The Wakeham Review of Science, Technology, Engineering and Mathematics (STEM) Degree Provision and Graduate Employability.

Invited submission of evidence by the Institute of Physics and Engineering in Medicine (IPEM)

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1. METHODOLOGY

This evidence was collected directly from UK academics active in teaching or research in the fields of Bioengineering, Biomedical Engineering and Clinical Engineering. It was compiled in response to a written invitation from Professor Sir William Wakeham to the UK Institute of Physics and Engineering in Medicine (IPEM), dated 20th October 2015. The request was delegated by the IPEM CEO to its Academic Advisory Group (AAG). A survey was created by the author, who is the secretary of the AAG, on 26th October after being independently verified for unbiased questioning by a higher education expert. An email invitation was then sent for anonymous completion to 80 UK academics of appropriate expertise from a total of 43 Higher Education Institutes or associated NHS Hospital Trusts, contactable through a central database maintained by the AAG. 30 responses were collected by the 9th November deadline (38% return rate). The survey, which asked for views and expertise through 10 questions, can be viewed at https://www.surveymonkey.com/r/WQTLK92.

2. THE RESPONDENTS

In this survey, 'biomedical engineering' (BME) is the adopted umbrella term for bioengineering, biomedical engineering and clinical engineering. Survey respondents had a broad teaching experience across a range of university biomedical engineering programme levels from early undergraduate years (FHEQ Level 4/5) to doctorate level (FHEQ Level 8), with the most common experience being at postgraduate masters level (Fig. 1). Respondents

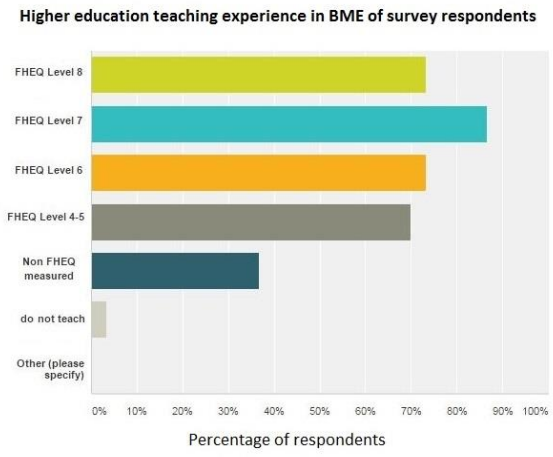

Fig. 1. Teaching profile of the 30 survey respondents

answered according to this experience across both undergraduate and postgraduate taught programmes, while some respondents offered additional experience through running CPD or one day professional body-organised meetings. The BME class sizes were reported to vary in size greatly from 10-140 students, with an average size of 45-50. Overseas (i.e. non-EU) students made up an average of 40% of class cohorts, although this varied markedly in responses (from 10%-100%).

3. GRADUATE EMPLOYMENT DATA

"We are keen to seek the IPEM's view on whether these statistics reflect concerns or trends for these disciplines that you share."

21 respondents felt confident in quantifying, as best as they could, the employment routes of their programme's graduates. Figure 2 shows a meta-analysis that averages these estimates for five employment routes. The data found that approximately one third of BME graduates go on to further study, while a further third enter either hospital or industry sectors of BME (22% industry, 12% hospitals). A final third enter other employment sectors, either staying in engineering employment (16%) or entering a non-engineering field such as teaching or finance (16%). Respondents felt less able to estimate unemployment rates in their cohorts at 6 months after graduation, but suggested 5-10% when able to estimate. This figure, while approximate, is slightly below the DLHE data value of 13.1%, but could represent a bias in academic staff being less informed of unsuccessful graduate job outcomes than they are of favourable ones. What is of note, however, is the good quality employment secure by recent graduates of BME programmes in many cases. Figure 3 lists examples of successful employment outcomes from anonymised graduates of three UK BME university programmes (Keele University, UCL and University of Strathclyde). It is noteworthy that many promising early-career jobs, or research training studentships, are won by these BME graduates at all three; success stories strongly outweigh case of graduate unemployment.

