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The Way Forward: Engineering Management

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Abstract: The challenges faced by the civil engineer of the future will be examined. This paper will explore the nexus of forces that exist and evolve that demand a set of skills, which are essential for strengthening the role, and increasing the visibility of the civil engineer in society. A way to prepare the engineers to meet these challenges will be presented. *Keywords:* Civil Engineering, Amplification, Regulation and Management.

1 Obligations and Limitations

It is obvious that our world is changing and we all understand that change is inevitable. This is how our society has advanced to its current state. The pace of this change has accelerated to an ever-increasing rate in the last thirty years, particularly with the advent of personal computers, the Internet, multi-tasking applications, and instant communications through social media. The complexity and the scope of the engineers' work has equally been affected by these changes. The traditional engineering curriculum that has provided our engineers with solid technical skills for problem solving in their own domain have become too limiting to serve society's expectations of an engineer's work.

The field of engineering management has evolved to address areas such as operations research, supply chain management, information technologies, decision engineering and the management of technology. What is absent is the notion of human interaction and the attention to the needs of the users of engineering works beyond the scope of technical problem solving.

The values that engineers are called upon to bring to their work extend beyond workmanship and materials that are part of the technical solutions. They extend to the dealings with one's own conscience as to how the work is produced, used, and impacts on current and future generations. These values are integral the core of the engineering practice and are explicitly articulated in the *Obligation of the Engineer* which is part of the Calling of an Engineers and the iron ring ceremony dating back to 1923.

It is thus clear that a profound understanding of the social implications of the engineer's work should be an integral part of an engineer's awareness the world of engineering practice.

The increasing complexity of the world and the ensuing heavy demands placed on the technical requirements of the engineer's skills have imposed an additional load on the engineering curriculum. The recognition that an additional set of skills to address the requirements for appreciation of societal needs is in direct competition with the exigencies for technical proficiency.

In recognition of the limits to the traditional engineering curriculum, attempts have been made to introduce courses that enrich the engineer's understanding and appreciation of the requirements of humans who are "the beneficiaries of their work".

The mission of accrediting institutions and organizations such as ABET and CEAB and professional licensing orders and associations have is to safeguard technical proficiency in engineering undergraduate programs. It is thus not surprising that the requirement for engineering management expertise is addressed at the Masters level and beyond.

However, one must question whether this practice deprives those with only an undergraduate degree of the opportunity to fully exploit their potential as both problem solvers and full contributors to society.

When I speak of engineering management as the way forward for the engineering process and society, what I have in mind is an engineering management discipline that opens the door wider for integrating the skills included in the current definition of engineering management. This will include the integration of subjects that will enable our undergraduates to incorporate key cognitive skill currently addressed in humanities curricula.

The above proposition may sound difficult to accommodate considering the constraints that are present. The discourse that follows might provide a way to change the current thinking and attaining the amplification required to reach what to some may seem unreachable.

2 Systems Theory and Capacity Amplification

In attempting to facilitate the introduction of changes to the engineering curriculum in a way that they receive wider acceptance by regulatory bodies and other stakeholders, it is worth considering Umpleby's (1990) "Strategies for Regulating the Global Economy". Umpleby suggests the application of several strategies that can be adapted and used in order to introduce desirable changes that may lead to the attainment of desired goals.

A key concept in the study of cybernetics and systems is the concept of power amplification. To extend the views of cybernetics and systems to the realm of engineering education an overview of salient concepts and definitions is in order. Key to

the discussion herein are the concepts of: system, variety, regulation, appropriate selection and amplification. Complete definitions of the cybernetics terms can be found in Principia (2005). Various researchers have invoked the application of systems and systems thinking in the quest for amplification of performance.

According to Senge (1990), the essence of Systems Thinking lies in the ability to shift from lower to higher-level strategies, as the circumstances require. In doing so one must be able to discern the underlying circular interrelations rather than focus on the more obvious linear cause-effect chains. In effect, Systems Thinking shifts the focus of attention from symptomatic action to systemic action. The amplifying power of strategy shifts is well documented in the literature by authors such as Senge (1990) and Beer (1972). Umpleby (1990) proposed a theory of regulation based on the law of requisite variety. He was the first to attach quantitative values to such amplifications. He has identified four levels of strategies shown in Table 1. In the one-to-one regulation of variety each side must match each of its opponent's moves with its own. In the one-to-one regulation of disturbance amplification is achieved because most citizens are law abiding and it is only necessary to control criminals. In ecological regulation, the constituents of the set exercise self-policing and compliance with regulations. Finally, in epistemological regulation amplification is achieved through a conceptual shift that changes the game itself. The last strategy example refers to the report to the Club of Rome *The Limits to Growth*. Every time there is a shift to a higher-level strategy a gain in amplification results by a factor of approximately a thousand. Umpleby points out that these strategies are recursive, i.e., they can be used at any level of analysis.

Table 1. Four Strategies of Regulation per Umpleby (1990)

Strategy	**Example**	**Amplification**
One-to-one Regulation of Variety	Football game	1/1
One-to-one Regulation of Disturbance	Crime Control	2/1000
Ecological Regulation	Antitrust Regulation	1/640,000
Epistemological Regulation	The Club of Rome	12/4 billion

Table 2. Four Strategies of Regulation. Proposed Analogy to Education

Strategy	**Example**
One-to-one Regulation of Variety	Courses
One-to-one Regulation of Disturbance	Programmes
Ecological Regulation	Regulatory Agencies
Epistemological Regulation	Students/Faculty/Society

3 Conclusion

These four strategies of regulation can be easily applied to engineering education. Umpleby has successfully quantified the regulatory amplification achieved by shifting to a higher-level strategy in the case studies considered. Are these relations

generalizable? Would they hold true for other cases, including the engineering education? These constitute research propositions that require further exploration. However, while data is yet not available for the case of engineering education, the research papers presented in this conference by many promising young researches demonstrates that there is a shift in the right direction.

4 References

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