Innovating Engineering Education: The RVS Approach: An Empirically Grounded Method to Improved Practice and Enhanced Student Experience

Clark, R [1]
Aston University
Birmingham
UK

Andrews, J
Aston University
Birmingham
UK

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INTRODUCTION

The RVS Approach

This paper builds on previous work (Clark, 2009; Clark & Andrews 2011, 2014) to continue the debate around a seemingly universal question…*"How can educational theory be applied to engineering education in such a way so as to make the subject more accessible and attractive to students?* It argues that there are three key elements to student success; *Relationships, Variety & Synergy* (RVS). By further examining the purposefully developed bespoke learning and teaching approach constructed around these three elements (RVS) the discourse in this paper links educational theory to engineering education and in doing so further develops arguments for the introduction of a purposefully designed pedagogic approach for use in engineering education.

1. Background

Bridging engineering practice with education theory to make it accessible for a global audience of engineering educators is not easy. However, one sociological ideology which is particularly suited for this task is that of Structural Functionalism which views society as a complex system of social structures which, when working together, produce a unified and productive culture (for further discussion see Parsons, 1975, Giddens 1984). As a discipline, the functional nature of engineering means that it has long played a key role in the development, and hence structure, of our society. Nonetheless, it may be argued that over the past century, engineering advancements have seen the profession evolve from being the cornerstone of industrial change to become what is possibly the most important driver of future societal development. At the core of such progression, and imperative to future sustainability, lies engineering education. Key to preparing upcoming generations to meet the needs of future society, the function of university level engineering education in innovating and building future societal structures should not be understated. Yet, despite the integral role that engineering innovation has played in sparking the digital revolution many Higher Education Institutions across Europe continue to struggle to recruit and retain students on to undergraduate engineering programmes with poor teaching often being cited as one of the reasons for high levels of attrition in engineering (RAEng., 2007; Engineering Council, 2010; BIS, 2011; Royal Society, 2011). In looking objectively at the reasons for this, it is not unreasonable to postulate that many university level engineering educators find pedagogy as a discipline to be inaccessible, in that it is full of unfamiliar and seemingly irrelevant sociological language and terminology. Hence few colleagues seek to actively engage with contemporary pedagogic practice and innovation much beyond any professional requirements their institution may demand. Whilst pedagogic practice is one issue currently faced by engineering education, the actually content of the curriculum is another. Indeed, a number of prominent Professional Bodies argue that graduate level engineers often lack the necessary skills and competencies required to succeed in industry (CBI, 2008; Bawden, 2010; Groom, 2014; Harris, 2014). Additionally, in the UK Engineering Faculties find themselves increasingly open to public scrutiny with the National Student Survey annually sparking debate and discussion around the student experience (NSS, 2014)

- **The History of RVS: A New Way of Looking at an Old Problem**

In seeking to bridge pedagogic innovation and good practice with engineering education one of the paper authors set about developing a teaching approach that would be both accessible to engineering colleagues and capture the main tenets of the relevant pedagogic theory (see Clark, 2009). Bringing together three distinctive concepts, Relationships, Variety and Synergy, a model of engineering education shaped and informed by experience began to take form. A number of pedagogical studies were undertaken in an attempt to identify the value of the three concepts individually and the RVS approach as a whole; and, collaborating with a social scientist, the notion that engineering education has a vital function to play in promoting societal change and innovation soon became a central tenet of the approach (for further details with regards to the underpinning research see Clark & Andrews, 2014). From a theoretical perspective one key theory, that of Scholarship, emerged as being particularly relevant to the approach.

2. Scholarship & Engineering Education – The Way Forward?

Previous work by the paper authors (Clark & Andrews, 2014) draws attention to the link between student retention in higher education and the quality of learning and teaching (for further discussion in this area see, for example, European Commission, 2013; Harvey & Williams, 2010; Tinto, 2010; Barnett & Coates, 2005; Biggs, 1993; Prosser & Trigwell, 1999). From an academic perspective 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). In developing the RVS approach each of these is considered not only integral to academia as a whole, but also vital to an engineering education. The following paragraph revisits Boyer's arguments linked Scholarship to engineering education contextualizing the key arguments in such a way so as to provide a solid foundation for the RVS approach.