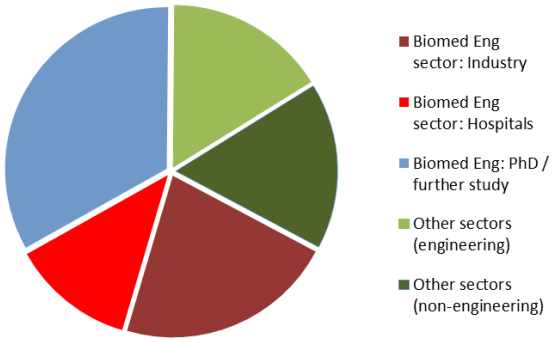

Fig. 2. BME employment destinations profiled from 21 respondents. Unemployed data not included in pie chart

Employment	University
PhD in Biomedical Engineering	Strathclyde
Regulatory Affairs Manager, large size company	Strathclyde
Senior Installation Engineer, multinational company	Strathclyde
Quality Engineer, multinational scientific company	Strathclyde
NHS Biomedical Engineer	Strathclyde
Project Manager, overseas tech company	Strathclyde
Data Scientist, UK SME	Strathclyde
R&D lead, medium size UK company	Keele
Area Manager for UK large size company	Keele
Biomedical Engineer, overseas hospital	Keele
PhD in Biomedical Engineering	Keele
Associate Lecturer, overseas university	Keele
Research Fellow, overseas university	UCL
Research Associate, UK university	UCL
Biomedical Engineer, SME	UCL
Biomedical Engineer, Multinational	UCL
NHS Biomedical Engineer	UCL
Lecturer in Medical Engineering (overseas university)	UCL
PhD in Biomedical Engineering	UCL

Fig. 3. Example careers from graduates of three UK BME programmes, showing that many obtain high quality jobs

4. GRADUATE SKILLSET ANALYSIS FOR BIOMEDICAL ENGINEERS

"It would be especially useful if you felt able to share with us any explanations that you may have for the observed statistics"

The next three figures explore student perceptions about BME and the challenges of obtaining a career as a biomedical engineer after university study. Figure 4 asked for reasons why students choose to study Biomedical Engineering, and three distinct reasons were equally reported in individual answers : one based on the theme of societal benefit, one highlighting the interdisciplinary nature of the subject (medicine and engineering) and a third representing the exciting new technologies and treatments being generated by the field. Ambitions of applicants were heavily tied to this final reason (Fig. 5.), with half of applicants for BME programmes wanting to become an innovator or worker at the forefront of the field, and over a quarter wanting to target a specific BME career, such as working for a multinational medical device manufacturer or being an NHS clinical engineer.

Figure 6 is central to this evidence submission, and asked respondents about the main challenges facing graduates in obtaining subsequent same-sector employment. Answers belonged to five broad categories, with the high level of competition stated most frequently in 11 of the 30 answers. Here, answers suggest that employment opportunities are rather limited in UK hospitals. The relatively small UK BME private sector, often formed of SMEs, also favour workers with workplace experience over new graduates, and do not typically run graduate training programmes. SMEs also prefer to recruit through contacts or agencies rather than traditional graduate methods. Table 1 on the next page outlines notable survey responses from each of the five identified challenges. Overall, BME appears to suffer from being a poorly defined degree subject, so employers struggle to characterise a BME graduate skillset against traditional engineering specialisms, where this is well known.

