And God Made Engineers! Is 'the knack' innate or taught?
An analysis of Students' Learning Journeys

R.P. Clark[1]
Associate Dean Learning & Teaching
School of Engineering & Applied Science
Aston University
Birmingham, UK.
r.p.clark@aston.ac.uk

J.E. Andrews
MSc Programme Director
Engineering Systems Management
Aston University
Birmingham. UK
j.e.andrews@aston.ac.uk

Conference Key Areas: Engineering Education Research: Lifelong Learning: Internationalization

Keywords: Research: Distance Learning: Reflection: Learning Journeys

1. INTRODUCTION

Starting with the research question 'Are Good Engineers Made or Born?', this paper draws upon the findings of a narrative analysis of a piece of coursework submitted by 35 MSc Professional Engineering students during the first part of a distance learning programme. The coursework, which comprises a 3,000 word 'Evaluative Review' requires the students to provide a reflective account of their 'learning journey' into engineering through to when they begin their MSc. In analyzing each narrative account the researchers gained a depth of insight into the different learning encounters, events, enablers and barriers faced by the students as they progressed from school to university and through to employment. Following a phenomenological approach four key '*Engineering Life-Points'* influencing and impacting students' journeys towards becoming a Professional Engineer, were identified. These were: *Engineering Imagination: Engineering Awakening: Engineering Endeavours: Engineering Self-Awareness.* This paper explores these four '*Engineering Life-Points'* in the context of engineering education in an attempt to discuss whether engineers are 'born' or 'made'.

[1] Corresponding Author
R.P.Clark
r.p.clark@aston.ac.uk

1.1 Background: The Master's in Professional Engineering by Work-Based Learning.

Developed as part of a Government funded Gateways initiative led by the UK's Engineering Council (EC) the MSc Professional Engineering by *Work Based* Learning was constituted as a collaborative venture between Higher Education and Industry. Guided by the "EC Guide to Professional Engineering", each university offering the programme, whilst conforming to the framework, has subsequently developed their own curriculum and delivery methods.

Managed and delivered by the School of Engineering and Applied Science, the Aston University MSc Professional Engineering (MSc Prof Eng) program, which is not attached to any specific department or engineering discipline, was developed in 2010. Designed in accordance with UK-SPEC and in line with the Engineering Council's output standards for accredited degree programs, the MSc Prof Eng. is both multidisciplinary and flexible in nature; meaning that it is able to meet the bespoke professional requirements of individual engineers and their employers from a range of backgrounds and technical disciplines. Completion of the program does not guaranteed Chartered Engineer status, rather this is dependent on an individual being able to demonstrate the required competences.

Following enrolment, student engineers take 5 core and 4 elective modules, all of which are underpinned by the concepts of problem and project based learning. Developed so as to acknowledge the fact that engineers increasingly find themselves asked to solve a number of complex, global issues such as those related to global warming, sustainability and pollution[1,2] the MSc Prof Eng. provides engineering students with the high levels of transferable skills and competencies expected of contemporary professional engineers. In doing so, one of the key aspects of the programme is that right from the onset it encourages 'out of the box thinking'. Indeed, it is such 'thinking' that underpins the first part of the programme, the Evaluative Review.

1.2 The Evaluative Review (ER)

In seeking to investigate whether "good engineers are made or born", this study is grounded in the findings of a phenomenological study which involved a critical analysis of 35 Evaluative Reviews (ERs). The inaugural piece of coursework for the MSc Prof Eng (Work Based Learning) programme, the ER requires students to provide a reflective and reflexive account of their individual learning journey. The importance of reflection in developing oneself as a professional was discussed as far back as the early 1930s by Dewey[3] , who in pointing to the value that experience has shaping the way we live our life argued that "... *all direct experience is qualitative, and qualities are what make life-experience itself directly precious. Yet reflection goes behind immediate qualities, for it is interested in relations . . ."* (p. 293). By starting with the Evaluative Review, the MSc programme begins in such a way so as to take students completely out of their 'engineering comfort zone'. It requires that students move beyond their normal engineering and science epistemology to reflect not only upon where they acquired such epistemology but also how it guides and informs their current thinking and decision making processes[4,5,6]. Likewise, the ER challenges students' ontological perspective, making them think in some depth about their individual life-experiences and how

such experiences have acted to shape and influence their subsequent learning journey.

Within their ER students are encouraged to provide evidence that they have looked at the underpinning social-science literature, particularly that relating to education, sociology, psychology and management. Deliberately positioned at the beginning of the MSc Programme, the ER acts both as a bridging 'course' between undergraduate and postgraduate level of study but also to enable those students who have not previously studied an 'English language medium' qualification to get to grips with what is required. Student engineers are encouraged to consider their own ontological and epistemological drivers and to think about how their current working life is influenced by their past experiences. Perhaps more importantly, within the ER, students are expected to articulate how they have learnt from past significant incidents and how such incidents may be used to guide, inform and enhance future decisions.

