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Relationships, variety & synergy: the vital ingredients for scholarship in engineering education? A case study

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This paper begins with the argument that within modern-day society, engineering has shifted from being the scientific and technical mainstay of industrial, and more recently digital change to become the most vital driver of future advancement. In order to meet the inevitable challenges resulting from this role, the nature of engineering education is constantly evolving and as such engineering education has to change. The paper argues that what is needed is a fresh approach to engineering education – one that is sufficiently flexible so as to capture the fast-changing needs of engineering education as a discipline, whilst being pedagogically suitable for use with a range of engineering epistemologies. It provides an overview of a case study in which a new approach to engineering education has been developed and evaluated. The approach, which is based on the concept of scholarship, is described in detail. This is followed by a discussion of how the approach has been put into practice and evaluated. The paper concludes by arguing that within today's market-driven university world, the need for effective learning and teaching practice, based in good scholarship, is fundamental to student success.

Keywords: relationships; synergy; scholarship; student-success; variety

Introduction

Introducing an innovative new learning and teaching approach in which the concepts of Relationships, Variety & Synergy (RVS) are used synchronously as the basis for change within engineering education, this case study starts with the research question, 'To what extent can the "RVS" approach to engineering education enhance students learning experience?' In doing so, the paper provides a useful and useable approach to learning and teaching that is specifically aimed at engineering educators working in higher education. In today's fast-changing global society, the role of engineering has changed from being one of technical innovation to become a fundamental driver of future societal advancement. In order to meet the challenges and expectations required of such an unprecedented role, engineering education has to change and keep pace. This case study introduces a useful and useable learning and teaching approach that has been purposefully developed to meet the needs of engineering education. Taking into account the need to make sure that any proposed changes to engineering education need to be articulated in such a way so as to be perceived as accessible by *all* engineering colleagues, the approach is unique, in that it was developed *by* an engineer *for* use in the engineering classroom. It encapsulates the concepts of

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RVS, within a pedagogical framework the purpose of which is to enhance the student experience and in doing so, promote success. This paper provides an overview of the approach and discusses some of the evaluation and critique underpinning its development.

Background: learning and teaching in engineering. The UK context

The quality of teaching within UK universities has received much public attention of late – most notably in the context of the National Student Survey (see HEFCE 2014), which puts the UK Higher Education Sector under the spotlight on an annual basis. More recently, the (Education Policy) White Paper 'Students at the Heart of the System' outlined the government expectation that there will be 'a renewed focus on high quality teaching in universities so that it has the same prestige as research' (BIS 2011, 2). Looking specifically at engineering education, it is evident that the university level engineering education has not been immune to such scrutiny with some evidence suggesting that in the UK, universities are failing to produce engineering graduates equipped with the necessary skills and competencies required to operate within the profession (Bawden 2010; Parker 2012). This was recently emphasised in a UK Government-commissioned report that reviewed the engineering skills being developed at all levels of education in the UK (Perkins 2013). The result of this is that many employers are being forced to look overseas to fill engineering vacancies (Spinks, Silburn, and Birchall 2006). Indeed, engineering is one of the few shortage occupations identified by the Home Office (2012) as an area where employers may choose to recruit and sponsor overseas (non-European) workers. Shortages of suitably qualified candidates entering the profession are made worse by the fact that, for some years, universities have experienced difficulties in firstly recruiting, and then in maintaining, student numbers on engineering programmes (RAEng 2007; Royal Society 2011; Engineering Council 2013). Conversely, at the same time as demand for engineers is increasingly reflected in government and professional rhetoric, matters are not helped by the fact that in the UK (as in much of the rest of the world) engineering continues to fail to attract high numbers of women and individuals from minority backgrounds (Burke and Mattis 2007; NSF 2009). It may be argued that the image of engineering education programmes does little to address this issue, with only 14% of new entrants to the profession being female (WISE 2011); indeed the majority of new entrants to the profession in the UK continue to be young, white, men (RAEng 2009). Thus, the questions of how to encourage more young people from all backgrounds onto engineering programmes, and then, once they have enrolled, as to how to keep them engaged, represent a significant dilemma facing engineering education today. Given this situation, it may be argued that if this issue is not dealt with as a matter of urgency, predictions regarding future shortages of engineers over the next two to three decades will see the UK increasingly struggling to compete in a competitive and fast-moving global society (Spinks, Silburn, and Birchall 2006).

The scholarship of engineering and engineering education

It is important to note that engineering education is not alone in being subject to public attention regarding the quality of teaching. Contextualised by what can be described as the massification of higher education, debates focusing on problems pertaining to student retention, and questions regarding quality in learning and teaching have, over the past two decades or so, been widely discussed in the literature (Biggs 1993; Prosser and Trigwell 1999; Barnett and Coate 2005). Much of this debate is grounded in the concept of scholarship proposed by Boyer (1990), who argued that there are four separate, but overlapping areas of scholarship (discovery, integration, application and teaching). Each of these is not only integral to academia as a whole, but also can be specifically applied to the engineering education context. The value and appropriateness of applying Boyer's conceptualisation of scholarship to engineering education is discussed in the literature (Al-Jumaily and Stonyer 2000; Felder, Rugarcia, and Stice 2000; Wankat et al. 2002). From the perspective of the RVS approach, Boyer's work is particularly useful as it provides a comprehensive and accessible approach, which in linking research, teaching and learning, captures the main concepts fundamental to engineering education. The following paragraphs provide a brief overview of Boyer's approach. The approach was adopted as it both links and transcends the concepts of research, practice and teaching thereby providing the ideal tool upon which to build a distinctive approach to engineering education for use by colleagues across a range of different settings.

