IDENTIFYING UNMET TRAINING NEEDS FOR POSTGRADUATE RESEARCH STUDENTS IN THE BIOMEDICAL SCIENCES THROUGH AUDIT OF EXAMINERS' REPORTS

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ABSTRACT

Aim/Purpose	Understanding the educational needs of postgraduate research candidates (PGRs) is essential to facilitate development, support attainment, and maintain graduate quality.
Background	The production and effective defence of the research thesis are the summative assessment tools used in postgraduate research education. Examiners' reports provide a rich source of feedback and indicate the gap between the candidate's level of performance and that expected for the award. This provides a lens through which to view the unmet training needs of PGR cohorts.
Methodology	Following a review of all examiner reports for PGR assessments held over a 12 month period, we explored the quantitative and qualitative dimension data in context in order to identify common training needs for our PGR students. Utilising this theoretical framework and standard thematic analysis, we identified recurring themes and were able to determine key areas for future focus.
Contribution	This study utilises independent comment from postgraduate research candidate thesis and oral examination assessment to identify unmet core research training needs.
Findings	We recognised seven key areas identified by the examiners for improvement: i) quality of scientific writing, ii) general presentation of thesis, iii) statistics /data analysis, iv) understanding / critical appraisal, v) experimental design, vi) English language and vii) supervision. Academic literacy and numeracy stood out as

key areas for future training focus. The results highlight areas for future focus in educational provision and targeted training for PGRs undertaking biomedical and life sciences research within our faculty.

Recommendations for Practitioners	Evaluation of postgraduate research programmes should include feedback from a variety of sources and not rely solely on employability and completion rates as measures of success. The examination committees are an important source of feedback on the individual and the programme with regard to attainment of core research skills.
Recommendation for Researchers	Regular and wide reaching evaluation of postgraduate research programmes and support available is required to ensure the sector can meet the changing needs of our PGR cohorts.
Impact on Society	Doctoral graduates are entering increasingly diverse employment fields. Ensuring the quality of graduates and supporting their journey through candidature ensures the greatest value for society once in the work place.
Future Research	This study highlights unmet training needs of PGRs as identified by an independent expert. The impact of engagement with training and the importance of prior experience are not explored in this study, nor is the student perspective on the process. These will reveal additional dimensions to the evaluation process.
Keywords	doctoral training, education, feedback, learning needs assessment, quality outcome, quality graduates

INTRODUCTION

The success of postgraduate research programmes is primarily measured on the quality of the graduates produced and their employability (CFE Research, 2014), but an important measure in the UK is successful timely submission of the thesis and completion of the examination (HEFCE, 2013).

This has been used to positively discriminate between Higher Education Institutions in terms of research council funding in England, and the prospect of timely completion is certainly something that doctoral candidates value (Webb, 1996). Numerous situational and individual factors influence the outcome for postgraduate research (PGR) candidates. Latona and Browne (2001) proposed that factors affecting on time completion could be grouped into three categories: i) institutional / environmental, ii) supervisory arrangements / relationships, iii) student cohorts and characteristics. Whilst this is a reductive approach, it provides a useful framework. Our study is focused within the domain of institutional / environmental factors as the emphasis is on training needs and provision for PGRs and acquisition of core research skills that facilitate completion of the award. Within our faculty, we seek to enhance the research environment through the quality of educational provision for our PGR candidates by focusing on strategic research strengths, learning from national and international surveys and reflecting on local trends in successful PhD completions. Through understanding the needs of our cohorts and the requirements for award, we look to enhance outcomes for our students.

PGR students are defined as candidates who pursue a programme of novel independent research. They are supervised by key subject experts and supported by educational and development programmes. For PGR candidates, pursuing doctoral and masters programmes, 'the Dublin descriptors' provide the accepted benchmark criteria for a successful graduate for specific award levels across higher education (Joint Quality Initiative, 2004). The descriptors cover the expectations of skills, knowledge, and attributes associated with the qualification. The development and standardisation of qualification level descriptors through the European Qualification Framework, has facilitated the standardisation of criteria for the award of PGR qualifications across Europe. The strategy provided students educated within Europe with comparable educational capital, endorsing the ethos of international mobilisation and fostered flexibility for postdoctoral employment. The composite countries

of the UK adopted the framework and have validated their quality control processes in line with these European wide recommendations (QAA, 2008, 2010, 2014). Although the criteria for doctoral degrees is standardised across Europe, training and assessment is not.

In terms of training, there has been a drive in the UK to improve researcher education and ensure development of core transferable skills, largely driven by the recommendations of Roberts review (Roberts, 2002) with granularity later provided through the work of Vitae and the development of the Researcher Development Framework (Vitae, 2010). This has been recognised internationally and adopted in a number of countries or adapted to meet local needs (Smaglik, 2016). The challenge for universities is to maintain the quality of PGR graduates, provide the very best research and educational opportunities to facilitate timely completion, and equip our graduates for careers across various sectors to meet the needs of society.

The way in which doctoral students learn and develop throughout their educational journey towards independence is of relevance in this context. Doctoral learning frameworks have largely focused around models of transition, examining the stages through which candidates pass during their programme of research, relating to key progress milestones (Gardner 2009; Tinto, 1993). Whilst the nomenclature used by researchers in this area varies, they track development of skills and knowledge, through to integration and creation of knowledge, and on to active operation within the field. These were summarised by Pifer and Baker (2016) as knowledge consumption, knowledge creation, and knowledge enactment. These models are not perfect, but are broadly helpful. Indeed the concept of transitional change implies a wide range of skills and developmental needs and associated changes in student behaviour and identity as they progress, and it allows for variation in student need, pace of learning, and prior experience / expertise (Figure 1).
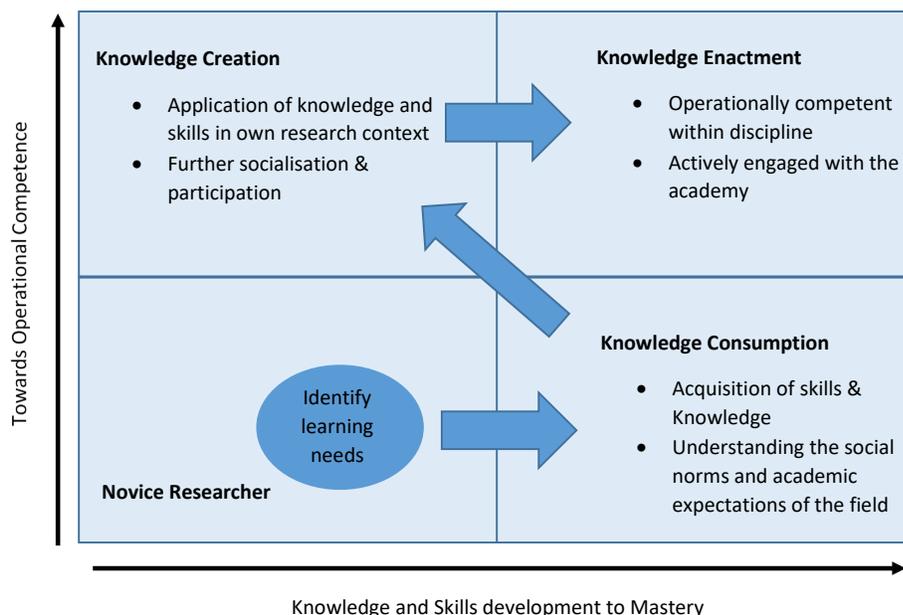

Figure 1. Doctoral learning frameworks are centred around phase transition.

