OCCUPATIONAL SOCIALISATION - A NEW MODEL OF THE ENGINEER'S FORMATION

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Abstract -- *We explore the formation of the engineer from school pupil selecting engineering as a career path to practising professional by drawing on survey evidence from undergraduates and recent Scottish graduates. It is not a smooth progression but a series of rather ill matched offices. The individual experiences dissonance in adjusting his self-conception to meet the demands of the environment and in revising his model of the profession. Some do not adjust and are lost to the profession. The entrant's naïve concept of engineering is predicated on a public image of an essentially practical occupation. The university portrays the professional dealing with theoretical models and imposes on them the "grade culture". Students attracted to practical work or unable to cope with assessment drop out. After graduation adjustment to employment brings further dissonance. Rather than highly theoretical modelling most deal with more "fuzzy" problem solving where "soft skills" dominate. Most make this adjustment but it disturbs their individual self-image. We propose that the engineer's formation requires the novitiate to make several radical adjustments to their self-image. A significant minority does not survive.*

Introduction; Professional Socialisation

The situation which prevailed until around the end of the eighteenth century where work for most was an integral part of home life has given way to a situation where for most it is compartmentalised and divorced from social life. Sociologists describe people as having "multiple group membership" and recognise that one's professional occupation forms an important part of one's personal and group identity. There is little recent work on this topic in any major profession. Our interest developed as we believed that the extent of professional identification of entrants to undergraduate engineering courses might prove to be a predictor of academic performance. We believed that strong identification would generate motivation to succeed and also might mean that the entrants already had more understanding of the technology. Our model with evidence derived both from our own researches and from the literature offers a plausible explanation although the link has yet to be proved.

Ginzberg [22] saw occupational choice as a largely irreversible process which takes place over a period of 6 - 10 years developing from fantasy, tentative choice at about the age of 11 to realistic choice at about 17. We doubt the realism as most school leavers are singularly ill-equipped with realistic knowledge of occupational roles. Super's [41] development took a whole life perspective with the tentative stage extending to about age 24, choice extending to age 44 and thereafter just being maintained. Individuals tend to enter an occupation which matches their image of self-identity [41] but choice is a compromise between the individual's preferences and the constraints of the demand for skills by the employment market, [20]. Hughes [24] view that " a career consists of a series of status and clearly defined offices, the moving perspective in which a person sees his life as a whole and interprets the meaning of his various attributes, actions and the things which happen to him" remains relevant today. In our model the entrants have already embarked on this evolution and clearly identifiable stages can be related to the situational stages through which they progress. The changes required may conflict with their conception of the "engineer". They may experience dissonance and attendant disillusionment and cause some highly committed entrants to be poor performers in undergraduate courses. To achieve the goal of professional status "you must generate an ambition that will sustain you through many years of preliminary training" [44]. The partition of professionalisation into stages, while not arbitrary, can be conducted in a number of different ways. Hall's [23] describes the medical profession as a progression from generating an ambition through gaining entrance to an institution and acquiring a clientele to developing a set of informal relationships with colleagues. This is not altogether appropriate to the engineer, few of whom will practice as independents. Our model reflects the major situational changes in the engineer's formation. Typically an engineer progresses from secondary to tertiary education without an intervening period of employment. After graduation some but probably a minority will enter a formal graduate training scheme. The majority enters directly to their first appointment and receive a greater or lesser degree of formal training within that post. For them the transition from graduate trainee to established engineer is likely to be

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anything but clearcut. Nevertheless these are the stages around which we have built our model.

Moore [34] suggests that "the specialist in his field must be supreme for who but another specialist can challenge him." We maintain that an expert is generally judged by his peers but a professional's competence is generally taken on trust by lay clients – hence the emphasis placed by professions on ethics and codes of conduct. Graduates face a mismatch between their education and the functions that they must perform e.g. [4], [34]. Schon [38] notes in particular that the problems engineers must analyse due to their complexity no longer yield to standard techniques. "Technical problem solving is a radically incomplete description of what engineers do (it becomes) understandable as a reflective conversation between with the materials of the situation." Are graduates prepared for this by their education? Describing the approach of Dean Wilson an engineer working in the third world Schon says "He has not expunged problem solving from his practice but has embedded it in relevant and *rigorous* reflection in action." (our italics)

The Model (Figure 1)

Our data had not shown that entrants in whom we could detect evidence of professional socialisation, of identification with their chosen profession performed better in their first year studies. We conducted a longitudinal survey of all years of our BEng (Honours) courses and recent graduates and a review of the literature. Our model, described below and supported by these investigations suggests the possibility of conflict between professional socialisation and student socialisation and later of the need to re-identify as an emerging engineer. We suggest that student culture is not entirely compatible with that expected of the professional engineer.