The first area, the scholarship of discovery comes closest to the concept of research and is often perceived to be integral to academic life. From an engineering education perspective, it may be argued that the scholarship of discovery is pivotal to engineering, in that the profession makes a significant contribution to the sum of human knowledge; in doing so engineering and engineering education incorporate disciplined investigation through the scholarship of discovery and the pursuit of knowledge. An important aspect of the scholarship of discovery is that like engineering and engineering education, it focuses not just on outcomes, but also on the process. Aligned to the scholarship of discovery is the scholarship of integration. However, the difference is that the scholarship of discovery asks what is it we *want* to find out, whereas the scholarship of integration makes 'connections across disciplines, placing specialties in larger context' (Boyer 1990, 18). In this way the scholarship of integration seeks to find meaning in discovery, moving beyond traditional boundaries to involve a variety of scholarly trends including those that are, 'interdisciplinary, interpretive, integrative' (21). The notion of 'thinking out of the box', pivotal to the scholarship of integration, is vital to engineering and engineering education. It involves the synthesis and interpretation of knowledge to bring new insights to original research and ways of looking at things. The third area of scholarship identified by Boyer (1990) is that of application. This is also relevant to an engineering and engineering education context as it is tied to disciplinary knowledge and thus encapsulates the concept of work-focused learning. Boyer's argument that the scholarship of application is far more dynamic than the simple acquisition and application of knowledge in that it necessitates the acquisition and application of skills and insight resonates with the overall aim of contemporary engineering education. The final area identified by Boyer, the scholarship of teaching, involves actively linking teachers' knowledge and understanding with students' learning. The scholarship of teaching acknowledges that *scholars are also learners* (24) and that teaching not only involves transmitting knowledge, but also transforming and extending it. The organic nature of knowledge transmission, transformation and extension is central to learning and teaching in university level engineering education. Indeed, Boyer's (1990) argument that '…As a scholarly enterprise, teaching begins with what the teacher knows. Those who teach must, above all, be well informed and steeped in the knowledge of their fields' (23) not only accurately captures the high levels of theoretical knowledge that engineering educators need to possess but also informs the basis of all good engineering education – that of sound discipline-specific knowledge and insight.

Whilst from Boyer's perspective, the relationship between the different areas of scholarship may be defined as conceptually and pedagogically interdependent, from an engineering education perspective a significant weakness with this approach is that, whilst Boyer (1990) clearly states that what is needed 'is a more inclusive view of what it means to be a scholar – a recognition that knowledge is acquired through research, through synthesis, through practice and through teaching ……' (24) the basis upon which this assertion is made appears to lack empirical grounding, in that it is not based upon sound pedagogical research. Instead, it seems to offer a purely theoretical approach. Conversely, other scholars have sought to critique the linkage between teaching and research (Jenkins et al. 1998; Robertson and Boud 2001; Jenkins 2004), focusing on the concept of discipline-specific research and how it may be applied within a teaching setting. Such research suggests that whilst discipline-specific research may be linked to teaching, such a linkage is at best tenuous, and at worst non-existent (Zaman 2004).

Described as 'amongst the most intellectually tangled, managerially complex and politically contentious issues in mass higher education' (Scott 2005, 53) the debate regarding the relationship between research and teaching continues. Developing this debate one stage further, there are arguments that in order to achieve high-quality scholarly outcomes, university teachers need to adopt an approach to teaching similar to that of research, founded upon academic rigor and evidence (Healey 2000; Trigwell, Prosser, and Ginns 2005; Elton 2005). For some, this represents a somewhat contentious notion, yet, for the concept of scholarship in engineering education to become a reality, evidence-based practice in learning and teaching across university level engineering education needs to become standard practice.

The SEER project: scholarship in engineering education research project

Project rationale

Previous work by one of the authors of this paper (Clark 2009) put forward a learning and teaching proposition developed to promote and enhance the student experience within engineering education. Put simply, the proposition as follows:

$$\text{Relationships} + \text{Variety} + \text{Synergy} = \text{Environment for Success}$$
$$(R + V + S = \text{Success}).$$

Together with an appreciation of technology, the above concepts were identified to be a credible and helpful focus for the creation of a learning environment in which students could be actively provided with the means to succeed. Importantly, the model was deliberately articulated in such a way so as to be accessible for colleagues from an engineering background (as opposed to educational experts or staff developers). Indeed, the ability to communicate with staff in a clear and meaningful way has been identified as key to the successful implementation of the approach. Framed within the theory of scholarship and other educational research, and encapsulating one of the author's own experiences both as a professional engineer and engineering educator, the RVS approach contests that there are three key components to the creation of an appropriate and innovative scholarly learning and teaching environment for engineering education. These three components are Relationships, Variety and, Synergy. In developing the approach the underlying aim was to bring research-based ideas into engineering education in such a way so as to enhance the student experience whilst providing a useful and usable framework for colleagues that would stimulate engineering teachers to engage with the scholarship of learning and teaching.

The first component, Relationships (R), are crucial to the learning environment in higher education and as such need to be valued and nurtured (Barnett and Coate 2005; Cowan 2006; Cornelius-White 2007; Foster 2008). In the learning environment, a myriad of complex relationships exist extending far beyond the classroom. From a learning perspective, the most important relationships are arguably those established within the university environment encapsulating friendships between students, and professional relationships between lecturers and students, support staff and students, and amongst faculty colleagues. Research suggests that relationships are key to addressing issues pertaining to retention and transition and that by engendering a 'sense of belonging' universities can do much to prevent high student drop out numbers (Read, Archer, and Leadwood 2003; Quinn 2005; Pitman and Richmond 2008; Shepherd 2013). By purposefully encouraging students to develop supportive scholarly relationships through the use of carefully designed pedagogic activities, including those based around project work, the RVS approach provides an active learning environment in which students not only gain from developing friendship and supportive networks, but also acquire the strong team working skills and abilities required by employers. Furthermore, by adopting a 'tutorial' approach to teaching, in which time and care is taken to develop an individual relationship with each student, a sense of trust and mutual respect between the lecturer and students is fostered.

The second component of the approach, Variety (V), relates to innovation in learning and teaching. In contemporary education, innovation is often associated with technology – yet, whilst technology has its place, there is a clear need for students to be subjected to a range of different learning experiences. Given the wide range of different ways in which students learn (Entwistle and Ramsden 1982; Entwistle 1991; Biggs 1993; Cuthbert 2005), it is important that all educators adopt a variety of approaches to teaching. This is particularly the case in engineering education where students need to be given a learning experience that is relevant to their own educational context, yet appropriate to the task in hand both for teaching and assessment (Prosser and Trigwell 1999; Fry, Ketteridge, and Marshall 2009). In engineering education there are numerous opportunities to introduce variety into the curriculum inside the university setting with laboratories, manufacturing workshops, simulation, role-play and much more for teachers to choose from.