Candidate development over time is characterised by acquisition of knowledge, skills and familiarisation with social and academic norms, integration of knowledge and the creation of knowledge, progressing towards increasing operational competence within the field. Learning needs are constantly analysed and addressed, as depicted by the arrows, allowing crossing of phase thresholds.

The motivation and drive of the student, the strength and scope of the research project, the supervisory team, and the wider environment have each been shown to impact on student development and success. The student and supervisor relationship has previously been highlighted as pivotal to the

success of the PhD candidacy (Latona & Browne, 2001), and it is clear that good relationships foster trust and a productive working environment (Maher, Gilmore, Feldon, & Davis, 2013). The focus and purpose of individuals within the team requires alignment of goals for best outcomes for all (Akerlind & McAlpine, 2017).Trust and respect for the abilities of other, honest and open dialogue, and feedback between group members appears central to successful function of the supervisory unit (Robertson, 2017). However, Weidman, Twale, and Stein (2001) discussed the role of socialisation in the development of an individual's professional identity. The role of socialisation and professional integration in postgraduate persistence and success was explored by Gardner and Barnes (2007), who utilised socialisation as a framework to examine the impact of postgraduate integration on motivation, persistence, and success. They defined socialisation as the process through which an individual learns the values, skills, attitudes, behavioural and professional norms, and key knowledge required for membership to a group or profession. Baker and Pifer (2011) later further examined the role of social interactions beyond the supervisor-student dyad and, indeed, within and outside the immediate faculty, in influencing doctoral education and professional identity development. Whilst environment and relationships have a role to play in doctoral success, the execution of the research, completion, and defence of the thesis are the responsibility of the individual, and one's motivation, drive and hard work are key to successful completion. The individual is at the centre of doctoral education, the student's learning needs should be a sharp focus throughout one's studies, but the process focused in most programmes in the early phase should build skills and good habits for lifelong learning (Pifer & Baker 2016).

Universally, students are assessed on their written outputs, the Thesis (or collection of published work or production of artefacts); students may also be required to attend an oral examination or defence of their thesis. This oral defence provides an additional dimension to the examination process, affording examiners a direct opportunity to discuss any issues arising with the thesis and to allow candidates an additional means of communicating their findings and engaging in intellectual discourse with leaders in their chosen field of research.

In the UK, students submit a Thesis of their work, which is examined by at least one external examiner and usually one examiner from within their University. The examiners are independent from the student, the supervisory team, and the work, but are experts in the given field of research. The examination processes minimally involves independent assessment of the written thesis followed by a viva voce examination over a number hours with the team of examiners to discuss the work, determine depth and breadth of understanding, the technical and analytical skills of the student, and that the student did indeed complete the work. The examiners of the PGR thesis act as gate keepers, assuring quality of graduates. Their subject expertise and understanding of the requirements for graduates mean they are well placed to examine the thesis, but also provide feedback on areas of strength and weakness observed in candidate's written work. Examiners written reports provide insight into their expectations of thesis quality (Kyvik &Thune, 2015), but also provide valuable formative feedback to the candidate on what changes could be made to raise the standard of the thesis to the level expected. (Holbrook, Bourke, Fairbairn, & Lovat, 2014; Holbrook, Bourke, Lovat, & Dally, 2004a, 2004b; Kumar & Stracke, 2011). Kumar and Stracke (2011) and later Holbrook and colleagues (2014) explored the role of examiners in assessment and feedback and discussed the notion that many examiners consider the doctoral / research masters thesis to be a work in progress, which can still be revised and submitted to meet the required standard. Kumar and Stracke (2011) argue that the examiners reports provide valuable individual feedback to the candidates to allow them to close the gap between current and required performance; indeed, in their recent paper they argued for comprehensive feedback to allow realisation of assessment for learning (Kumar & Strake, 2017).

By extension examiners reports can provide useful insight into areas of best practice and gaps in researcher education that could be addressed at an institutional / faculty level to allow candidates to close the gap between their current and expected performance in the production and defence of their thesis. This audit reviewed PGR examiners reports over a twelve month period to identify

common learning needs that would in turn facilitate development and / or delivery of targeted educational interventions for PGR candidates.

STUDY DESIGN AND METHODOLOGY

The study design employed here draws on the experience and theoretical framework utilised by Holbrook and Bourke (2004) in their large scale investigation of doctoral examinations through the use of examiners' reports and candidate information and outcome data. The multidimensional framework proposed by these authors includes analysis of i) quantitative information relating to examination outcome and quantifiable elements from the text (related to coding strategy), ii) analysis of content and patterns seen in the text and associated quality of communication, and iii) critical analysis and questioning of data emerging from i) and ii) with attention paid to traditions of the discipline and context of the study in order to identify areas for further elaboration and future focus.

The current study had a narrower focus and sought to analyse the quantitative and qualitative dimension data in context in order to identify common training needs for our PGR students. Utilising this theoretical framework and standard thematic analysis, we identified recurring themes and were able to determine key areas for future focus.

Similar approaches have been employed by other authors in studies examining doctoral training and quality assurance. Examiners' reports have been used in postgraduate education research as a source material for determining PhD candidate / thesis quality (Kyvik & Thune, 2015), identifying what examiners expect from students, and the language used in reports analysed to determine if the overall outcome could be predicted (Bourke, Hattie, & Anderson, 2004; Holbrook & Bourke 2004). Others have explored the value and richness of feedback provided by examiners to candidates and the role of the report in assessment of the written thesis (Holbrook et al, 2014; Kumar & Stracke, 2011).

THE CONTEXT FOR THE STUDY

This study was undertaken at a Russell Group University in the UK. The University hosts 30,000 students, almost 9,000 enrolled on postgraduate programmes. The School of Medicine, the faculty in which the study was completed, has 3,500 students; approximately 300 of these are Postgraduate Research students. This includes students at all stages (various years of study), studying full time or part time, and across the three PGR programmes available: MPhil, MD, and PhD. To put this in perspective, the School recruits similar numbers of students to several UK Universities including London School of Economics, Oxford Brookes University, and University of Portsmouth (HEFCE, 2013). Registered students pursue research in a variety of biomedical, health, and social care related disciplines. There is significant diversity in terms of project type whether clinical, (clinical trials, genetic analysis, patient experience, clinical imaging, etc.), laboratory based basic science (in vitro and in vivo), public health, psychology, social science, and epidemiology. The cohort reviewed consisted of sixty one students. Students were examined for PhD (50), MD (9) and MPhil (2) awards. The study received ethical approval from The School of Medicine Research Ethics Committee, Cardiff University.

