Title

helping first-year undergraduateConnecting students with researchers, research and each other to help their transition from school to university

Authors

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Abstract

Undergraduate research increasingly features in university mathematics degrees. Despite this, research papers are used infrequently in mathematics teaching, and this is especially the case for first-year undergraduates. Mathematical subjects are more likely than other STEM disciplines to pinpoint cognitive difficulty as the principal reason for not exposing undergraduate students to research papers. In this paper we test whether first-year students can engage effectively with research papers. We describe an intervention that exposes first-year, first term undergraduate students to current research in probability and statistics by asking them to read a research paper and summarise it for a general readership following an interview with the paper's author. Our findings show that the activity introduced students to new fields of knowledge and helped to develop a clearer understanding of scientific process, leading to a heightened sense of personal satisfaction at engaging closely with current research. We argue that structured reading of research papers can lead to productive and rewarding engagement with difficult content, recent and current research, and with research processes, and that this should make us reconsider the role of research papers in the undergraduate mathematics curriculum.

Keywords

Undergraduate education, research papers, Statistics and Probability, staff-student interviews, group work,

1. Introduction(O'Connor, 2017)(Russell, Hancock and McCullough, 2007)(Diamantopoulos, Dorff and Richardson, 2014; Gallian, 2012)first-year undergraduate , and that this is true for new and recent papers just as much as for older onesthemand recent . This is achieved by integrating staff for students to read and summarise. This exposes as well as helping to c, ing

(Wenk and Tronsky, 2011)disciplines outside of the al sciences(Coil*, et al.*, 2010; Lacum*, et al.*, 2012; Letchford, Corradi and Day, 2017; Lie*, et al.*, 2016; Murray, 2014)(Canziani, 2016; Jelsness-Jørgensen, 2015; McDonough, 2012)(Corradi, 2012)(Lacum, Ossevoort and Goedhart, 2014; Lacum*, et al.*, 2012)(Coil*, et al.*, 2010; Goldey*, et al.*, 2012; Gottesman and Hoskins, 2013; Kulkarni and Vartak, 2019; Letchford*, et al.*, 2017; Weigel, 2014; Wenk and Tronsky, 2011)By way of contrast, 'Even in the highest-level mathematics courses at undergraduate institutions, most students do not read mathematical research from professional journals' (Dietz, 2009). In spite of this, a m(Brown, 1976)(Brown, 1976; Dietz, 2009; Fisher, 2006; O'Brien, 2005; Rabin and Nutter-Upham, 2010; Rash, 2005)(Beck, 2018)(Brown, 1976; Fisher, 2006; O'Brien, 2005)(O'Brien, 2005)(Fisher, 2006)(Rabin and Nutter-Upham, 2010)(Brown, 1976)(Brown, 1976)in a (Dietz, 2009)(Brown, 1976; Rash, 2005)s

To this end, w

However, a(Cosgrove, 1981; Dietz, 2009; Dwyer, 2001; Leone and Morgan, 2000)To demonstrate this,*1.1 Overview*

An increasing emphasis is now placed on research-based education for undergraduate students at universities (O'Connor, 2017), and embedding research within university curricula is now commonplace in many subject areas. In mathematics this change to education has been slower than in other scientific disciplines (Russell *et al.*, 2007), though undergraduate research is increasingly found as part of university degrees (Gallian, 2012; Diamantopoulos, 2014). Much of the research activity is based on summer projects or other similar activities where students are engaged directly with research. For large cohorts of students, this is difficult to implement.

More practical, perhaps, is the possibility of introducing undergraduate students to research by exposing them to current scientific papers. This is routine in some disciplines, including in the sciences, but we know of few examples where this happens in mathematics: anecdotally, the perception is that mathematics undergraduates do not possess sufficient breadth or depth of knowledge to interact with current research papers.

In this paper we describe an intervention involving first year undergraduate students in the mathematical sciences, which exposes the students to current research in probability and statistics.

1.2 Students engaging with research papers

Exposing students to research papers is of course desirable. In the biological sciences, for example, schemes to engage students with research papers have been reported to improve students' critical thinking and confidence in analysing literature (Hoskins *et al.*, 2011; Downie, 2010). Undergraduate journal clubs have been a successful and convenient way of implementing this (Sandefur and Gordy, 2016). These, however, are often voluntary; not all students therefore benefit.

