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**Relationships, Variety &
Synergy: Promoting Scholarship
in Engineering Education.**

Abstract

Starting with the research question, *'To what extent can the 'RVS' approach to engineering education enhance students learning experience?'* the thesis that this paper is based upon is that within today's globalized society, engineering has shifted from being the scientific and technical mainstay of industrial and more recently digital change, to become what is arguably the most vital driver of future societal advancement. In order to meet the challenges and expectations required of such an unprecedented role, engineering education has to change. To meet the demands of such change, one of the paper authors have developed an innovative learning and teaching approach specifically for the purposes of engineering education. By bringing together the concepts of Relationships, Variety & Synergy, underpinned by the notion of Scholarship, this paper makes a distinctive contribution to engineering education. In doing so it offers an innovative and accessible learning and teaching approach that it is hoped will encourage colleagues to engage with the Scholarship of Engineering Education.

Introduction: Learning & Teaching in Engineering - The UK Context

Within today's globalized society, engineering has shifted from being the scientific and technical mainstay of industrial and more recently digital change, to become what is arguably the most vital driver of future societal advancement. In order to meet the challenges and expectations required of such an unprecedented role, there can be little argument that engineering education has to change. When considering university education as a whole it would seem that in the UK, the quality of teaching is constantly subjected to high levels of public attention - most notably in the context of the National Student Survey (NSS, 2011) which puts the UK Higher Education Sector under the spotlight on an annual basis. More recently, the new [Education Policy] White Paper 'Students at the Heart of the System' outlines the UK Government's expectation that in the near future there will be "a renewed focus on high quality teaching in universities so that it has the same prestige as research" (BIS, 2011, p 2). Looking specifically at engineering education, it is evident that the discipline 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 (CBI, 2008; Bawden, 2010). The result of this is that many employers are being forced to look overseas to fill engineering vacancies (Spinks et al, 2006). Indeed, engineering is one of the few

shortage occupations identified by the Home Office as an area where employers may choose to recruit and sponsor overseas (non-European) workers (Home Office, 2010). 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 programs (RA. Eng, 2007; Engineering Council, 2010; Royal Society, 2011). Conversely, at the same time that 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 & Mattis, 2007; NSF, 2009). It may be argued that the image of engineering education programs 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 (RA. Eng, 2008, 2009). Thus, the questions of how to encourage more young people from all backgrounds onto engineering programs, and then, once they've enrolled, of how to keep them engaged, represents 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 et al, 2006; RA. Eng, 2008).

The Scholarship of Engineering & Engineering Education.

It is important to note that engineering education is not alone in being subjected to public attention regarding the quality of teaching. Contextualized by what may be described as the massification of higher education, debates focusing on problems pertaining to student retention, and questions regarding quality in teaching and learning have, over the past two decades or so, been widely discussed in the literature (see for example, Barnett & Coates, 2005; Biggs, 1993; Prosser & Trigwell, 1999). 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 an engineering education context.

The first area, the scholarship of discovery comes closest to 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 incorporates 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 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 specialities in larger context* (Boyer, 1990, p18). 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* (p 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 is that of application (1990). 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-based 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* (p 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 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* (1990, p 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 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 (1990, p 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 (see for example, Jenkins et al, 1998; Robertson & Bond, 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, p 53) the debate regarding the relationship between research and teaching continues. Developing this debate one stage further, 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; Elton, 2005) represents what for many appears to be 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 the discipline needs to become standard practice.