Table 1. Demographic of the PGR cohort reviewed

	PGR Candidature		
	PhD	**MD**	**MPhil**
Total number of students	50	9	2
Full time study	50	7	2
Part-time study	0	2	0
Female %	58%	44%	100%
Students submitting within registration period	43 (86%)	6 (67%	1 (50%)
Students requesting an extension (%) (Exam Outcome O1-4)	7 (14%) (O1=2;O2=2;O3=3)	3 (33%) (O2=3)	1 (50%) (O4=1)

Examination process and recommendation for examination outcome

The examination of PGR degrees at the University is a two stage process (as at most UK Universities), regardless of whether PhD, MD, or MPhil. The Thesis is submitted and examined independently by at least two examiners, before a *viva voce* examination (oral defence). The examiners are required to independently assess the thesis against the criteria for award (see criteria below) and each prepares a written report on their reading of the work. These written reports are submitted before the *viva voce* examination. Immediately prior to the *viva voce* examination, the examiners will confer with one another in the presence of an examination Chair, in order to exchange copies of their independently written reports, identify the issues to be raised in the examination, and agree a broad strategy for the examination. The format of the assessment and the reports are the same regardless of the award being examined (PhD, MD, MPhil).

Criteria for Award

PhD / MD

- The degree of PhD/MD may be awarded by the University in recognition of the successful completion of a programme of further study and research, the results of which are judged to constitute an original contribution to learning and to give evidence of:

- The creation and interpretation of new knowledge, through original research, of a quality to satisfy peer review, extend the forefront of the discipline and merit publication;

- A systematic acquisition and understanding of a substantial body of knowledge which is at the forefront of an academic discipline or area of professional practice;

- An ability to relate the results of such study to the general body of knowledge in the discipline;

- The general ability to conceptualise, design, and implement a project for the generation of new knowledge, applications, or understanding at the forefront of the discipline, and to adjust the project design in the light of unforeseen problems;

- A detailed understanding of applicable techniques for research and advanced academic enquiry.

- In respect of the award of MD, the results of the study and research shall be judged to constitute an original contribution to medical or surgical knowledge, and shall afford evidence of originality either by the discovery of new facts or by the exercise of independent critical power. The candidate shall indicate in what respects the thesis appears to advance clinical knowledge and/or practice.

- In judging the merit of a thesis submitted in candidature for the degree of PhD/MD, the examiners shall bear in mind the standard and scope of work that it is reasonable to expect a capable and diligent student to present after the period of registered full-time or part-time study.

MPhil

- The degree of MPhil may be awarded by the University in recognition of the successful completion of a programme of further study and research, the results of which are judged to constitute a critical evaluation and analysis of a body of knowledge and/or an original contribution to knowledge, and to give evidence of:

- A systematic understanding of knowledge, and a critical awareness of current problems and/or new insights, much of which is at, or informed by, the forefront of the academic discipline, field of study, or area of professional practice;

- A comprehensive understanding of techniques applicable to the research or advanced scholarship;

- Originality in the application of knowledge, together with a practical understanding of how established techniques of research and enquiry are used to create and interpret knowledge in the discipline;

- Conceptual understanding that enables:

  - The critical evaluation of current research and advanced scholarship in the discipline; and

  - The evaluation of methodologies, the development of critiques of them and, where appropriate, the proposal of new hypotheses.

The oral examination is an integral part of the research degree examination process; it is not merely a ritual. It may serve different purposes, according to a candidates differing qualities and those of the written thesis, but the essential purposes are (taken from the University Senate Regulations):

-to enable the examiners to assure themselves that the thesis is the candidates own work.

-to enable examiners to assure themselves that the candidate understands the research that s/he has written about in the thesis

-to enable the examiners to assess the candidate's ability to locate his / her work within the broader context of the particular field of scholarship to which the project relates

-to give the candidate the opportunity to defend the thesis and clarify any obscurities and weaknesses in it, this is particularly important in borderline cases

-to enable the examiners to explore how the thesis might be raised to the required standard should they be unable to recommend the award at this stage.

At the conclusion of the *viva voce* examination, the examiners agree upon a joint report, which feeds back on the student's performance at *viva voce* examination, summarises requested corrections, and provides a formal recommendation regarding the award. That is, whether the candidate has passed or failed and if corrections are required. External examiners are also asked to complete an additional section of the form to provide any comments on quality and standards, which can include the conduct of the examination or any element relating to quality or the process.

The examination team recommend the outcome of the examination. Recommendations available range from pass with no corrections to fail with no additional attempt for resubmission, similar to previously reported by Bourke and colleagues (2004).

Outcome recommendations for PGR examinations

1. Pass, candidate approved for Award
2. Pass, subject to minor corrections the candidate is approved for award (complete within 12 weeks)
3. Pass, subject to corrections and amendments the candidate is approved for award (complete within 12 weeks)
4. Not approved, resubmit for the award on one further occasion (within 12 months)
5. Not approved for PhD / MD, Approved for MPhil (only in case of MD/PhD candidates)
6. Not approved for PhD / MD, Approved for MPhil with minor corrections (only in case of MD/PhD candidates)
7. Not approved for PhD / MD, Resubmit for MPhil (only in case of MD/PhD candidates)
8. Not approved for award and no further submission permitted.

For the cohort under review, students obtained an outcome recommendation between one and four, with most students obtaining outcome two or three (Pass but with the requirement to make corrections within 12 weeks) (Figure 2). During this period two PhD and one MPhil candidate received an outcome 4, which is effectively a fail with the opportunity to resubmit the thesis within 12 months. This represents a pass rate of 95% for PhD students submitting their thesis and is above the predicted average across UK Higher Education Institutions previously reported (HEFCE, 2013) and that previously reported by Bourke et al. (2004).
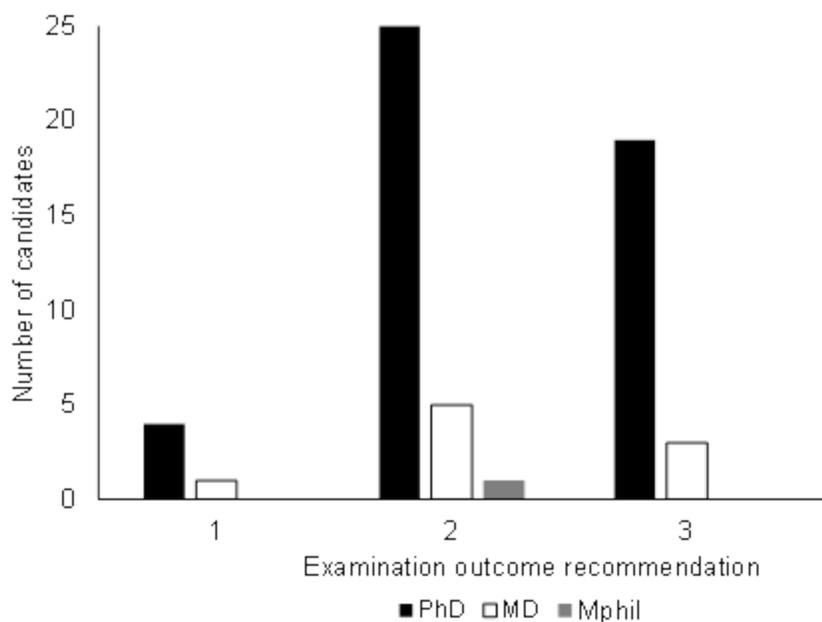

Figure 2. PGR degree recommendation outcome by degree.