Students will naturally find reading academic papers difficult. It has been suggested, however, that students engage more effectively with papers if they can interact with the researcher directly, which also has the additional benefit of enabling students to better understand the research process and to "humanize" the science (Hoskins *et al.*, 2011). This was first discussed by Cosgrove and his observations with a group of geography undergraduates (Cosgrove, 1981). Subsequent work showed that the activity 'enables students to better understand their lecturers as individuals, to explore how university research is undertaken, and to appreciate how research and teaching may be linked together' (Dwyer, 2001, p.359). These studies agree that the activity helps students learn.

1.3 The present research

We present an activity - 'Meet the Researcher' – which is designed to engage undergraduates in learning about research practices and processes by interviewing researchers about their work. (Note that we use 'professor' and 'researcher' interchangeably, for the sake of variation, even though only a small proportion of researchers in UK universities actually hold the title of Professor, and not all professors are researchers). Anecdotal evidence suggests that similar activities, which often go under different names, are quite widespread.

The activity is embedded in an introductory module in Probability and Statistics at the Department of Statistical Science at University College London (UCL). We present student perception of, and reaction to, 'Meet the Researcher', and make recommendations about how the activity might be used to promote better learning in Statistical Science and related disciplines.

1.4 Structure of paper

The paper is structured as follows. In section 2, the novel use of research in assessment will be described. Section 3 discusses student reaction to the task, before we conclude in Sections 4 and 5.

2. The 'Meet the Researcher' activity

The 'Meet the Researcher' activity has been part of an undergraduate course in probability and statistics at UCL since 2014. The module runs in the Autumn term in each academic year and at the time of writing is taken by between 220 and 250 first year students drawn from eight different degree programmes. an A complete list of all 37 research papers used in the activity in 2016-17 is given at the end of this article.theyThe activity forms part of the assessment for the module, counting for 10% of the overall mark which is roughly 1% of the mark for the year.

The activity is run as a group project. Students are allocated into groups of around six by the course convenor, and are not permitted to choose their own group. Each group is assigned a research paper (a different paper is given to each group) written at least in part by a current member of staff. In any given year, between 21 and 30 members of staff from the Department of Statistical Science contribute research papers.

Each group must write a one-page summary of their allocated paper within their group, that is, each group submits one summary. To help with the task, each group is permitted to interview the staff member associated with the paper for up to one hour, during which it is hoped students gain not only better understanding of the paper but also of the nature of the research process in the mathematical sciences.

Students are given approximately six weeks to complete the task. When the activity is set the students are given some specific guidance about how to approach it. The module leader devotes half a lecture (approximately half an hour) to explaining the general idea. He gives the students an exemplar one-page summary, based on a research paper that they are directed to read before the lecture and which they have discussed in an earlier lecture, and explains the process by which he extracted relevant information from the paper to include in the summary.

The following steps are suggested as an approach to the students:

- Week 1: a preliminary group meeting to review the task, and agree a time with the researcher;
- Weeks 1-2: read the research paper;
- Weeks 2-3: second group meeting to discuss the paper;
- Week 4 or 5: meet the researcher;
- Week 6: final group meeting to finalise and submit the report, a single-page co-authored summary of the research paper for which all group members receive the same mark. A template is provided for the students to write their summary.

The activity has ambitious aims to develop skills appropriate to the discipline, and to give students a taste of where their studies could lead them. Part of the remit of the course in which the activity takes place is to motivate the use of probability and statistics by exposing the students to real statistical investigations. The activity is an extension of this in which the students get more closely involved in an application of statistics than they can in a lecture. Giving students published research provides a link between the relatively simple ideas and methodologies that students learn in class, and modern statistical methods.

The form of the assessment means that students need to work effectively in groups and to use skills of comprehension to gain a general understanding of work well beyond their current knowledge. They also need to consider how best to use their time with the researcher, asking questions to help them to write their short summary. Asking the students to write such a short (1 page) summary is deliberate: this forces them to use their

judgement to make tough decision about what to include. Even then they need to write very concisely and in a manner that is clear and non-technical enough to be understandable to a layperson.

This paper considers student reaction to the 'Meet the Researcher' activity. All data come from one cohort who took part in the activity in the Autumn term of 2016, when 219 students were registered for the course.