The SEER Project: Scholarship in Engineering Education Research Project

Project Rationale

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

Relationships + Variety + Synergy = Environment for Success (R + V + S = Success)

This approach captures the argument that the required outcome of any learning and teaching encounter is success – for both the student and the teacher. The main challenge faced by engineering educators is how to create a learning environment in which such success can be achieved. Based on pedagogical theory and research, and encapsulating one of the author's own experiences both as a professional engineer and engineering educator,

the 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 & 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 also 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 numbers of student 'dropping out' (Read et al, 2003; Quinn, 2005; Garner, 2007; Pitman & Richmond, 2008). By purposefully encouraging students to develop supportive scholarly relationships through the use of purposefully designed pedagogic activities, including those based around regular and project work, the RVS approach provides an active learning environment in which students not only gain from developing friendships 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 & 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 significant within the discipline context, yet appropriate to the task in hand both for

teaching and assessment (Prosser & Trigwell, 1999; Fry et. al, 2009). In engineering education there are numerous opportunities to introduce variety into the curriculum inside the university setting with laboratories, manufacturing, simulation and much more for teachers to choose from.

Finally, in order to achieve a Synergenic (S) learning experience, the concept of constructive alignment (Biggs & Tang, 2006) was built upon in such a way so as to achieve Synergy not only within and across the curriculum, but also across 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 (RA Eng. 2007; Leitch, 2006; Spinks et al., 2006) 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 discipline specific skills as well as more transferable generic 'softer' skills. Additionally, the concept of Synergy in engineering education relates to a Synergenic 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 CDIO approach of conceive, design, implement and operate' (CDIO, 2011).

The uniqueness of the RVS approach is that it brings together all three distinctive components together in an empirically grounded, yet practically applied manner. By 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 not only in the measurable outputs of education (student results), but also in what is observed to be a notable growth in student understanding of key concepts and theories.

Having developed the RVS approach, the program lecturer set about introducing it into his teaching. In order to empirically evaluate the success and appropriateness of the approach it was decided to employ a social research to conduct a pedagogical research study. This paper is result of the subsequent collaboration.

Project Approach

- **Introducing RVS to Engineering Education.**

The RVS approach was first introduced into an Engineering Project Management offered at Graduate Level as part of a MSc in Engineering Management. Prior to redeveloping the program, student feedback for the previous three years was analyzed. 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) conceptualization of scholarship, the program lecturer considered in some depth how the RVS approach could best be introduced and embedded into the curriculum. From the onset, the idea that *Relationships* form the basis of a positive learning environment directed the lecturers approach. Focusing on the *relational* aspects of the learning environment he redeveloped the course materials in such a way so as to promote a sense of belonging and cohesiveness between the students, the lecturer and the program content. A 'tutorial' approach to learning and teaching was written into the curriculum in which students are given individual attention and encouragement. Active learning approaches, based upon group and project work are used to encourage students to form their own support networks and groups.

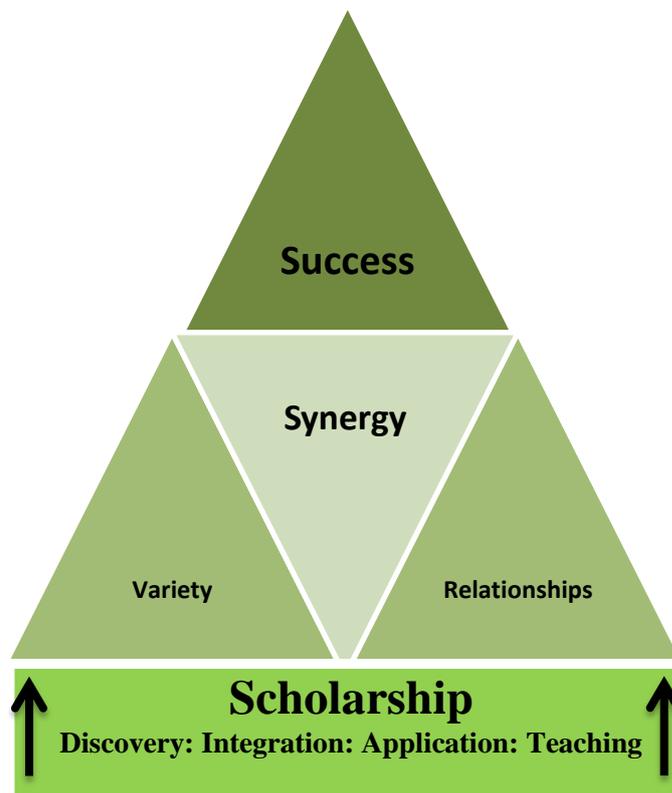
Concurrently, the concept of *Variety* was incorporated within and across the curriculum by 'thinking out of the box – and out of the classroom'. This involves integrating 'Engineering Heritage' into the curriculum; firstly as a learning and teaching tool to provide the engineering content and context for a graduate level engineering project; and secondly 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. Learning approaches used include fieldtrips, group projects, short films, traditional lectures, role-play and real-life case-studies. The concept of *Synergy* was achieved by aligning the learning and teaching tools with the RVS approach, and by building into the curriculum the expectations and requirements of professional bodies and employers. In this way the module provides students with a *Synergic* learning experience in which the module outcomes are constructively aligned with the overall program outcomes and with other external drivers such as employability. Furthermore, in order to achieve Synergy in learning and teaching, and in the critical evaluation of the RVS approach, the authors worked together to develop a conceptual framework upon which the evaluation of the RVS approach is built.