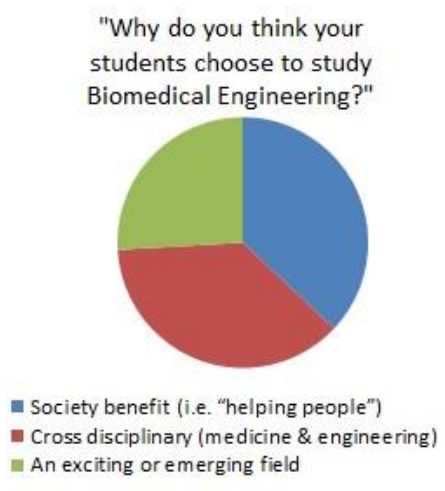

Fig. 4. Reasons given by 30 respondents for why students choose BME

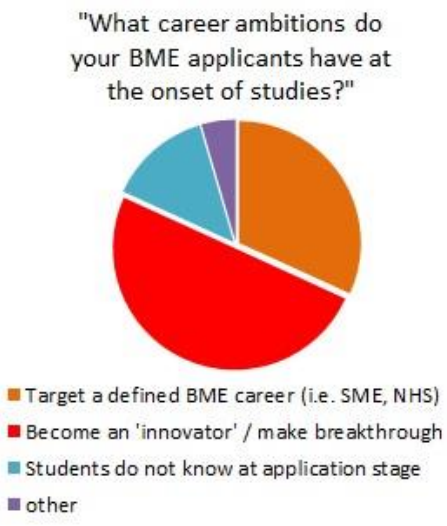

Fig. 5. Career ambitions of applicants to BME university programmes

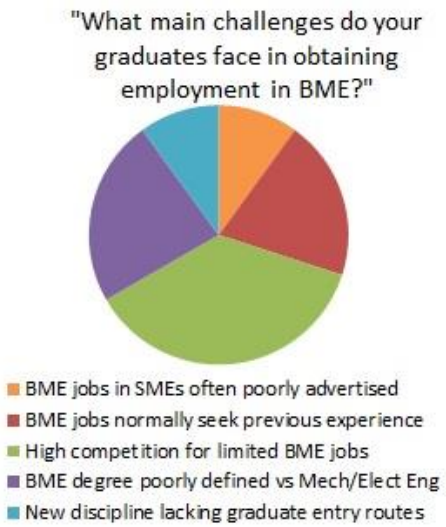

Fig. 6. Reasons why same-sector employment is difficult for BME graduates

Table 1. Selected responses to Figure 6 data giving selected answers about job challenges in BME

BME is a new discipline lacking established entry routes or training schemes for graduates
"There are not enough jobs for the number of graduates - a lack of employer training schemes"
"Proving competence to get shortlisted is hard, competing with pure Mech or Elect Engrs"
BME jobs normally seek previous relevant experience from an applicant
"Getting relevant work experience is difficult when much of the industrial base are SMEs"
"BME jobs often seek experience which graduates only get with employment: chicken & egg"
There is high competition for limited BME job opportunities in the UK
"In the NHS sector, there is huge competition for limited jobs"
"It's a small UK job market for health industry"
A BME degree is poorly defined compared to other established engineering disciplines
"The degree is poorly defined. BME graduates have no clearly dominant strength. e.g. a company manufacturing clinical equipment may prefer elect or mech expertise"
"Stiff competition from other more technical, established engineering degrees"
"Companies want specific elect/mech/software engineers not broad-skilled BME grads"
BME jobs in SMEs often advertised through atypical routes or poorly described in adverts
"Finding BME companies to employ graduates - they are commonly small and difficult to find"
"Finding biomedical engineering jobs; many times these are not advertised as such"

Table 1 gives selected respondent answers and shows an overall theme: that BME is currently quite unestablished, and therefore undefined, as a subject area. Thus, as well as employers being unfamiliar with the skillset and competences of BME graduates compared to other engineering graduates, employers also feel unfamiliar with the job description details or advertising publicity routes for BME-specialist roles. They also lack means to develop new BME recruits through job training schemes. Thus, employers tend to often recruit from those with past experience in the field, making new graduate entry even harder. This effect is exacerbated even further by the SME-heavy nature of the field, where small companies struggle for dedicated training infrastructure.

Figure 7 explores this Biomedical Engineer skillset further. Respondents were asked to rank the importance of different aspects of a generic engineer skillset, as defined by the Engineering Council UK-SPEC competencies of Chartered Engineer (CEng), on a Likert scale from 1-5 for importance in BME practice. The results are interesting, with a Biomedical Engineer being required, as might be expected, to implement engineering solutions and device development as the most important demonstrable parts in their professional skillset.