3. **Student reaction**ere(Fung, 2017)

3.1 Gathering information from students

A single question was presented to students to gather their opinions and experience of the "Meet the Researcher" task. The question was posed to students on the institutional Virtual Learning Environment (VLE) immediately before they submitted their reports to the VLE. Though only one report per group was required, all group members needed to submit thereby ensuring that all students were given the opportunity to respond.

The question was open ended, and students were provided a text box in which to write their thoughts.

> 'Say you are meeting up with a friend following the 'Meet the Researcher' activity. What would you tell them about it? Feel free to mention anything at all, for example what you learned, what you enjoyed or didn't enjoy, what was easy or hard, or anything else'.

Though answering the question was optional, 213 students offered a response from a cohort of 219 students.

The resulting responses were coded, focussing in particular on mentions of learning and the different ways students reported learning. To preserve anonymity, each student who responded was allocated an ID number using the format Sx, where x ranges from 1 to 213 (the number of responses). We discuss three aspects of the students' responses using snippets of the students' responses: what students said they learned, the different learning

they experienced with their peers versus with researchers, and the value they placed on difficulty of material for learning.

3.2 *What students said they learned*

Of the 213 who students answered our question, 136 specifically mentioned learning in their reply. (Dietz, 2009)(O'Brien, 2005)We identified different kinds of learning in the students' response: knowledge (broadly defined as what they know, most commonly facts and theories), skills (how that knowledge can be applied, and other practical competencies), and attributes (their mindset and whole way of thinking).

The students' response to the activity was overwhelmingly positive, which is in line with findings from elsewhere that the majority of students found the use of research papers in their courses to be effective (Dietz, 2009; Fisher, 2006; O'Brien, 2005). Of those students who reported learning, 73% (n=99) reported acquiring new knowledge about the subject, 27% (n=37) reported developing new skills, and 9% (n=12) said they had gained insight into attributes that are appropriate to research. It's interesting to note that most students who reported learning, 83% (n=113) said they learned <u>either</u> knowledge, <u>or</u> skills, <u>or</u> attributes. The largest subset (n=82) consisted of those students who reported learning solely in terms of acquiring knowledge, for example:

> 'During the face to face talk I could feel [Dr F's] enthusiasm about the statistics and his deep insight into statistical theories such as Bayesian framework. He explained his idea ... in a understandable way and list a number of examples which are really helpful'. (S145)

Of those reporting learning, 28% (n=37) reported skills acquisition, and 20% (n=22) reported learning solely in terms of acquiring new skills. These skills tended to be so-called 'soft skills' such as team-work, communication, and writing. Here's a selection of what students had to say:

> 'This activity does help to improve my team work ability'. (S65)

> ‘Having completed the 'Meet your Professor' activity, I developed new skills in communication, for example, writing formal emails and asking concise questions to gain effective answering’. (S76)

Of those who reported learning, only a small number made reference to learning research-appropriate attributes through the exercise, or reporting a change in awareness about the discipline (8%, n=13). Most students were vague on this count, saying they had managed to get a glimpse or insight, for example ‘into how actual statistical science is done and presented’, but some were more specific:

> ‘[The project] enabled me not only to gain a deeper understanding of statistics, but also the importance of coherence and communication ability in conveying the statistical information to suitable audience, in this case, somebody with a very basic knowledge’. (S4)

Much smaller numbers of students reported acquiring both knowledge and skills (n=14). In eight of these cases we observed a relationship, most commonly with knowledge being learned as a result of skills acquired by working through the task:

> ‘I have learn [sic] the team working skills when faced with hard questions and we share our knowledge to solve the hard questions’. (S12)

In the other six cases there was no clear relationship between acquiring new knowledge and learning new skills:

> ‘It was a challenging task but I found it enjoyable as I learnt about some statistical models and also how to summarise reports’. (S202)

3.2 Different learning with professors and peers

Of the 136 students who reported that they had learned something, nearly half (n=63) identified the researcher as the source of their learning. A similar number (n=51) also

reported that their peers were a source of learning. But the similarities hide an important difference. Most student reports of learning from the researcher identified dialogue as the means of learning, whereas collaboration tended to be how they learned from their peers. Group work may, of course, include verbal interactions, but only five students specifically mentioned that talking with their peers helped them to learn. This is how some students reported the relationship between talking to the researcher, and acquiring knowledge:

> 'I got many useful advice from our Professor. For instance, after the first-time read of the essay, I did not get the ideas about the main point of the article. Our Professor suggested us to focus more on the statistical models and the results corresponding to them instead of the mathematical methods. This allowed us to understand the article much easier.' (S137)

Many students said that learning had come about when the group put questions to the professor to gain the relevant knowledge:

> 'The professor was really good to us. He answered all the questions and explained every detail. I have almost understood his paper'. (S135)

> 'As the article is quite a challenge for us right now, we were still a little confused with some questions before meeting the professor. However, I have found that it is really useful for us to meet the professor. During the meeting, the professor has solved the questions we prepared. And also, we have known the aim of this paper much more deeply'. (S140)

These quotes suggest that the learning that took place came about when the groups established shared understandings and identified their learning needs, which then made the professor's explanations relevant and meaningful. Although a majority of students said they viewed the professor as a source of knowledge, the nature of the interview meant that they were placed in a much more active relationship to knowledge than in a traditional lecture format.

Perhaps not surprisingly, students approaching an expert with questions about things they didn't understand said that a friendly disposition helped their learning. Each one of the 15 students who mentioned the professor's attitude said it had helped them acquire knowledge, while none reported that it helped them learn about skills, or attributes. Patience was a theme that came up many times. One student describes a fruitful meeting with the professor that seems to owe as much to the professor's attitude as to their expertise:

> 'We wrote a list of questions (almost 35 questions) before we met the professor. He was such a kind guy that he answered all of the questions patiently. In our paper, there was a lot of mathematics things we can't understand, he tried to explain it using simplest knowledge. He was humorous as well, so we felt quite free in the meeting. We got a lot from this meeting, after this, we can soon understand the paper and begin our summary work'. (S105)

If a large proportion of students thought that dialogue with the researcher helped them acquire knowledge, a much smaller group (n=9) thought that they learned through dialogue with peers. Two students said dialogue helped them acquire knowledge, and some reported that dialogue with peers helped them learn both knowledge and skills:

> 'I enjoyed the process of discussing and struggling for the summary and working hard together with the whole team. […] It is easy to express your ideas, but it is quite hard for summarizing the ideas of the whole group. Anyway, it is really a good experience in term one [of the first year]'. (S142)

> '[…] everyone was active and shared the ideas with each other […] Overall, I learned a lot from this activity, not only the theoretical knowledge, but also how to well cooperate and communicate with others'. (S114)

Given the context and aims of the task - for groups of first year students from different disciplines to produce a summary of a research paper for a general readership, and to enlist the researcher's help when faced with difficult questions – it's hardly surprising that they

didn't learn from each other in the same way they did from the researcher. Even so, it is noticeable that expressions such as 'exchanging our ideas' and 'discuss the paper … and shared the ideas' are scarce when students describe working with each other. More common are comments in which students refer to dialogue in a more general sense:

> 'the meeting went well and […] my team covered any confusions related to the research paper very well, since we had already had a decent understanding of the paper. I enjoyed learning new statistical approaches, which we may learn later in the course'. (S10)

Also common is when students reported that learning happens not through dialogue, but through successfully negotiating the group dynamic. This is cited a number of times (n=12) as a way to acquire new skills:

> 'During the activity, I have learnt … how to work as a team. I feel so lucky ... because every member in the team is reliable and always willing to help each other. We had group meetings to do the draft together and discussions among each other to make the report better'. (S131)

> 'The first difficulty we encountered was the group aspect, but this was easily overcome once we got dialogues going out of group meeting and it was beneficial for us to learn how to articulate and express ourselves when it comes to statistics and scientific papers. This was definitely testing especially with the group authorship issues but I felt we dealt it well because we all got along'. (S193)

One student shows how difficult learning prompted better group dynamics in order to finish the task, and to spark a stronger relationship with the subject as a whole:

> 'I will say it is not an easy task as the paper is too technical, full of unfamiliar concepts. At the beginning, it seems that everyone in the team was busy doing their own things, which made me very anxious. However, harder things will strech [sic]

you further. We finally worked together and finished the task and I developed a stronger [sic] interest in statistics'. (S14)

The comment that 'harder things will stretch you further' is important. This student evidently found the task, the paper's content, and the group context to be 'hard'. This raises a key question - what's the value of difficulty, for learning.