The Surveys

To test the validity of our model we surveyed by questionnaires all years of our current Bachelor of Engineering (BEng) students and recent graduates from the course. They were issued in class and so the response rates were 100% in all but year 2 where, due to classroom activities, the response rate was 72%. Informal interviews were also held with 14 students drawn from across the courses. Post graduate questionnaires were sent by post. Discounting 10% returned as "no longer at this address" and a further 25% overseas the return rate was 54% but as this constitutes only 13 valid responses conclusions drawn must be tentative.

The undergraduate questionnaires mainly used spectra of perceptions of courses. Students were asked to mark respectively on each (i) their preconception of the course before entry (ii) their present perception of the course now and (iii) their preconception of their occupational roles. They were also asked for a free form statement of their conception of the engineer's role before entering the course and now. Further questions sought to determine what were their best and worst anticipated and experienced aspects of university life.

Preconceptions, Conceptions and Anticipations Compared

Overall the students were anticipating a course which was more practical than theoretical, more individual than team, difficult but exciting and balanced between project and calculation. To explore how their experiences had matched up to these expectations we constructed a series of differences based on prior, current and anticipated scores. These differences were tested using the t-test. Where significant changes were detected in the progression from first to final year these are also discussed. Table 1 shows an analysis of these results.

We detected strong evidence that the respondents had found the course to be significantly less practical than they expected and that they deplored this aspect. They also found it significantly more boring and difficult than anticipated but despite freeform comments the dominance of calculation over project did not reach significance. Students in the early years found the course dominated by calculation while those in later years found more emphasis on projects, Graph 1. It surprised us that they had found the course more team based than expected this was explored further.

The students saw their careers as being somewhat more practical than their course but the difference did not reach significance. They clearly saw the role of the professional engineer as team and project based in comparison with the academic approach. They anticipated a more exciting life. Sadly this measure fell markedly amongst final year students. The extent to which the individual's view of the future was set before or since entering university is indeterminate however, the students in general seem to see their future as being closer to their prior expectations of the course than to its reality. They tend to see the future as more theory based but this did not reach statistical significance. The lone individual pursuing calculations now becomes team based project activity particularly marked in the later years in the course, Graph 2.

Factors anticipated and experienced -

The students' freeform responses required interpretation. More than half, when coming to the University, were most looking

forward to the course and learning particularly practical work and its relation to theory. They expected a lot of hands-on work, engines often being mentioned, and exploring theoretical concepts by group project work. Only 5 mentioned theory in isolation and 4 instanced problem solving skills. A number mentioned the challenge but as this was what we had termed the induction programme we cannot be certain of its interpretation. The second highest group of responses, rarely first mentioned or sole attraction, centred on social aspects such as meeting new people and campus life. It was noticeable that those who declared that they were anticipating qualifying, entering a career and earning money were predominantly third and fourth year students. Current perspectives have probably influenced their hindsight. Many of the students clearly saw entering University as a step on the road to adulthood. Leaving home, leaving school, being treated as an adult and independence were among the descriptors they used. The student who had come to University to "avoid work" would be disappointed at the effort demanded by the course and possibly part-time employment

Some of our distinctions may be artificial. Exams could be academic difficulty of the content or the hard work of "swotting"? Fears about the difficulty of exams may be analogous to "can I cope"? Together these 3 groups accounted for 82% of responses, entrants were obviously apprehensive (ii) about the difficulty of the course, the demands of assessments and their ability to meet these criteria. That 21% were dreading maths, a subject which most academics would say is the backbone of engineering, is a cause for concern. A third year student said "I really struggled in the first year….I had to work hard but it was tough!"

Described as "being poor" around 15% of the entrants were anticipating financial stringency. The need for part-time employment is often cited as the major cause of early casualty so this is relatively low. A small number mentioned their concerns about changing their social group, both leaving old friends and making new.

Students had most enjoyed the activity based practical work, lab work and projects which together account for 52% of the responses but they annotated their responses with comments such as "what little there's been" and "what happened to the practical guys?" A second year student said "I feel cheated! You showed us labs and told us it was a very practical course. All we get is calculation, calculation, calculation ... and boring lectures!!" Where, rarely, lectures were a "most enjoyed" item this referred to components of projects. 12.3% of students most enjoyed achievement, usually expressed as passing exams. The attractions of campus, the helpfulness of lecturer, campus atmosphere (11.4%) and social life (17.7%) were the other main groups. Many of those who had commented favourably on staff also listed poor staff attitudes as amongst the points they had most disliked. Clearly staff, like students, are a mixed bunch.