However, the five purple competencies highlighted in Figure 7 indicate more. These purple rows are the top five CEng competencies, identified through a separate survey question, where respondents feel that the BME professional skillset, as identified, is currently lacking in graduates. Note that these five shortfalls were ranked as highly important and that they heavily relate to workplace or practical skills, such as project management, engineering design and communication skills. Figure 8 outlines an additional survey question that asks the respondents to rank learning activities which are effective, in their experience, in developing workplace skills. Design-based project work, team work through scenario-based learning and opportunities to develop communication skills, through report writing or giving presentations for example, rated most effective. Thus BME programmes should adopt more 'soft' skills development approaches to better develop engineering workplace skills.

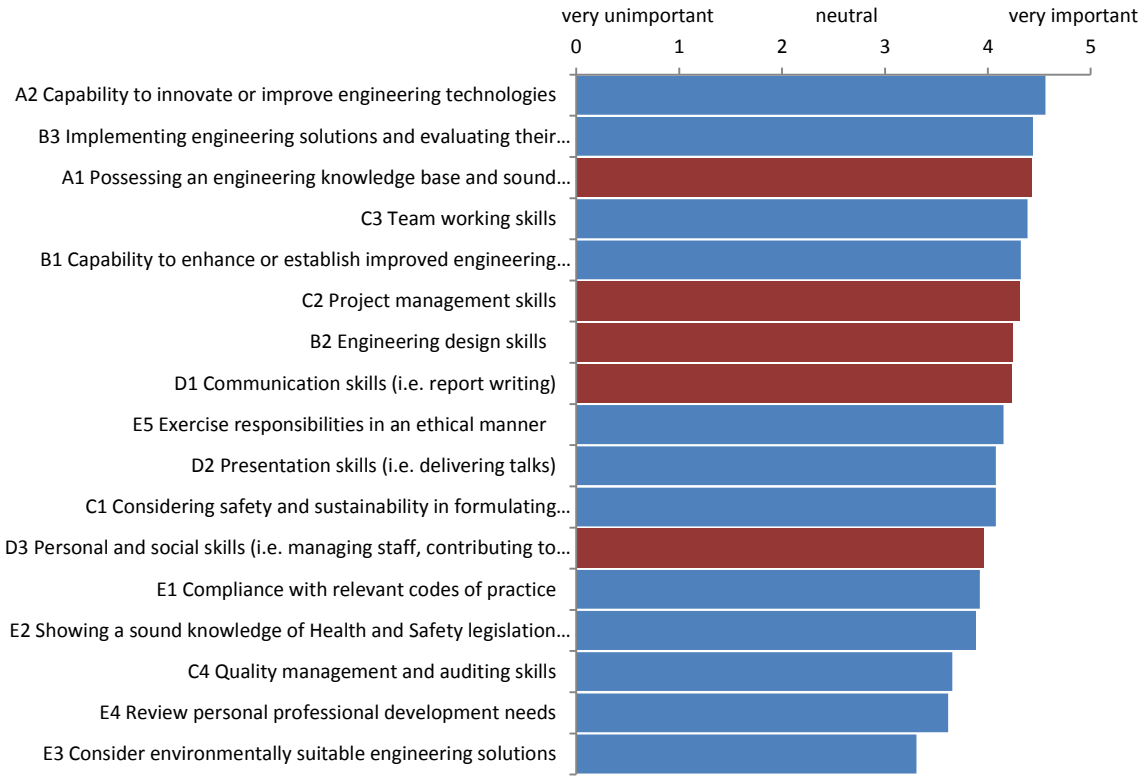

Fig 7. Respondent's ranking of importance of different engineering skills for a practicing biomedical engineer (skills defined by UK-SPEC CEng competencies A-E). Purple bars are the five considered most lacking in BME graduates

