is higher than for the UK-based students with 68.9% of overseas students having studied the equivalent to A-Level maths prior to commencing their MPharm.

Table V shows that the majority (73%) of universities ($n = 16$, 70% response rate) perform mathematics diagnostic tests (MDTs) on new students to give an indication of their initial mathematical ability. These MDTs take various formats, but usually involve a multiple choice test, taken early in the first semester of Level 1, involving a number of simple pharmaceutical calculations. The MDT must be completed in a set time (generally around 30 min) and the papers are marked and returned to the students. Students performing badly (mark $<70\%$) are generally provided with additional help. The majority of schools of pharmacy (90.9%) have a support network for students performing badly in MDTs or otherwise struggling with numeracy. Help provided includes one-to-one assistance by academic tutors, enrollment for foundation mathematics courses, web-based mathematics packages, remedial lectures, workshops and tutorials.

Of those who responded to the survey, 60% had changed their approach to the teaching of pharmaceutical calculations since the Peppermint Water case (Table V). Examples of changes in approach included;

- Additional calculations have been added to the extemporaneous dispensing classes to illustrate dilutions.
- Now concentrate on numeracy at Level 1 and Level 2. Level 2 students have to do calculation exercises each week and two tests of the exact same format as the registration exam. PCCAL packages are available on pharmaceutical calculations in Open Access Centres.
- Students are made aware of this case in formulation science classes and are made aware of the potential consequences of making such a mistake.
- Mathematics skills taught and assessed throughout the course from Level 1 up to Level 4 with complexity increasing accordingly. Final year exams reflect the types of questions in RPSGB Registration exam. All without the use of a calculator and with a pass mark of 70%.
- Have emphasised dilution of waters—now appears in calculation exercises and tests. Also included in formulation classes.
- "The level of instruction has increased. However, this is not directly related to the Peppermint Water case but more to the general reduction in numeracy skills of students entering higher education."

Table V shows that only 60% of the universities responding have changed their approach to teaching pharmaceutical calculations since the introduction of the compulsory calculations section in the registration exam. Just under half (44.4%) the respondents said that they did provide specific guidance/instruction or practice questions, of the type found on the registration exam, that may be of use to students when they come to sit their exam.

Discussion

There are many instances in which community pharmacists employ their numeracy skills as part of their professional practice. These include working out doses, calculating quantities and concentrations and performing calculations related to extemporaneous dispensing. Many pharmacy owners and mangers also perform calculations related to business management on a regular basis. It is vital, therefore, that pharmacists are able to routinely perform calculations accurately so as not to compromise patient safety or damage the reputation of the profession. Both the RPSGB Accreditation Document (Dewdney, 2002) and the QAA subject benchmark statement for pharmacy (Quality Assurance Agency for Higher Education, 2002) designate the demonstration of ability to perform pharmaceutical calculations accurately as essential for successful completion of the MPharm. The Peppermint Water case has led to those within the profession questioning the capabilities of pharmacy graduates to perform pharmaceutical calculations accurately (NPA, 2000; Nathan, 2000).

Concerns have been raised about the numbers of students taking mathematics as an A-Level subject (Mustoe, 2002) and studies have demonstrated a reduction in numeracy standards of university entrants from 1991 to 2000 (Cox, 2000). Importantly, it has been suggested that the competency of

pharmacy undergraduates with respect to numeracy has declined in recent years (Nathan, 2000; Batchelor, 2004). In the current study, through investigation of the views of community pharmacists and pharmacy undergraduates and by ascertaining the approaches taken by other schools of pharmacy, we aimed to improve the quality of pharmacy education with respect to numeracy at QUB. In so doing, we wanted to ensure that our graduates were fully prepared for entry into practice in the community.

The response rate from undergraduate pharmacy students was very high. This is to be expected, as questionnaires were distributed at the end of lectures, thus providing a "captive audience". Despite what could be perceived as an application of pressure to complete the questionnaire, the students responded well with many adding several comments and opinions. The age profile of community pharmacy respondents meant that the study was slightly skewed towards younger pharmacists. However, it was notable that several pharmacists over 55 years of age declined to complete the survey, despite detailed explanation by the authors of the nature and purpose of the study. A number of these individuals claimed to be "out of touch" with modern pharmacy education and, therefore, felt unable to contribute meaningfully.

As can be seen from Tables I and III, there has been no marked decline in the number of pharmacy students with A-level maths in Northern Ireland. This is in contrast to at least one other pharmacy school, where an approximate halving of the proportion of entrants with A-Level maths has occurred in recent years (Batchelor, 2004). In addition, the majority of our students rate their mathematical ability as either "good" or "excellent" (Table II). Moreover, and importantly, approximately 68% of the community pharmacists surveyed rated the mathematical ability of Pre-registration students as either "good" or "excellent". Despite this, the RPSGB and PSNI have both introduced a separate calculations section onto their registration examinations. In 2002, the RPSGB decided to change the exam process by adding a separate calculations section which would be taken as part of the open book paper and which must be passed independently of the other papers with a 70% pass mark. The paper consists of 20 Multiple Choice Questions, in a true or false format, which is not negatively marked. Candidates are not allowed the use of a calculator in the RPSGB exam. The PSNI followed suit in 2005 by also incorporating a separate calculations section of the same format into their registration exam. Currently students in Northern Ireland are allowed to use a calculator in their registration exam.