Finally, in order to achieve a Synergistic (S) learning experience, the concept of constructive alignment (Biggs and Tang 2007) was built upon in such a way so as to achieve Synergy not only within and across the university curriculum, but also across the entire educational pathway and into society – including industry and the professional bodies. The importance of aligning the engineering curriculum with the requirements of professional bodies and industry is reflected in the literature (Leitch 2006; Spinks, Silburn, and Birchall 2006; RAEng 2007), which argues that in order for engineering graduates to meet the fast-changing requirements of the profession, they need to be equipped with high-level engineering-focused skills as well as more transferable generic 'softer' skills. Additionally, the concept of Synergy in engineering education relates to a Synergetic classroom environment in which teachers and students work together to solve engineering-related problems or reach an academic goal. A good example of Synergy within engineering education may be found in the Conceive, Design, Implement andOperate approach to learning where students experience the full project life cycle (CDIO 2013).

The final component of the formula, Student Success, is defined within this context not only in terms of academic achievement, but also in terms of increased feelings of belonging manifested by enhanced engagement with learning and teaching (for further discussion about the importance of 'belonging' see Andrews and Clark 2011; Thomas 2012). The uniqueness of the RVS approach is that it brings all three components together in an empirically grounded yet practically applied manner. Taking account of all three components concurrently, an enhanced learning environment is created for both students and lecturers alike. This environment is one in which student and teacher success is evident in the measurable outputs of education (student results) but also in the evident growth in students' understanding of key concepts and theories and the teacher's confidence in their practice.

Too often university engineering education remains essentially didactic in nature and fragmented as a consequence of modularisation. 'Enlightened' individuals advocate change, yet communicating this to the wider academic community and seeing action is a significant challenge. The RVS approach in its simplest form highlights the areas on which to focus effort in order to bring about change and with it the opportunity for student success.

Having developed the above learning and teaching approach, the lecturer set about introducing it into his teaching. In order to evaluate the success and appropriateness of the approach it was decided to conduct a pedagogical research study into the approach. In order to deal with issues of validity and reliability, an independent social researcher, the author of the second paper, was employed to undertake this evaluation.

Project approach

Introducing RVS to engineering education

It was decided to pilot and test the approach on a graduate level Engineering Management programme. Both colleagues who were responsible for developing and testing the approach teach on this programme and both have a management role within the Engineering Faculty (one as Associate Dean and the other as Programme Director). The module to which the case study applies was developed and taught by the first colleague and covered the subject of engineering project management theory and practice. Prior to redeveloping the module, student feedback for the previous three years was analysed by the two researchers. It was evident that the students' were generally dissatisfied with the traditional learning and teaching approach of formal lectures and tutorials and that they experienced difficulties in applying theory to practice. Taking into consideration Boyer's (1990) conceptualisation of scholarship, the first stage of the project involved considering how the RVS approach could be embedded into the curriculum. Right from the onset of the module, the lecturer made a point of focusing upon the *Relational* aspects of the learning environment. This was achieved by redeveloping the course materials in such a way so as to promote a sense of belonging and cohesiveness between the students, the lecturer and the module content. A 'tutorial' approach to learning and teaching was written into the curriculum such that students were given individual attention and encouragement. Active learning approaches, based upon group and project work were used to encourage students to form their own support networks and groups.

The concept of *Variety* is embedded into the curriculum by 'thinking out of the box – and out of the classroom'. In the example considered, this involved integrating 'Engineering Heritage' into the curriculum; first as a learning and teaching tool to provide the engineering content and context for a graduate level engineering project; and second to create an environment in which students can discover for themselves the fundamental principles of engineering management and apply such learning to their individual projects.

By aligning the learning and teaching tools with the learning and teaching approach, and by building into the curriculum the expectations and requirements of professional bodies and employers, the module lecturer provided a *Synergistic* learning experience in which the module outcomes are constructively aligned with the overall programme outcomes and with other external drivers such as employability. Within the module a variety of learning and teaching approaches are used in such a way so as to provide synergy across the curriculum within an environment based upon positive learning relationships. Learning approaches used include field trips, group projects, short films, traditional lectures, role-play and real-life case studies. In order to achieve Synergy in learning, teaching and in the critical evaluation of the approach, the authors worked together to develop a conceptual framework upon which the pedagogical value of the RVS approach was critically evaluated.

Methodology

Using a mixed methodological approach, an exploratory study was undertaken the aim of which was to investigate the primary research question 'To what extent can the RVS approach to engineering education enhance students learning experience?' The RVS approach itself was developed by a senior academic based upon his experiences as a lecturer, manager and engineer. The fieldwork was conducted by a social scientist who is a lecturer in engineering management. The total sampling frame over a two-year period was 90 students. Attendance on the field trip that was the focus of this study was not compulsory but all of the students whom attended agreed to participate in the observations ($n = 30$ *in year* 1 and $n = 44$ in *year* 2). The field trip is the capstone component of the project management module.

The data from each part of the study were initially analysed in isolation before a meta-analysis of all the data was undertaken.

The first stage of the research comprised non-participatory, overt observations. Utilising the conceptual framework, an observational schedule was developed and used to make a contemporaneous record of the students' learning experiences. Two distinctive sets of observations were undertaken during two field trips with two different cohorts of students. Embedded in the RVS approach, the pedagogical basis of the field trips was the 'Heritage of Engineering'. The students' interactions, communications and behaviours were observed, recorded and analysed following an approach based upon grounded theory methodology (Strauss and Corbin 1998) in which the qualitative data were analysed using a system of open coding and axial coding. The purpose of following such an approach was to enable the observer to undertake a systematic enquiry in such a manner so as to achieve a high level descriptive and conceptual ordering from the data and in doing critically analyse the value of the RVS approach.

The second stage of the study comprised a quantitative survey aimed at capturing students' perceptions of the various components of the RVS approach. The survey was administered to a group of 90 students to which the response rate was 95.55% ($n = 86$). The questions, which in addition to building on the findings of the observations, were grounded in the literature, were divided into three sections covering Relationships, Variety and Synergy. The survey findings were analysed using descriptive statistics.

Conceptual framework

Defined as 'the basis of analysis', Strauss and Corbin (1998) argue that concepts represent the 'building blocks of analysis' (202). From this perspective, a conceptual framework brings together the building blocks, articulating and clarifying relationships between them. In this way the framework provides a coherent foundation upon which subsequent empirical investigation may be conducted. This perspective was also discussed by Dewey (1938) who drew attention to the importance of conceptualisation arguing that: 'The conceptual dimension is held to be logically an objective necessary condition in all determination of knowledge' (263).