Following examination of Thesis and *viva voce* interview, 61 PGR candidates were provided with a recommendation from their examination panel. Decisions ranged from outcome 1 – outright pass, to outcome 4, which requires substantive revision and resubmission of the thesis within 12 months.

Material reviewed for audit:

The examination report for all PGR students examined over a twelve month period between 1st July 2014 and 30th June 2015 were reviewed. Reports were anonymised and allocated a number for the purposes of the study. The report documents consisted of independent written reports on the quality of the thesis and the research project design, implementation and interpretation of data from at least two examiners, a joint report written post *viva voce* examination, recommendation for examination outcome, and feedback on the examination process and quality. Specifically, the authors reviewed all anonymised reports. Using standard coding and thematic analysis, we identified recurring themes. In line with application of grounded theory, we sought theoretical saturation (O'Reilly & Parker, 2012), whereby all categories were aligned to specific and distinct learning needs in this case. We examined the occurrence of specific issues across the study population and, for each individual candidate, we assessed the breadth of issues identified by the examiners. A spreadsheet was created listing all study subjects, annotation of presence or absence of the seven categorised issues was assessed separately for the two independent examiners reports and for the joint report following *viva voce* examination. The study examined the outcome recommendations for the overall assessment, as outlined in University Senate Regulations, and analysed feedback provided in reports in context to iden-

tify key areas of training. In addition, the study examined concordance of areas identified by external and internal examiners, and tracked whether concerns remained following *viva voce* examination (present in the joint examiners report), and investigated if there was any correlation between examination outcome and number or types of issues identified.

Seven areas identified for teaching and learning support improvement

Thematic analysis of the examination reports identified a number of key common areas for improvement highlighted through examination of the thesis and / or at the viva voce examination. Seven key areas for improvement identified were i) Statistical analysis / data analysis ii) Use of English language, iii) Standard of scientific writing, iv) Experimental design, v) Understanding / Critical appraisal, vi) Presentation of thesis, and vii) Supervisory issues. These themes are defined in Table 2.

Table 2. Areas of improvement identified through review of PGR examination reports

Issue identified	Description
Statistics / data analysis	Any comments related to the appropriate analysis or interpretation of data / use of statistical tests.
English language	Any issues specifically relating to quality of written English
Standard of scientific writing	Any issues relating to standard of scientific writing, deviation from expected standard of scientific explanations and the ability to write concisely
Experimental design	Any issues raised relating to experimental design, including cohorts / samples selected, selection of suitable controls for experiments and appropriate choice of methodology to answer the research question
Understanding of the subject / critical appraisal of data, particularly in context	Any issues relating to understanding the research, interpretation and or its place in the wider context of the research area, including awareness of the current literature
Presentation of the thesis	Any issues relating to the presentation of the thesis including formatting, grammatical and spelling errors, and the presentation of figures and tables
Supervisory issues	Any issues relating to the supervision or support received by a PGR student that has impacted on the quality of the project / presentation of thesis

RESULTS

Examiners reports are an essential tool in the assessment of PGR candidates work; they provide a summary of the examiners academic judgement on whether or not the thesis presented meets the required benchmark for the award. It may indicate areas the examiner wishes to explore at the *viva voce* examination and can set the agenda for this defence. However, as well as assessment, the examiner's report provides formative feedback on how the thesis can be amended to improve the quality and reach the required standard, and forms the basis of any required corrections. The report is an important means by which the examiners can provide feedback to the Candidate, Supervisor, and University on the overall quality of the thesis, the candidate, and raise issues around the examination process. The present audit of examiners reports revealed seventeen out of the sixty one reports, raised no areas for specific improvement (28%). For these candidates, only complementary comments were included in the reports; example comments are included in Table 3. The remaining seventy two percent of reports contained comments on how the thesis, the project, or candidate's performance or understanding might be improved. Severity of comments varied across the cohort for the various themes; example comments are provided in Table 4.

Table 3. Examples of positive comments received on thesis submission and viva voce examination performance

Example comments – Positive feedback on PGR theses
This is an excellent thesis, one of the highest quality that I have read in a long time, and I enjoyed reading it very much.
Excellent quality of research training, supervision and monitoring
The candidate has made an excellent job of writing the thesis. It is extremely well-written and almost devoid of grammatical and typographical errors, making the thesis a pleasure to read.
A remarkably well written, eloquent and clearly presented thesis. Statistical analyses are described in such a way to demonstrate what they were and why they were used, rather than simply being listed without further explanation.
Thesis is exceptionally well presented, with very few typographical errors. The introduction and discussions of data reveal a very good grasp of the literature.
A very well – written thesis which is nicely formatted without spelling or grammatical errors

Table 4. Areas of improvement identified through review of PGR examination reports

Issue identified	Example quotes
Statistics / data analysis	'...with regards to the statistical assessment, some of the experiments were clearly analysed using the wrong tests, especially where data from paired samples were compared using unpaired tests (the candidate) does not seem to be very clear about why they sometimes used ANOVA and sometimes t-tests, up to a point where they may have even misinterpreted or over interpreted some of their findings.' 'It is recommended that the student attend a comprehensive statistics course for research scientists (specifically scientific NOT clinical)' 'It is difficult to ascertain how many times experiments have been repeated and exactly what is being compared with what for statistical purposes. There is also frequently over interpretation of the data as it has been concluded that there are changes even though there are no statistical differences between the groups tested.' 'There are also several statistical concerns, particularly with regard to the need to account for potential confounding factors in interpreting the impact of therapy on some measurements.'
English language	'The use of English is unsatisfactory.' 'This thesis is challenging to evaluate. The use of English throughout makes understanding the work difficult…'
Standard of scientific writing	'not an easy read, the prose was factually dense and repetitive, particularly in the results sections. The introduction, whilst comprehensive would have benefitted from some editing and more incisive analysis…' …'makes considerable use of the first person plural in the active voice. This is used extensively but not exclusively…although I do not believe this to be the case, this could cast doubt on the candidate's personal contribution.' 'In the current form the thesis is somewhat too descriptive' 'The candidate needs to have a hypothesis in the introduction. The major findings are lost in the work and need to be highlighted further.' Time and again I wanted much more detail, particularly about patients and methodologies used. This lack of detail undermines confidence in the validity of the analysis. The Introduction and discussion sections are often lacking in detail or are inaccurate.

Issue identified	Example quotes
Experimental design	'There needs to be Justification of methodology and methods used' 'There was Lack of demonstration of reproducibility of data' '…some crucial controls seem to be completely missing.' 'The candidate really needs to provide demographic details of the patients recruited to the study. Specifically where the participants in the two groups age and sex matched. I have a feeling the two groups may have differed substantially.' 'The candidate did not perform a power calculation to inform the number of patients to be recruited to the study. Whilst this may not have been entirely possible, it is normally considered scientifically correct and requires at least some discussion.' 'Unfortunately…the approach did not afford significant new functional insights'
Understanding of the subject / critical appraisal of data, particularly in context	'My main critique is that as a body of work there was very little in the way of synthesis and the students own critique of the work.' 'Some of the conclusions made in the results sections need to be amended with more objective language to reflect the limitations of the experimental data.' 'The thesis lacks a good coherent discussion where results are pulled together and put into context of other results and outcomes as well as its impact on care.'
Presentation of the thesis	'…some of the … data is very poor with over exposed images and many poor or poor quality…also negative controls are not included..' '…many of the figures in the introduction were adapted from other sources and did not reproduce well in the printed version.' 'There were issues with…presentation and style – Figures, tables, writing style, referencing and formatting' 'The thesis contains numerous typographical and inconsistent grammatical errors, some of which affect scientific accuracy…some of the figures are not presented clearly' The figures are however very confusing as many of them are labelled incorrectly and do not match the numbers in the list of figures at the front of the thesis.
Supervisory issues	'The thesis was not presented in a satisfactory structure and the writing suggests that the candidate had minimal supervision.'