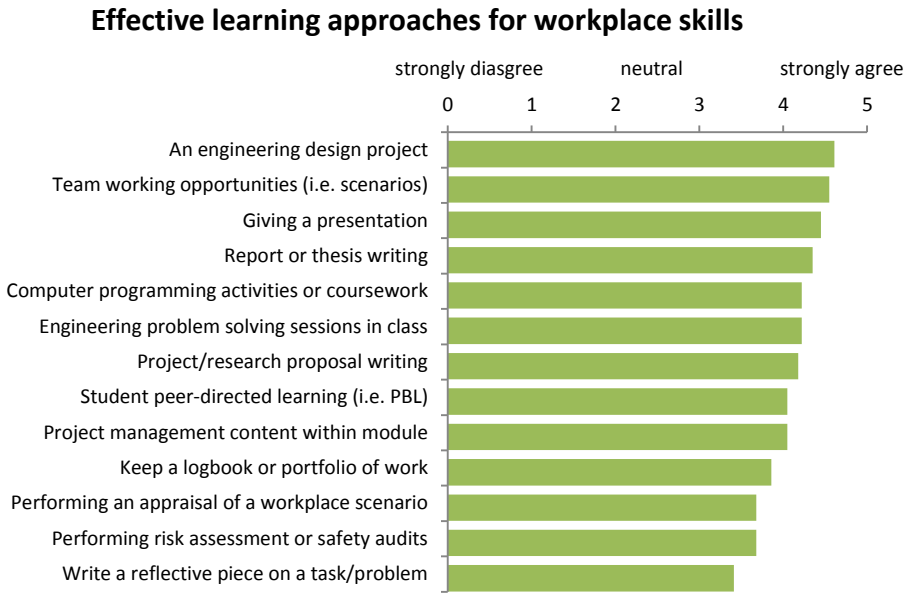

Fig 8. Respondent's ranking of the effectiveness of different learning approaches in universities that can be used to develop workplace skills useful for BME graduates in their careers

This section of the IPEM evidence outlined expert insight into the issue of employability for BME university programmes, identifying key areas of the engineering skillset where BME graduates are falling short of expectations, namely in delivery of workplace skills, and suggesting effective and contemporary teaching methods that can impart such skills into BME graduates. Many of these teaching methods are familiar to the author, who can comment at greater length if required.

5. GRADUATE EMPLOYMENT AND ACCREDITATION IN STEM

"Further detail on the review and what it is seeking to achieve can be found here: http://www.hefce.ac.uk/kess/stemreview"

This final section describes additional survey questions which addressed the wider remit of the Wakeman review. Figure 8 looks at data where respondents were asked to identify employer engagement opportunities that their BME students experience to develop new career pathway strategies and learn of the requirements of typical BME jobs. While expert lectures from industry speakers were common, as was site visits to industrial or hospital settings, it was noted that relatively simple careers advice approaches, like adopting a local department careers champion or the incorporation simple career insight content into the curriculum, were rarely used. Such techniques, particularly the incorporation of careers content directly into taught module content, have been used successfully by the author on his UCL campus and distance learning programmes.

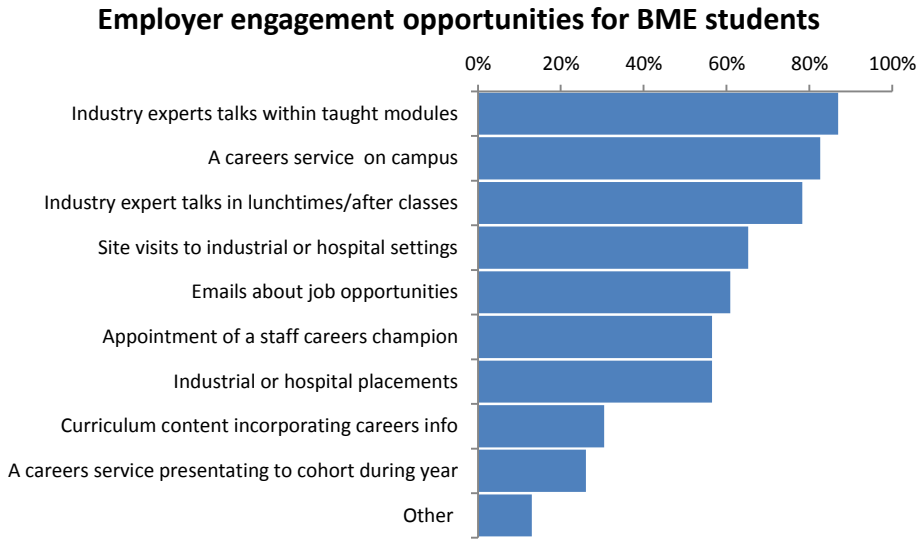

Fig 8. Respondent's ranking of the effectiveness of different strategies to inform BME students of career options