- **Conceptual Framework**

Defined as *'the basis of analysis'* Strauss & Corbin (1998) argue that concepts represent the *'building blocks of analysis'* (p 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 conceptualism arguing that... *'The conceptual dimension is held to be logically an objective necessary condition in all determination of knowledge'* (p263).

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: Conceptual Framework: The Scholarship of Engineering Education



The above conceptual framework shows that student success is achieved by integrating the concepts of Variety and Relationships in a Synergenic manner that is underpinned by the concept of Scholarship.

Critical Evaluation of the RVS Approach

- **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 first stage of the research comprised non-participatory, overt observations. Utilizing the conceptual framework, an observational schedule was developed and used to make a contemporaneous record of the students' learning experiences. Two distinctive sets of observation took place with two separate cohorts of students.

Based upon the conceptual framework, the 'observational schedule' was used as a basis for a qualitative record of students' learning on two separate fieldtrips in which the 'Heritage of Engineering' 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 and analysed using a grounded theory approach.

Both fieldtrips 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 fieldtrip because of its rich engineering heritage. The first stop of the fieldtrip was the Clifton Suspension Bridge just outside the city.

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 findings from the observations were analysed using a grounded theory approach (Strauss & Corbin, 1998). 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.

Research Findings

- **Stage 1: Observations**

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 with much of the infrastructure reliant on Brunel's railways, bridges and tunnels. The second part of each of the fieldtrips was to the ss Great Britain, which is moored in 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).

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 range of cultural backgrounds was diverse across the two cohorts with students originating from 17 different countries. Upon arriving at the Clifton Suspension Bridge, both cohorts of 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 contextualize both the historical and contemporary significance of the bridge. The discussion and debate was 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, on each occasion, they 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. It was interesting to note that, in both cohorts, 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 sociological benefits resulting from its completion.

The second part both fieldtrips was to the ss Great Britain. Upon 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 a prior arranged presentation by the exhibit manager. *Breaking into small groups the students were observed linking their classroom learning to the real-life example that was before them. They appeared equally interested in the external engineering of the ship as they were with its internal make-up (notably, the majority of students in both cohorts seemed particularly taken with the engine rooms). Discussions centered 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 both cohorts were able to contextualize their learning in a 'real-life' setting. Conversely, although most of the time was spent looking at the 'engineering' aspects of the ship, the crew and passenger cabins sparked 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 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 speakers to gain more insight into the project and the broader project management profession. The researcher's final narrative following the observations of the first cohort 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”.