3.3 The value of difficulty for learning

One of most common responses to 'Meet the Researcher' activities from staff is that published research is too difficult for students to understand. Our findings suggest that on the contrary, difficult content serves to promote learning. Just over a third of respondents mentioned difficulties of some kind. The most frequent comments were in relation to the statistical and mathematical content of the paper and what the professor said in the interview (20%, n=42), and also in relation to the task requirements (8%, n=17), and the experience of working in a group (8%, n=17).

The content of the research paper and what the professor said in the interview was most commonly conceived as 'hard' or 'difficult'. The gap between the students' current knowledge and the paper's content is deliberately large. The activity guidelines make reference to this: 'Let's be honest: you will probably not understand many of the more technical aspects of the paper, especially on first reading …'. Students tended to see this as a positive thing:

> 'It was an enjoyable process to understand a research paper that is beyond my current statistical knowledge'. (S4)

In fact, evidence of a positive link between difficult content and student learning is overwhelming. Two-thirds (68%, n=29) of those who said they found the content difficult also reported learning. Of these 29 students, 25 said they had acquired new knowledge. Many found that the interview helped bridge this gap:

> ‘It was good to be able to ask questions and have a simplified explanation of the formulas that were difficult to understand. The experience definitely clarified the report and made spotting errors in our summary easier’. (S70)

Many comments about difficult content said that students benefited from working in groups:

> ‘[The paper’s difficulty] only made the feeling of success after understanding it with the help of my group even greater’. (S207)

> ‘I have learned the team working skills when face hard questions and we share our knowledge to solve the hard questions’. (S12)

Some recognised that the process brought benefits despite the content’s difficulty:

> ‘I've learnt how to communicate with group mates better. I didn't really enjoy reading the paper we got because it's so complicated and long ... It was a good experience nevertheless’. (S86)

Some simply thought the knowledge gap between themselves and the professor proved too large for the task, and one student thought the professor didn’t manage to explain the paper in terms the students could understand or use in their summary:

> ‘It was an interesting experience to talk to such an intelligent person, however, the difference of the knowledge between us and the prof was too big to understand too much’. (S29)

Some students were also disturbed by the *perception* that others had an easier paper. This is unavoidable given that each group received a different paper, and the students picked up on this.

> ‘I thought our paper was a lot more difficult to summarise than the paper that the other groups had to summarise, which I felt was a bit unfair’. (S195)

Students used a wider range of language to volunteer information about how they found the task difficult: 'hard' and 'difficult' were prominent but so was 'challenge', indicating perhaps that they saw it as something to be overcome. We observed a near-perfect relationship between how students perceived the task to be difficult and what they reported about learning: of the seventeen students who said they found the task difficult, sixteen said they learned either knowledge (n=8) or skills (n=11) or both. Some students used the group work context to help approach the difficult task as a challenge.

> 'What was most difficult was attempting to describe statistical ideas in layman terms but I feel this is a challenge my group was able to successfully overcome'. (S115)

The guidelines for the activity had ended by saying that 'writing such a short report is a very difficult task'. A large proportion of students commenting on the task's difficulty focused on precisely this issue:

> '[…] The hardest part of the task was deciding which parts to leave out of the summary as a large paper had to be condensed into one page'. (S75)

> 'It helped us to learn to pick out key information to include in the short report'. (S79)

> 'The hardest part may be that we have different opinions about which part is more important, especially for writing a summary'. (S104)

Despite a high proportion of students not having English as their first language (the course convenor estimates this to be around 40%) only one said this was a problem.

As with all assessed work at the university, the summaries were second marked by another member of staff and a sample were reviewed by an examiner from another university to ensure the marks and feedback were consistent with other modules, and comparable with other universities.

> ‘If you ask about the hard part for me, I think is the pages of the article is too long for me to read it due to my poor English, so it takes me long time to read it. However it is a quite improvement after reading it’. (S119)

The difficulties of group work offer more complex picture in relation to student learning. As noted above (3.2.3), 51 students from the total cohort – both those who reported learning, and those who didn’t - reported that the group work environment had helped them learn, either specifically through dialogue or through collaboration more generally. Of these students, 17 of these students reported finding the group work environment difficult. There’s no doubt that working in groups made the task more palatable for some:

> ‘I felt intimidated about the idea of interviewing the professor, but when you're working with group it makes it much easier’. (S183)