The least enjoyable aspects were also mostly course related. Lack of practical work (29%) or too much difficult theory (30%). Many students mentioned specific subjects but rarely was this mathematics. Course presentation (21.9%) was criticised, boring lectures, poor support material, unhelpful staff and poor organisation were mentioned. The amount and timing of assessment (24.5%) and its fairness (4.5) were concerns. Problems of self management were mentioned by only a handful of students and only 6 students commented on financial difficulties.

Student's free form comments and interviews reiterated concerns about the lack of practical, emphasis on calculation and hypothetical or abstract nature of examples which they could not relate to real life. "Everyone knows how to do calculations but not everyone know when and what applications to use them for" was a typical comment. Many commented on workloads and the difficulty of assessments. However they did not want less assessment. "It's what makes us work." one said "you have to feel you are getting credit or you don't get motivated." Another said it helped to distinguish the industrious and able student from others in the peer group. Another frankly admitted he was finding the course difficult but commented "I know they don't hand out degrees for nothing." Passing the course was seen as more important than learning for the future.

The image of the engineer and students comments. Students were asked to state what they had seen as the role of the engineer before they entered University and their current perception of the role. It is of course difficult to generalise from their fee form responses. The range of perceptions was broad. Views of the profession held by students before entry ranged from near certainty to complete ignorance. A number of students wrote "I had no idea." There appeared to be 2 main groups. Some saw the engineer as essentially practical and their views had undergone a major revision since entering University. Others had seen the role as more problem solving, theoretical design and "making things valued by society". Their views had undergone little adjustment. Many described the role as being challenging and "very appreciated in society." Another third year student described the engineer as "a fully responsible person" and others talked of the need for ensuring safety in engineering design. A majority of students described a practical hands-on role, sometimes coupled with the application of theory. They described an engineer as someone who "fixes engines", has "a technician's job except that it would involve paperwork" and "someone who did a lot of practical work, not a desk job." Almost all of these students had revised their opinions after starting the course. A first year student saw it as "much more professional and calculated", and another as "not much practical work. Has to be good at maths." This emphasis on the need for calculation, theory and office based work was very marked in first year responses. Uncertainty seemed more prevalent at year 2 where one student said "it is hard to

pinpoint the actual role of the engineer." More emphasis was on problem solving and innovation but there appeared to be an element of cynicism in several of the replies e.g. an engineer is "somebody who sits at a desk all day analysing one beam out of 1,000 that someone else has designed" and "a person using pen and paper instead of a computer." "This new professional engineer has no idea how to work a lathe ..." This was by no means universal as others felt the role was important and well regarded by society. There were still very mixed views in the third year but in general the responses had more of a ring of acceptance. Respondents frequently mentioned theoretical, calculation based design. Even emphasising the separation from the hands-on aspect, e.g. "designs machines, not maintenance!" and "predominantly design based but theoretical" (from students whose initial concept had been of a hands-on engineer). Managerial aspects of the role appeared but mostly following statements on designing or inventing. Many had begun to look forward to the extrinsic rewards of a career. The only notes of cynicism were from one student who had revised his opinion from "A very competent and difficult job, thoroughly responsible and very appreciated in society" to "It's not difficult at all, just constant and organised work but not really appreciated by society." Honours year students seem to have polarised more in to 2 groups. Both felt they had a fairly clear and realistic appreciation of the role they would fill. One group was epitomised by the student who said at interview, "I know what it will be like. Just more of the same." [What do you mean "the same"?] "Long hours of calculations. Just more and more calculations. Stuck between four walls all day, every day doing boring calculations." They had low scores on the boring / exciting scale for view of their future role. The other group was looking forward to an exciting and challenging career with a managerial component in their role of active, team-based design or project work. General competence rather than detailed knowledge from their degree would be needed. One commented, "It wasn't what you had learned. You don't really use that. It was showing you could do it." For some the excitement was tempered with trepidation about the responsibility they would have to accept. As put by one who had accepted a job, "There will always be someone checking my work until I know what I am doing. I find it really scary. I mean it's life and death. Someone could get killed offshore because of me if I get a number wrong." Students interviewed from the first group were looking forward to extrinsic rewards but had little enthusiasm for the role they anticipated fulfilling. Those in the latter group, several with confirmed employment in prospect, were enthusiastic and talked mainly of the job itself.