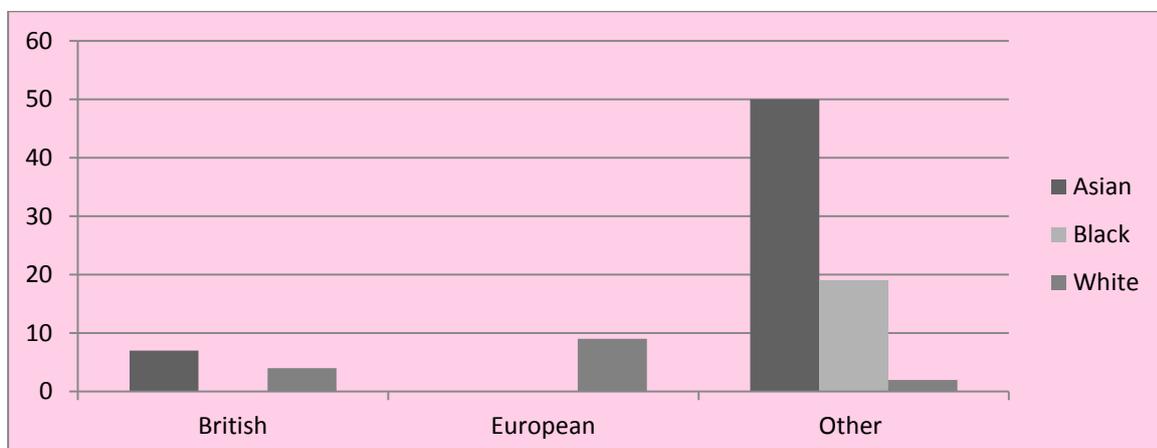
- **Stage 2: Questionnaire Focusing on Students’ Perceptions of the RVS approach**

The questionnaire was divided into four main sections: Demographics (including work experience): Relationship questions: Variety questions: and, Synergy questions.

Sample Demographics

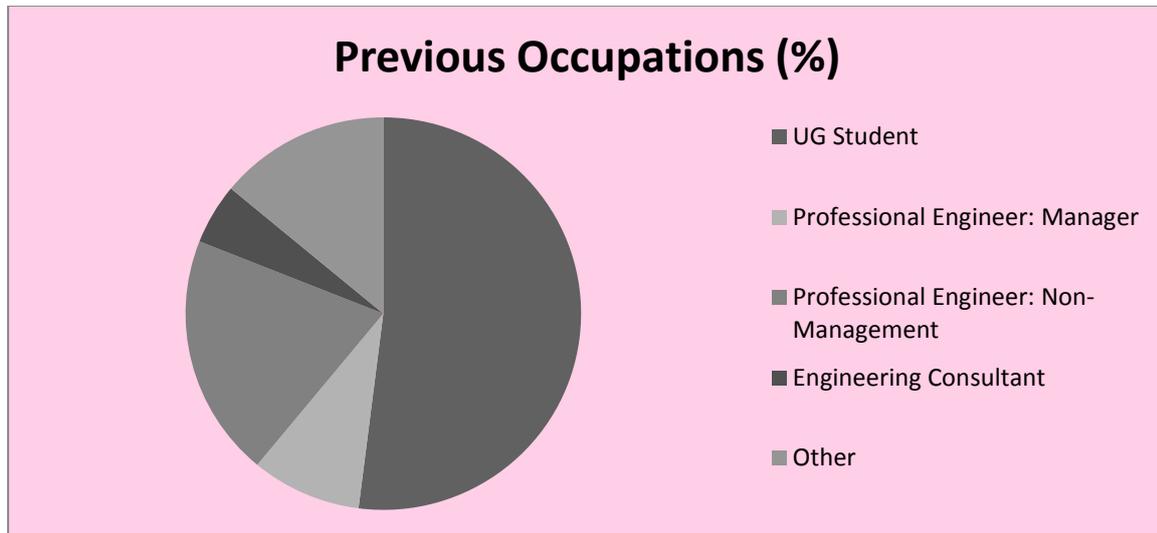
The questionnaire was administered to a total of 90 students. The response rate was high with 86 responses were received across the two cohorts. With regards to gender, 65 of the respondents were male, 21 were female. The students originated from 17 different countries across the globe. The students were asked to define their ethnic background. The data was coded and simplified into 3 primary categories, Asian, Black, and White. Each category was then further sub-divided into British, European and Other. Figure 1 below shows that half of the sample were of Asian ethnicity from a Non-UK / EU background.