More specifically, there’s evidence of a relationship between finding group work difficult and developing skills in a group work setting. We have already noted the relationship between the group work context and developing skills (Section 3.2.3), and some of the students whose comments we cited earlier do specifically report learning in relation to the difficulties of group work (S14, S193). S79 was more explicit than most, however:

> ‘It was challenging to coordinate the group and everyone had different opinions, but that too [was] an opportunity to develop skills’. (S79)

Students also reported a range of unresolved problems with groups. The most commonly reported issue was to do with sharing responsibilities. The activity was done in groups and each group received a single mark for their report. As one would expect this led to some grumbles about whether each member was pulling their weight, but among the entire cohort of 213 respondents these complaints were few (n=6). A small number of students (n=3) said the assignment would be better if it was an individual piece of work.

The groups were randomly allocated and students weren't allowed to change, and two students specifically endorsed the module leader's decision in this regard, making reference to befriending other students.

It's not surprising to find that in a large group drawn from different degree programmes a number of students found the logistics difficult.

> 'However working in a group was particularly difficult when individuals weren't as willing to participate and work together. With conflicting timetables and sports commitments etc. it was very difficult to find time to work together on the project'. (S167)

4. Discussion: does 'Meet the Researcher' help students learn?

We have shown that setting students the task of working together to interpret research papers and interview researchers helps students to learn advanced statistical methods and improve their teamwork and written communication skills. It affords students an insight into the university as a research environment and helps the transition from school to higher education and to working with each other and learning with researchers.

,three(O'Brien, 2005)(Dwyer, 2001)(Dietz, 2009)(Cosgrove, 1981; Dwyer, 2001)(Brown, 1976; Dietz, 2009)(O'Brien, 2005)(Gallian, 2012)While many students report acquiring knowledge as an outcome of engaging in the activity, their exposure to research processes as they learn about the research content is arguably more valuable than subject knowledge per se. Our study reveals that many students recognise the utility of core academic competencies such as critical reading, identifying learning questions, and writing a summary. In many cases this is because the students understand the task requirements and recognise the value of behaviours that help them achieve the task objectives. The module leader's design of a task with a clear objective, and his provision of adequate resources to meet it (in the form of a group work setting and an opportunity to interview a researcher) go a long way to fulfil Dwyer's call for careful scaffolding to promote skills development and an understanding of how researchers in a discipline do their work (Dwyer, 2001).

Special notice should be taken of the extent to which students report that the task helped them develop writing and language skills. This is particularly important in the mathematical sciences, where undergraduates are generally not given many opportunities to develop their literacy skills. Demand for support in writing tends to be very high in UK universities; increasing student numbers and an increasing percentage of EFL students means that demand is growing at a time when traditional models of support such as the personal tutor system are under more strain. 'Meet the Researcher' activities, especially when focused on a writing task, can help embed literacy-based skills development in an authentic, relevant and engaging learning context.

Our evidence also shows that difficult learning, when carefully structured through the interrelationship of a writing task, demanding statistical content, and a group work environment, all help to promote interest and engagement. The evidence about what students learn in terms of statistical knowledge counters objections that first-year undergraduate students are not able to engage with research-level publications. In fact, a short unpublished comparison and analysis of six different 'Meet the Researcher' activities, including the one discussed here, shows that engaging with peer-reviewed published research can form the basis of a rich learning design; students move from simple to complex modes of learning as they go through different cycles of interaction with peers and with their professor (Grindle *et al.*, 2019). This supports findings elsewhere that the students found the most difficult aspect of the coursework to be the most interesting (Downie, 2010). In short, engaging with published research can provide the foundations of a robust and very productive learning design (Laurillard, 2013).

While other authors have found that the difficulties of group work are a key issue for students (Dwyer, 2001), these are not borne out by the present study. Indeed, the majority of students were positive about their experience of group work. Our findings show that students are sensitive to the effect of good team work, as well as its absence, whether the cause was intentional (a colleague not pulling their weight) or not (a timetable clash).

We think that such positivity about group work arises from two sources. On one hand, students see that the task's intellectual scope is too great for a single individual, and that they need to work together to understand the paper, quiz the researcher, and write a summary of the paper's main points. On the other hand, they see that the task's practical scope is modest enough for them to complete it in the allotted time, if they work together, and this gives them enough slack to make the group work enjoyable.