Where areas for improvement were identified, the data was examined in order to rank these by frequency of occurrence in i) any part of the report document, ii) external examiners report, iii) internal examiners report, iv) joint report. For each student in the cohort, areas identified for improvement were tallied (if an area was identified more than once in a report (i-iv), it was only counted once for that student).

DETERMINING THE FREQUENCY OF OCCURRENCE OF KEY ISSUES

Determination of frequency of occurrence of issues across any element of the report saw quality of scientific writing identified as the most common area requiring improvement (52% students), closely followed by general presentation of thesis (48%) and statistics and data analysis (44%). The next highest ranked issues were understanding / critical appraisal (38%), followed by experimental design (34%). Two other issues were identified at lower frequency: English language (highlighted in two examination reports) and supervisory issues (identified in one report). Assessment of frequency of occurrence of issues across reports allowed comparison on occurrence overall and comparison of the key elements identified by internal and external examiners (Table 5). We were also able to quantify and rank occurrence of issue, and determine whether the rank order is the same overall as for external examiners reports and internal examiners reports.

Table 5. Frequency of issues identified in PGR examiners reports

	Statistics / data analysis	English language	Standard of scientific writing	Experimental design	Understanding / critical appraisal	Presentation of the thesis	Supervisory issues
Overall	27 (44%)	2 (3%)	32 (52%)	21 (34%)	23 (38%)	29 (48%)	1 (2%)
External Examiners	17 (28%)	2 (3%)	19 (31%)	14 (23%)	20 (33%)	16 (26%)	0
Internal Examiners	14 (23%)	1 (2%)	19 (31%)	15 (25%)	9 (15%)	13 (21%)	0

Number in parenthesis is the percentage of students in the cohort for which each issue was highlighted, total number of students reviewed = sixty one.

Ranking of the issues by frequency highlighted the most common issues (Table 6). Comparisons across the report and between external and internal examiners, revealed that whilst the top three issues varied a little between the whole report, individual external and internal reports, two key issues were consistently in the top three: standard of scientific writing and statistics / data analysis.

Table 6. Ranking of issues identified in examination reports

Rank	Area for improvement
1	Standard of scientific writing
2	Presentation of the thesis
3	Statistics / data analysis
4	Understanding of the subject / critical appraisal of data, particularly in context
5	Experimental design
6	English language
7	Supervisory issues

Concordance of issues identified between examiners

In order to examine concordance between examiners, the independent examiners reports were cross referenced to determine if the same issues had been raised by both examiners. This was investigated at the level of the key issue areas. From the analysis, it would appear that agreement between written feedback from examiners was variable (see Table 7). There was 100% agreement between examiners in the two students for whom standard of English language was identified as an issue. Across the other issues, concordance varied from 55% for comments regarding experimental design, 40% for statistics / data analysis, and 33% agreement on the issue of presentation of thesis. There was 27% agreement between examiners when the issues of scientific writing and understanding / critical appraisal were analysed.

Table 7. Concordance of issues identified in individual examiners reports.

Area for improvement	Percentage agreement between examiners
Statistics / data analysis	40
English language	100
Standard of scientific writing	27
Experimental design	55
Understanding / critical appraisal	27
Presentation of the thesis	33
Supervisory issues	0*

*Supervisory issues were identified for one student following viva voce examination; this was noted in feedback on examination process, not in examiners' individual or joint reports.

The one case where supervisory issues were raised in the feedback on the examination process following the *viva voce* examination was not highlighted by the individual examiners in their independent reports.

Issues remaining after the *viva voce* examination

Issues which remained to be resolved following the *viva voce* examination were identified in the joint report. The proportion of examination reports where areas for improvement were identified post *viva voce* was markedly reduced. Following *viva voce* examination, reports identified areas for improvement in 37% of the examinations compared to 72% before the oral examination. The key areas identified reduced in number, but ranking of areas closely mirror the areas highlighted in the individual examiners reports on thesis.
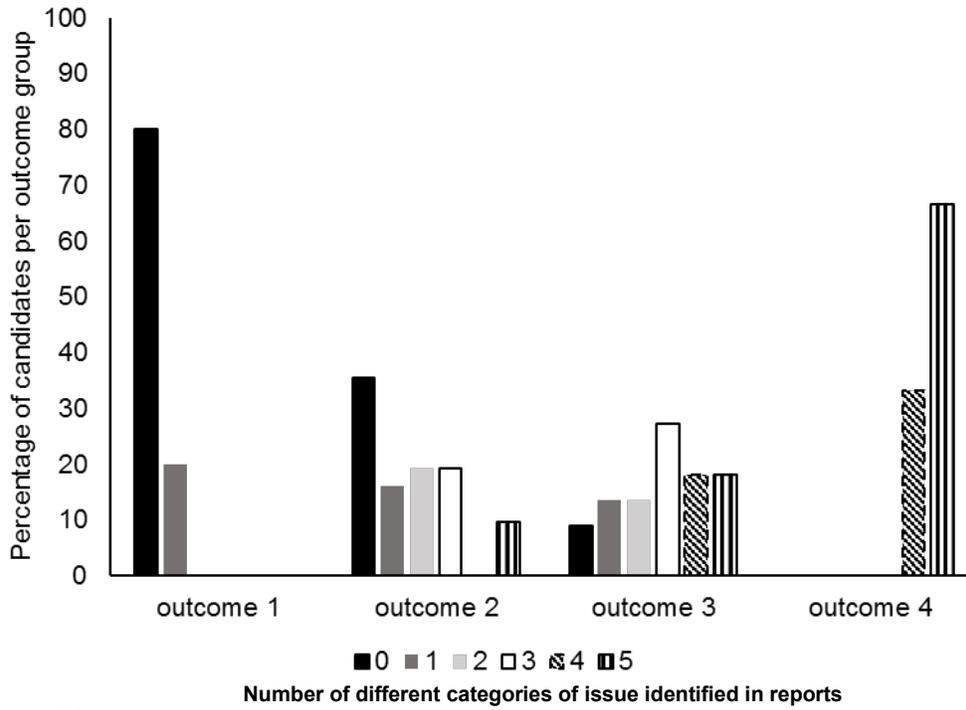
Table 8. Ranking of issues identified in following viva voce examination

Rank	Area for improvement
1	Presentation of the thesis (16%)
2	Statistics / data analysis (13%)
3	Understanding / critical appraisal (13%)
4	Standard of scientific writing (7%)
5	Experimental design (7%)

Examining the relationship between examination outcome recommendation and number and types of issues identified by examiners independently and following viva voce examination