The first area of Scholarship conceptualized by Boyer comes closest to the concept of research and is thus generally perceived to be integral to academic life. From an engineering education perspective, the Scholarship of Discovery is reflected in the pursuit of knowledge required to conduct scientific research, not only within an engineering context, but also within an educational setting – taking appropriate steps to assure engineering teaching, like engineering practice, is grounded in solid research findings and critique. Associated with the Scholarship of Discovery is the Scholarship of Integration. However, whilst the Scholarship of Discovery considers *what* it is we want to find out, the Scholarship of Integration is manifest in *connectivity across the disciplines* with each area of expertise placed within the larger context. Within an engineering education environment the Scholarship of Integration is particularly useful as it encourages both teachers and learners to look beyond traditional disciplinary boundaries in a way that is *imaginative*, *interdisciplinary, interpretive* (and) *integrative* (Boyer, 1990, p 21). Through blending the practical engineering expertise and scientific epistemology of one of the paper authors with the sociological expertise and socio-political ontology of the other, the foundations of a cross-disciplinary approach emerged into which the third area of Scholarship, that of Application, was neatly slotted. Representing the cornerstone of work-based and active learning, Boyer's argument that the Scholarship of Application necessitates the acquisition *and* application of practical skills and insight, resonates with the overall aim of the writers approach to engineering education; hence it represents an important aspect of the strategy outlined below. Having considered the first three elements of Boyer's approach to Scholarship in some depth, the paper authors set about developing a model of engineering education which allowed them to take the fourth element of Scholarship, that of Teaching and actively apply it to an engineering education setting. In doing so the below approach combines three distinctive concepts, Relationships, Variety and Synergy to provide an innovative, yet uncomplicated scholarly model that can be easily adopted and adapted by colleagues working in any area of engineering education.

Discussion: RVS = S^2: Relationships + Variety + Synergy = Student Success.

As previously noted, the evidence base underpinning the RVS approach is discussed in some depth in recent publication (Clark & Andrews, 2011, 2014). Building on this discussion, the concept of Scholarship is contextualized by wider higher education theory and engineering education research. However, perhaps most important is the fact that the RVS approach encapsulates the authors' first-hand experiences in engineering, social science, educational research and teaching. Aligning with the argument that the purpose of higher education is to promote 'student success' (Thom, 1997; Berger, 2001; Upcraft et al, 2005; Kuh et al, 2006; Tinto, 2006), the notion of independent learning and *self-authorship* in higher education (Kegan, 1994; Baxter Magolda & King, 2004; Hodge et al, 2009) is integral to the way in which student success is defined for the purpose of the RVS approach. It should be noted that this definition is in fact a frequently evaluated and refreshed to capture ongoing research based discussion…

> *Successful engineering education requires high levels of individual self-discipline as well as the ability to work well in cross-disciplinary teams. Successful graduate engineers should be capable of applying generic and technical knowledge, skills and competencies in a manner that is practically sound, innovatively driven and theoretically grounded.*

Within the context of the above definition, the main challenge faced by engineering educators is how to create a learning environment in which such success can be achieved. It is this fundamental question that the RVS approach aims to address. Engineering education is notoriously 'difficult', indeed, students need to apply themselves academically and practically from the moment they start their undergraduate studies. More importantly, the applied nature of engineering means that there is a need for engineering education to provide an environment in which individual student identity's as *professional engineers* can be nurtured. The centrality of students' self-perception in terms of how they associate with engineering represents a key factor in how learning is approached. In developing the RVS approach the paper authors looked holistically at engineering education, purposefully synthesizing the concepts of Scholarship and 'Self-Authorship' to provide the underpinning ethos to the RVS= S^3 approach. Like the different elements of Scholarship, Self-Authorship was initially considered as an individual entity. Identified as being particularly relevant to engineering education, the notion of Scholarly Self-Authorship within the engineering learning environment requires a mature approach to independent learning, requiring students to recognize the value of self-motivation, teamwork and other generic transferable skills (Baxter Magolda & King, 2004).