Graduate Responses

As noted above, only 13 questionnaires were returned and so conclusions are tentative. In total, 10 graduates were interviewed. Most of the graduates were working in an engineering environment, the majority office based, and found the work challenging, Table 2. Even with a small sample, the transition from University had been described as from very easy (1) to very difficult (5) with a mean of 2.75. The three main factors identified by respondents as facilitating the transition were helpful, supportive colleagues, prior experience or training. A typical comment at interview was, "It was tough, really tough at first, but I'm getting the hang of it now. There's a lot of good guys there and they really helped me." Adapting to the work environment with its attendant responsibility and uncertainty about what was expected had brought about difficulties. The knowledge and skills gained at University had been of some use to most students but comments suggest that the personal and inter-personal skills were most applied. One commented that no longer needing to carry knowledge in his head aided the transition while another had difficulty applying theory to practical situations. None had found their work exactly (1) matched their expectations while one found it not at all as expected (5). The average of 2.75 suggests that in general they felt they had some conception of what lay ahead of them. Most graduates felt their course had not provided them with enough practical and experimental experience. None felt they had acquired an excess of these. They had acquired about the right amount or too little in the way of personal and managerial skills and knowledge of applications packages although two ex-students considered they had had too much exposure to one or more of them. Most graduates would have welcomed an increase in applications and process skills but throughout their course undergraduates bemoan their excessive workload. The young engineers were asked to rate various factors about their perceptions of their current roles. Their responses are summarised in Table 3. It is evident that in general they have found their positions fulfilling, technically challenging and enjoyable. If to some it is stressful, perhaps due to the technical challenge which most experience most feel secure. The aggregated measure sums the scores (with the stress score subtracted from 5) and reduces them to a five point scale. Clearly most of the respondents have found their jobs to their liking. The graduates were asked to indicate the extent of their agreement with a number of statements. Table 4 is an analysis of their responses. Graduates were generally neutral about how well their course had prepared them for industry and the importance of theory in their job but considered that people management was more important than theory. How much the experience conformed to expectations is somewhat coloured by the fact that a third of the respondents had prior industrial experience. The remainder disagreed that the work was what they had expected, they had generally needed training, were not immediately allowed to handle major projects and did not feel fully trusted by their colleagues.

They rated the status of the engineer in society neutrally. None ticked the extremes of the 5 point scale and the mean was 3.4. The respondents were asked about the content of their current jobs. Two had spent the whole of their first year in training. Second year experience was quite varied but the average breakdown of their time is shown in Table 5.

Connelly and Middleton's [7] earlier survey of local graduates was not confined to our graduates and was not specifically intended to investigate socialisation but some of the findings are relevant. Responses from 162 and 100 were received to its two parts . The strongest reasons for selecting their course were related to their having a strong interest in the subject and to the career prospects it would provide. Similar reasons were given in a contemporaneous survey of our undergraduates. They had intrinsic motives for pursuing a career in engineering e.g. its being interest, challenge, variety, creativity and career prospects. Remuneration and status were considerably lower ranked. They believed the key elements which an engineering degree course should contain were ability to put a broad theoretical grounding into practice followed by problem solving and personal and interpersonal skills. Graduates comments mirrored the concerns of our undergraduates. An extreme a view was "many graduates find that their degree has been largely useless - much too theoretical and not designed to be of immediate practical". More typical was "engineering courses should try to be industry relevant and less theory based. The GEEP Report found "engineers expressed the need for a more practical approach with ... applications oriented rather than "hands-on" experience". Briggs and Hodgson [5] and McCaulley [32] give an international perspective. Constructive comments suggested that courses should contain "thinking, motivation, creativity and interpersonal skills. They identified as their greatest training needs management and finance and budgets. Around a third of the respondents indicated that their careers had not lived up to their expectations. The reasons given related not to a loss of interest in engineering but to feelings that their skills were underutilised and that their colleagues undervalued them. Dissonance, where it exists after graduation seems to stem less from a loss of enthusiasm for engineering as from a need for more challenging work with better career prospects.

Discussion

We believe that our model, Fig 1, is supported by the evidence we have obtained both through our surveys and from the literature. In the engineer's schooldays where tentative occupational choice is made a radically different environment from university is provided. In small classes able pupils,the elite in their peer group, are cosseted and coached for exam success e.g. [47]. It is in the teacher's interest that they attain their qualifications. The transition from this environment to one in which numbers are high, the abilities of peers are on a par and they are expected to learn much more autonomously cause acute anxiety. This Wankowski maintains is one of the primary causes of student failure.