In proposing a conceptual framework upon which to conduct research into the scholarship of engineering education, the scholarship of integration acts as a linkage between the scholarship of discovery and application (Figure 1).

Critical evaluation of the RVS approach

Starting with the research question, 'To what extent can the RVS approach to engineering education enhance students learning experience?', an exploratory study was undertaken utilising a mixed methodological approach. Rather than look for statistical correlations, the researchers set out to observe first-hand the student learning experience. Descriptive statistics were collected in an attempt to gain an insight into students' learning experiences (as opposed to identifying causal linkages between variables). The first stage of the research comprised non-participatory, overt observations. Utilising the conceptual framework, an observational schedule was developed and used to make a contemporaneous record of the students' learning experiences. Two distinctive sets of observations took place with two separate cohorts of students. The second stage of the study comprised a quantitative survey aimed at capturing students' perceptions of the various components of the RVS approach. The observer, one of the paper authors, has a social science background and has undertaken observational training with the police service. The findings from the observations were analysed using a phenomenological approach. Questions, which in addition to building on the findings of the observations, were grounded in the literature, were divided into

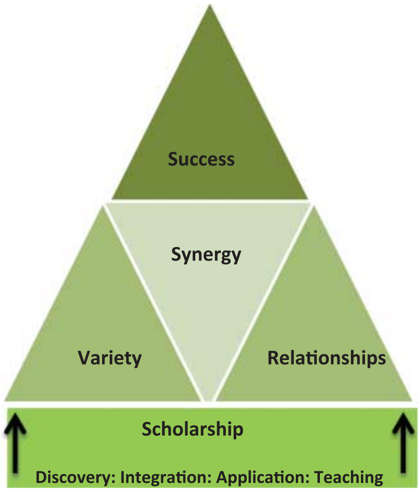

Figure 1. Conceptual framework: the scholarship of engineering education.

three sections covering relationships, variety and synergy. The survey findings were analysed using descriptive statistics.

Research findings

Stage 1: observations

Based upon the conceptual framework, the 'observational schedule' was used as a basis for a qualitative record of students' learning on two separate field trips in which 'Engineering Heritage' formed the pedagogical basis of the sessions. The learning experiences of two separate cohorts, both studying Engineering Project Management as part of a Master's in Engineering Management were observed. During the first set of observations, the sample comprised 24 males and 6 females; the second sample was larger with 36 males and 8 females. The ethnic makeup of both groups was diverse, with the majority of the students being of a minority background. In total, the students originated from 17 different countries.

Both field trips involved a two-stage visit to the city of Bristol in the South West of the UK. Bristol is located about 100 miles away from the university and was chosen as an ideal location for the field trip because of its rich engineering heritage. The first stop of the field trip was the Clifton Suspension Bridge just outside the city. Designed and built by an individual whom many believe to be the most influential British engineer of all time, Isambard Kingdom Brunel (BBC 2002), the Suspension Bridge provides an excellent example of the wider value that engineering adds to society. A testament to the importance of engineering is that large parts of Brunel's Victorian engineering innovation are still in use today, an example being the railway infrastructure comprising many cuttings, bridges and tunnels. The second part of each of the field trips was a visit to ss Great Britain, which is moored in a dry dock with a purpose built museum in Bristol city centre. The first ship to combine the screw propeller and an iron hull, the ss Great Britain is considered the forerunner of modern shipping and provides an ideal example of engineering heritage and contemporary engineering innovation in that the manner in which the ship has been restored and preserved owes much to the engineers of today (for further details see Watkinson et al. 2005).

Upon arriving at the Clifton Suspension Bridge, the students were given the opportunity to explore at their own pace. In small groups, they were observed looking in wonder at the technical and aesthetic aspects of the bridge. Being engineers first and foremost, many understood the engineering detail very well, but by experiencing the bridge for themselves they were able to contextualise both the historical and contemporary significance of the bridge. The discussion and debate were observed to be around both engineering and non-engineering issues. What was most notable was the manner in which the students, working in small groups, actually ‘looked’ at the bridge. The majority not only walked over the bridge, but also walked under it and around it – closely examining and commenting on the engineering and architecture as they did so. Lively discussions relating to the capacity of the bridge, the strength of the cables and the severe, yet beautiful, geological environment in which the bridge had been built indicated the students’ level of interest and provided a good example of ‘action learning’ in progress. Interestingly, the concepts and theories relating to engineering project management formed the basis of some discussions, with students’ different professional and demographic backgrounds providing an interesting mix in which learning took place. That the majority of students had not been previously exposed to ‘Engineering History’ in a UK context was evident as the students grouped together to debate how, when the bridge was built, the project managers might have interacted with the workforce and managed the whole process. Throughout the visit, knowledge-exchange between and across the groups of students was very apparent. Their level of understanding in respect of the wider societal aspects of the bridge varied, with one or two commenting on how the bridge itself would have radically changed the lives of the two communities it connects. Upon leaving the bridge, many of the conversations had turned away from the technical aspects of the structure and were focused more on the project management involved in its building and the sociological benefits resulting from its completion.

Arriving at the ss Great Britain, the students entered the dockyard obviously excited and in a state of ‘awe’ as they took in their surroundings. The ‘wow factor’ that engineering can have was apparent as the students commented: ‘Wow’; ‘Look at this’; ‘This is something’; ‘Just imagine …’. Such was their interest in what they were seeing, it proved difficult to get the students to an arranged presentation by the exhibit manager. Breaking into small groups, the students were observed linking their classroom learning to the real-life example in front of their eyes. They appeared equally interested in the external engineering of the ship as they were with its internal make-up – particularly the engine rooms and power source. Discussions centred on the various characteristics associated with the ship design and construction. Almost all of the students commented on the way in which the technical aspects of the overall design of the ship, when considered together with what they perceived would have been a difficult and somewhat ‘basic’ work environment, would have meant that the construction of the ship would have been a highly complex and somewhat fraught process. The ship itself provided the ideal medium with which the students were able to contextualise their learning in respect of engineering project management. Conversely, although most of the time was spent looking at the ‘engineering’ aspects of the ship, the crew and passenger cabins sparked a debate about the conditions on board. Like the bridge, the ship promoted discussion around a range of subjects with students contrasting their personal experiences with the history, artefacts and stories relating to the ship. The final part of the trip took place at the bow of the ship with a short presentation and discussion with the Project Manager who led the conservation work on the ship. With noise and work going on all around as further conservation and building work within the dockyard environment took place, the classroom truly represented a ‘real’ project environment. The speaker’s knowledge and enthusiasm for the high profile conservation project was obvious to the observer, indeed several students took advantage of the speaker to gain more insights into the project and the broader project management profession. The researcher’s final narrative summed up the experience:

> The visit had provided the opportunity to get out of the classroom. It was ‘real-life’ learning at its best. The opportunity for the students to interact with two very different, but linked historical Projects – both of which have a particular place in contemporary society. Two examples of real-life engineering at work. The chance to meet real people who

solve real problems. To think about how, in the past, engineering has contributed to building our society. Every student I asked had enjoyed the day.

