"Equipping the future quality practitioner given expert characteristics and future manufacturing and e learning developments"

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Abstract

Purpose: This paper reports on an investigation undertaken across five countries to elicit what the perceived traits and characteristics of an expert in Quality and in conjunction with these traits, to understand what role technology may play in the provision of education of quality experts in the future.
Methodology/Approach: A questionnaire which investigated what quality practitioners and managers in Small to Medium Size firms perceive to be an 'expert' in quality was developed. A semi structured interview based on this questionnaire was the method of deployment in twenty Small to medium size organisations from Spain, Poland, Greece, Sweden and Ireland. The questionnaires were translated into the national language for each participating country and the results were then reverse translated back into English.
Findings: Most surprisingly perhaps the expert characteristics that defined an expert quality professional were significantly biased towards soft or networking building skills as opposed to skills with an analytical base. This will have a significant impact both on how quality professionals work and in how training is delivered.
Research limitation/Implication: The survey results indicate that a 'Pareto flip' in the provision and focus of education is required. Given how the manufacturing environment is expected to change, provision of tools and techniques that will facilitate employees learning the skills required to deploy quality in a virtual and networked learning and manufacturing environment is critical.
Originality: This paper researched what the possible futures in both manufacturing and e-learning are to understand what environment the quality professional will be operating in and possible modes of deploying these requisite skills.
Keywords: E-learning, Novice to Expert, Quality Management, Barriers to uptake, Learning companions.
Paper Type: Conceptual

1. Introduction

The paper is organised into seven sections. Subsequent to the introduction: section two investigates the role of the Small to Medium size Enterprises and more specifically, the role of the TQM practitioner or 'Quality Manager' within these firms Section three discusses a proposed framework to assess the attributes and characteristics that are core in the definition of a quality expert, namely the novice to

expert trajectory and uses this as a means of defining what the key learning outcomes for education aimed at up-skilling this subset of learners in SME's are an what the perceived barriers to uptake of training are.
Section four puts forward the research instrument, its construction, rationale, testing and means of deployment across the five participant countries and provides an overview of the results obtained.
Section five discusses the results of the survey, namely what are the characteristics and traits of an expert in quality and what are the individual and organisational barriers to adopting the training required to attain this 'expert' status.
Section six investigates what the future holds for manufacturing environments and what possible developments in e-learning are.
Section seven presents a synthesis of the research, given individual and organisational barriers to uptake of learning in SME's, What is required to become an 'expert' quality practitioner and future manufacturing and e-learning technologies what are the implications for the SME professional wishing to become expert moving into the future?

2. The Role of SME's and Quality Managers.

SMEs are defined officially by the EU as those with fewer than 250 employees and their annual turnover may not exceed €50 million. SMEs account for a large proportion of Europe's economic and professional activity. In practice, 99% of businesses in the European Union are SMEs, and they provide two-thirds of all private sector jobs. So small firms are, in fact, the real giants of the European economy. Micro-businesses (those with fewer than 10 employees) dominate employment in countries such as Italy (47%) and Poland (41%), whilst the share of large enterprises in total employment in the United Kingdom is just 46% [1]. It is these firms and their employees that form large swathes of Europe's economic landscape. Manufacturing industries which constitute a large proportion of these SMEs have recently found themselves in a challenging economic climate. Between in 1995 and 2004 in Ireland, employment in the services sector increased by 58% in comparison to growth of the manufacturing sector of just 5.6% [2] and the EU15 has lost approximately 1.5 million manufacturing jobs since 2001 [3]. Critical to the long term survival and prosperity of these firms is their ability to apply tools and techniques which ensure their effectiveness in production and distribution of goods regionally, nationally and internationally. "Production as a process that simultaneously involves the material transformation, human labour and value creation necessarily depends upon the skills and knowledge of individual workers and on the collective knowledge of a range of social and technical conditions and processes that makes production possible.[4] Identifying the employees that are responsible for instigating the tools and techniques within these firms ensures the continued existence of these firms and will continue to support these firms is therefore critical in a long term strategy to support within company development.