2. METHODOLOGY

This short paper further develops arguments presented in a previous paper in which the value of reflection and reflexivity within 'distance' professional engineering education was discussed[7]. Adopting an Action Research approach[8] and utilising a phenomenological research design[9] a narrative analysis of students Evaluative Reviews was undertaken. Working together the two researchers critiqued 35 ERs, a total of around 115,000 words. The reflective and reflexive manner in which the Evaluative Reviews are composed mean that they comprise a rich data source. Narrative analysis techniques, whilst time consuming, provided the opportunity for the researchers to identify and analyse how the students related their individual life-stories. Theming the data into different 'phenomenal strands the researchers gained insight into individual students *characters, events and happenings central to those experiences"*[10].

Confidentiality was maintained by anonymising the student accounts; whilst issues of reliability and validity were dealt with through the development of an 'analytical framework' which enabled the researchers to systematically breakdown, code and categorize[11] the individual student accounts into 'manageable' units of analysis[12]. Comparative phenomenal themes and sub-themes were identified before the data was critiqued. The result of this critique is found below.

3. FINDINGS

Building on previous work[7] this study identified four distinctive points within the student engineer's lives where engineering influences were particularly strong. These four-life points, which generally occur in a chronological order are: The sparking of the *Engineering Imagination* at an early age: A raised awareness of individual leanings towards the discipline in what for many was an *Engineering Awakening*: A personal struggle to develop that awakening within an educational setting that was beset by *Engineering Endeavours,* and finally: A professional awareness and pride in being an engineer during which *Engineering Self-Awareness* results in an individual identifying themselves, and taking pride, in being an engineer. Each of the four 'life-points' are now discussed within the context of the study.

The first life-point relates to early childhood experiences which act to *spark* an individual's *Engineering Imagination*. This life point was discussed in all but a few of the ERs with the students identifying key early experiences between the ages of around 4 to 10 years. The majority of the students described becoming aware of an innate interest in discovering how things work. Many described 'hands-on' childhood learning in which they were encouraged to develop their in-born interest by experiential learning through play. For a minority of students the initial engineering spark did not come from within themselves but was instead ignited by contact with, or awareness of, a role-model. Indeed, a number of the students described external role-models, famous engineers and scientists whose activities had sparked their *Engineering Imaginations*; whilst for others, the initial spark came from observing family members who participated in engineering activities.

The second life-point, *Engineering Awakening*, encapsulates events at junior or high school level whereupon those individuals who had not previously been aware of any interest in engineering suddenly became aware of an almost 'innate' leaning towards the discipline (both in a practical and academic sense). This time of *Engineering Awakening* was also described by many of those students whose *Engineering Imaginations* had been sparked at an early age, meaning that experiential learning through play suddenly became meaningful. A third group of students, experienced an *Engineering Awakening* a little later in adolescence as they pondered on which subject to study at university. Sparked by careers advisors or teachers, this smaller group had not considered engineering before this time. In referring to engineering in this context, it should be noted that in many cases the explicit definition of what engineering is about was not apparent to the students until a late stage in their *Awakening*.

The third 'life-point' is reflective of the fact that most of the students on the programme originate from developing countries. For many of the students *Engineering Endeavours* do not only describe the rigours of secondary education and undergraduate engineering programmes, but capture the efforts made by the students to become engineers. For some, such *Engineering Endeavours* are almost unimaginable for those of us in the developed world. One young male African student described walking hundreds of miles, begging and sleeping rough to get to an interview with an international oil company. Others had parents who sacrificed their own careers and comforts to enable their child to become an engineer. Both male and female students vividly described individual struggles on the journey towards becoming a graduate engineer. Some of the female students described gender based prejudices and other 'gender-based' barriers, such as lack of facilities for women within the organisations in which they were placed. Rather than turn them away from engineering, such barriers generally acted to strengthen the young women's resolve to become an engineer. The one common factor when comparing the overseas cohort against the UK cohort was the increased value and status of engineering outside the UK.

The final life-point *Engineering Self-Awareness* represents the stage at which the majority of engineers found themselves at upon enrolling in the Master's Programme. For many, the ER is the first time that their asked to reflect upon their own strengths and weaknesses as practicing engineers. For some this task is incredibly difficult, with one or two students finding themselves rewriting their ER four or five times. Most however, agree that the experience is worthwhile as in reflecting upon their own professional development they are able to consider in some depth how they have

developed and grown into the profession. The common starting point for many ERs is a very descriptive account and it takes some effort on the part of students and teachers to develop the deep reflective account that the ER requires. A typical piece of early feedback common across many submissions would be;

You need to move away from simply describing situations and explore more deeply what caused them to happen, how you acted, what went right / wrong and of course what you learned, not simply technically, but about yourself and the skills you were developing.