Following an analysis of the observational data the findings were used to shape and inform the development of the questionnaire.

Stage 2: Questionnaire focusing on students' perceptions of the RVS approach

The questionnaire was divided into four main sections: demographics (including work experience), relationship questions, variety questions and synergy questions.

Sample demographics

The questionnaire was administered to a total of 90 students. The response rate was high with 86 responses received across the two cohorts. With regard to gender, 65 of the respondents were males, 21 were females. The students originated from 17 different countries across the globe. The students were asked to define their ethnic background. The data were coded and simplified into three primary categories: Asian, Black and White. Each category was then further sub-divided into British, European and other. Figure 2 shows that half of the samples were of Asian ethnicity from a non-UK/EU background.

The students brought with them a mixture of prior work experience ranging from undergraduate study only to senior management in the engineering industry. Figure 3 provides an overview of the sample's work-related antecedence.

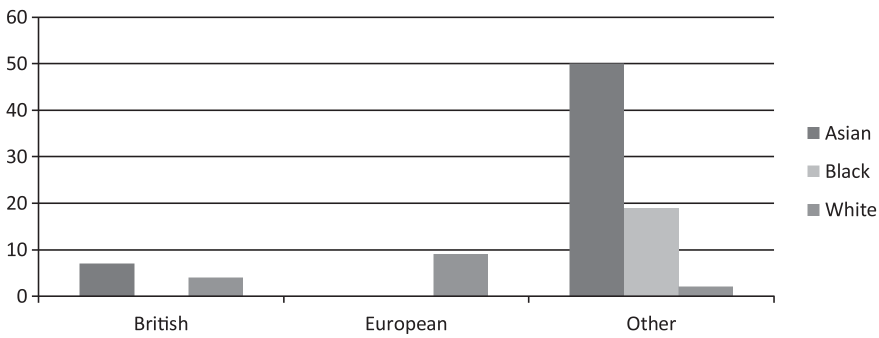

Figure 2. Students' ethnic background.

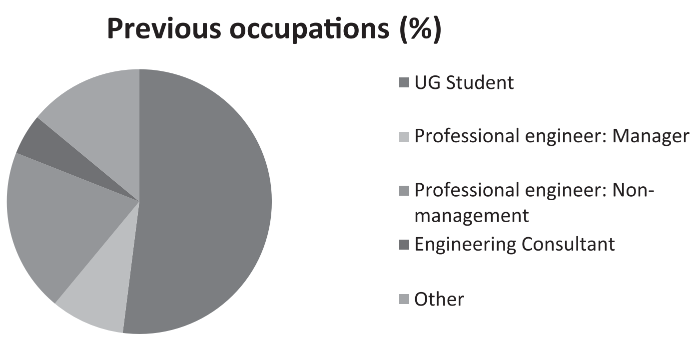

Figure 3. Students' previous experience.

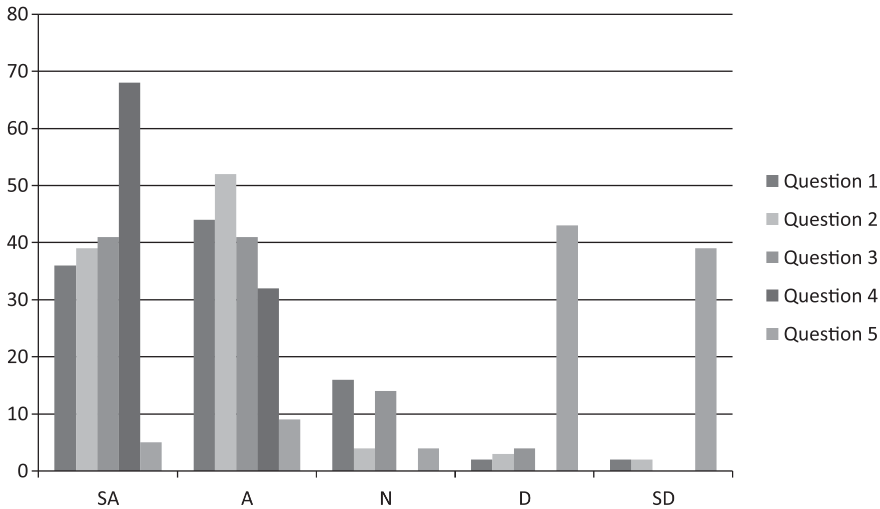

Figure 4. Student perceptions in relation to ‘Relationships’ (%). Note: SA, strongly agree; A, agree; N, neutral; D, disagree and SD, strongly disagree.

The research revealed that the majority of students had no prior work experience (other than work-based learning) and had enrolled on the Master’s Programme directly from their undergraduate studies.

Relationship question statements

As a discipline, Engineering Project Management requires people to work together in teams. Engineering Project Managers require high levels of communication skills and the ability to build relationships with people at all levels. The value of the RVS approach in promoting this is apparent in the students’ perceptions as depicted in Figure 4. Across both cohorts, the lecturer worked hard to enhance the student learning experience by developing individual relationships with the students. The module was designed in such a way so as to promote group working and team cohesion. For ‘relationships’ the statements were:

(1) The group work in the module has enabled me to build some close friendships;
(2) The group work has provided the opportunity for me to develop my communication skills;
(3) Working with others on the same course has helped me understand the main issues;
(4) The module lecturer has been approachable throughout the module and
(5) I found it difficult to work in a group.

The results of the ‘relationship’ question statements show that the manner in which the programme was taught encouraged the students to develop strong relationships with each other. It also shows that the lecturer was perceived to be ‘approachable’ by all of the samples.