The mainstay of quality deployment in both large and small industries is the suite of tools collectively known as "Lean Manufacturing" this incorporates concepts of total quality management such as Value stream mapping (VSM), Total Preventive Maintenance(TPM), Error proofing, Visual management and rapid changeovers, all underpinned by an ethos of continuous improvement. Several research studies have shown that lean manufacturing produces higher levels of quality and productivity and better customer responsiveness [5],[6], [7] By implementing lean principles TRW Automotive electronics group has reduced man days lost by 81%, reduced the time to

move raw material by 61%, increased production inventory turns by 28% and decrease capital expenditures by 71%[8]. At John Deere, application of lean tools has facilitated the introduction of a Just in time material delivery system and a pull system of production [10]. At Lockheed Martin Missile and Space corporation they are infusing lean technologies into all their satellite production efforts resulting in significantly reduced production costs and program cycle times cut by 50%[9] These are but a few of reports from manufacturing industries on the gains achieved as a result of application of Total Quality Management Techniques. The benefits accrued as a result of application of lean tools in large scale manufacturing are directly transferable to SMEs and support for the phenomenon is long overdue. Economies require a human infrastructure of knowledge workers who can apply their intelligence in production, but the education and training system must be a learning system that can facilitate life long learning and provide the high levels of group orientation and teaming required for intensive economic organisation. [11] Thus, the cornerstone of the foundation of these firms is in the individuals who are responsible for ensuring the long term competitiveness of the firms. The quality manager. While the tools and techniques for quality management have been comprehensively identified, the key traits and characteristics of the individual have not. The research posits that identification of the traits and characteristic of a quality expert should form the key learning outcomes of education focused on up-skilling these managers and will then investigate if these key characteristics can be nurtured given future projected manufacturing and e learning environments. Identification of quality expert skills and attributes in turn builds towards the requirements for developing SME's that in turn lead to "Knowledge creation, continuous improvement, knowledge as a source of value and synthesis of innovation and production" [11]

3. The Novice to Expert Trajectory.

Banners' model of skill acquisition [15], based on ascending levels of proficiency, was originally developed by Dreyfus and Dreyfus [16]. According to this model, nurses pass through five stages of career development: novice, advanced beginner, competent, proficient and expert. This model can be directly transcribed to the quality practitioner. "Learning in all domains is a lifelong process that can be monitored, assessed and scaffolded. The linear progression as described by Benner can also be visualised as a framework or "scaffold" through which practioners need to move through and build if they are to attain this status of expert. Lajoie [14] states "Models of expertise can assist us in determining what to monitor, how to assess, and where to scaffold learners so that they eventually become independently proficient in their chosen fields" The means to understand how to educate individuals in this independent proficiency lends itself in turn to a high level of mobility and transferability of skills nationally and internationally. The novice to expert trajectory was chosen as the vehicle for means of assessment as it has high face validity and comprehension level of the term between academia and industry is high. A clear definition of Expert at this juncture is vital however. Foley & Hart [17] define the term expert as "someone who has attained a high level of performance in the domain as a result of years of experience" and Nuccio [18] has defined experts as "those who have mastered the perceptual, motor, cognitive and interpersonal skills necessary for performance with a few to no errors". For the purpose of this research, an expert in the context of quality is defined as "An individual who has acquired the knowledge, skills and aptitudes required to effect deep and sustained organisational changes driven by tenets of applied total quality management principles" This is what

facilitates moving the organisation from the effects of low level learning to gaining the more profound benefits to be had from higher learning. The moving of a sufficient number of key individuals within the firm along this Novice to expert trajectory[Figure 1]