In order to unpick differences between the learning needs of candidates receiving the lower examination outcomes, trends in outcome recommendation, and numbers and types of issues identified by examiners and those remaining post *viva voce* were scrutinised. Figure 3 illustrates the polarity observed in the number of issues identified by examination outcome; predictably those receiving the highest level outcome had the least number of issues. Conversely, those receiving lower outcomes (two through four) were seen to have a greater number of areas for improvement. Panel A clearly illustrates the dichotomy between the outcome groups, moving from a low number of issues in the outcome one group through a transition across outcome two and three to a greater number of issues in the outcome four group. There is a low number of candidates in outcome groups one and four, but a trend is apparent. When scrutinising the relationship between outcomes and number of issues post *viva voce*, as outcome band increases, so does the number of issues identified. The small group size for outcome 4 has an impact here – the number of issues is more variable.
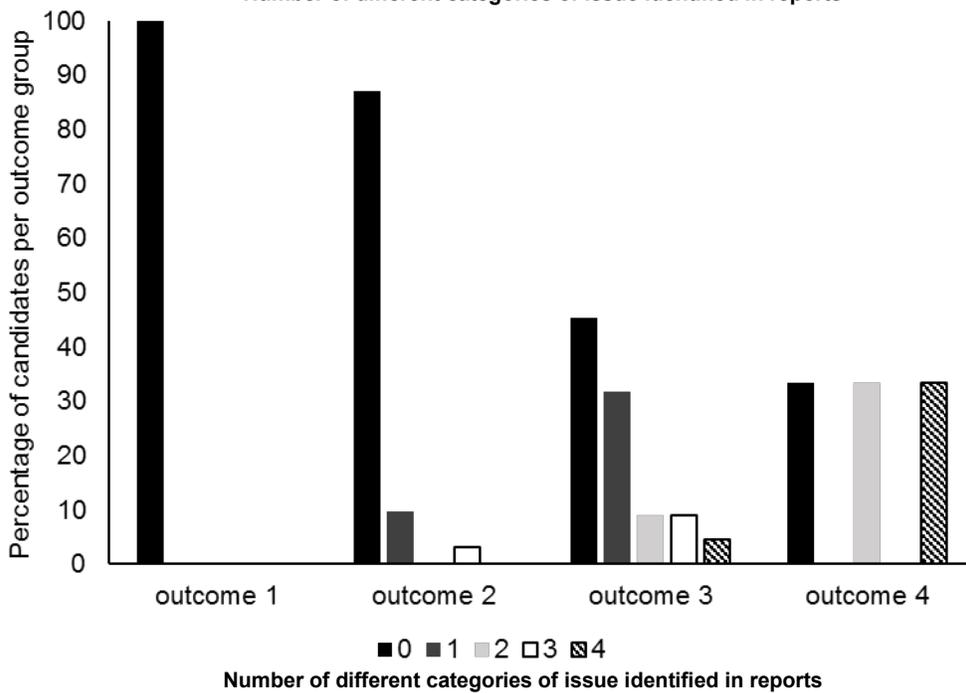
A

B

Figure 3. PGR degree recommendation outcomes and the number of areas identified for improvement by examiner following examination of thesis (Panel A) and post viva voce examination (Panel B).

From the data it is clear that there were examples of candidates with outcome two or three who had a high number of issues identified and, for some, these issues remained following *viva voce* examination. The nature of the issues was compared in more detail to determine key differences between the groups, examiners classification, and severity of issues – with specific focus on areas that could be targeted for educational intervention. To allow comparisons to be as close as possible, all candidates with five issues highlighted at any outcome level and all outcome four candidate reports were compared. Examiners reports highlighted similar areas across the three outcome groups, and the level of details provided varied across the individual examiners reports on thesis. Considerable differences were seen in the post *viva voce* joint examiners' reports for outcome two and three compared to outcome four. Feedback to Outcome two and three candidates tended to be prescriptive and short in nature, for example,

> 'Enhance depth and critical appraisal of the literature review in chapter X. Enhance presentation of figures, tables, references. Greater level of critical reflection of project in context.'

> 'Gaps in the literature to be filled, lack of use of figures to be corrected, improve presentation.'

> 'Main weakness was the written presentation of the thesis.'

> 'our individual reports identified substantial issues with the presentation of thesis – this will be addressed by the student as corrections.'

Reports with these outcomes also tended to indicate examiner satisfaction with student performance at viva, that the examiners were satisfied at the candidate's abilities to improve the thesis to the required standard, e.g., 'performed very well.' 'he defended his thesis well. There was good grasp of the methodology used and the limitations…the hypothesis was clear and the results adequately discussed and placed in context.'

> 'The candidate defended his thesis extremely well. Clearly had carried out the work himself, could justify his choice of methodology and able to defend those choices. He was able to put his work in context and showed a clear path of how the work could proceed.'

> 'The candidate gave a robust defence of their work in the oral examination.' 'The student performed very well throughout their viva and defended the thesis with rigour and enthusiasm.'

This was in stark contrast to the post viva reports for candidates who received an outcome four. These students received very detailed feedback on what was required to elevate the thesis to the required level for the award. The issues discussed went beyond changes to the presentation of the thesis or inclusion of additional literature and further discussion of the work in the wider context, but honed in on specific fundamental flaws in the work, required new analysis or significant reinterpretation, or cast doubt on the students understanding of the research / data or context.

> 'The candidate was generally able to deal with most of the questions, setting the thesis in the context (of the wider study) seemed to be more challenging. The candidate was not always clear of the implications of their thesis, or how these inform or affect further research and treatment.'

> 'Chapter X should be omitted, it adds little to the body of work. This can be supplemented by significant additional analysis of the data. (The data) is rich enough for a more in-depth analysis, production of more integrated conclusions…The literature review needs changes, most importantly in pulling the results together into a discussion that examines them in the context of accepted current knowledge and scholarship.'

> '…as the viva proceeded and the questions became more detailed about the actual methods used and conclusions drawn from the results, the candidates' answers became vague and in

some cases absent. On questioning the candidate was unable to demonstrate a satisfactory knowledge of the topic, the methods used and the experimental plan within the thesis.'

For two of the three candidates comments were also made which relate to the students intellectual ownership of the work.

'Both examiners were satisfied that the work reported in the thesis was the candidates own work, even though the initial ideas developed within the thesis seem to have mainly been developed as part of a larger study. It was not always clear if the candidates own initiative was followed throughout the thesis or if the work was very much led by the bigger (group) study.'

'…when asked for the rationale for the approach taken the reply was "that is what I was told to do"'

DISCUSSION

PGR examiners utilise their written reports to provide a summative assessment of the quality of the thesis and deliver formative feedback on how the thesis might be improved to meet the required standard for the award (Holbrook, Bourke, Lovat & Dally, 2004a; Kumar & Stracke, 2011). Examiners reports are a rich source of feedback on candidate's written work and, in the case of this audit, can provide feedback on candidate's performance during the oral defence. The audit utilised PGR examination reports to determine common areas highlighted for improvement by examiners, to facilitate educational interventions to reduce / remove the gap between expected and actual performance in the written presentation and defence of the PGR candidates' thesis.