Variety question statements

The concept of ‘variety’ is particularly pertinent in engineering education as it enhances the students learning, whilst exposing them to different engineering-focused learning experiences. Building variety into the curriculum in an innovative and academically valid manner was not easy. However, by using a number of different tools and approaches – and by taking learning out of the

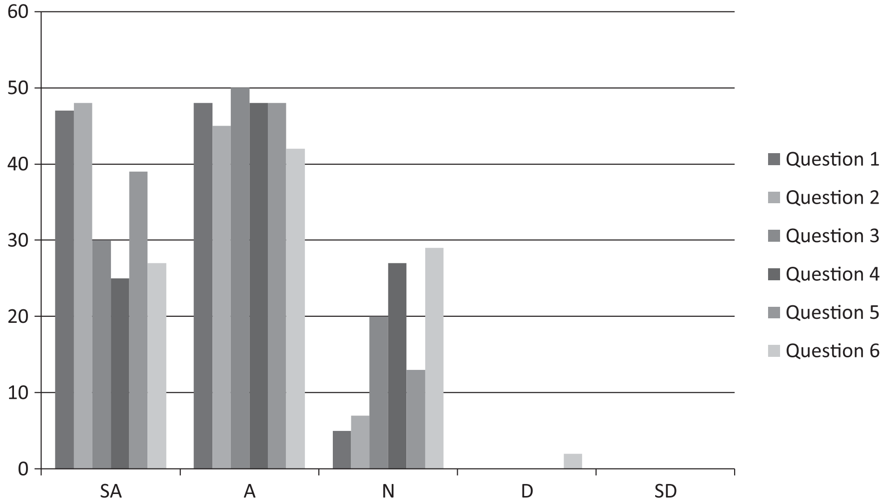

Figure 5. Student perceptions in relation to ‘Variety’ (%). Note: SA, strongly agree; A, agree; N, neutral; D, disagree and SD, strongly disagree.

classroom/laboratory, the lecturer put together a varied curriculum which placed student learning at the centre. For ‘variety’ the statements were:

(1) The different learning and teaching approaches used in the module have made the content more interesting;
(2) The different learning and teaching approaches used in the module have made the content more understandable;
(3) The use of real-life examples has helped me appreciate the range of practical issues I may encounter in engineering project management;
(4) The facilitated class discussions have been helpful in helping me understand the issues;
(5) The lectures provided the foundation for the rest of the module and
(6) The field trip made me think about my own approach to project management.

The results of the ‘variety’ question statements show that the RVS approach to learning was overwhelmingly perceived positively by the students (Figure 5).

Synergy question statements

As previously discussed, the adopting of a synergistic approach to learning and teaching was developed out of Biggs’ concept of ‘Alignment’ by taking into account the wider aspects of the scholarship of learning as applied to engineering education. Thus, the programme was designed in such a way so as to meet student expectations whilst fitting in with academic, professional, industrial and societal demands. The statements relating to ‘synergy’ were:

(1) The content of the module is relevant to modern-day engineering practice;
(2) The module content provides a good foundation for the coursework;
(3) The group work in the module is good preparation for working in a team;
(4) The real-life case studies used in the module help me understand the theoretical background and
(5) The field trip has brought to life the theoretical and practical issues surrounding Engineering Project Management.

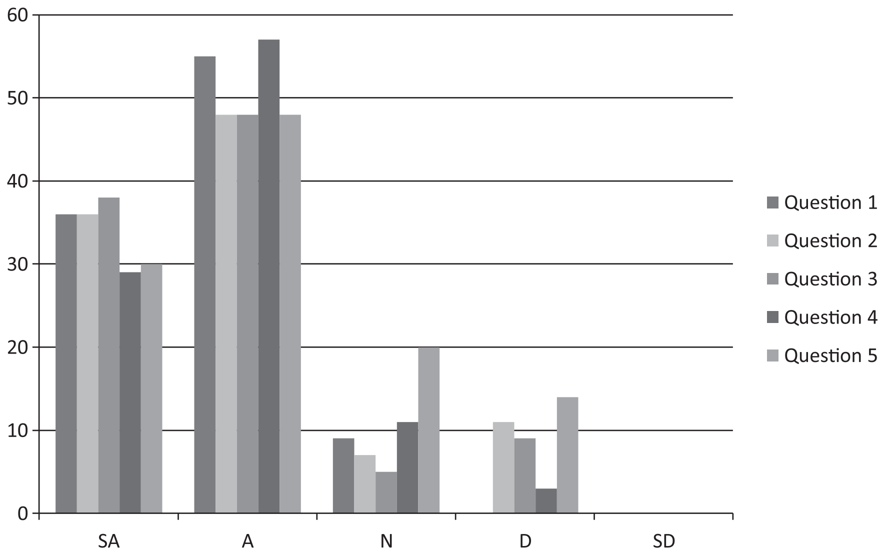

Figure 6. Student perceptions in relation to ‘Synergy’ (%). Note: SA, strongly agree; A, agree; N, neutral; D, disagree and SD, strongly disagree.

The survey results suggest that by adopting a synergistic approach to learning and teaching, the module lecturer had put together a programme that allowed the students to conceptualise the theoretical underpinning of the course in such a way that brought ‘learning to life’ (Figure 6).

Discussion

Today’s students are used to a fast moving, multi-dimensional existence – something that needs to be considered when developing a learning approach. This is where the variety and synergy elements of the RVS approach comes into play with action being taken to make the learning space somewhere in which the students *want* to engage with learning. By acknowledging that teachers are in the ‘driving seat’ the approach has provided the impetus for colleagues to explore different approaches to teaching. One immediate output of this is in a programme of seminars which are being offered to allow colleagues to share good practice whilst investigating new ideas in a safe and collegial manner. One of the limitations of the approach is that it does not suit those students who prefer ‘traditional’ learning environments or who are mainly suited to ‘surface learning’. Additionally, there can be little argument that innovative learning and teaching requires high levels of commitment from colleagues. Whilst this is not necessarily a weakness, using the RVS approach does take considerable time and effort. Indeed, it should be recognised that within today’s highly pressured teaching environment, colleagues may simply not have the time to use the approach in all of their teaching.