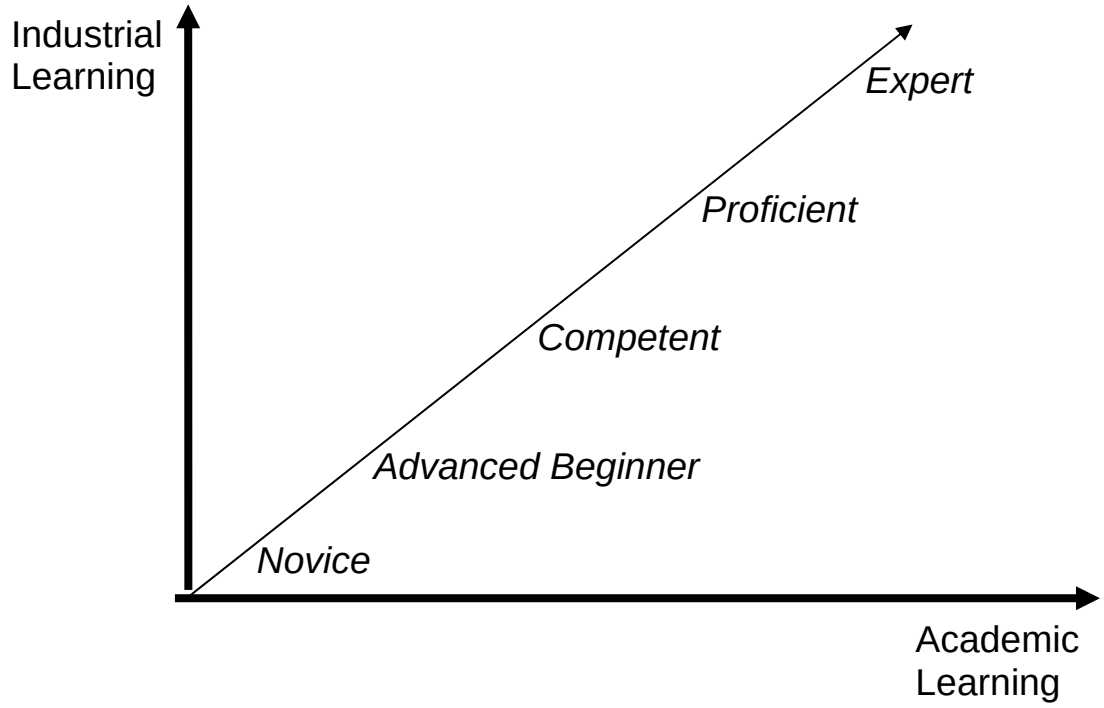

Figure 1: Novice to Expert Learning Trajectory.

4. Research design and deployment.

Based on these prior definitions of expertise and a previous study carried out by Cone and Murray[19] to investigate the characteristics of expert triage nurses as a comparison, A questionnaire was constructed which included questions designed to elicit;

a) Personal traits/Behavioural attributes	(Q1 – Q3)
b) Knowledge	(Q4 – Q6)
c) Business Competencies	(Q7-Q10)
d) Individual barriers to uptake	(Q11)
e) Organisational barriers to uptake	(Q12)

Given that novice learning tends to happens through repetition in a well understood context that focuses on problem solving skills it then becomes possible to understand what is required to move from novice to expert and to build or 'scaffold' a learning program based upon these requisite competencies as each will change depending on what level of expertise has been achieved. This includes skills such as use of heuristics, insight, a focus on problem definition and alacrity in applications of TQM tools and knowledge in ambiguous settings.. The questionnaire was validated by pre testing on individuals with operational and academic experience in Quality deployment. The mode of enquiry chosen was qualitative interview based research using semi structures questions to guide the interviewee. This method was chosen over a quantitative means of assessment as a questionnaire containing prescribed responses with likert type scaling would have artificially limited the range and depth

of response the study was looking to obtain. The study stipulated that the respondents were working in the quality function in their respective SMEs Each of the five participant countries translated the questionnaire as required into native languages and pre validated the instrument in their own institution. The same instrument was used in each participating country and a table of comparison was drawn up to compare and contrast responses to the interview questions.

5. Results

In total five countries participated in the study, Poland, Spain, Greece, Sweden and Ireland. The following presents sample findings from this preliminary investigation into the characteristics and attributes of the Expert practitioner in quality. The responses to selected questions are structured for comparison by adjective comparison and an analysis to the key response findings is presented:

Q1) What personal qualities and characteristics are innate in quality experts?
The most commonly recorded adjectives used by respondents to describe a quality experts characteristics ranked by the number of times the word appeared were; communication skills, organisational ability, analytical, perspective, insight, leadership and motivational skills. There were a large number of once off terms that were not necessarily repeated but that fell into a classification. In total 94 adjectives were used across the 5 countries. A first run organisation of the data uncovered that the characteristics described could be naturally categorised into three overarching group headings, namely:
a) Interpersonal skills including communication and ability to motivate,
b) Character based skills including assertiveness, humility, diligence, insight, ambition
c) Cognitive constructs including Engineering, problem solving, systematic