The audit was completed within a Medical School at a UK University. The PGR student population of the School is similar in size to many UK Universities; research focus for the cohort was diverse, but all studies were classified as life sciences / biomedical research. The anonymised audit utilised standard thematic analysis to identify common areas highlighted for improvement by examiners. Seven key themes emerged, which were ranked i) quality of scientific writing, ii) general presentation of thesis, iii) statistics and data analysis, iv) understanding / critical appraisal, v) experimental design, vi) English language and vii) supervisory issues. The themes that emerged were not surprising and mirror themes identified in previous studies utilising examiners reports on doctoral (Holbrook, Bourke, Fairbairn & Lovat, 2014; Holbrook Bourke, Lovat & Dally, 2004a, 2004b; Kumar & Stracke, 2011; Mullins & Kiley, 2002).

Examiners highlight issues where they consider the standard in that area to be below that required for the award the candidate seeks (Mullins & Kiley, 2002). Exploring the areas highlighted (excluding supervisory issues which we will address later), two main areas for PGR student education focus emerge: i) Academic literacy and numeracy and ii) Cognitive ability.

The three most common issues flagged by examiners (scientific writing, presentation, and statistics / data analysis) and also English language fall under the umbrella of academic literacy and numeracy and highlight the importance of developing core skills around the appropriate analysis of data and the ability to communicate complex concepts with clarity, both in the form of written prose and in the presentation of data in figures and tables, but also in the overall presentation of the thesis as a body of work.

The other issues highlighted relate to cognitive abilities of candidates (critical analysis and understanding of the research undertaken, evaluation of the validity of the methodology and experimental design, which is very much linked with the ability to construct a cohesive evidence based argument to support the overall conclusions of a research project.)

In common with many University faculties, the study faculty runs a suite of training for their PGR students. The programme is mapped to the domains of the Vitae Researcher Development Frame-

work (Vitae, 2010) and covers a wide variety of core and specialist skills; students are encouraged to identify their learning needs and select and access training as required. The areas identified in this audit map directly to Vitae's researcher development framework Domains A1-A3. We offer courses and workshops on scientific writing, statistics, experimental design, and critical analysis, yet in common with the wider Higher Education sector, some of our students are not quite operating at the level expected for PGR graduates in the production and defence of their thesis in key areas. The reasons for this require exploration. Is there an issue with the students recruited to PGR programmes? Is there an issue with the content of the programmes currently offered? Are students engaging with the educational opportunities? Or is there a disconnection between the candidate's knowledge / skills and their ability to apply them to the production and defence of the thesis?

This study did not examine student educational attainment at recruitment to PGR programmes nor did it scrutinise engagement with educational training programmes, but it is something that should be considered when taking forward our findings. The quality and accessibility of provision are important drivers for student engagement, but the validity and applicability of such provision is also important to independent adult learners; the investment in time must be seen as a benefit to the PGR candidate.

Academic literacy and numeracy skills must be acquired to allow candidates to demonstrate understanding of their research and its place in the field, communicate the knowledge they have created, and become part of the academy. Development of these skills is often fraught with tension, anxiety, and frustration for the PGR candidates (Hackathorn & Ashdown, 2015; Ross, Bergin, Aitchinson, & Catterall, 2011). Examiners highlight the need to demonstrate competence in this area, and students and supervisors acknowledge the importance of developing these core skills. How this can be more effectively achieved is a key question for us, if we are to maintain and enhance quality of graduates. Previous studies of teaching academic literacy skills to undergraduate students have recognised the importance of embedding skills throughout a programme with incremental increase in difficulty to improve mastery over time (Gunn, Hearne, & Sibthorpe, 2011). There is an argument that PGR programmes do not work to the same model of curricula based education, assessment, and feedback cycles, but we can draw important lessons from this work. The authors found that students were better able to master academic literacy skills when they had repeated opportunities to apply skills in various contexts; they argue that the application of skills in different contexts allowed for deeper understanding and the ability to apply the knowledge with ease to future foreign situations.

Research looking at how such core skills are developed in doctoral programmes has largely focused on the development of academic writing skills, where students and supervisors have pinpointed the writing of the thesis as the most difficult, yet most important writing task for PGR candidature (Ross et al., 2011). When students and staff were questioned on how such skills were developed, the most common response was via supervisor feedback on written work for the thesis. Students felt that, whilst this was important, it was often ineffective, frustrating, and unstructured. Students valued feedback from supervisors, but felt such feedback lacked a framework to assist their development. Conversely, writing for publication was pinpointed by students as being a difficult but highly rewarding means of developing writing skills. This may be a consequence of perception of a framework being in place and a more succinct focus for the task at hand, but this activity was seen as the most effective way of raising writing skills above the expected threshold, which many students find themselves struggling to meet (Ross et al., 2011).

Supervisor feedback is essential in the process of academic writing; these individuals are experts in the field, familiar with the candidates work and also familiar with the standard required for the thesis – it is indeed a duty of the supervisor in the PGR process (Maatta, 2015). However, many supervisors do not feel it is their role to develop the writing skills of their students, anticipating a certain level of competence from the outset (which may be unfounded) and supervisors themselves not feeling that they can offer the pedagogical frameworks required to develop such skills in their students (Catterall, Ross, Aitchinson, & Bergin, 2011). Institutional support for PGR candidate development

varies, but reports indicate that students value opportunities to develop their skills through such means. Ross and colleagues (2011) found that doctoral students value writing workshops and writing groups with expert input and academic and peer review of written work in the development of writing skills.

Overall the PGR educational courses and workshops at the University appear to be appropriately designed, organised, and well received (based on evaluation feedback). Whilst satisfaction is noted in our feedback locally, this has not directly translated to universal operation at the appropriate level. It could be that students are compartmentalising their learning and not applying the knowledge from such sessions to their research studies. The distance in time of the learning session from the time they actually apply the learning may negate the benefits of such sessions; if students aren't taking opportunities to practice and perfect the skills learnt in their day to day research studies, and receive constructive feedback (which could be better facilitated by PGR supervisors), the benefits will be lost. Reviewing the current literacy and numeracy training programmes available, recommending increasing provision and accessibility to writing workshops and writing groups and engaging with supervisors in collaborative provision of support for development of literacy and numeracy skills across the PGR programme has the potential to enhance students experience and the quality of graduates.

Turning attention to educational interventions to improve cognitive abilities in PGR students, the literature relating to development of such skills in doctoral education is sparse. Cognitive apprenticeship theory appears to fit well with the PGR student / supervisor dynamic. Students learn through interactions with their mentor (supervisor). Purposeful discussions centre on key events (designing experiments, considering implications of results) with the mentors describing their theoretical framework for decision making and articulating their thought processes to influence the development of such skills in the mentee. A recent study looking at the effectiveness of such a model noted the variability of effectiveness in developing key cognitive research skills, and the importance of the relationship and engagement from both sides of the partnership (Maher et al., 2013). Latona and Browne (2001) highlight the supervisory relationship as being central to the success of PhD completion. This was further explored by Lindsay (2015), who highlights the characteristics of supervisory relationship in the context of timely completion. The author notes that whilst critical thinking and emancipation through continual development of the thesis are more appropriate to the development of independence and important in learning how to 'do' research, students respond to functional project management style relationships. Peer assisted learning and group discussion opportunities are valued by students, can improve skills acquisition, and provide context and comparative situations for consideration, (Stracke, 2010) thus provide a good platform for learning. Such group discussions are a standard feature of biomedical science (lab meetings), their value cannot be underestimated in PGR education. These concepts, whilst informative, do not consider the wider faculty and the role they play in the socialisation and development of skills, knowledge, and professional behaviour and identity of the candidate. Through socialisation and integration, doctoral students learn the norms of operation within the discipline and develop the skills to function within the profession. These interactions are difficult to quantify and influence in a systematic operational way, but social networks and belonging have been shown to influence performance, satisfaction, and retention (Baker & Pifer, 2011; Dunn, Hemphill, & Beaudoin, 2016; Gardner & Barnes, 2007). When we consider how we might enhance educational provision in our context, in light of our findings, there is the potential to review basic cognitive skills training and assess effectiveness and accessibility, but also consider how we might better sign post educational opportunities to our students and provide greater support for faculty socialisation.