Naive socialisation

Most of our undergraduate entrants are direct from secondary school, aged around 18. The majority of respondents did not feel that their schools had prepared them well for university. Add to this is the disenchantment many of them feel when their concepts of engineering appear, in the light of university's treatment of the subject, also to be misguided and high early casualty rates become predictable. Many report an interest in technological studies at school, at home in cars and planes or having a near relative, arguably a role model who is an engineer. Fenster's [19] also found that "too often students tell them the reasons they have chosen engineering is because they like to fix cars.." Females are much more likely to indicate that they have been influenced by a parent, friend or teacher whom they admire [28]. These contacts have given them an attractive but unrealistic precept of the role and duties of an engineer. Closer questioning reveals that they see the engineer as essentially a practical person with direct hands on contact with "engines". Questioning students on lack of motivation evokes the typical response "We thought we would spend most of our time in the labs. Instead we sit all day in boring pointless lectures". While science students identify with the theoretical aspects of their courses, engineers show a marked preference for practical sessions [12]. What we term the *embryo* professional socialisation is unrealistic and naive. Many engineers adhere to the view that schoolchildren have poor conceptions of the engineering profession. Tonkinson and Gazey [42], however, solicited the views on 34 questions of a total of around 1800 schoolchildren in upper primary and lower secondary schools. They compared their responses with the preconceptions of 108 industrialists of what the responses would be. "Overall, the pupils ...perceptions of engineering and manufacturing were quite positive" and much more favourable attitudes than the industrialists predicted. Our entrants generally said that they were motivated to join an engineering course because of a strong interest in they subject, epitomised for many as essentially practical. These are much more intrinsic than the findings of More and Kohn [36] where their sample of dental students instanced factors involving prestige, financial earnings, human service, autonomy and manual skill as their main motivators. This dominance of intrinsic motivational factors, particularly mention creativity and challenge, has been found in all previous work (e.g. [11], [39] and John from the responses of comparatively large samples concluded that applicants, entrants to engineering courses and professional engineers

held a positive set of attitudes towards the subject but were inclined to believe that their profession was not generally viewed as "prestigious". Although entrants views are naive their embryo socialisation should provide an exploitable base on which to promote commitment to engineering studies.

Transitional dissonance

We now examine the match between these attitudes and expectations and the environment of and actions demanded by a typical undergraduate course. Students who have perceived engineering as essentially practical expect to spend a high proportion of their time in the laboratory or on other practical activities. First year students can, however, spend around 80% of their time in formal lectures. Lecturers may espouse constructivist principles but in general the approach is transmissionist and concentrates on abstract principles rather than applications. Lectures do not necessarily imply transmissionism but commonly do and "that lecture remains the dominant method of teaching in higher education continues to be regularly confirmed.." [25] Our students complain about the theoretical approach, perceived as divorced from applications and fail to see relevance in the codified knowledge presented to them. Engineering courses in general favour the dual qualification system i.e. a degree followed by a period of apprenticeship in a technical post. This has the "major disadvantage (of) the acute separation of theory from practice" [17]. We detected emotions ranging from resignation to shock and anger about the extent of maths, theory and abstract exercises and the paucity of practical work in the course. Models for the future development of engineering courses rarely mention the students' points of view e.g. [28], [48]. Entwistle [16] noted that in the major quality assessment of Scottish universities few departments rated as excellent attracted favourable comments on teaching practice. He also observed that many staff allow traditional and ineffective methods of teaching to go unchallenged. Undergraduate performance is judged by marks or grades. One student said "I know that we learn is important to our futures but at the end of the day it's passing the exams that's important". Laurillard [29] has illustrated that although most lecturers maintain that they value evidence of deep learning, assessments predominantly test only surface learning. We suggest that this concentration on grades and on "regurgitation" of knowledge will be in conflict with the preconceptions of many students. Becker's work in American Universities, although dated is suffiently important as to merit a short summary. He described a prevailing situation in which students seek to limit the teacher's expertise by bargaining for good grades, trading these for their continued good behaviour. In a joint paper Hughes [26] on the training of physicians they observe that (students) "believe that it (medicine) is a great body of facts" which will be imparted to and subsequently used by them. They quickly form friendship groups and are divide into work groups. Realising that they cannot learn everything some concentrate on facts they believe will be of value to them in subsequent practice. The majority perceiving that their progression depends on achieving good grades employ strategies such as making files of and pooling past exam papers, attempting to predict future exam questions and tacitly or overtly seeking cues on what may appear and be valued in assessments. This allows them to minimise workload and to concentrate on aspects which carry credit. This modus vivendi results in students and staff accommodating themselves to the demands of learning a body of knowledge and of providing evidence that standards are being maintained. These objectives are being achieved, however, while students are pursuing objectives quite different from those espoused by faculty. Becker [1] quotes a student saying "in fact if you really try to learn something, it would handicap you as far as getting grades goes". Pirsig [37] introduces the subtlety that re-gurgitation should "convince the teacher you were not imitating". Our findings and work more recent e.g. [31] confirm these findings. Elton has said that "examinations ... favour these students that put the passing of examinations higher than their interest in the subject of study." [14]. Cryer [9] reported that some of the most able of the students at MIT withdrew from their courses, disgusted that they could obtain better grades by concentrating on assessment objectives rather than what they saw as "worthwhile" objectives. We contend that many entrants are likely to find that their courses do not meet their expectations and this imposes demands markedly different from what they had anticipated. This results in disillusionment and the student experiences dissonance. Whether the dissonance leads to withdrawal or to a re-alignment of expectations will depend on the individual. Similar disillusionment has been reported by others in other professions. Law undergraduates found little in their courses related to real legal work says. "A schooling so removed from everyday realities leads us to question the strength of its impact on the self-conceptions of students", [30]. We are not arguing that disparities between the students' naive perceptions of the engineering profession and the culture of the University are the sole cause of disillusionment. The problems caused by the difference in the approach adopted and demands of University compared with the school environment are well documented. Wankowski [44] says "I would not hesitate to state that...emotional disenchantment, arising from an initial academic and social disorientation on entering university, is one of the most important factors in student failure." Add the particular disparities in engineering to the general and a recipe for widespread disenchantment is generated.