In evaluating the approach, the first notable outcome is that it inspires student engineers to react positively; levels of engagement are high with attendance rates being constantly over 90%, whereas in programmes which do not use the approach, attendance is generally nearer 50%. Taking into account the findings of previous work that argues that women and minority students may be disadvantaged within an engineering education environment (Takahira, Goodings, and Byrnes 1998; NSF 2000; May and Chubin 2003), the approach seeks to counteract potential problems by encouraging students to become responsible for their own learning whilst promoting wider generic skills such as team-working and communication (McCarthy and Higgs 2005). Indeed, by encouraging students to develop strong collegial relationships and to work together to critically analyse and solve engineering problems from a variety of different perspectives, synergy in learning occurs. Moreover, by providing a learning environment which deliberately takes account of engineering education perspectives, the RVS approach is ideal in assisting students to deal with threshold concepts (Land, Smith, and Meyer 2008).

In developing the RVS approach, the authors of this paper have created an innovative and empirically grounded approach to learning and teaching in engineering education that aims to encourage engineering educators to engage with the concept of scholarship. One of the main drivers of this approach has been the need to move away from the complexities and seemingly idiosyncratic language manifest across pedagogical and sociological disciplines towards a more engineering 'friendly' and an appropriate model which has been tried and tested in the engineering classroom. The case study upon which this particular paper is based has been disseminated across Europe with positive feedback being received from university management, faculty and students. Indeed, student feedback indicates that the RVS approach works by providing students with a supportive, interesting and interactive learning environment. Discussions with students emphasised the need to promote engagement through innovative and evidence-based teaching practice.

The RVS approach is being 'rolled out' to a number of engineering modules, the pedagogical value of which will be critically evaluated and the results used to develop a tool with which an individual may assess their own learning and teaching approach utilising the RVS Model. By continually developing and critiquing the approach, and by disseminating the knowledge acquired from the ongoing evaluation, the RVS approach has the potential to positively impact engineering education on a wide scale. Given the high numbers of students who 'drop out' of engineering studies the need to develop an 'engineering-friendly' pedagogical approach has never been so high.

The perceived value of the approach to promote a clear, common language for action amongst staff has led to the framework being adopted as the basis for a cross-school learning and teaching development strategy. The results of this work will be the subject of a future paper.

Conclusion

This case study has explored the value of a new approach to learning and teaching in engineering education. In reflecting upon the various issues discussed, the authors of this paper believe that the real value of the RVS approach is that it provides an engaging and accessible scholarly approach that can be adopted by colleagues across a range of engineering education settings.

In conclusion, within today's market-driven university world, the need for effective learning and teaching practice, based in good scholarship is fundamental to student success. The RVS model provides an uncomplicated approach to engineering education that has been shown to work. Indeed, feedback from colleagues across the EU indicates that at the very least, RVS provides a useful and useable tool that could potentially positively impact future engineering education in a wide range of disciplines and educational settings.

References

Al-Jumaily, A., and H. Stonyer. 2000. "Beyond Teaching and Research: Changing Engineering Academic Work." *Global Journal of Engineering Education* 4 (1): 89–99.

Andrews, J., and R. Clark. 2011. "Peer Mentoring Works!" Final Report: HEFCE/Paul Hamlyn. What Works! Final Project Report. Aston University & Higher Education Academy. ISBN. 978 1 85449 417 7. http://www1.aston.ac.uk/eas/research/groups/eerg/current-projects/

Barnett, R., and K. Coate. 2005. *Engaging the Curriculum in Higher Education.* Maidenhead: OU Press.

Bawden, A. 2010. "Skills Shortage is Getting Worse Bosses Warn." *The Guardian*, May 18. Accessed February 11, 2011. http://www.guardian.co.uk/education/2010/may/18/skills-shortage-worsens

BBC. 2002. "Churchill voted greatest Briton." Accessed July 28, 2011. http://news.bbc.co.uk/1/hi/entertainment/2509465.stm

Biggs, J. 1993. "What Do Inventories of Students' Learning Process Really Measure? A Theoretical View & Clarification." *Educational Psychology* 63 (1): 3–19.

Biggs, J., and C. Tang. 2007. *Teaching for Quality Learning at University.* 3rd ed. Maidenhead: SRHE.

BIS. 2011. "Students at the Heart of the System." London: Department for Business, Innovation & Skills, HMSO.

Boyer, E. L. 1990. "Enlarging the Perspective." In *Scholarship Reconsidered: Priorities of the Professoriate*, edited by E. L. Boyer, Chapter 2, 15–25. Princeton, NJ: The Carnegies Foundation for the Advancement of Teaching.

Burke, R. J., and M. C. Mattis. 2007. *Women and Minorities in Science, Technology, Engineering & Maths.* Cheltenham: Edward Elgar.

CDIO. 2013. "Conceive, Design, Implement, Operate." Accessed June 6, 2013. www.cdio.org

Clark, R. 2009. "The Importance and Challenges of Alignment in Engineering Education." Presented at Total Engineering Education 09 Symposium, Shanghai, China, October 22–25.

Cornelius-White, J. 2007. "Relationships are Effective: Meta-Analysis." *Educational Research* 77 (1): 113–143.

Cowan, J. 2006. *On Becoming an Innovative University Teacher.* Buckingham: SRHE, OU Press.

Cuthbert, P. F. 2005. "The Student Learning Process: Learning Styles or Learning Approaches?" *Teaching in Higher Education* 10 (2): 235–249.

Dewey, J. 1938. *Logic – The Theory of Inquiry.* New York: Holt.

Elton, L. 2005. "Scholarship and the Research and Teaching Nexus." In *Reshaping the University: New Relationships between Research, Scholarship and Teaching*, edited by R. Barnett, Chapter 8. 99–118. Maidenhead: Society for Research into Higher Education.

Engineering Council. 2013. "Engineering Courses in the UK." Accessed June 6, 2013. http://www.engc.org.uk/

Entwistle, N. 1991. "Approaches to Learning & Perceptions of the Learning Environment." *Higher Education* 22 (2): 201–204.

Entwistle, N., and P. Ramsden. 1982. *Understanding Student Learning.* New York: Croom Helm.

Felder, M. R., A. Rugarcia, and J. E. Stice. 2000. "The Future of Engineering Education V. Assessing Teaching Effectiveness and Educational Scholarship." *Chemical Engineering Education* 34 (3): 198–207.

Foster, K. C. 2008. "The Transformative Potential of Teacher Care as Described by Students in a Higher Education Access Initiative." *Education and Urban Society* 41 (1): 104–126.