Q2) How do experts organise information and relevant data?
Most commonly recorded adjectives in response to this question included deep analysis of crucial data, that data was organised by regulatory requirements as per ISO or QS system accreditation requirements, that all data is stored in a systematic and organised way and that data was not just analysed for resolution of problems but that it was analysed for innovation or improvement also. Use of databases and information filtering methods. Collecting, processing and storing of data in a systematic and organised way. Ability to move from detail to broad perspective and understand the strategic significance. They understand statistics and the inter relationships between data. Has knowledge of information generation and problem analysis. Responses to this question could be categorised into two themes:
a) The physical and logical means of data collection and storage.
b) The means by which the data was mined and analysed for meaning

Q3&4) What are the academic and professional qualifications required to become a quality expert?
Sixteen out of the twenty respondents surveyed indicated that at a minimum an undergraduate degree was important. They also indicated that the discipline studies should make reference to development of analytically orientated skills. Five

respondents indicated that a masters level qualification was prerequisite to becoming an expert in quality. Opinions with respect to what professional and academic qualifications were required were more contextually embedded in each organisation as there was wide 'within country' variances in response to this question.

Q5&6) What other domain knowledge/training is required to be a quality expert?
Repeatedly a sound knowledge of productions methods and processes emerged as key knowledge however also consistently expressed that knowledge across other functional business areas including technical design, marketing, sales, supplier and customer relationship development/negotiation was critical. Responses were delineated in two categorisations:
a) Interdepartmental experience including operations, sales, marketing, HR etc.
b) Negotiation and customer and supplier development orientated knowledge.

Q7) What internal/External business resources do experts rely on?
Responses included being part of a strong internal and external company network, having complete and full backing from senior management, support from related departments and training. Four categories emerged in response to this:
a) Internal support network including other departments.
b) External company networks of support
c) Top management support critical to carrying out role
d) Training resources.

Q8) What business competencies and skills do quality experts bring to their role?
Emotional intelligence. Firmness, focus, courage, inquisitiveness, in depth analysis, communication, interpersonal skills, responsibility, project management and problem solving expertise, ability to translate strategy into action, The ability to present data, connect functions, deep knowledge of validation and verification, practical experience in system implementation, leadership skills, sales experience, operational management experience. Separating the responses into headings mirrored the results from question one. Indicating that managers used the same assessment set for business skills to be brought to a role as they did for assessing the innate characteristics of the quality manager.
a) Interpersonal skills including communication and ability to motivate,
b) Character based skills including assertiveness, humility, diligence, insight, ambition
c) Cognitive constructs including Engineering, problem solving, systematic analysis.

Q10) Can you best describe how a quality expert reacts to unexpected challenges at work?
Respondents again yielded a very broad spread of responses to this question, ranging from: The ability to look at problems from a wider perspective, that they listen to and collect facts, ability to find root cause of problems and put in place measures to ensure issue does not re-occur, adopts a long term perspective to problem solving. Ability to prioritise and communicate issues effectively, that they are calm and collected and will take sufficient time to understand a problem fully before deciding a strategy, remains composed, understands which relationships and quality tools to use to resolve issues effectively. Categories of response to this question include:

a) Ability to analyse problem and all possible effects
b) Ability to apply correct problem solving technique

c) Use of interpersonal skills to communicate, delegate, prioritise and organise
d) Character qualities including composure and perspective.

Q11) Individual Barriers to adoption of e-learning:
Individual barriers to adoption of e-learning centred around three core themes, in order of how these appeared were:

a) Sufficient time
b) Knowledge of availability
c) Interest or relevance to job applications

Q12) Organisational Barriers to adoption of e-learning
a) Large resource allocations in terms of labour hours
b) Prohibitive cost
c) Questions as to the quality or recognition of online learning courses.

Both sets of concerns, individual and organisational must be tackled if e-learning is to become a dependable, recognised and widely available educational resource for the quality professional, particularly for SME's who are less well able to absorb the impact of poor learning outcomes.

6. Future state of the art in e learning and e-manufacturing, implications for moving learners in quality along the novice to expert trajectory.