Student socialisation

Students who do not experience or who overcome initial dissonance, in general adopt the norms of the campus. Becker describes grades as "the currency of the campus" [2]. Most students place passing assessments as the most important performance criterion. Elton [14] found that the most common complaint by students against staff was their failure to prepare them adequately for exams. Becker's findings on cue seeking and negotiation are presented above. Entwistle [16] found that "many of the students revising for finals….relied heavily on reproducing the understanding of their lecturers". Grades may be seen as a means to an end but students may also gain a sense of achievement from their attainment and for some may have become the primary objective. We found that senior students find they understand the theory but they still feel ill-prepared to apply it to practical situations.

Anticipatory socialisation

As students progress through their course they increasingly contemplate their futures in the profession. By the fourth year they have polarised into those who foresee an exciting, challenging, project orientated occupation and those who dread only more calculations, theory and analysis as they work in isolation. Many by this stage have accounts from recent graduates to colour their perceptions. We do not at this stage have much evidence to indicate whether these contrasting precepts have any bearing on post selection job satisfaction in their early careers.

Nascent professional socialisation

We found that a minority of our graduates enter a formal training scheme. The majority are, as they put it, "thrown in at the deep end". They found the environment and the work to be different from what they expected and were unsure what was expected of them. Do they experience dissonance? They certainly feel unsure of themselves, they are concerned about the possibility of error, they feel a need to orient themselves in a new environment. But we would now hesitate to describe their experience as dissonance. They describe feelings of excitement and challenge, albeit tinged with trepidation. We see the eyes of graduates light up as they describe a singular success, a challenging problem or a large responsibility. We have coined the word *translumenence* to describe this "enlightenment". Graduates rarely report on feeling under threat should they make a mistake. Helpful, supportive colleagues are frequently cited as helping them through the early stages. They still complain, however, that their degrees did not prepare them to be able to apply theory in practical situations. They have found that problems are less structured then they had anticipated and so they have to learn new approaches to solving them but they rely heavily on advice form longer established colleagues. They have found that engineers have to bring to bear non-technical expertise, which must be learned, and managerial and communications skills that they now value more highly the subject knowledge. They generally feel the need for training both in technical and managerial skills. Successful career management relies on clarifying ones ambitions and then making and seizing the opportunities to achieve them [13]. Career progression no longer can be seen as ending with entry to one's chosen occupational niche.

Mature professionalisation

Our surveys did not include mature professionals and we have to turn to the literature for evidence of this stage. To a large extent the conceptions formed in the early stages prove enduring although the initial feeling of being theorists amongst practitioners evaporates. The excitement may be tempered and they have learned to deal intuitively with complex problems which in their "apprenticeship" required a great deal of conscious thought and information seeking. They continue, however, to hold their profession in high regard e.g. [28], and find their occupations to be interesting, creative and exciting, [42]. Within 5 years of first appointment more than half of them will be spending more than half of their time on management activities, [18]. Although we found some one third are disappointed in their careers this seems to stem more from feelings of underutilisation of their skills and poor regard by their colleagues rather than disenchantment with engineering.