Fry, H., S. Ketteridge, and S. Marshall. 2009. *Teaching and Learning in Higher Education: Enhancing Academic Practice.* 3rd ed. London: Routledge.

Healey, M. 2000. "Developing the Scholarship of Teaching in Higher Education: A Discipline-Based Approach." *Higher Education Research & Development* 19 (2): 169–189.

HEFCE. 2014. National Student Survey. Accessed March 5, 2014. https://www.hefce.ac.uk/whatwedo/lt/publicinfo/nationalstudentsurvey/

Home Office. 2012. "Government-approved shortage occupation list." Accessed June 6, 2013. http://www.ukba.homeoffice.gov.uk/business-sponsors/points/sponsoringmigrants/employingmigrants/shortageoccupationlist/

Jenkins, A. 2004. *A Guide to the Research Evidence on Teaching-Research Relations.* London: Higher Education Academy.

Jenkins, A., T. Blackman, R. Lindsay, and R. Paton-Saltzberg. 1998. "Teaching and Research: Student Perspectives and Policy Implications." *Studies in Higher Education* 23 (2): 127–141.

Land, R., J. Smith, and J. Meyer. 2008. *Threshold Concepts Within the Disciplines.* London: Sense Publications.

Leitch, S. 2006. *"Leitch Review of Skills: Prosperity for all in the Global Economy – World Class Skills."* London: HM Treasury.

May, S. G., and D. E. Chubin. 2003. "A Retrospective on Undergraduate Engineering Success for Underrepresented Minority Students." *Journal of Engineering Education* 92 (1): 27–39.

McCarthy, M., and B. Higgs. 2005. "The Scholarship of Teaching & its Implications for Practice." In *Emerging Issues in the Practice of University Learning & Teaching*, edited by G. Neill, S. Moore, and B. McCullin, 4–10. Dublin: Higher Education Authority.

NSF (National Science Foundation). 2000. *Women, Minorities, and Persons with Disabilities*. Vol. 00-327. Arlington: NSF.

NSF (National Science Foundation). 2009. *Closing the Gender Skills Gap: A National Skills Forum Report on Women, Skills and Productivity*. London: National Skills Forum.

Parker, J. 2012. "Engineering, Industrial Policy & STEM Skills." President Royal Academy of Engineering. Accessed June 6, 2013. http://www.cbi.org.uk/media-centre/news-articles/2012/09/sir-john-parker-on-engineering-industrial-policy-and-stem-skills/

Perkins, J. 2013. "Professor John Perkins' Review of Engineering Skills." Department for Business Innovation and Skills. Accessed January 6, 2014. https://www.gov.uk/government/publications/engineering-skills-perkins-review

Pitman, L. D., and A. Richmond. 2008. "University Belonging, Friendship Quality, and Psychological Adjustment During the Transition to College." *Journal of Experimental Education* 76 (4): 343–362.

Prosser, M., and K. Trigwell. 1999. *Understanding Learning and Teaching.* Buckingham: SRHE, OU Press.

Quinn, J. 2005. "Belonging in a Learning Community: The Re-Imagined University and Imagined Social Capital." *Studies in the Education of Adults* 37 (1): 4–17.

RAEng. 2007. *Educating Engineers for the 21*st *Century*. London: Royal Academy of Engineering.

RAEng. 2009. *Inspiring Women Engineers.* London: Royal Academy of Engineering.

Read, B., L. Archer, and C. Leadwood. 2003. "Challenging Cultures? Student Conceptions of 'Belonging' and 'Isolation' at a Post-1992 University." *Studies in Higher Education* 28 (3): 261–277.

Robertson, J., and C. H. Boud. 2001. "Experiences of the Relation between Teaching and Research: What do Academics Value?" *Higher Education Research and Development* 20 (1): 5–19.

Royal Society. 2011. *Increasing the Size of the Pool.* London. The Royal Society.

Scott, P. 2005. "Divergence or Convergence? The Links between Teaching and Research in Mass Higher Education." In *Teaching Reflective Skills in an Engineering Course*, edited by D. Socha, V. Razmov, and E. Davis. Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exposition. Accessed May 24, 2011. http://www.urbansim.org/pub/Research/ResearchPapers/Teaching%20Reflective%20Skills%20in%20an%20Engineering%20Course%20final%20submission.pdf

Shepherd, J. 2013. "Undergraduate Drop Out Rate Falls to 7.4%." *The Guardian*, March 22. Accessed June 6, 2013. http://www.guardian.co.uk/education/2013/mar/22/undergraduate-dropout-rate-falls

Spinks, N., N. Silburn, and D. Birchall. 2006. *Educating Engineers for the 21*st *Century: The Industrial View.* London. Royal Academy of Engineering.

Strauss, A., and J. Corbin. 1998. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. London: Sage.

Takahira, S., D. J. Goodings, and J. P. Byrnes. 1998. "Retention and Performance of Male and Female Engineering Students: An Examination of Academic and Environmental Variables." *Journal of Engineering Education* 87 (3): 297–304.

Thomas, L. 2012. "Building Student Engagement and Belonging in Higher Education at a Time of Change: Final Report from the What Works? Student Retention & Success Programme." York: HEA. Accessed March 5, 2014. http://www.heacademy.ac.uk/resources/detail/what-works-student-retention/What_works_final_report

Trigwell, K., M. Prosser, and P. Ginns. 2005. "Phenomenographic Pedagogy and a Revised Approaches to Teaching INVENTORY". *Higher Education Research & Development* 24 (4): 349–360.

Wankat, P. C., R. M. Felder, K. A. Smith, and F. S. Oreovicz. 2002. "The Scholarship of Learning and Teaching in Engineering." In *Disciplinary Styles in the Scholarship of Teaching and Learning: Exploring Common Ground*, edited by M. T. Huber and S. Morreale, Chapter 11. Washington: AAHE/Carnegie Foundation for the Advancement of Teaching.

Watkinson, D., M. Tanner, R. Turner, and M. Lewis. 2005. "ss Great Britain: Teamwork as a Platform for Innovative Conservation." *The Conservator* (29): 63–76.

WISE. 2011. "Women in Science and Engineering." Accessed July 20, 2011. http://www.wisecampaign.org.uk/

Zaman, M. Q. 2004. *Review of the Academic Evidence on the Relationship between Teaching and Research in Higher Education*. London: Department for Education and Skills.

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