Figure 1: Students’ Ethnic 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 2 provides an overview of the sample's work-related antecedence.

Figure 2: Students Previous Experience



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

- **Relationship Questions**

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 3. 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 questions were:

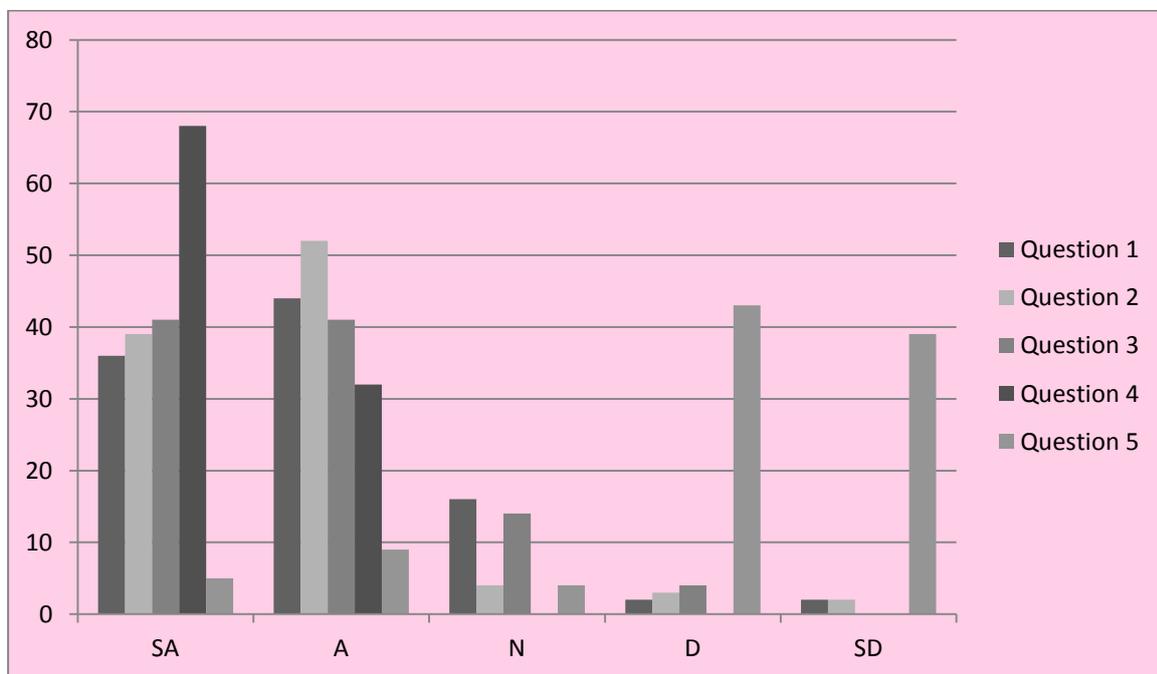
1. The group work in the module has enabled me to build some close friendships
2. The group work has provided the opportunity for me to develop my communication skills
3. Working with others on the same course has helped me understand the main issues

4. The module lecturer has been approachable throughout the module
5. I found it difficult to work in a group.

The results of the 'relationship' questions show that the manner in which the program 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 sample.

Figure 3: Student Perceptions in Relation to 'Relationships' (Percentages)

SA – Strongly Agree: A – Agree: N – Neutral: D – Disagree: SD – Strongly Disagree.