General discussion

Our evidence supports our model but there are issues which we would like to investigate further. We are concerned about the third who have found their careers have not lived up to their expectations and about approximately the same proportion of final year students who are not looking forward to their futures. Are there links between the two groups? We would also like to find ways to dispel what Stevenson [40] described as "one part of genuine life against two parts of drudgery between four walls". Those responsible for engineering courses almost never take account of the expectations of the entrants or pay more than lip service to the voice of industrialists [33]. From leaving school to professional practice engineers see the profession as having a strong but not necessarily hands-on orientation and bemoan the abstract nature of degree courses. Industrialists observe that recruits lack practical awareness and are swingeing in their criticisms e.g. "what hits me every time I interview a new graduate ... is the total lack of industrial awareness these young people have". Jackson [27] commented that "those who hire our graduates are increasingly concerned about their capabilities". Students

and industrialists recognise that the general knowledge they acquire will largely be superfluous and that before they can be competent they will have to learn the specialised knowledge relevant to the job they have entered. Industrialists regularly rank problem solving, communications and managerial skill higher than technical knowledge yet propositional knowledge dominates. It is perpetuated because academic course content, level and standards are dictated largely by the need to satisfy two groups of auditing bodies, the internal and external academic validating bodies and the professional accrediting institutions. Architects of engineering courses sought academic respectability by increasingly "scientising" the course with the inevitable consequence of increasing abstraction and many courses remain largely theoretical and "real engineering" is equated with a mathematical approach to the subject. This is not uniquely a British problem but is widely reported overseas [5]. Accreditation of its courses by a professional institution has benefits to a university and an occupation seeking to establish itself as a profession gains by association with academe as it legitimise its claims to holding sway over a specialised body of knowledge. Negotiations will take place over content but Eraut [17] maintains that "the traditional higher education concern with disciplined, codified propositional knowledge has usually triumphed". The institutions aver that it includes the ability to apply the knowledge, [35] but Schon [38] argues that it omits much that practitioners would see as the essence of what they practice. We believe this concentration on codified knowledge creates a gravitation which will resist efforts to emphasise deliberative processes and skills at the expense of some of the procedural knowledge. To put it more simply that produce graduates who know how as well as knowing that!

Conclusions

Our evidence supports our new model for the formation of the professional engineer which complements rather than replaces other models. In particular it provides an additional dimension on the novice, advanced beginner, competent, proficient, expert progression model [10]. It establishes a base from which the acute problems often encountered in the early stages of formation can be explored. The problem is not the low general view of engineering. *It is that its image attracts a substantial proportion of entrants with misconceptions of the engineer's role and unprepared for the theoretical approach adopted by universities, which is itself a mismatch with the needs of the industry.*

Can we end on a more optimistic note? We believe we can. There are encouraging signs that universities are at last beginning to do more than debate the need to concentrate more on process skills. The dissonance which entrants experience stems less from a misconceptions of their eventual roles as engineers but from the approach of universities. The dissonance would be reduced by more convergence with industrial needs as would implementation of the EPC Engineering Graduate Output Standards [15]. Innovation revealed in published work is largely in later years of courses. It needs to be extended to the earlier years where the most serious attrition is experienced. The evidence shows that from the naive stage through to practising professional engineers hold a positive set of values about their knowledge and their profession. Such motivational values if harnessed can enhance achievement at the degree stage [17], [8]. The profession has long insisted that the image of engineering must be raised to attract more entrants of the right calibre. Were this easily achievable it would not remain an issue. Institutions, academe and industry should strive to give those with a genuine interest in engineering a more realistic impression of the nature of the engineer's role. To be sure we would lose some to whom this image was not attractive but the rest would be better prepared for the early years at university. The result could be less disenchantment with a significant drop in early casualties.

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Table 1: Analysis of Means of Computed Difference Scores of Student Responses

	Before to Now	Before to Future	Now to Future
Practical to Theoretical	-1.11 *	-0.70	+0.41
Individual to Team	+0.58 *	+1.19 *	+0.60 *
Exciting to Boring	-0.62 *	-0.01	+0.56 *
Difficult to Easy	-0.33 *	-0.32	-0.02 *
Calculation to Project	+0.13	+0.60 *	0.73 *

Scores based on 5 point scales (-2 to +2) and n =112 . * indicates significant difference of means (95 confidence interval

Routine, fairly mundane	1	Overseas	-
Challenging, interesting	6	Engineering environment	9
Mostly onshore office based	6	Other	1
Mostly offshore	3		

Table 2. Responses to " ...Which of the following best describes your first appointment after graduation?"