Having discussed the underpinning basis of the RVS=S^3 approach as an holistic entity, it is important to explore and rationalize the three distinctive components of the approach; *Relationships, Variety and Synergy.* Previous research suggests that within higher education *relationships* play a crucial role in promoting a positive learning experience and as such need to be valued and nurtured (Baxter-Magolda & King, 2004; Barnett & Coates, 2005; Cowan, 2006; Cornelius-White, 2007; Foster, 2008). Furthermore, recent work by the paper authors looking at the experiences of around 1,000 UK undergraduates (from across a wide-range of disciplines) found that relationships are key to addressing issues pertaining to retention and transition (Andrews & Clark, 2011; Clark et al, 2013); indeed, by engendering a ‘sense of belonging’ universities can do much to prevent high numbers of students ‘dropping out’ (Read et al, 2003; Quinn, 2005; Garner, 2007; Pitman & Richmond, 2008). Questions of *how* to promote positive working relationships within the engineering education environment are fundamental to the value of the RVS= S^3 approach. Like the majority of colleagues, the paper authors have experienced difficulties in managing student ‘group work’ encountering issues amongst group members associated with cultural misunderstandings (Montgomery, 2013; Rienties et al, 2013), communication breakdown (Brockhorst, 2013; Freeman & Greenacre, 2011) and conflict between individuals (Oladiran et al., 2011; Nordstrom & Korpelainen, 2013). In looking objectively at the issues, the need to encourage students to develop supportive and mutually beneficially relationships as soon as possible is evident. Thus, by focusing firstly on the need to nurture positive relationships amongst the students, the RVS=S^3 approach necessitates the development of programme materials that build on individual strengths whilst promoting group cohesion. Whilst the ‘active learning’ approaches frequently utilized within engineering education provide the ideal means by which colleagues can encourage students to develop friendships and supportive networks, the role that Faculty play in promoting a positive learning environment through building positive scholarly relationships with students is also key to scholarly student success within the RVS=S^3 approach.

The second component of the RVS formula, *Variety* firstly relates to innovation in learning and teaching and takes account of the wide-range of different ways in which students learn (Entwistle & Ramsden, 1982; Entwistle, 1991; Biggs, 1993; Cuthbert, 2005). In engineering education there are numerous opportunities to introduce *Variety* into the curriculum inside the university setting with laboratories, manufacturing, simulation to name but a few. However, within the RVS approach *Variety* is about far more than simply exposing students to different learning environments and approaches it is about providing them with the means by which they will be able to tackle the variety of practical engineering problems they will encounter in the future. Fundamental to this is the authors’ belief that one of the main functions of engineers and engineering is to act as a bridge between between Science and Society (RA.Eng, 2010), hence the need to equip student engineers with the skills and abilities to sustain this link is vital.

The final element, that of *Synergy* is viewed as being both an *Engineering Education Catalyst*, sparking innovative learning and teaching within the discipline, but also as a *Scholarly Glue*, binding together academic, professional, industrial, individual and social factors. Synergy is initially achieved by purposefully aligning the intended learning outcomes with the teaching tools and approaches (Biggs & Tang, 2006), taking account the demands of professional bodies and expectations of industry (RAEng. 2007; Leitch, 2006; Spinks et al., 2006). Ontologically, the approach promotes positive and collegial working relationships within engineering education settings, encapsulating students’ individual and collective epistemologies through a variety of means which maximize scholarly success.

3. Concluding Remarks: Questions for Discussion and Further Research

This paper set out to continue the discussion about the RVS approach (Clark & Andrews, 2014) and in doing so provide colleagues with a further understanding of the underpinning language and philosophy of the approach. Notably, in developing the discussion, the paper has seen a slight enhancement to the approach with the emphasis on student success being expanded to capture scholarship in a more focused manner. Additionally, the definition of success proposed in this paper takes builds on previous conceptualisations of success to articulate success as being both student and graduate focused. Bringing together the issues discussed in this paper with previous research and dialogue (Clark, 2009; Clark & Andrews, 2011, 2014) a number of questions are raised which will form the basis of ongoing research and critique:

1. How can the RVS approach be further developed so as to meet the needs of contemporary and future engineering education?
2. How suitable is the approach for use in engineering education management?
3. Is RVS transferable across disciplines including non-engineering focused subjects?
4. What is the best way of collecting evidence to support the development of the RVS approach?
5. Is any single one concept more relevant than the others in terms of engineering education?

In conclusion, the purpose of the RVS approach is to make pedagogic theory and practice more accessible and relevant to engineering educators. In doing so it is hoped that the approach will provide a model of engineering education that colleagues may adopt and adapt for their own purposes.

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