Contact with each of the pharmaceutical societies allowed us to obtain the following statements:

> Before 2005, calculation questions were embedded within the open book paper of the PSNI Registration Examination. A candidate was required to pass this examination before going on the register, but it was difficult, without detailed analysis of the results, to demonstrate competency in calculations questions. Hence, it was decided by Council to introduce a calculation section within the open book examination, the purpose being to ensure that candidates going on the register were able to do pharmaceutical calculations accurately (Scott, 2006).

> This (calculations) section was introduced following a significant number of candidates performing poorly in the calculation questions across the old style papers. The calculations section as a rule performs better than the other sections with regards to marks (McGarry, 2006).

After each RPSGB examination sitting The Pharmaceutical Journal publishes statistics on examination performance and, as may be seen from Table II, pass rates in the calculations section are extremely high. In the first sitting of the new registration examination in Northern Ireland there was a 96.75% pass rate in the calculations section. The four candidates who initially failed the calculations section all passed the special written test on their second attempt. Results were similarly impressive in the two multiple choice calculations exams of the same format and standard as the PSNI pre-registration calculations exam sat by our Level 2 students. In the first exam, taken in week 6 of Semester 1, the mean score was $91.7 \pm 7.6\%$, with only one out of 134 students achieving a score below 70%. In the second exam, taken in week 10 of Semester 1, the mean score was $84.7 \pm 9.7\%$, with just six students achieving a score below 70%.

The results above suggest that the decline in numeracy standards of pharmacy students and pre-registration trainees has been exaggerated, or is perceived rather than real. This may be due to the fact that students are more likely to rely on calculators than qualified pharmacists are and, hence, appear less capable to older colleagues, used to using pen and paper methods (Tables I and III). In fact, some pharmacists believe that pre-registration students have poor mental arithmetic skills (Table IV). Most agree, however, that the use of a calculator is an essential double check in practice and, as such, should be allowed in the registration examination (Table III). The results from the different pharmaceutical societies' exams, which are of approximately the same standard, suggests that pre-registration students are capable of performing pharmaceutical calculations accurately with or without a calculator. An alternative view may be that the range of measures taken by schools of pharmacy (Table V) to address perceived shortfalls in numeracy standards of their student intakes may simply be working effectively.

It is obvious that by practising calculations regularly, under appropriate direction, confidence and competence will improve. It was interesting to note that of our own students, those in Level 1 and 4 had less confidence in their ability to perform mathematical calculations than did the Level 2 and 3 students. More of the Level 1 and 4 students also believed that they needed more support with respect to numeracy and that additional time should be spent on pharmaceutical calculations in the MPharm programme. This is likely to be due to the timing of the teaching of basic numeracy skills in our MPharm degree. In Level 1 and 2 students receive extensive instruction in numeracy as it applies to pharmacy. Eight hours of teaching time are spent on numeracy at the beginning of Level 1 and an MDT is taken in week 1 of Level 1. This is followed up by a second MDT to assess progress later in the semester. Students have access to a website dedicated to numeracy, PCCAL packages and numerous online calculations exercises, as well as one-to-one support from experienced staff when required. Students also routinely perform calculations as part of the "physico-chemical principles" module. In Level 2, students are required to employ their numeracy skills in pharmaceutical chemistry, in addition to the exercises detailed above in extemporaneous formulation and dispensing. In Level 3 and 4, calculations performed by students are more of an applied nature, being mostly related to statistical analysis, pharmacokinetics and business management rather than the basic addition, subtraction, multiplication and division that form the basis for dose and quantity calculations. Our survey was carried out early in the first semester. As a result, Level 1 students perhaps did not have an appreciation of the extensive range of teaching, support and self-study materials available to them. Level 4 students, as they had not performed basic calculations exercises for 2 years, may simply have been out of practice or believed that they had forgotten what they had learned. It was notable that the majority of students in all Levels would like additional classes related to basic calculations. This is clearly difficult due to pressures of time within the MPharm programme, especially with the upcoming addition of subjects related to pharmacist prescribing. However, to improve confidence, as this is what it appears is required rather than an improvement in numeracy standards, a website is currently being developed that can be accessed by all students in each Level of the QUB MPharm programme. This site will provide further instruction in basic numeracy and pharmaceutical calculations and will contain a number of exercises of the same format and standard as the registration examination.

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