4. DISCUSSION

The four life-points identified in this study reflect individual engineer's journeys towards becoming professional engineers. For the majority, irrespective of gender or where they live in the world, becoming an engineer was not an 'easy option'. Indeed, for most students the journey into engineering represented a personal battle in which social, economic and educational barriers had to be first identified and then overcome.

The first life-point identified in the analysis, those early childhood experiences which act to *spark* an individual's *Engineering Imagination* was discussed by over two-thirds of the cohort. These students seem to have been born with 'the knack'; indeed some of them described themselves as being a 'born engineer'. An enquiring mind, together with an individual need to discover how things work, are two personality characteristics described within the ERs.

The second life-point, *Engineering Awakening*, was described by the majority of the students, most of whom had displayed 'engineering tendencies' from a very young age having had their *Engineering Imagination* 'sparked' some years earlier. For these students, high levels of ability in maths, physics and practical based subjects provided the context for their engineering interests. For a small number of students, the *Engineering Awakening* did not occur until their abilities were recognized by others who suggested to them that they should consider engineering as a career. It is difficult to tell whether these students were born with innate abilities towards engineering or whether they such skills as they progressed through school. What is certain is that almost all of the students exhibited high levels of ability in maths and science whilst at school. The exception to this was, perhaps not surprisingly, those students who had entered engineering at the technician rather than degree level (within the study such students originated from the UK).

All of the students had individual stories to tell about how they became an engineer. For some, the *Engineering Endeavours* they had to endure had little or nothing to do with the discipline itself but instead involved overcoming poverty, ignorance and in some cases political turmoil and social unrest. For these students, the journey towards engineering was steeped in an individual desire to become an engineer. Such students seemed to have no choice but to overcome the barriers as they felt drawn to become the engineers they were born to be. For the UK students the *Engineering Endeavours* tended to be more educational, with difficulties generally reflective of an education system that does not include engineering until further or higher education.

The *Engineering Self-Awareness* depicted within the ERs represented a real struggle for a minority of the students, whilst others appeared to grasp the concept of reflection once encouraged to do so. Looking objectively at the papers it would appear that those students who readily grasp the concept of reflection are the ones who describe in some detail early childhood experiences whereby their individual *makeup* and *Engineering Imaginations* meant they were destined to become engineers. These students, who represent the majority in this small sample, were undoubtedly born with the 'knack' … an innate ability to 'engineer'. The few remaining students, those who were not aware of any innate ability, became engineers as a result of their education or as a result of serendipitous life events.

5. CONCLUSION

In looking at the findings of the four *Engineering Life-Points*, it may be argued that engineers are both *born* and *made*. The majority of those engineers embarking on the Master's in Professional Engineering by Work Based Learning appear to have been born with the 'knack'. For such students, engineering was not so much as a life-choice but more their individual destiny. They were simply born to be engineers. For the other (minority of) students becoming an engineer was either a deliberate choice or reflective of educational circumstances.

In conclusion, irrespective of which group the students belonged to, one thing that the majority clearly had in common was a passion for the discipline; it was this passion that drove their individual *Engineering Ambitions* resulting in their enrolment on the MSc Programme. The hard work needed to get to where they are at the ER stage is evident throughout, so is the desire to do more and overcome the challenges identified in the individual narratives.

REFERENCES

[1] IMechE. (2009). *Education for Engineering: IMECHE Policy Summary*. London: Institute for Mechanical Engineering.

[2] RAEng. (2008). *Engineering.* House of Commons Committee on Innovation, Universities, Science and Skills. London. Royal Academy of Engineering.

[3] Dewey, J. (1934). *Art as experience*. NY: Pedigree.

[4] Moon, J. (2004). *A Handbook of reflective and experiential learning: Theory & practice.* London. Routledge

[5] Alvesson M. & Skoldberg G. (2000). *Reflexive Methodology: New Vista's for Qualitative Research.* London. Sage.

[6] Nightingale, D. & Cromby, J. (1999). *Social constructionist psychology.* Buckingham: Open University Press.

[7] Andrews, J., Clark, R. & Glew, B. (2011). "A Matter of Professionalism? Reflection and reflexivity in continuing engineering education and practice. *WEE. World Engineering Education Conference.* Lisbon. Portugal.

[8] Norton, L. (2008) *Action research in teaching and learning: a practical guide to conducting pedagogical research in universities*. Abingdon: Routledge

[9] Marton, F. & Saaljo, R. (1976). "On qualitative differences in learning – II outcomes as a function of the learners conception of the task". *British Journal of Educational Psychology.* 46.2. pp 115-127.

[10] Coffey, A. & Atkinson, P., (1996). *Making Sense of Qualitative Data.* London. Sage.

[11] Cousin, G. (2009). *Researching learning in higher education.* London. Routledge

[12] Cohen, L., Manion, L., & Morrison, K. (2007). *Research Methods in Education.* London. Routledge.

.