	MINIMUM	MAXIMUM	AVERAGE
Fulfilment in role	3	5	3.83
Financial rewards	1	4	3.25
Technical challenge	2	5	3.42
Stress (reversed, i.e. 5 - score)	1	4	2.66
Security	2	5	3.25
Enjoyment	3	5	4.14
Aggregated Job Satisfaction	2.4	4.7	3.5

Table 3. Role Perception Scores (1 = Low; 5 = High; n = 12)

STATEMENT	MINIMUM	MAXIMUM	AVERAGE
I did not need a lot of training before undertaking my work	1	4	2.7
My University education prepared me well for industry	2	4	3.2
Engineering is more dealing with people than formulae	3	5	4.0
Knowing the background theory is the most important factor in my job	2	5	2.9
Within a few months I was trusted to handle major projects	1	4	2.7
I felt my colleagues looked on me as inexperienced	2	5	3.2
I felt very unsure of myself when I started my first job	2	5	3.5
The work I do is just what I expected before graduation	1	4	2.7
Professional qualification is not important in my position	1	5	2.4

Table 4. Graduates Responses to Statements About Their Experiences Since Graduation (n = 12)

Technical Liaison	Training	Report Writing	Customer Liaison	Meetings	Design	Project Man.	Internal Liaison	Other
16.2	7.2	18.9	9.1	8.6	8.9	11.5	8.8	10.7

Table 5. Average Distribution of Graduates' Activity (n = 13)

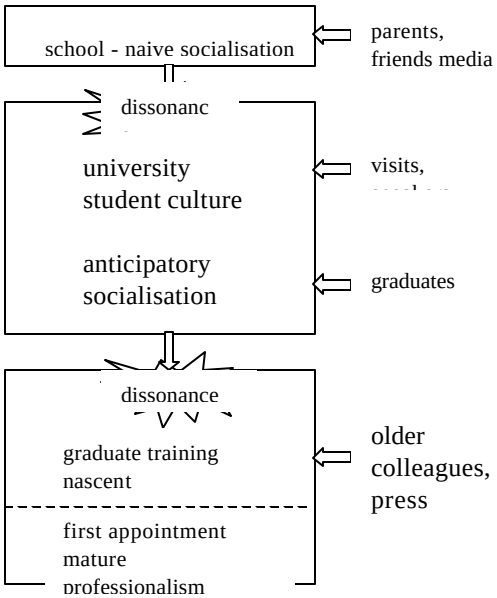
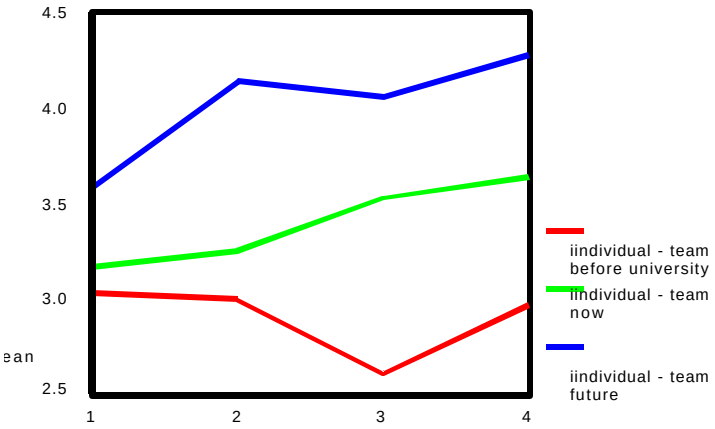
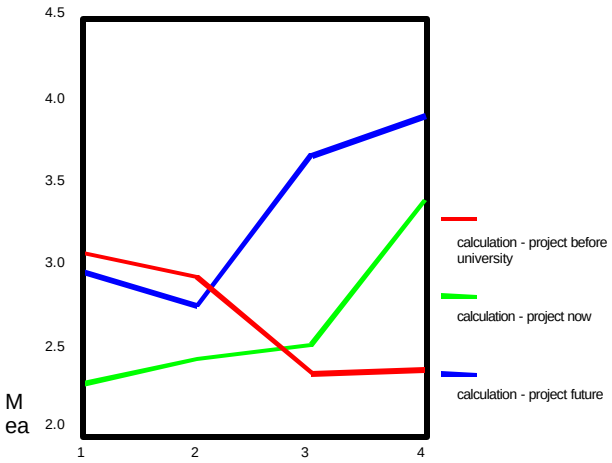


Figure 1 The Model



Graph 1 respondents academic stage



Graph 2 respondents academic stage