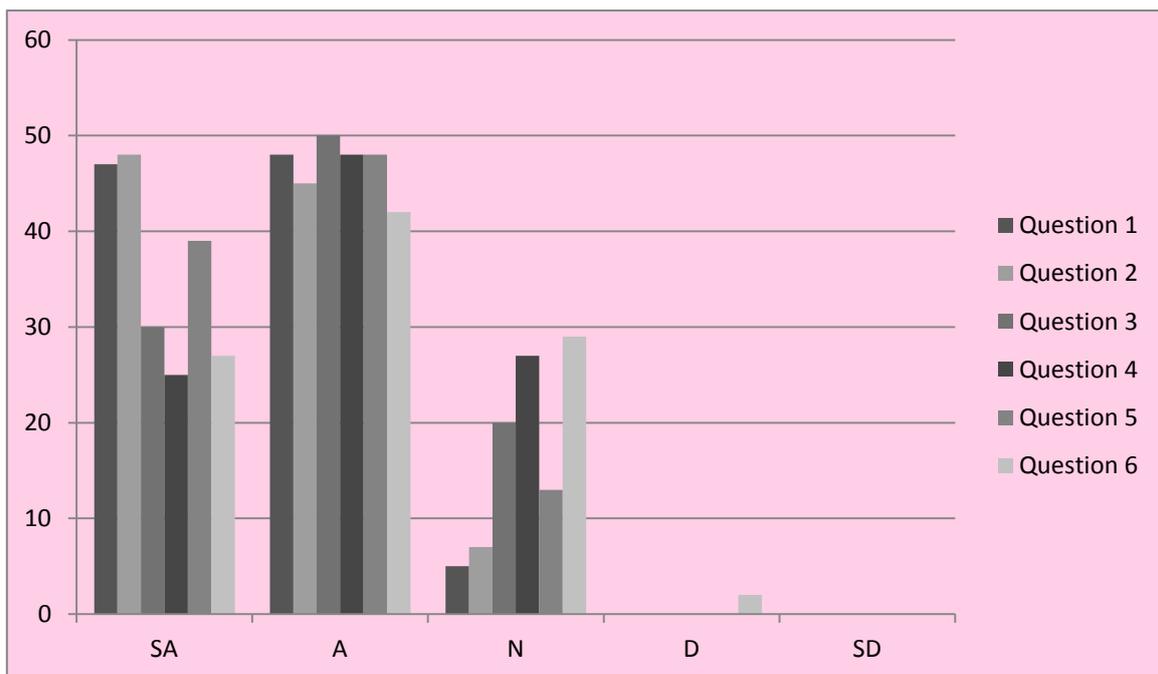
- Variety Questions

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 classroom / laboratory, the lecturer put together a varied curriculum which placed student learning at the centre. For Variety the questions 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.
6. The fieldtrip made me think about my own approach to project management.

Figure 4: Student Perceptions in Relation to 'Variety' (Percentages)

SA – Strongly Agree: A – Agree: N – Neutral: D – Disagree: SD – Strongly Disagree.



The results of the variety questions show that the VRS approach to learning was overwhelmingly perceived positively by the students.