The final matter addressed in the survey was the subject of course accreditation for BME subjects, which was asked through three survey questions. Firstly, it was noted that no professional body was dominant in the sector, with four professional bodies offering similar accreditation assessments (Fig. 9). The main reason for a university seeking accreditation of a BME programme was as a quality assurance 'kitemark' of quality for the course, with a second major reason being to meet student demand or expectation for their course to be accredited (Fig. 10.). Lastly, a poor response was found when asking respondents about the value of Chartered Engineering (CEng) status, with half of respondents unsure as to its worth. This was perhaps surprising as many BME jobs are based in small, medium or large (international) companies where CEng status can be a valuable career step to securing promotion and securing independent/principal engineer roles within the private sector.

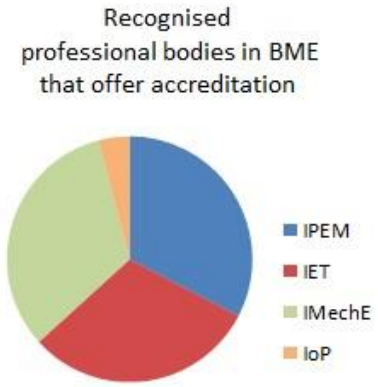

Fig. 9. Choice of BME degree accreditation bodies in the UK

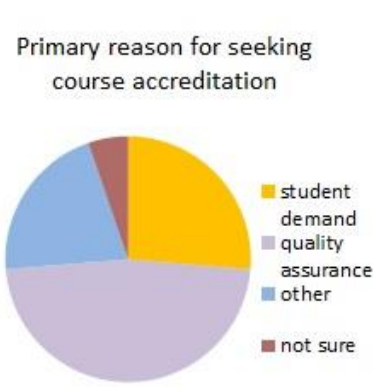

Fig. 10. Reasons given by 19 respondents for seeking accreditation of their BME degrees

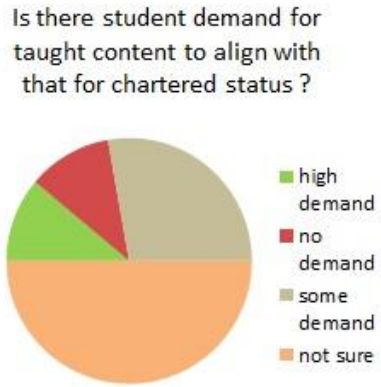

Fig. 11. Perceived student demand for Chartered status, or working towards this after further postgrad work experience.

ABOUT IPEM

IPEM is the Learned Society and professional organisation for physicists, clinical and biomedical engineers and technologists working in medicine and biology aiming to advance physics and engineering applied to medicine and biology for the public good. Physicists, engineers and technologists play vital roles in delivering our healthcare and IPEM is the professional organisation that represents this workforce.

IPEM
Institute of Physics and Engineering in Medicine

Its members help to ensure that patients are correctly diagnosed and safely treated for illnesses such as cancer and stroke. They also maintain and manage medical equipment such as MRI and ultrasound scanners, X-ray machines, drug delivery systems and patient monitors. Their research and innovation leads to new technologies and methods that advance medical treatments. IPEM is also a charity with around 4,000 members from healthcare, academia and industry.

More can be found at www.ipem.ac.uk.

ABOUT THE AUTHOR

Dr Jamie Harle has worked for nine years as an academic at The Open University, The University of Liverpool and University College London, delivering and developing a range of innovative educational programmes in physics and engineering applied to medicine to UK and overseas students. Prior to that he completed research and training in the NHS. He is Graduate tutor in the UCL Department of Medical Physics and Biomedical Engineering and was the recipient of the UCL Provost's Award for Leadership and Impact in Teaching in 2015, as well as winning the University of London CDE Teaching and Research Award in 2014.