Manufacturing research, in keeping with objectives as stated by the manufutures platform [13] has identified a number of pillars around which manufacturing research should centre, these including focusing on new, high value added products and services, business models and transformation of existing R&D and educational infrastructures to support world class manufacturing technologies fostering researcher mobility and lifelong learning. The virtual factory of the future will manufacture in adaptable networks linking OEMs with equipment suppliers, value chain partners and services selected according to need at any given time. Its composition will not be limited by physical co location, nor by a need to maintain rigid long-term relationships. At the heart of the new enterprises will be knowledge management, network management and relationship management based on trust and ethics. [13], [19] But how will this manifest itself for the professional in quality management? It is posited that the gap between the working and learning environments will merge and that the quality practitioner will need to understand how to be effective in an environment that can be described by and will depend upon technologies that use [20]:

a) Intelligent agents for continuous real-time remote, distributed and web based monitoring of and analyses of devices, machinery and systems
b) Remote, distributed and web based quality control systems integrated with intelligent predictive agents
c) Dependable and scalable information platforms for complete transformation, optimisation and synchronisation of plant floor problems, issues and solutions

d) A virtual design platform for collaborative part, process and tooling design amongst designers, suppliers and engineers as well as rapid part and process validation.

If this is the perceived future of manufacturing, the future state of the art in e-learning according to recent studies include incorporating learning theories such as responsibility sharing [21], socially distributed cognition [22], reflection and articulation [23], reciprocal learning and learning by teaching [21] and weaving them into concepts for e learning that include the use of agents and learning companions[26] An 'learning companion' is a computer simulated character which has human like characteristics and plays a non authoritative role in a social learning environment, an 'educational agent' is a kind of computational support which enriches the social learning environment either by providing virtual participants to enhance the member multiplicity of communities or foster communication between among real participants, parents, volunteers, teachers and books and other educational resources[24]. If technology is to support the merging of the learning and work environments, then these agents and companions as will need to flex to highly contextualised work environments to guide, support and mentor the SME quality practitioner through this distributed networked environment of people services and processes to become experts in deploying the total quality management principles. According to the research, these agents and companions will need not only to guide the quality expert in these domains to ensure learning outcomes are achieved, but will also need to cater for not only the learning and deployment of TWM principles, but must also cater to imbuement of the characteristics as described in the results of the questionnaire. The question is whether it is possible to design learning so that these qualities can be remotely learned, contextualised to match the environment that the learner is working in such a way that communication is effective and personal instead of the psychological and relational distance often imposed by use of such technologies. In future, integrated delivery systems that promote learning and flexibility will be better prepared to face the challenges imposed by a complex and competitive environment. [25]

7. Discussion

We have entered the perfect 'Electric storm' where technology, the art of teaching and needs of learners are converging [26], Use of the novice to expert trajectory proved a valuable tool in assembling the various constructs or scaffold that will contributes to delivering an education towards an individual achieving a title of future expert in quality practitionership given technology enabled learning and manufacturing environments. Of significance was the preponderance of 'soft' or relationship building skills in response across the three areas of research, innate characteristics, and knowledge and business skills. On average adjectives describing the ability of the quality expert to negotiate, listen, understand, lead and motivate were consistently referenced to by respondents. The age old chestnuts of lack of time and cost to engage in e-learning emerged along with concerns as to the quality of learning as the prime barrier to adopting e-learning courses These results when combined with the technologies currently under development for learning and manufacturing make a fascinating combination. The possibility of agents and learning companions which can adopt different teaching methods depending on the learners needs being used to

guide these learners through educational resources adapted for the context specificity in which the quality professional operates is limitless.

In conclusion, the results of the research also brings to the fore another question. The current syllabus of quality management programs places in excess of seventy to eighty percent of teaching time and emphasis on the analytical tools and techniques required by the quality manager. The remainder of syllabus topics cover project management, accounting and an occasional module on organisational behaviour. Our results suggest that a 'pareto flip' is required if third level institutions are to provide training that is going to support the SMEs role in the economy long term. On the strength of the results obtained, significantly more emphasis is required on the teaching of competencies in negotiation, network development, information sharing and dissemination, communication, leadership and motivation. How may agents and learning companions be deployed to support these learning needs and help the SME practioners move from novice to expert? It is these characteristics with conjoined analytical skills that in the future will lead to development and mobility of future professional experts in any domain. Analysis of the skills required by the expert or even 'elite' is a succinct and meaningful way of defining what the learning outcomes of education program developed to support these employees. That delivery mechanisms that will be meaningful in the environments in which work which will benefit not only the learner, but also their firms and long term, the economy in which they participate.

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