- Synergy Questions

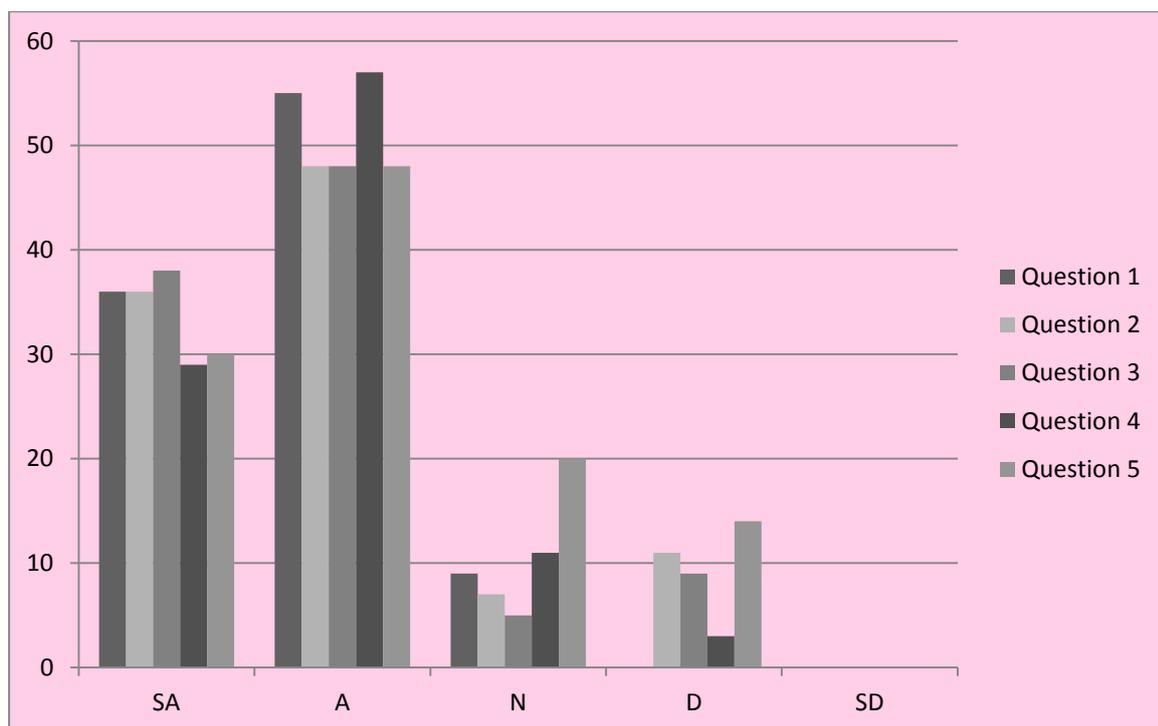
As previously discussed, the adopting of a Synergenic approach to learning and teaching was developed out of Biggs' concept of 'Alignment' by taking into account the wider aspects of

the Scholarship of learning as applied to engineering education (Biggs & Tang, 2007). Thus the program was designed in such a way so as to meet student expectations whilst fitting in with academic, professional, industrial and societal demands. The questions 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
5. The fieldtrip has brought to life the theoretical and practical issues surrounding Engineering Project Management.

Figure 5: Student Perceptions in Relation to 'Synergy' (Percentages)

SA – Strongly Agree: A – Agree: N – Neutral: D – Disagree: SD – Strongly Disagree



The survey results suggest that by adopting a synergistic approach to learning and teaching, the module lecturer had put together a program that allowed the students to conceptualise the theoretical underpinning of the course in such a way that brought 'learning to life'.

Discussion & Conclusion

In developing and critically evaluating the RVS approach the paper authors 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. This has been achieved by moving away from the complexities and seemingly idiosyncratic language manifest across pedagogical and sociological disciplines towards a more engineering 'friendly' and appropriate model which has been tried and tested in the engineering classroom. The module upon which the RVS evaluation has been based has a pass rate. Student feedback indicates that the RVS approach works by providing with a supportive, interesting and interactive learning environment. The RVS approach inspires student engineers to engage with their own learning; levels of attendance in sessions are consistently over 90% with students making the most of the range of learning opportunities provided.

By providing a learning environment which deliberately takes account of engineering perspectives, the RVS approach is fundamental to student success. Experience of using the approach has shown that it is ideal when dealing with threshold concepts (Land et al. 2008). By encouraging students to develop strong collegial relationships and work together to critically analyse and solve engineering problems by looking at them from a variety of different perspectives, synergy in learning occurs - ultimately promoting success.

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 utilizing the RVS Portfolio. 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.

Conclusion

In conclusions, as a discipline engineering has never been so important to society. Whilst it may be argued that the discipline has long played a central role in societal advancement, underpinning the agricultural, industrial and more recently the digital revolutions, society's

need for highly motivated and educated engineers has arguably never been greater. Conversely, the demands placed on engineering education to produce the next generation of engineers, are, in the UK at least countermanded by reductions in university funding and increased student demand and expectation. The RVS approach has been developed over a number of years to provide an approach that is both accessible to engineering educators and underpinned by scholarship. The authors contest that this approach offers the means by which engineering educators can tackle the challenges of the contemporary university environment in such a way so as to promote and enhance engineering students learning.

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