Assessment literacy is another area we could better support for PGR candidates. Improving candidates understanding of the requirements of the PhD / MD/ MPhil and the applicability of key skills to their performance in the assessment process and to careers beyond the candidature may be helpful in promoting engagement with training and enhancing graduate quality overall. We could better sign

post the benefits of educational opportunities, e.g., completing a statistics course will enhance data analysis skills, allow better understanding of data generated and the data of others, and therefore allow selection of the correct analysis tool to demonstrate understanding/ defend choices in the thesis and a *viva voce* examination. We could also look to develop a range of sessions which students can access at various stages of training to ensure students are supported to surpass the threshold for key skills in a timely manner. Central to improving developmental opportunities is provision of better feedback on performance against standard expected for the award, so that students can better gauge their progress and remediate areas of need.

In one report a supervisory issue was highlighted, whilst not a PGR student learning need, it indicates a potential staff training need. The examiners note in their report on quality and standards, 'The thesis was not presented in a satisfactory structure and the writing up suggests the candidate had minimal supervision.' The PhD candidate in question received an outcome four (fail, with opportunity to resubmit within 12 months). The examiners concluded that 'the thesis needed substantial reworking on both intellectual and presentational grounds.' The candidate's performance at viva assuaged the examiners fears in terms of understanding, but the content and presentation of thesis was deemed as significantly below the standard required for the award and a task likely to take some time to complete. The level of supervisory oversight and feedback provided by the team in the writing of the thesis cannot be gauged in the present study, but it places review of supervisor training on the agenda as an area for attention to support enhancing student experience and graduate quality.

It is important that staff have the appropriate skills, knowledge, and access to training for the role as PGR supervisor. This will enhance the quality of the research training experience for our PGR candidates and enhance graduate quality, through provision of appropriate training and support. Good practice would indicate the follow-up of the supervisory team involved in the case to determine the circumstances, not least to ensure that the candidate has adequate support during the period allowed for revision of the thesis. Sharing of key cohort information with supervisors is also important for enhancement of quality. Making staff aware of common issues noted by examiners and areas requiring support can highlight areas for supervisor focus in candidate education.

LIMITATIONS OF THE STUDY

Whilst the study group examined was of a reasonable size (61), the candidates were studying for a variety of awards (50 PhD, 9 MD and 2 MPhil) and a variety of disciplines across biomedical and healthcare research. Whilst there was a reasonable number of study subjects included overall, there were relatively low numbers of MD and MPhil students, which may reduce the ability to make general comparisons for these groups. Likewise, when examining outcome as a measure of quality, numbers at either end of the scale (outcome 1 and outcome 4) were low. The audit did not include data on student engagement with educational opportunities; we therefore cannot draw conclusions about the effectiveness of current educational provision from this study. The audit utilised official university PGR examination documents in this retrospective study. There is a possibility that examiners may have 'held back' in their written appraisal; follow-up of examiners through interviews at the time may have yielded a more candid view. The study in no way takes into account the student voice; the experience from the candidate point of view was not represented in the documentation and therefore not considered here. Candidate feedback on process and opinion of learning needs should be sought as part of any review of training and prior to introduction of changes to educational provision.

STRENGTHS OF THE STUDY AND WIDER IMPLICATIONS

The strength of the study is the systematic analysis of complete examiners' reports for a 12 month period for all PGR students examined. No report was excluded, and therefore the data fully reflects all registered completing students for the faculty. Through review in this way and not through selection and follow up of a particular cohort up to a specific date, we have captured the breadth of performance across a time period and not just those who have submitted within the anticipated time

frame. A cohort focused approach in this instance may lose valuable data associated with performance and training needs for those who may have needed to take an interruption from their studies, and therefore would have potentially been missing from the data set. The study analysed the examiner reports for 61 PGR candidates, the cohort was relatively large, and the research was focused in one key area, biomedical research. All students were registered within a UK Medical School, and whilst the research topic was varied, more than 90% of student projects were laboratory based biomedical research focused. The cohort was of a similar size to many UK university PGR cohorts and the demographic details of students were known and reported. The examiners' reports provided a rich source of information relating to the quality of the thesis, performance at *viva voce* examination, examination outcome, and provided opportunities for examiner comment on quality and process. The provision of independent reports from two examiners for each assessment also allowed for determination of agreement of examiners on key issues identified. The study highlights learning needs for our learners, which act as a focus for our training programme locally. Candidate feedback on process and opinion of learning needs should be sought as part of any review of training and prior to introduction of changes to educational provision. The study is of interest to the wider doctoral training community as it provides evidence of the value of examiners' reports in the identification of unmet learning needs and a potential means of assessing the success of training programmes. It provides a reliable source of feedback on quality against expectations.

Which in turn gives us pause for reflection. Do our students receive the feedback they deserve at the point of need? Do they seek feedback? Are we providing opportunities for feedback? And what of the quality of the feedback received? With the PGR examination being such a 'high stakes' summative assessment, we need to provide ample formative feedback opportunities. And whilst feedback is appreciated at the examination (Kumar & Stracke, 2017), that can feel too little, too late for the failing candidate.

It also strengthens the argument for us to pay close attention to the process of doctoral education not just product. In biomedical research, our focus is often drawn to discussion on the quality of graduates, provision of researchers with key practical skills to meet the needs of industry, who have developed competency in cutting edge technology. Kemp, Newman, and Chapman (2012), argue that these key skills are developed at the bench day to day, but the process of research, development, and feedback cycles facilitate attainment of important skills and provide a means of understanding of the complexities of our world and how to better interpret findings. Similar sentiment is echoed in a more recent report examining the impact of increasing doctoral student numbers in Europe and China (Bao, Kehm, & Ma, 2018).

CONCLUSIONS

The audit of examiners' reports identified academic literacy and numeracy and cognitive abilities as the key areas were PGR candidates could improve their abilities to enhance the quality of PhD thesis presented and oral defence of their work. Consideration of the key educational literature relating to doctoral education highlighted areas of best practice for consideration. To enhance PGR educational provision we must first examine engagement of our students with current provision, examine content, validity, and accessibility of current provision in collaboration with students and their supervisors, and look to provide opportunities to embed key skills development throughout PGR programmes. We should also better educate our students of the requirements of PGR awards and expectations of examiners and sign post students as to where these key skills can and will be used in future careers. Through collaborative provision and pertinent signposting we can enhance quality through effective engagement with researcher education programmes.

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