Finally, we haven't looked at the marks our students received for their work, and so we aren't able to support or contradict remarks by Dwyer (2001) and Cosgrove (1981) that variation in experience threatens students' chances of doing well(Cosgrove, 1981; Dwyer, 2001). Given that each group of students received a different research paper, and therefore interviewed a different member of staff, it is inevitable that student experience of the activity will vary from group to group. While in some ways this is unfortunate, it is not practical to do otherwise with such a large cohort. This idea of variation in experience was reported by students in different terms. Sometimes their experience was real (e.g. professor pitched it too high, paper was too hard), and sometimes it was perceived (paper was ok but some groups had easier work). In the present case it seems that the limits set on meeting the researcher (a one-hour interview, and no subsequent contact), an emphasis on summarising only the main points of the research, and a template for the summary, meant that the risk that variations in experience would translate into variations in the quality of student work was minimised.

5. Concluding remarks

(Dwyer, 2001)For many students, especially those in the mathematical sciences, understanding what research is, and the process of research, remains a mystery throughout their degree course. It is hoped that 'Meet the Researcher' motivates students by showing how their current knowledge is the basis for advanced topics, or perhaps to showcase areas of research that are outside the scope of an undergraduate course. Such activities, when well conducted, helps to 'lift the veil' of research and demystify the research environment (Fung, 2017; Evans *et al*., 2018).

However, research-based activities will only have a lasting impact if they are embedded, perhaps in different forms, throughout the course of a degree programme. As students progress through their studies, they may have different questions and wish to explore different topics; the activity could become more bespoke as these interests emerge. Many have found that such strategies improve engagement with core course material, as well as increasing the number of undergraduate students in the mathematical sciences who go on to further study (Gallian, 2012).

Consideration should be given to the ways that 'Meet the Researcher' can be used to develop skills in a setting that is authentic to the discipline and relevant for the students, in keeping with Cosgrove's observation that the activity can be adapted and serve as model for other subjects and settings (Cosgrove, 1981). It remains to be seen how the activity could be adapted to better promote skill development. One option is that skills development could be promoted through the content of the activity as well as through the task and the context. For example, could students learn writing skills by interviewing the researcher about how they wrote the paper? Another option is that repeating the activity over subsequent years would help students refine key abilities (such as summarising a text) that they have first developed here.

Objections may be raised that students acquiring knowledge from staff in this way may be enjoyable for the students but at best is little more than an expensive way to transmit information. Our evidence suggests that on the contrary, the task puts the students in an active learning relationship to the content, and to the researcher as the content author: they are not passive recipients of someone else's ideas. This is particularly clear in the early stage of the task, where many students reported they were able to discuss the paper with their peers and come to the interview with a good sense of what questions to ask to help them understand the paper and write the summary. A possible variation of this activity involves using PhD students rather than academic staff as the 'Researcher'. While this may have logistical advantages, and perhaps alleviate student anxiety about interviewing members of staff, other authors have found that undergraduate students get less out of the process (Downie, 2010).

We infer from the students' comments that international students as well as UK students felt that the activity helped them build a more rounded and personalised sense of the university environment. The cohort under consideration contained a large proportion of students whose first language is not English. Of interest in future would be whether activities such as 'Meet your Researcher', held early in their university careers, held any particular value for them in terms of integration, negotiating the norms of Anglophone culture, as well as language skills.

In all, the 'Meet your Researcher' activity reported here has been a resounding success and has positively contributed to student learning and engagement. It is undeniable that the task itself requires more staff input than a typical undergraduate lecture course, for both the course convenor and those contributing academic papers for students to read. However, the overwhelming positivity of students toward the task, and indeed the enjoyment that the researchers report in discussing their paper with students (which we don't discuss here), shows that setting such an ambitious task is feasible. We hope that this serves as a proof of principle for a wide-ranging set of initiatives combining research and education in the mathematical sciences.

Author biographies

Nick Grindle is Senior Teaching Fellow in the UCL Arena Centre for Research-based Education. He has taught at UCL, Imperial College, the Open University, Birkbeck, and Oxford Brookes University. He is investigating how 'Meet the Researcher' activities can be adapted to help students develop better feedback literacy.

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Paul Northrop is Associate Professor in the Department of Statistical Science at University College London. He was awarded a PhD in Statistics from UCL in 1996 for a thesis on the spatial-temporal modelling of rainfall processes and extended this work as a Natural

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